COMMODITY SCIENCE IN RESEARCH AND PRACTICE

NON-FOOD PRODUCTS' QUALITY & INNOVATIONS

EDITED BY RENATA SALERNO-KOCHAN

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Contents

Quality is a way of thinking that makes it applicable

and is constantly looking for the best solutions.

Edward Deming

Non-food products constitute a diversified group of commonly used goods, including, for example, textiles, footwear, cosmetics, household chemicals, electronic equipment, household appliances etc. There are various customer's expectations for such products and depend on numerous factors of cultural, economic, psychosocial and technical nature. Moreover, customer's expectations for these products and its quality are changing.

In contemporary times, in the era of *foresight* technology, the manufacturers wanting to catch or even often to keep their customers are forced to use the most recent raw materials and technical solutions. The present consumer more often and often looks for products distinguishable by its physicochemical properties, functionality, durability and reliability. Consumers pay also attention to the product marketing, economic and environmental aspects. Therefore, to stay ahead of consumer's expectations and to meet current requirements for safe use of products and environmental protection, in different scientific disciplines, including commodity science, researches undertake comprehensive studies.

This monograph is one of eight books entitled "*Commodity Science in Research and Practice*". It consists of 20 chapters written by the Authors from various commodity centres in the world, associated at the International Society of Commodity Science and Technology (IGWT) headquartered in Vienna. The common topics joining all monograph chapters are non-food product quality and innovativeness. The results of researches on innovative solutions in quality shaping and control within selected product groups such as textiles, cosmetics, detergents, paints and engine oils and marketing aspects related to consumer's behaviours on the non-food product market as well as enterprise strategies in launching innovative products on the market are presented.

I sincerely recommend this monograph to all who are interested in non-food product quality. I recommend also other monographs of this series where you can find a number of interesting issues.

Renata Salerno-Kochan

A STUDY ON INNOVATION AND MARKETING STRATEGY OF KOREA SMARTPHONE IN THE WORLD AND EUROPEAN MARKET

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Introduction

A smartphone is a mobile phone which has more advanced computing capability than basic feature phones (Nusca 2009). In the beginning, smartphones typically connected to a media player and a digital camera. But modern smartphones include all of those functions plus the functions of GPS navigations unit, Wi-Fi or 3G, LTE (long term evolution)which can use wireless internet service in a high speed, and 3rd-party apps and accessories. The most popular smartphone operating systems are Google's Android and Apple's iOS. And most popular smartphones are Samsung's Galaxy series and Apple's i-phone series (Charles 2013).

When i-Phone was launched in 2007, most experts prospected Apple dominate the world smarten market in a long time. Until 2011, the Apple's iPhone was the most popular smartphone in the world. But, Galaxy S3 was launched in the latter part of 2011, Samsung, Korea smartphone manufacture, was catching up the all competitors. Now, Samsung Galaxy is the most popular not only Asian market but also other continent market. Up to now, Samsung was crushing Apple in smartphone sales (Figure 1).

But, some expert prospect this phenomenon will not last for a long time. Because, they expect that technology differences between Samsung Galaxy and other smartphone will decrease. Besides, other competitors like a Huawei and Zte which are Chinese smartphone manufacturers will emerge new strong companies with high quality and low price.

Curiously, despite the rise of competition in the digital world, few have attempted to address about world and European smartphone industry. Therefore, this study focuses on status of world smartphone market and suggests enlarging strategy from a Korean company standpoint. Especially, we look into European smartphone market.

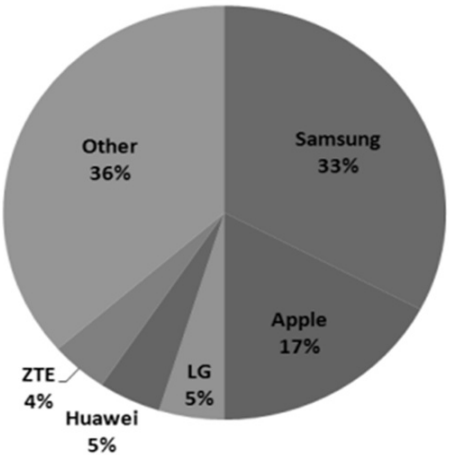

Figure 1. Smartphone Global Market Share (2012)

Source: Samsung is Crushing Apple ... 2013.

Diffusion of Innovation and Chasm Theory

When people met the smartphone for the first time in 2007, it was the innovation to them. And it was also the chasm to them compare to former mobile phone. So, we look into Diffusion of innovation theory and Chasm theory in this phrase.

According to the diffusion of innovation theory (Rogers 2003), diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system. Rogers insisted that innovation is adopted by gradually. The adoption steps consist of 5 steps. It is innovators, early adopters, early majority, late majority and laggards (Figure 2). Innovators want to be the first to try the innovation. Early Adopters enjoy leadership roles, and embrace change opportunities. Early Majorities are rarely leaders, but they do adopt new ideas before the average person. Once again, they typically need to see evidence that the innovation works before they are willing to adopt it. Late Majorities are skeptical of change, and will only adopt an innovation after it has been tried by the majority. Laggards are bound by tradition and very conservative and very skeptical of change and are the hardest group to bring on board (Rogers 1962). Diffusion of innovation theory explain how, why, and at what rate new ideas and technology spread through cultures (Rogers 2003).

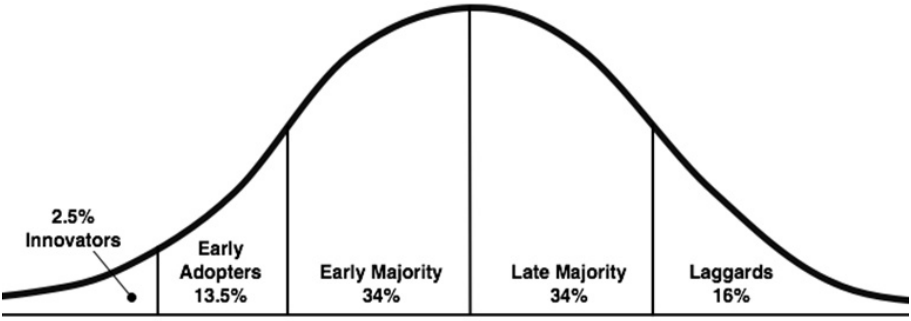

Figure 2. Rogers Adoption/ Innovation Curve (1962)

Source: Rogers (2003), "Diffusion of innovation".

The diffusion of innovation theory can apply to new idea and technology. But, it was hard to apply advanced technology like an information technology. So, Geoffrey Moore (1991) presented the Chasm Theory in his book *Crossing the Chasm*. Moore insisted that there is a gap that exists between the early adopters of any technology and the mass market (see Figure 3). His book illustrated that a lot of technologies at first seem to penetrate the market by enthusiasts, but finally fail to get wider adoption. So to create a company that is worth hundreds of millions of dollars, entrepreneurs need to come up with strategies that will help them build a bridge across that gap (Iskold 2007). Moore thinks visionaries and pragmatists have very different expectations, and he try to explore those differences and suggest techniques to successfully cross the "chasm (*Wikipedia*). At first, smartphone market had a chasm. But, now smartphone popularized by most consumer of world.

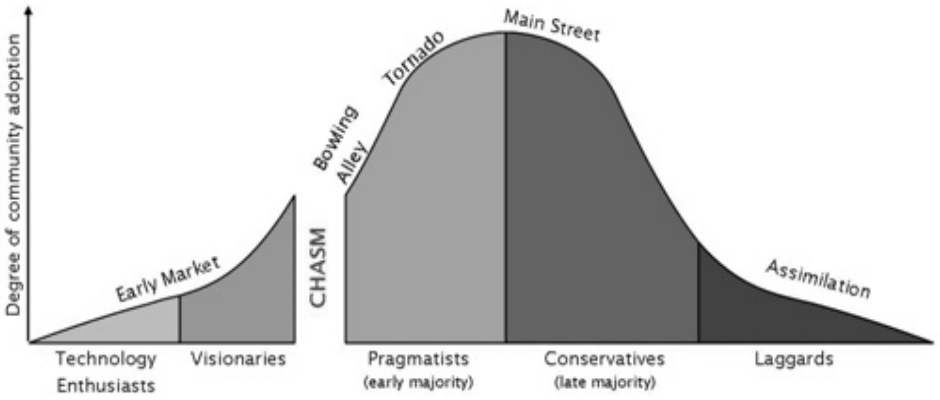

Figure 3. Chasm between Visionaries and Pragmatists

Source: Wikipedia.

Overview of smartphone market in the world and European Market

Worldwide mobile phone sales to consumers totaled about 2 billion units in 2013. This was an increase of 6 percent compared to 2012 (*Gartner Report* 2013). Mobile phone market typically divided into two large markets. Those were feature phone and smartphone market. Smartphone market makes up about 55 percent of overall mobile phone sales in 2013.

Worldwide smartphone sales to consumer reached about 1 billion units in 2013. Before long, many experts expect that smartphone will dominate mobile phone market. The collapse of Nokia demonstrates this phenomenon. Sales of feature phones will continue to decline. Not only developed countries but also developing countries such as China and Latin America want to replace their old feature phones with smartphones (Figure 4).

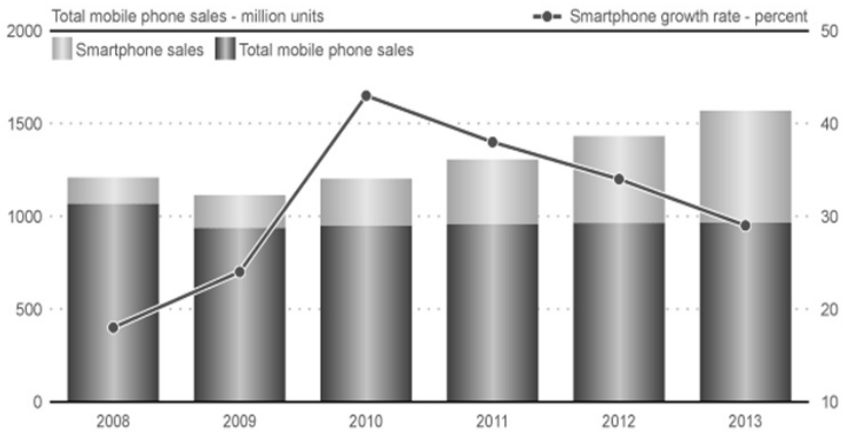

Figure 4. Smartphone/mobile phone growth sales

Source: Samsung Economic Institute Report 2013.

When first iPhone was launched on June 29 2007, we believed that no competitors can keep pace with Apple. But, now Samsung Galaxy dominates the smartphone market. Samsung's fast follower strategy had a noticeable effect on the world so far. Up to now, Samsung's innovation strategy has been worked brilliantly. In 2013, Samsung got about 33% of the global smartphone market share. But, Apple had 17% of the global market share. Samsung got twice as many sales volumes as Apple. It was nothing like anyone had expected. In this digital war, Samsung is the only company to successfully keep pace with Apple, both from an innovation and sales point of view (Stevenson 2013).

In Europe, Android smartphones such as Galaxy account for more than 70% of the European market in 2012. It was up 10% per cent on the same period last year - with over half of all mobile phones sold manufactured by Samsung. Samsung Galaxy series are far more popular in Europe than their iPhone counterparts (*Android and Samsung*... 2013).

As a result of the above, Korean smartphones not only Samsung but also LG are very popular in the world. Especially, Samsung Galaxy is very popular in Europe. Therefore, Korea took amount of dollars owing to smartphones. In a Samsung Galaxy series, the critical success factors to a leading business are likely to be intellectual things such as brands, products specifications and technical capabilities. The key success factors of Samsung are summarized as followers.

First, Samsung Galaxy series adopt Google's android operating system and it was very common to the world. Android is open system. But, Ios is closed system to the customer. So, a lot of new customers hesitate to buy iphone. As a result, every year number of users of android are increasing (Figure 5). Therefore, Samsung became a champion in the smartphone market.

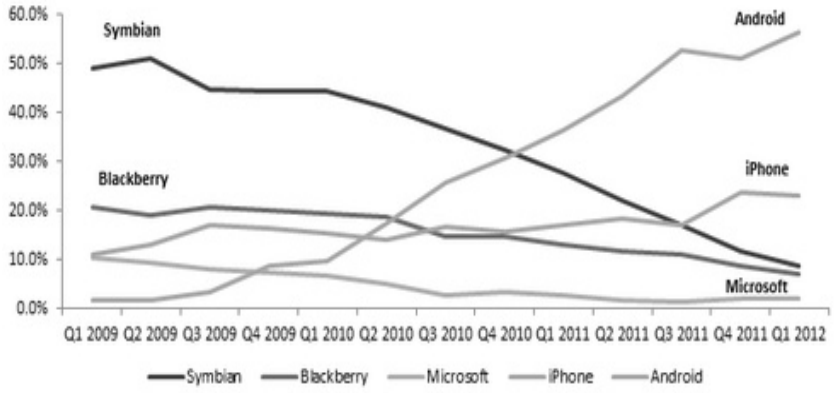

Figure 5. Global Smartphone Operating System Market Share

Source: Gartner (2013).

Second, Galaxy provides to users simple usage and larger screen than iPhone. Those are very important factor to consumers. In fact most people regard Galaxy as the more hassle-free and user friendly product than iPhone. It was lead to victory of digital war.

Third, Galaxy phone's upgrades are more impressive than those of iPhone since Samsung released Galaxy S3 in 2011. Besides, Galaxy has smaller amount of electromagnetic wave than iPhone. Therefore, most consumer of the world pays attention to Samsung's new Galaxy phone.

In conclusion, Samsung Galaxy had done excellent performances in three main areas which are technology, design and branding. Once Samsung enter the market, Samsung focus on innovation as its core competence to gain the market share. This is the critical success factor. As you see (Table 1), market share of Samsung smartphone in the Europe is increased every quarter and every year.

Table 1. Smartphone Marketshare in the Europe

Vendor Marketshare %	Q4 '12	2012	Q4 '13	2013
Samsung	29.0%	30.4%	29.6%	32.3%
Apple	22.0%	19.4%	17.6%	15.5%
Huawei	5.0%	4.3%	5.7%	5.1%
LG	4.0%	3.8%	4.5%	4.8%
Lenovo	4.2%	3.4%	4.7%	4.6%
Others	35.7%	38.8%	37.8%	37.7%
Total	100.0%	100.0%	100.0%	100.0%

Source: Strategy Analytics (2014).

Conclusions and Future Strategy

Up to now, this paper study about smartphone market not only global market but also Europe market. As I stated earlier, Samsung Galaxy series is most popular smartphone in the world. To defending the world champion, Samsung must create various idea. And also, to adapt itself to the rapidly changing each market's circumstances, Samsung concerned should focus on developing appropriate strategies. So this paper suggests some strategies to develop Korean smartphone manufacturer. Because downhill of smartphone is detected in China and Japan, so Korea smartphone manufacturer keep strict guard over the competitors. Korea smartphone manufacturers need to keep in mind that as follows

First, diverse model of smartphone must be developed and produced from a design and function standpoint. Korea smartphone manufacturer must be improved constantly, because many competitors are rushing to introduce new models continuously. If smartphone model such as Samsung Galaxy series and LG G series models are not diversified, most of consumers turn their back on Korea smartphone.

Second, central and local governments should administrative support in a various aspects. Unless they support companies, many Korea smartphone manufacturers and parts suppliers run into difficulties. When two parties work well together, synergy effect is created. And also many consumers will buy Korea smartphones. These lead to take a lot of revenue.

Third, Korea smartphone companies concerned must always search all competitors not only Apple but also other smartphone manufacturers such as Lenovo, ZTE, HUAWEI and SONY. If they don't do so, Korea smartphone manufacturer are overtaken by competitors. So, they concerned must check many competitors to continue present glory.

From the above, it is apparent that continuing attention and right R&D are needed to lasting nation of world's number best smartphone manufacturer.

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EFFECT OF BROMELAIN ON SELECTED PERFORMANCE PROPERTIES OF GEL LAUNDRY DETERGENTS

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Introduction

Gel laundry detergents account for only a small percentage of the washing products market however recent years have seen an increased interest in products of this type. Gel laundry detergents are classified as liquid washing agents. Essentially, the only difference between gel and liquid laundry detergents is the level of viscosity. The viscosity of liquids takes values around 300 mPas, whereas the viscosity of gels amounts to around 3,000 mPas. With such high viscosity, gels can be applied locally, i.e. directly on the stain, where they stay in place without running. This procedure is quite commonly used for stubborn stains, and increases the effectiveness of removal particularly of fat stains (Olszańska, Ogonowski & Ossowska 2002; Hines 2005; Sadlowski 1999). The mechanism of action is associated with better emulsification of fat stains in the local presence of surfactants at a relatively high concentration.

Enzymes are important ingredients of liquid washing agents (including gels). The most commonly used are proteases (hydrolysis of proteins), lipases (hydrolysis of fats) and amylases (hydrolysis of starch). Enzymes are effective at quite low concentrations, in the range of decimal fractions of a percent, and at low temperatures, ca. 30°C. In addition, they are completely biodegradable and have no adverse impact on the natural environment (Jetendra & Ashis 2013; Deepti, Imran, Sanjiv, Anupama & Sandhya 2012; Romdhane, Fendri, Gargouri, Gargouri & Belghith 2010).

Enzymes are usually produced by biotechnological synthesis but they can also be obtained by direct extraction from plants. One of such plant enzymes is bromelain derived from pineapple. Bromelain belongs to the group of protease enzymes. The activity of the enzyme is high in the temperature range from 40 to 65°C and in the pH range from 4.5 to 9.5 (Jutamongkon & Charoenrein 2010; Sree, Jayakumar, Vijay, Chintu & Babu 2012).

The paper examines the effect of a plant enzyme (bromelain) on selected performance properties of gel laundry detergents.

Material and methods

The study examined gel laundry detergents containing the plant enzyme bromelain. For the purpose of comparison, an enzyme-free gel laundry detergent and a commercial product were also tested. The formulation of the gel laundry detergent, which was prepared on the basis of own research, is specified in Table 1.

Table 1. Formulation of gel laundry detergent

INCI Name	Composition [wt%]			
	Gel 0	**Gel 0.25**	**Gel 0.5**	**Gel 1**
Sodium Stearate	5.0			
Laureth-7	18.0			
Laureth-3	2.0			
Bromelain	0	0.25	0.5	1.0
Preservative	0.5			
Aqua	to 100			

Source: own research.

The tests were performed with commercially available bromelain produced by SERVA Electrophoresis GmbH, with the commercial name of "Bromelain from pineapple stem".

The commercially available gel laundry detergent which was also tested is referred in the study as COMM. The composition of the product, based on the manufacturer's data, includes 5-15% anionic surfactants, <5% nonionic surfactants, phosphonates, soap, enzymes, fragrance.

Viscosity measurement

Dynamic viscosity measurements were performed with Brookfield DV-III rotational viscometer. Viscosity is measured with a rotating measuring tip called the spindle, which is immersed in the test fluid. Testing was performed at a temperature of 20°C, with the spindle rotating at 10 rpm.

Foaming properties measurement

The foaming properties were determined using a method set out in the Polish standard (*Polish Standard – foaming properties* 1974). The method involved a measurement of the volume of foam produced by a free flow of the gel laundry detergent solution from a distributor onto the surface of the same solution inside a graduated cylinder. Measurements of volume were performed after 30 s, 1 min and 10 min. The concentration of the test solutions was 1 wt%.

Based on measurements, two parameters were determined:

- foaming ability, *FA* [cm^3] – volume of foam produced after 30 s.
- foam stability, *FS* [%]:

$$FS = \frac{V_{10}}{V_1} \cdot 100 \qquad [\%]$$

where: V_{10} – volume of foam measured after 10 min [cm^3]
V_1 – volume of foam measured after 1 min [cm^3]

Washing properties measurement

The washing properties were determined on the basis of methodology set out in the Polish standard (*Polish Standard – washing properties* 1993). The method involved washing of pieces of soiled test fabric in the test washing agent and in the reference washing agent, in strictly defined conditions. The concentration of the test gels was 1 wt%. The composition of the reference washing agent: sodium tripolyphosphate (4 g/dm^3), sodium carbonate (1.5 g/dm^3), potassium palmitate (2 g/dm^3). Three types of stains were investigated: tannic, fat and protein. After washing, the pieces of fabric were rinsed and ironed, and their degree of whiteness was assessed.

Based on tests, the following parameters were determined:

- washing ability, *WA* [%]:

$$WA = \frac{X - B}{A - B} \cdot 100 \qquad [\%]$$

where: X – average degree of whiteness of soiled fabric after washing,
B – average degree of whiteness of soiled fabric before washing,
A – average degree of whiteness of unsoiled (control) fabric,

– relative washing ability, *RWA* [%]:

$$RWA = \frac{WA_t}{WA_s} \cdot 100 \qquad [\%]$$

where: WA_t – washing ability for fabric washed in the test washing agent solution,
WA_s – washing ability for fabric washed in the reference washing agent solution.

Results and discussion

The viscosity of gel laundry detergents versus enzyme concentration is shown in Figure 1. Viscosity levels of the test gels were in the range of 3,000-5,000 mPas. An addition of enzyme caused a monotonic increase in viscosity from 3,200 mPas (base sample) to 4,800 mPas (sample containing 1% of the enzyme). The viscosity of the commercial gel was 4,300 mPas.

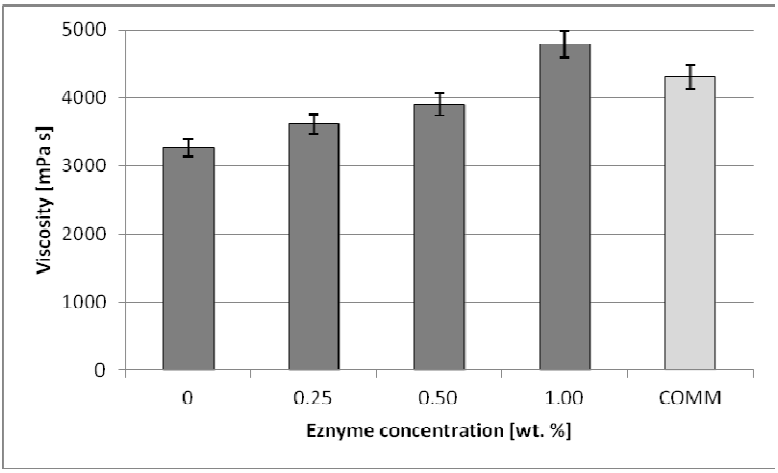

Figure 1. Viscosity of the gel laundry detergents vs. enzyme concentration. COMM – commercial product

Source: own research.

The foaming properties were analyzed on the basis of two parameters: foam ability [cm^3] and foam stability [%].

The foaming ability (Figure 2) of 1% solution of the enzyme-free gel was 270 cm^3. A 0.25% addition of the enzyme did not change that value. A reduction in foaming ability can only be observed after adding 0.5% and 1% of bromelain. The foaming ability levels were 190 and 210 cm^3, respectively. For a solution of the commercial gel the parameter was 250 cm^3.

The foam stability (Figure 3) drops slightly along with an increase in enzyme concentration up to the level of 73% for a sample containing 1% of bromelain. The lowest foam stability, equal to 67%, was recorded for the commercial product.

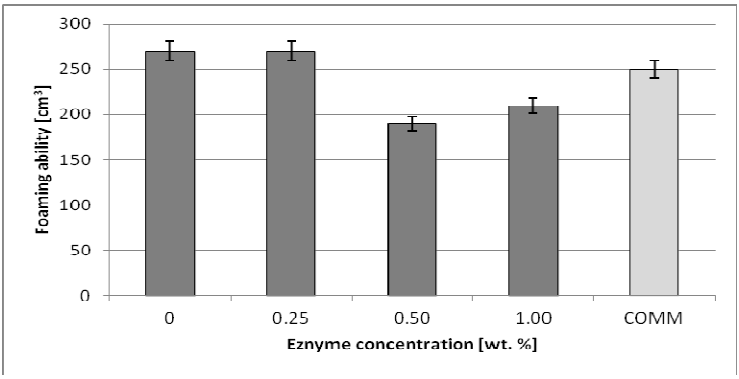

Figure 2. Foaming ability vs. enzyme concentration. COMM – commercial product

Source: own research.

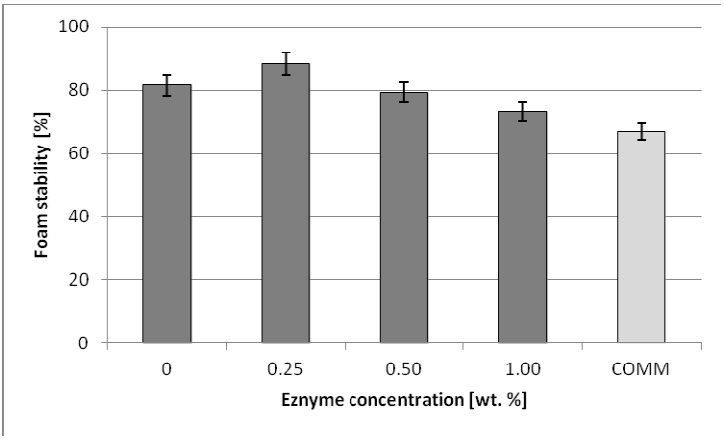

Figure 3. Foam stability vs. enzyme concentration. COMM – commercial product

Source: own research.

The washing properties of the test gels were examined on the basis of two parameters: foam ability and relative washing ability.

The washing ability as a function of bromelain concentration is shown in Figure 4. The test was performed for three different stain types: protein, tannic and fat. Significant changes in the washing ability were observed essentially just for protein stains. The washing ability determined for the enzyme-free gel

was 25%, and for the gel containing 0.25% of the enzyme – 38%. A rise in enzyme concentration to 0.5% caused a further increase in washing ability, though only to 40%, which was not a spectacular change. An increase in enzyme concentration to 1% had any impact on the washing ability.

The lowest washing ability was noted for the commercial product. For fat and tannic stains, the difference between the commercial product and the other samples was not large. Nevertheless, for the protein stain the washing ability of the commercial product was only 15%. The value is 10 units lower than that of the base sample (enzyme-free) and 25 units lower than the value determined for the sample containing 0.5% of bromelain.

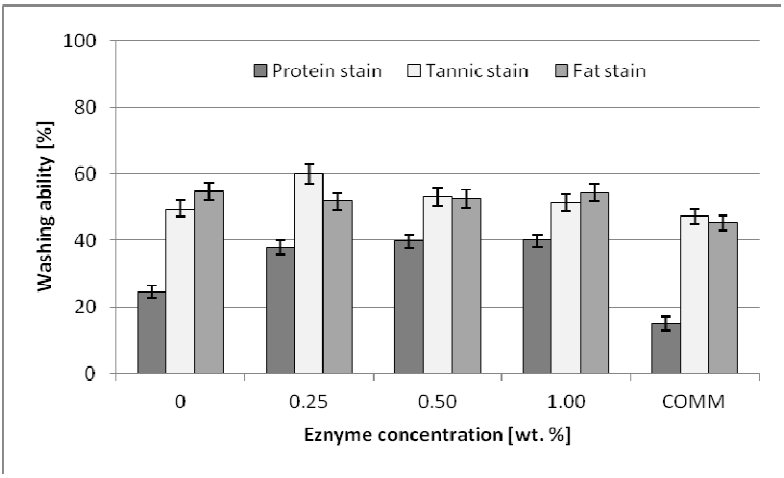

Figure 4. Washing ability vs. enzyme concentration. COMM – commercial product

Source: own research.

The correlation between the relative washing ability and the concentration of bromelain in the sample (for three different stain types: protein, tannic and fat) is shown in Figure 5. The parameter is comparative in nature. It defines to what extent the washing ability of the test liquid is inferior or superior to the washing ability of the reference washing agent. The relative washing ability is specified as a percentage and amounts to 100% for the reference washing agent. Accordingly, for washing agents with inferior washing properties the relative washing ability will assume values below 100%, whereas for superior washing properties the parameter will exceed 100%.

As can be seen, the relative washing ability determined for all the test samples in the study was higher than 100%. The highest levels of this parameter, however, were recorded for enzyme-containing gels. Regardless of enzyme concentration the relative washing ability was ca. 400% for protein stains.

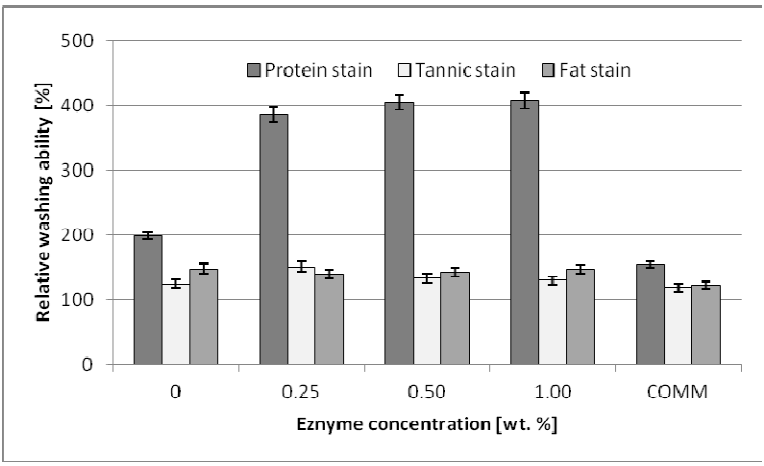

Figure 5. Relative washing ability vs. enzyme concentration. COMM – commercial product

Source: own research.

Conclusions

The study investigated the effect of bromelain concentration on performance properties of gel laundry detergents. A gel formulation was prepared, and product samples were made. The samples differed only in enzyme concentration: 0, 0.25, 0.5 and 1wt%. Tests of dynamic viscosity, foaming properties and washing properties were conducted. For the sake of comparison, the same tests were also performed for a commercially available product.

Based on the tests, the following findings were made:

- The dynamic viscosity of the test washing agents was within the viscosity range characteristic for gel detergents,
- An increase in bromelain concentration induces an increase in viscosity in gel laundry detergents,
- Small amounts of bromelain (up to 0.25%) added to the gel laundry detergent have no effect on the foaming ability and foam stability,
- A 0.5% (and greater) addition of bromelain triggers a slight decrease in foaming properties,
- A 0.25% addition of bromelain causes a major increase in the washing ability for protein stains,
- Bromelain was not found to have any effect on the washing properties for fat and tannic stains.

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THE ANALYSIS OF SENSORY PROPERTIES -THE CASE OF SELECTED FACE MOISTURISERS

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Introduction

According to Nielsen, the value of Poland's market of cosmetics in 2013 amounted to PLN 8.5bn (*Jaki będziesz...*2014), and the sale of cosmetics for face, makeup and shower gels is steadily increasing. Stiff competition and easy access to products pose a great challenge for manufacturers. The so-called own brands, offered by discount stores, go through a period of rapid development. According to 2012 data, cited by the Cosmetics and Chemical Industry Forum, a new discount store is opened in Poland every 32 hours (*Jaki będziesz...*2014). Over the last two years hypermarkets have recorded a significant increase in the assortment of branded cosmetics.

Consumers pay special attention to skin care effects, and they purchase the products that guarantee appropriate skin conditions - adequate moisturising, improved flexibility and smoothness.

The chains of stores offer higher quality products and limited product lines. Consumers follow the "Fashion for Poland" trend, which reflects the so-called economic patriotism. Consumers often make a conscious choice purchasing Polish products.

Creams are emulsions composed of fat and aqueous phases, mixed with the use of an appropriate emulsifier (a substance that stabilises an emulsion) (Fey & Petsitis 2011).

Creams are preparations for maintaining proper skin conditions. Depending on their physical state, creams are solid or semi-liquid cosmetic emulsions, among which there are two groups: lipophilic emulsions (W/O - water-in-oil), and hydrophilic emulsions (O/W - oil in water) (Dutkiewicz 1998, Kowalski & Panek 2003). Producers also offer creams which combine W/O and O/W compositions. Other available products include polyphase

emulsions (multiple emulsions - W/O/W). Despite their high oil content, they generate the same impression of freshness as O/W emulsions (Fink 2007).

Creams can be classified as oiling, moisturising and special-purpose ones. All creams have the following composition:

a) the fat layer - the so-called fat base – and they include fat-soluble substances: paraffin, vaseline, mineral oils, waxes, ceresin, vegetable and animal fats, lanolin, silicones, higher fatty alcohols and emulsifiers, antioxidants, essential oils, herbal extracts, and some preservatives;

b) the aqueous layer - water and substances which dissolve in water: alcohols (glycerol, sorbitol, glycol), water-soluble vitamins, alantonum and proteins, amino acids, trace elements, herbal extracts and some preservatives;

c) additives - biologically active compounds (vitamins), liposome, fragrances, which are added at the temperature of 30-35 ˚ C (Adamski & Kaszuba 2008; Wilczewska & Puzanowska-Tarasiewicz 2007).

Oil-creams are W/O emulsions. Their major function is skin nutrition, smoothness and flexibility. It is achieved thanks to the addition of nutrients - active substances: vitamins (especially fat-soluble, but also in water), lecithin, cholestines, enzymes and mineral salts, estrogens and fitohomons.

Emulsifiers in this case are waxes, glycerol esters, fatty alcohols and higher fatty acids, cetyl-stearyl alcohols and lanolin.

Moisturising creams are O/W emulsions. Their main task is to restore the skin's appropriate water content, i.e. maintaining its proper humidity and water content in tissues (Oborska 2004). Moisturising creams are designed both for day and night use. Products in this group have the following composition:

a) they contain fatty substances (i.e. vegetable oils, lanolin, thin waxes, ceresin, silicone oils) which create a grease film on the surface of the skin. In addition to that, they reduce the penetration of the emulsion into the deeper layers of the epidermis,

b) they contain hydrophilic-protein substances (e.g. derived from almonds, wheat and peaches), collagen or elastin, as well as sugars – e.g. hyaluronic acid. They build a water film on the skin which is almost imperceptible. Also, they prevent water evaporation from the skin surface,

c) they contain organic acids - lactic acid, phosphoric acid, boric, citric, bactericidal and fungicidal substances - hydroaceto acid and sorbic acid. In addition, they maintain appropriate pH levels (4-6),

d) they also contain supplementary materials (i.e. biologically active compounds), which are responsible for supplying the skin with appropriate substances:
   - low molecular weight hydrophilic compounds (amino acids, glycerol, D-panthenol or glycolic acid salts) which bind water for several hours.
   - fatty components (e.g. ceramides, phospholipids and derivatives of cholesterol, fatty acids and placenta). They are designed to build into the lipid layer of the skin and supply the missing part of the intercellular cement
   - vitamins (Marzec 2005; Wilczewska & Puzanowska-Tarasiewicz 2007).

As compared with oiling creams, moisturising creams have a different degree of hydration and greasiness of the skin and the time required to maintain the beneficial effect of dampening.

Cosmetics designed for day use have a much lighter texture (they contain more water than fat), and they provide better protection against pollution, sunshine or free radicals. On the other hand, night use cosmetics have greater density and contain more fatty substances and nutrients (resulting in faster and easier skin regeneration). Also, they contain fruit acids or retinol (Martini 2007).

Cosmetic creams contain preservatives that prevent the rancidity of fats and cosmetic deterioration. It is not true of cosmetics which are packaged anaerobically and produced in sterile conditions. They also contain pigments (colouring agents) and anti-corrosion agents, which are designed to prevent packaging degradation (Jędryka & Kaniewski 1997).

The main functions of cosmetic creams include skin care and regeneration as well as the protection of the epidermis (Jędryka & Kaniewski 1997). Moisturising creams restore proper skin moisture and maintain appropriate water levels in skin tissue. They contain special lipid compounds, which, together with the skin, are responsible for the water balance of the epidermis. Moisturizing creams also contain wax-fatty substances, which are responsible for moisturizing the skin and reducing the degree of water evaporation. The creams of this type contain water-soluble substances such as glycerine, glycols and polyglycols, which perform hygroscopic functions, retaining water in the cells. Moisturizing creams can be used for all skin types, except oily skins (Brody 2001; Goździalska & Jaśkiewicz 2012; Sułek, Małysa & Pytlas 2006).

The application properties of cosmetic products are dependent on the consistency of emulsions. The degree of viscosity is usually the determining factor which assigns cosmetics to particular groups of products (e.g. milks, lotions or creams).

Research methodology

The process of developing the composition of a cosmetic cream comprises two main stages: optimising the effectiveness of a cosmetic product and optimising its utility features (Kowalski & Panek 2003). The subject of the research was to analyze the utility (sensory) properties of cosmetic products. To a large extent, the introduction of products on the market and consumer buying decisions are determined by products' sensory properties which manifest themselves during application (Gawęcka & Jędryka 2001).

These properties are mainly associated with such factors as smell, the comfort of use, consistency, the ease of use as well as the sensory sensations which occur after application.

The analysis comprised the following stages:

- consumer preference surveys, which allowed for the identification of sensory quality attributes as well as the brands and types of products tested on a group of 200 people aged 18, both males and females, with basic vocational education, secondary education and higher education, representing various professional activities - students, workers, pensioners, unemployed people, residents of rural areas, small (up to 100,000), medium (up to 500,000) and large cities (over 500,000) from Poland's entire territory;
- analysis of the quality attributes selected for sensory tests;
- sensory analysis carried out by 15 members of the Sensory Analysis Team, part of the Society of Commodity Science in Krakow, comprising women and men over the age of 18, holders of university degrees, representing different Polish regions.

The authors wish to thank Dr. Paweł Turek for his contribution to sensory tests.

Results and discussion

Most respondents (86% - 172 people) use moisturising creams, which implies that as many as 14% of them do not use this cosmetic (mainly male respondents). More than 87% apply moisturisers at least once a day, and 67% of them use creams at least twice a day (as recommended by dermatologists – in the morning and in the evening). Two respondents apply creams very rarely - once a week, and one – less frequently than once a week. Respondents who use creams once a week, or less frequently, have secondary vocational education and they reside in rural areas (one female and two males) (Figure 1).

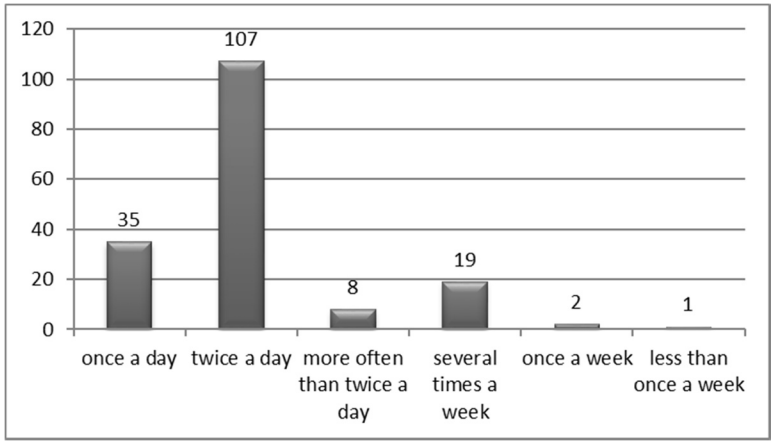

Figure 1. Frequency of the use of day moisturising creams

Source: own research.

Respondents were asked to provide not more than 3 answers concerning the use of face creams. The answers confirm consumer awareness in the area of the right choice of cosmetics.

Most respondents refer to daily care activities (94%) and skin hydration (92%). When applying creams, consumers give attention to nourishment and regeneration. Only 16% of respondents intend to improve skin quality – the major parameter characterising the condition of human skin. Relatively few people choose anti-wrinkle (4% - 40+ females) or reduction-in-redness functions (9%, including 80% of males). None of the respondents points to the other uses of creams - Table 1, Figure 2.

Table 1. Answers to the question: "For what purpose do you use face creams?"

Purpose	Number of respondents	[%]
daily care	162	31.4
skin hydration	158	30.6
skin regeneration	63	12.2
reduction in redness	15	2.9
nutrition of skin	83	16.1
improved quality of skin	28	5.4
anti-wrinkle	7	1.4
other	0	0
Total:	516	100

Source: own research.

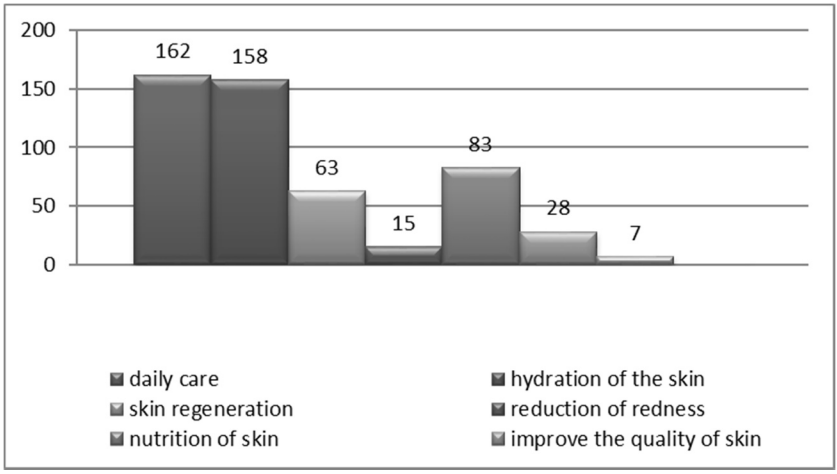

Figure 2. Answers to the question: "For what purpose do you use face creams?"

Source: own research.

Respondents were asked to indicate the most frequent place of making a purchase of cosmetics (Figure 3). The results indicate that supermarkets (52%) are followed by drugstores (31%). A small number of people choose pharmacies (8%) or the Internet (7%, all them city residents). A small percentage of respondents (2%) buy in local shops (persons above the age of 60).

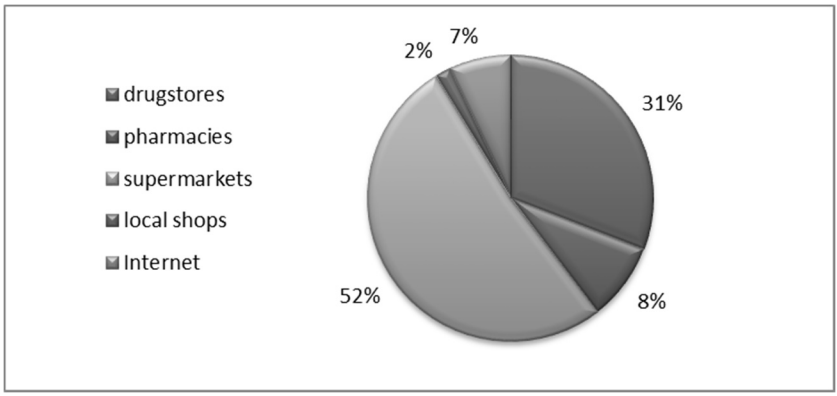

Figure 3. Analysis of the most frequent place of the purchase of creams

Source: own research.

Another question referred to the sum of money spent on face creams. Generally, respondents buy cosmetics at a price ranging from PLN 5.00 to

PLN 19.99 PLN (62% of respondents). A relatively large group of females are willing to spend from PLN 20 to PLN 39.99 (13%), or above PLN 40 (12%). A similar number of respondents (12%) indicated a price range below PLN 5 (mostly students and disability pensioners). People out of work did not answer this question, which implies that they dot nor regard cosmetics to be basic commodities (Table 2).

Table 2. Analysis of the question: "How much money do you spend on the purchase of face creams?"

Response	Number of respondents	[%]
not more than PLN 4.99	22	12
5.00 – 9.99	49	29
10.00 – 19.99	57	33
20.00 – 39.99	23	13
more than PLN 40.00	21	12
Total:	172	100

Source: own research.

Most consumers decide to buy creams several times a year - more than half of respondents (62%). Every third respondent makes a purchase of creams once a month, and 2% of respondents once a year. No respondents buy more frequently than once a week. This proves the efficiency of one unit of cream which is sufficient for a period of one month to several months.

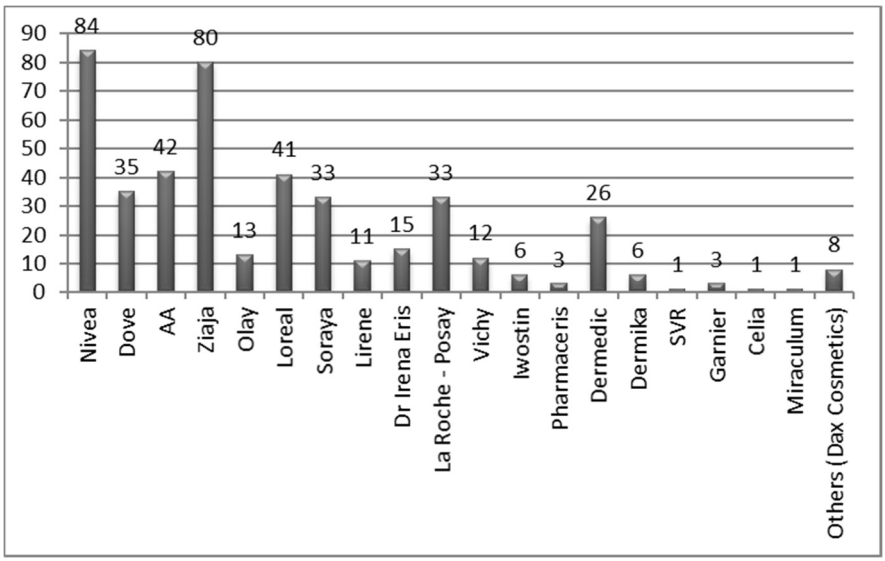

Figure 4. The most popular brands of face moisturising creams

Source: own research.

The market offers a wide range of face moisturising creams including the cheapest products, so called own brands, and premium products - dermo-cosmetics or special-purpose creams (Jędryka & Kaniewski 1997).

Respondents were asked to name up to three most frequently purchased face creams (Figure 4). The indicated brands included domestic products as well as foreign manufacturers specialising in so-called dermo-cosmetics, representing various price ranges. Nivea turns out to be by far the most popular brand (49%), followed by its Polish counterpart - Ziaja (47%), AA (24%) Loreal (24%), Dove (20%), Soraya (19%) and La Roche - Posay - 19% (the highest rated brand of dermo-cosmetics), and Dermedic - 15% (a Polish manufacturer of dermo-cosmetics). As many as eight of respondents indicate Dax Cosmetics as "other" (5%).

Respondents were also asked to identify up to three types of creams that they use on a daily basis (Figure 5).

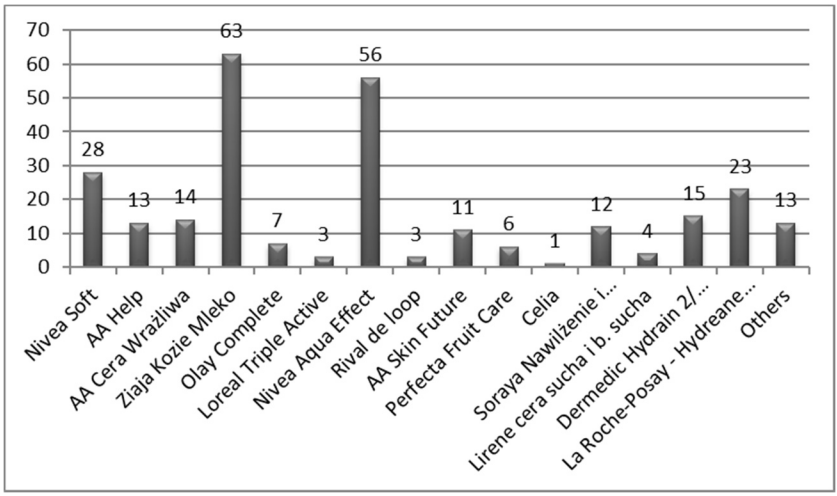

Figure 5. The most popular moisturiser creams

Source: own research.

Ziaja Kozie Mleko turns out to be the most popular brand (37%), followed by Nivea Aqua Effect (33%), confirming the leading position of these brands on the market of face moisturisers. Among dermo-cosmetics, consumers give priority to Hydreane Extra Riche La Roche - Posay (13%) and its Polish counterpart - Hydrain Deremedic (9%).

Other popular brands include AA - AA Help (8%), AA Sensitive Skin – (8%) and AA Skin Future (6%).

The creams not named in the survey but pointed to by respondents included Olive Cream Ziaja (7 out of 13 indications - 4%).

Quality attributes were referred to by a group of 172 respondents (as part of the research surveys), persons above the age of 18, females and males. Respondents represented a versatile group in terms of their education, professional activities and place of residence. The selected quality properties were used in further sensory tests.

Respondents pointed to the following determinants of quality:

1. **absorption**
2. **ease of use**
3. **greasiness**
4. **consistency**
5. **fragrance**
6. face hydration
7. uniformity
8. colour
9. dermatologically tested
10. efficiency.

The first five attributes of quality identified by respondents were selected for sensory tests. Further sensory analyses were carried out on 5 different products selected by respondents in the survey.

The tested products included Polish and foreign brands representing different price ranges (Table 3).

Table 3. Tested creams

Brand	Name	Price [PLN]	Nominal content
Dermedic	Hydrain 2	42.90	50 g
La Roche Posay	Hydraene Extra Riche	49.99	40 ml
Ziaja	Kozie Mleko	7.49	50 ml
Nivea	Aqua Effect	15.99	50 ml
Perfecta (Dax Cosmetics)	Fruit Care	19.99	50 ml

Source: own research.

The study aimed to identify consumer most preferred face moisturisers without consideration given to brand or price.

A qualitative assessment and evaluation of preferences with the use of the order method was carried out on coded samples; a light masking technique was used in a specially designed room in accordance with relevant Polish Standards (PN-ISO 6658:1998, PN-ISO 8586:1996).

The analysed properties included consistency, ease of use, absorption and greasiness. Each parameter was assigned, according to the investigator's assessment, a score from 1 to 5, where 1 indicated the worst assessment and 5 - the best.

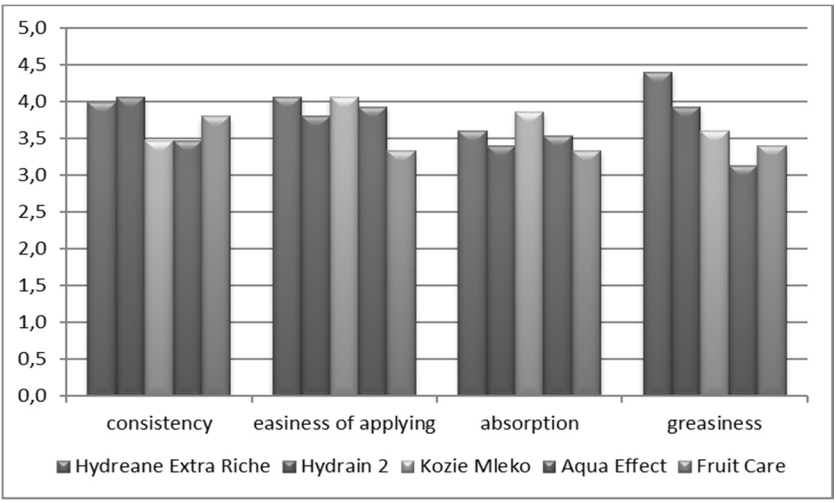

Figure 6. Summary of ratings of quality attributes (consistency, ease of use, absorption and greasiness) of the tested products

Source: authors' own research.

Then, the evaluators were asked to rank the samples in the order of preference according to a specific criterion - consistency, fragrance and general preference (an overall rating), where 1 indicated "the worst" and 5 - "the best".

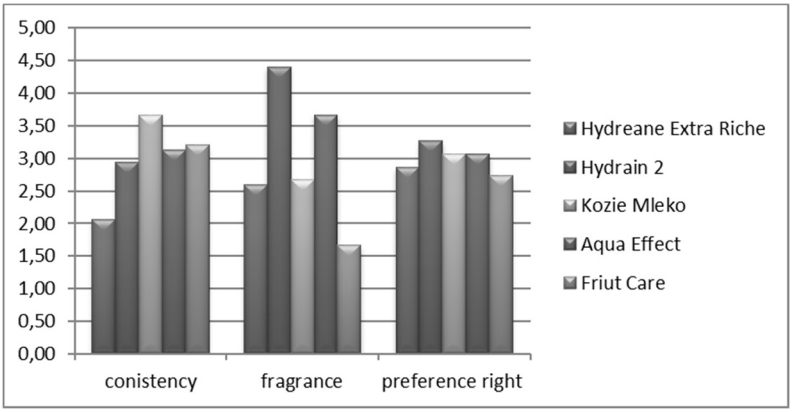

Figure 7. Summary of general preferences with the use of the order method

Source: own research.

The masking light technique was used to avoid biased opinions. The tested samples were coded and their ordering was changed each time.

The first visual impression is often the deciding factor in making a buying decision. Therefore, the third assessment of sensory tests concerned packaging preferences. Consumers were shown the packages of products with coded numbers and asked to assign the highest score (5) and the lowest score (1) to the preferred packaging. The assessed properties included graphics design, clarity, attractiveness, necessary information placed on the product and effective communication.

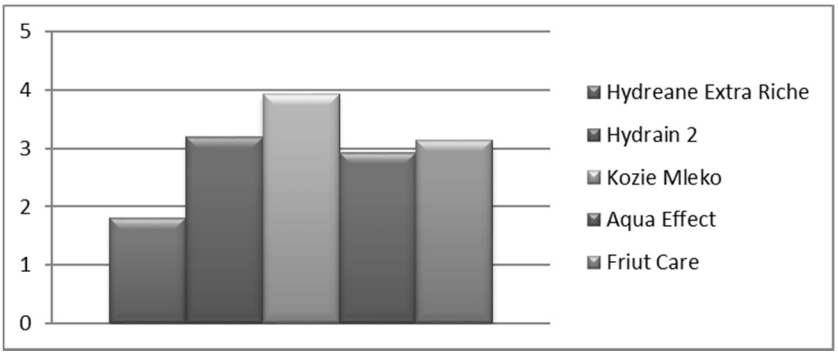

Figure 8. Analysis of packaging preferences

Source: own research.

The top rating was given to cream "Ziaja - Kozie Mleko" – white and grey colours, referring to dermo-cosmetics or special-purpose products. The package contains necessary information, highlights the active ingredients, so consumers can easily find information on the product.

Hydrain 2 ranked second. The package has white, silvery and blue colours, with the dominating white colour. Also, the package is enriched with a drawing of water droplets and information provided by dermatologists. The clear graphics indicates that the cream belongs to the premium sector of products.

Fruit Care ranked third in the assessment. Unlike the previous products, the packaging is colourful, making use of white, green and orange colours. The use of the white colour contributes to the clarity of graphics, increasing product attractiveness.

Aqua Effect took fourth place in the ranking. The packaging is dominated by the white colour; other colours include pink and grey.

The lowest score was assigned to the most expensive product - La Roche - Posay. The use of the white colour with some elements of blue – a typical

design used by this brand – did not appeal to consumers. A number of samples are attached to the package (Figure 8).

During the qualitative assessment the highest score was assigned to Hydreane Extra Riche, followed by Hydrain 2 and Kozie Mleko, while Aqua Effect and Fruit Care ranked last (Figure 9).

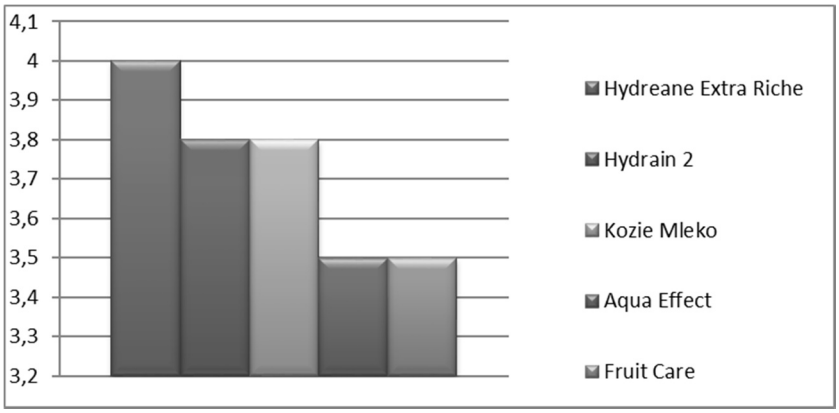

Figure 9. Analysis of the final results of qualitative assessment

Source: own research.

The next assessment conducted by the Sensory Team concerned preferences, assigning the highest score to Hydrain, followed by Aqua Effect and Kozie Mleko. Unlike in the first assessment, Hydreane Extra Riche took fifth place (Figure 10).

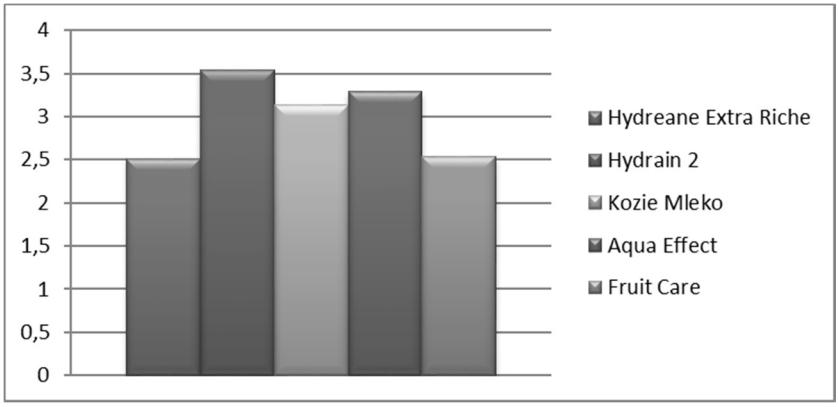

Figure 10. Analysis of the final results by the order of preference

Source: own research.

Taking into account the third assessment (packaging preferences), the tested products can be ranked in the following order (from most to least preferred):

1. Hydrain 2 - Dermedic.
2. Kozie Mleko – Ziaja.
3. Aqua Effect - Nivea.
4. Hydreane Extra Riche - La Roche Posay.
5. Fruit Care - Dax Perfecta.

It is worth noting that the cheapest of the creams – Kozie Mleko ranks second on the list. The product's very low price (PLN 7.49), its general availability and attractive packaging as well as a positive sensory evaluation of selected parameters encourage consumers to make a purchase.

The last but one place was taken by the French cream Hydreane Extra Riche, offered by pharmacies. Apart from the first very good assessment, the results of the subsequent tests were less favourable.

Conclusions

The results of the conducted research study indicate that consumers in Poland usually buy creams in hypermarkets and drugstores. The most popular brand is Nivea, Ziaja, followed by AA, Loreal, Dove, Soraya or La Roche – Posay, and Dermedic.

Consumers regard the following qualitative properties to be the most significant factors: absorption, ease of use, greasiness, consistency and fragrance.

The study shows that product prices do not always correspond to product quality and parameters.

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THE EFFECTS OF THE ENGINE OIL EXPLOITATION ON ITS VISCOSITY

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Introduction

Lubricants (motor oils) play an important role in proper functioning of the mechanisms (car engines). Constant development in research based technology enables the manufacturers to improve the lubricants and offer top-quality products. They are usually designed to fit specific conditions of use. The conditions are oftentimes particularly challenging and, as a result, the quality of such motor oils has to decrease in the process of exploitation thus leading to a so-called ageing and degradation (Droździel & Ignaciuk 2004, Urzędowska & Stępień 2008, Urzędowska & Stępień 2010). It gives rise to shortening the time between each oil change (even by half). In order to determine the optimal timing of oil changes it is particularly useful to perform some specific oil tests during the process of oil exploitation (Jakóbiec 2008, Jakóbiec & Budzik 2007, Litwiński 2011, Podniało 2002, Urzędowska & Stępień 2012a, 2012b). Thanks to them, it is possible to determine the properties that affect the operational suitability of engine oils. The factors that may affect the engine oil's suitability are as follows:

- viscosity
- base number and acid number
- lubricating properties
- oxidation
- corrosion properties
- washing and dispersing properties
- flash-point
- pollutant content

All of the above have a significant effect on the engine oil exploitation period which, in turn, informs the users that the oil still protects all parts of the engine.

Several methods can be applied in the research and analysis of engine oils. The knowledge of engine oils features and verification of methods suitable for their analysis enables the creation of systems for quality observance within the engine operation period. Inayatullah et al. (2011) deals with application of acoustic emission technique to observer the engine oil's viscosity. Karpovich et al. (2001) deals with universal device for motor-oil quality control. For the evaluation of the condition of automotive engine oil, the oil's viscosity is one of the most important parameters. Using microacoustic viscosity sensors, an oil-viscosity measurement can be performed on-board (Jakoby et al. 2003). Various sensor principles for the on-line monitoring of thermal aging of engine oils considered Agoston et al. (2005) Wang (2002) examined road tests of oil condition sensor and sensing technique. The newly designed sensors were installed in three vehicles and tested on the road. The test results indicated that the degradation of engine oil could be divided in three stages: (1) good, (2) rapid increase of total acid number (TAN), and (3) rapid increase of viscosity (Wang 2001). Automobile engine reliability, maintainability and oil maintenance provides Youngk (2000). The analysis in this paper is based on a review of oil, engine, and bearing technologies and on a survey of vehicle operators. The results indicate engine reliability is significantly dependent on the period between oil changes (Youngk 2000).

The viscosity index and the base number of motor oils are the most important parameters to be measured in order to assess their performance and service time (Al-Ghouti et al. 2010). Viscosity describes the physical properties of a liquid to resist shear-induced flow. It can depend on several parameters, such as:

$$\eta = f(T, \gamma, P, t, S, V)$$

1. Substance Temperature Parameter (T). Changes in temperature have a great effect on the viscosity of the substance. A good example is the viscosity of various mineral oils, which can decrease by about 10% when the temperature rises by 1°C only.
2. The Shear Rate (γ). This factor has a significant effect on the viscosity of many liquids. The viscosity decreases with increasing shear rate.
3. The next parameter is related to the pressure (P). The intermolecular resistance is a result of a compressive pressure of the liquid. Only high pressure compresses liquids. This phenomenon also occurs in gases.
4. Time (t) is of influence on the viscosity because of the constant shear rate to which the substance is subjected.

5. Parameter (S) is related to the physicochemical properties. It has a decisive influence on the viscosity, it also defines the state of the matter, e.g. whether it is water, oil, honey or a polymer melt.
6. Voltage (V) may be another parameter. It is characteristic of the suspension with a high dependence of the flow on the size of electric fields which act on substances (Schramm 1994).

Materials and methods

The main objective of the study was to assess the direction and intensity of changes in selected rheological properties of motor oils. The research was conducted on a Castrol Tection mineral oil, class: 15W40. The producer claims that Castrol Tection guarantees top-level protection of engines offered by different manufacturers. It was designed to meet the needs of European engines Euro 4, Euro 3 and older, as well as American ones. It provides excellent engine protection, extended oil change intervals and versatility. Castrol Tection can be used in the engines of trucks, buses, commercial vehicles, as well as construction and agricultural machines. The oil has the following specifications: ACEA E3, E5, E7, API CH-4, Cummins CES 20.076, 20.077, Mack EO-M Plus, MB-Approval 228.3, RVI RLD, Volvo VDS-2, MAN M 3275, DAF – standard oil change intervals. The oil operated in the vehicle Volkswagen Transporter produced in 1993. This is a 4^{th}-generation car, in which the drive unit is a diesel engine with a capacity of 2370 cm^3. This engine is 5-cylinder with maximum torque of 168 Nm and power at 3700 rev./min. equal to 75KM or 55kW.

Oil samples were collected and analyzed at the beginning of the test and then, each time, after making another thousand kilometers. Therefore, sample no. 1 is an oil sample after 1000 km of use. The last, 10^{th} sample, was collected after the end of the full exploitation cycle, i.e. ca.10 000 km. After each collection of a sample (ca. 50ml of oil), the engine was supplemented with a similar amount of oil so as to have the appropriate amount of lubricant.

The manner in which the substance was collected was created specifically for the purpose of this study. It was a special device consisting of a large syringe with a thin tube attached to its tip. The sample was collected via bayonet tube which is used to check the oil level. A thin tube was inserted into the bayonet tube and then the oil sucked through the syringe. Before the procedure the engine was turned on in order to ensure homogenization of oil. Then the samples were examined in the rheological laboratory.

A modern rotary viscometer Rheotest RN 3.1 produced by RHEOTEST Medingen GmbH was used for the purpose of the measurements and this study. The instrument operates at the torque range from 0,1 to 160 mNm and speed range from 0,1 to 1000rpm. The S1 measuring system that was used is

capable of measuring the viscosity at shear rates of 0,13 ÷ 1300 S-1 and in the range of 1 ÷ 107 mPas. The device is connected to a computer which allows a direct observation of all graphical measurement parameters in the entire course of the test. In addition, the computer program which supports the device enables to fit the obtained experimental data to one of several rheological models describing the relationship between the shear stress τ (TAU) and the shear rate (D).

Figure 1. Rheotest RN 3.1 produced by a German company, Rheotest Medingen GmbH

Source: own work

The device consists of two coaxial cylinders. The outer cylinder is a stationary part which allows the researcher to adjust the temperature. The liquid to be examined is located between the outer and the inner cylinder, and it can be sheared for a long time. The rotary motion of the rotor (inner cylinder) causes the laminar flow, by which the following factors are determined: viscosity, shear rate and shear stress.

Results and discussion

Engine oil viscosity tests were carried out on 11 samples. The study of each subsequent sample was held at the following shear rates:

1. Constant shear rate $D=100s^{-1}$
2. Constant shear rate $D=200s^{-1}$
3. Increasing shear rate from $D=0s^{-1}$ to $D=300s^{-1}$
4. Decreasing shear rate from $D=300s^{-1}$ to $D=0s^{-1}$

The measurement of each of the variants was carried out for 60 seconds, which gave approximately 30 measurements of each variant. The results of tests at constant shear rate are summarized and presented below. The table shows the average viscosity of each sample, from the fresh oil sample to the used oil that ran ca. 10 000 km. Additionally, standard deviations were calculated, as well as ratios D=100s^{-1} and D=200s^{-1}.

Table 1. Summary of test results at constant shear rate

mileage	D=100s^{-1}		D=200s^{-1}		$\frac{D=100}{D=200}$
	$\bar{x}$	s	$\bar{x}$	S	
0	260.1	1.4	256	0.8	1.0160
1 000	185.8	2.7	182.3	1.8	1.0192
2 000	205.4	1	204.7	0.9	1.0034
3 000	209.6	1	207.3	0.8	1.0111
4 000	214.9	1.4	212.2	0.8	1.0127
5 000	253.3	1.2	243.8	0.9	1.0390
6 000	214	1.7	212.7	1.2	1.0061
7 000	204.2	1.5	203.8	1.1	1.0020
8 000	206.9	1	206.1	0.9	1.0039
9 000	199.9	1.3	199.4	1.1	1.0025
10 000	209.8	1.3	207.4	1.1	1.0116

Source: own research.

On analyzing the standard deviation, which is low in all cases, it can be concluded that the measurement results were stable, and that the calculated average viscosity gives a precise view of the results.

The graphs showing the changes in oil viscosity after each 1000 km are presented below. The graphs are based on the data from the table 1 and they show the above mentioned relationship at a constant shear rate D=100s-1 i D=200s-1. Moreover, the graphs show the trend line.

The above graph presents a decrease in viscosity with an increase in mileage. The “0” sample (fresh oil) has a significantly higher viscosity than any other sample. A decrease in viscosity is gradual in every subsequent sample. However, between those samples the decrease is never as sharp as between the “0” sample and the next one. The designated regression line shows that the motor oil viscosity has a tendency to a slight decrease. It is also worth noting that there is a particular difference in results in samples 1 and 5. The probable reason for such large deviations compared to others is a mistake while retrieving the oil sample. The following graphs do not include flawed samples, as well as the “0” sample in order to show that the mistakes did not seriously affect the test. This step was taken to prove beyond any doubt that

the oil viscosity decreases slightly with mileage. On analyzing the graphs without these 3 samples, a slight fall in viscosity after each stage of exploitation cycle can be observed.

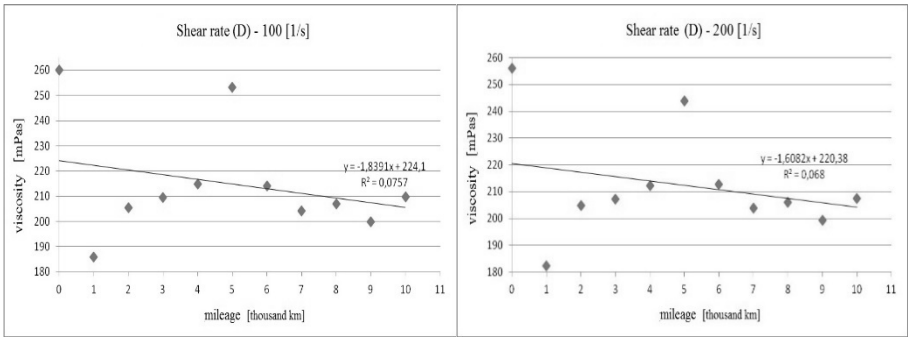

Figure 2. The relationship between the viscosity and mileage [shear rate (D)=100s^{-1} and (D)=200s^{-1}]

Source: own research.

In fig. 4 all viscosity results are presented regardless their shear rates. It can be observed that the viscosity is higher at the shear rate of D=100s^{-1} than at D=200s^{-1}. In samples 2, 7, 8, 9 the points on the graph almost overlap. The smallest difference can be observed with respect to the sample 7, wherein the difference is merely 0,3mPa·s. The largest difference (1,5mPa·s) is present in relation to the sample after 5 000 km. While comparing the obtained results in the same chart it can be observed that the trend line has a similar course in both, the shear rate D=100s^{-1} and D=200s^{-1}. The lines should cross at 16 000 km (prediction). The producer, however, recommends replacing the engine oil after 10 000 km. These guidelines were followed and the trend was not further verified (with empirical data) beyond 10 000 km.

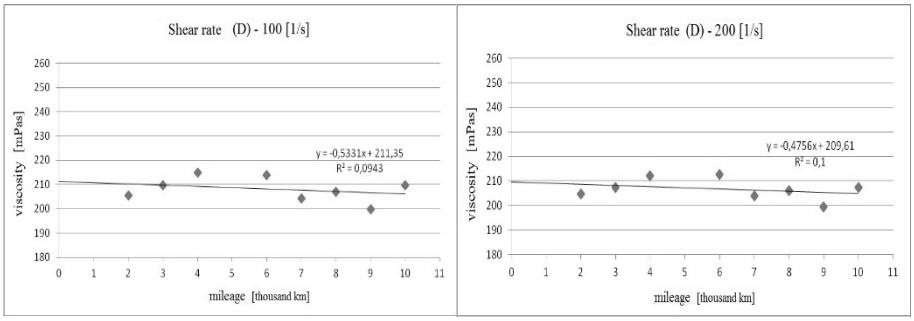

Figure 3. The relationship between the viscosity and mileage [D=100s^{-1}] and [D=200s^{-1}] – excluding flawed data

Source: own research.

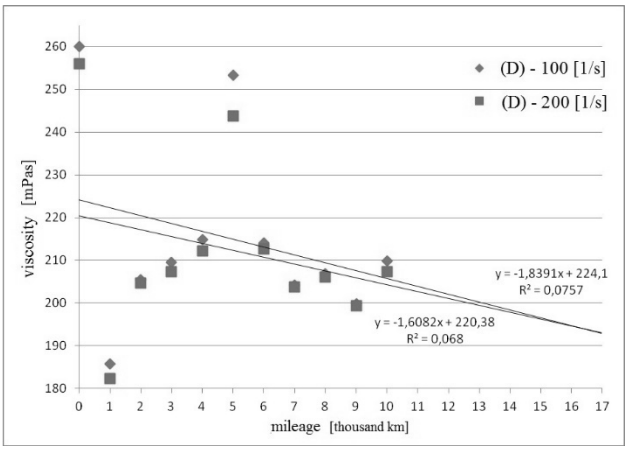

Figure 4. The relationship between the viscosity and mileage [D=100s^{-1} i D=200s^{-1}]

Source: own research.

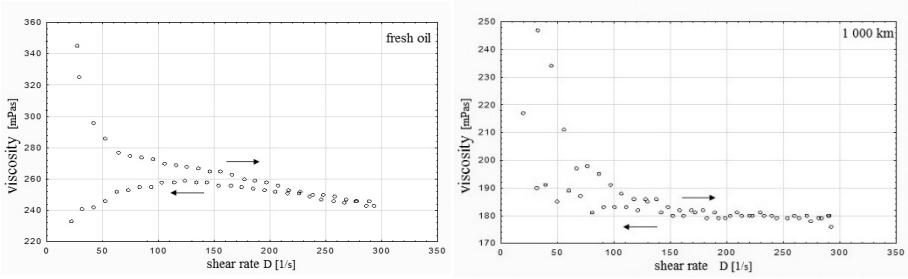

Figure 5. The relationship between the viscosity and shear rate [fresh oil] and [mileage 1 000 km]

Source: own research.

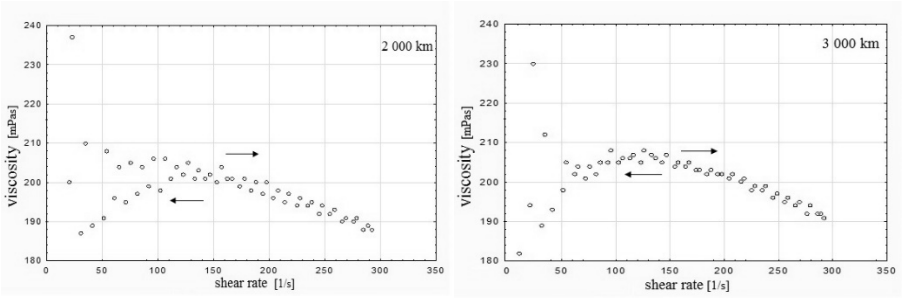

Figure 6. The relationship between the viscosity and shear rate [mileage 2 000 km] and [mileage 3 000 km]

Source: own research.

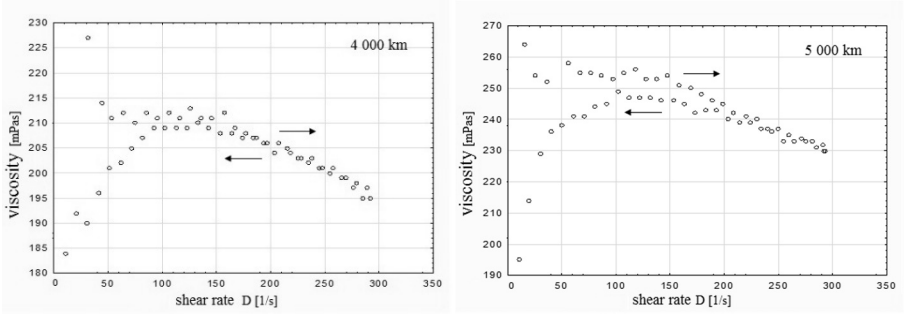

Figure 7. The relationship between the viscosity and shear rate [mileage 4 000 km] and [mileage 5 000 km]

Source: own research.

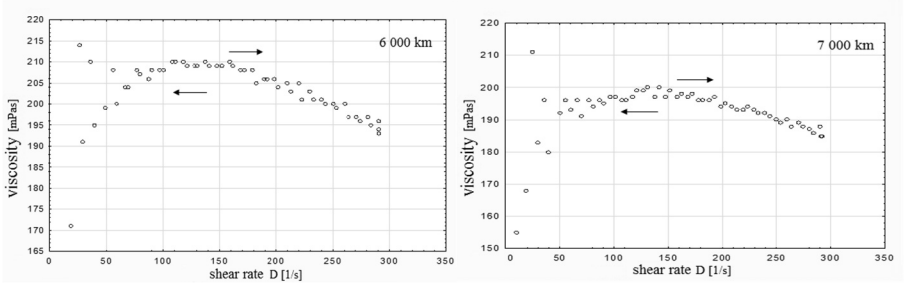

Figure 8. The relationship between the viscosity and shear rate [mileage 6 000 km] and [mileage 7 000 km]

Source: own research.

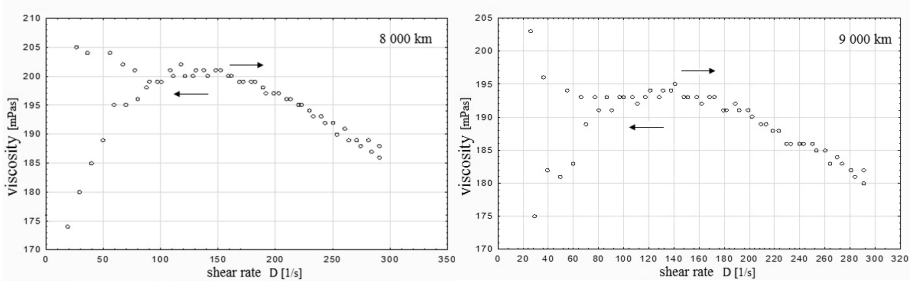

Figure 9. The relationship between the viscosity and shear rate [mileage 8 000 km] and [mileage 9 000 km]

Source: own research.

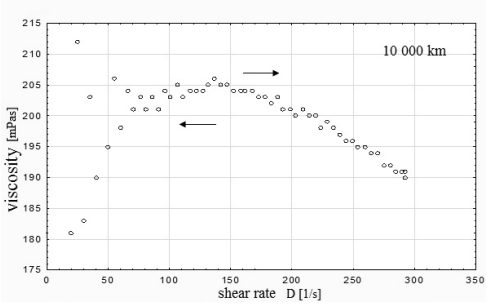

Figure 10. The relationship between the viscosity and shear rate [mileage 10 000 km]

Source: own research.

In fig. 5 to 10 viscosity curves are presented, which illustrate the change in viscosity at increasing shear rate from D = 0 to D = 300s^{-1} in 60 seconds and then at decreasing shear rate to D = 0 in another 60 seconds. Each graph presents the results of both increasing and decreasing shear rates (the direction of change of shear rate during the test was marked on the graph with arrows).

Changes in viscous potential of fresh oil (fig. 5), based on undertaken tests, had a parabolic course. At shear rate from 0 to 50s^{-1} viscosity fell rapidly, which could be due to the forces that influenced the previously stationary liquid. At speeds over 50s^{-1} the changes progressed more slowly thereby the graph assumed the character of exponential curve. The shear rate reached 300s^{-1} and then it fell in the course of the next 60 seconds down to D=0. The viscosity increased and then it decreased to the levels significantly lower than in the previous phase (an increase in speed). Viscosity curves showed a clear hysteresis loop.

On analyzing the oil viscosity curves presented in fig. 5-10 it can be observed that all the curves share a similar shape. The dynamic viscosity of the tested oils changes in the course of oil exploitation and it can be connected with the ageing and degradation which takes place in the high-temperature part of the engine, that is in the lubricating layer on the cylinder liner. In the graphs illustrating viscosity changes after 2 up to 5 000 km a strong viscosity hysteresis is still retained.

The layout of the graphs illustrating the mileage from 6 to 10 000 km is slightly chaotic. The disappearance of hysteresis is clearly noticeable. It is almost impossible to pinpoint when viscosity is affected, at an increasing shear rate or at a decreasing one. The points often overlap or mix.

All the changes that take place in the course of the engine oil exploitation can be caused by the pollution arising from the wear of engine parts forming sludge, soot or ash. The changes in rheological properties can also be ascribed

to the age and mileage of the car used in the tests. Due to the car's high mileage it is possible that the clearances between the piston and the cylinder liner affected the final results. It is also probable that the unburned fuel found a passage to the engine sump thus leading to the dilution of engine oil during operation.

Conclusions

1. In order to ensure a good and long use of machines it is crucial to protect them from ageing and wear. To prevent wear and galling, the machine protection must be at the highest possible level.
2. On the basis of the study it can be concluded that the Volkswagen Transporter engine oil was properly chosen. During the entire life cycle, the results showed only a slight decrease in dynamic viscosity. Based on the obtained results it can be stated that the oil protected the engine very well and it remained in the viscosity class specified by the manufacturer.
3. The results indicate that the analysis of the above elements is not sufficient to fully assess the degree of degradation of engine oil. In order to make a comprehensive assessment of the quality of engine oil it is necessary to carry out more advanced studies.

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COMMODITY SCIENCE APPROACHES TO QUALITY FORMATION OF WATER-DISPERSION PAINTS

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Introduction

Water-dispersion paints are increasingly spreading in Ukraine because of harmful solvents absence, ease deposit of coatings and its high performance properties, ease tinting and other advantages compare with paints on organic solvents (Sviderskyi & Karavayev 2010; Karavayev 2012; Karavayev 2013).

Mineral fillers have significant influence on water-dispersion paints and coatings quality formation. It can partially replace expensive pigments improve the paints and coatings properties, perform specific functions: to regulate the paints rheological properties, be as reinforcing elements in the coatings and more. The results of our previous research have shown that Ukrainian chalk and kaolin are perspective mineral fillers of water-dispersion paints (Sviderskyi & Karavayev 2012; Karavayev & Sviderskyi 2012; Karavayev, Sviderskyi & Zemlianoj 2012; Karavayev & Sviderskyi 2012a; Sviderskyi & Karavayev 2013; Karavayev & Sviderskyi 2013).

The previous publications devoted to development of water-dispersion paints with Ukrainian mineral fillers and evaluation of coatings properties (Karavayev & Sviderskyi 2012b; Karavayev & Sviderskyi 2013a; Karavayev & Sviderskyi 2013b; Karavayev 2014).

The purpose of the article is developing approaches to water-dispersion paints quality formation by optimization of mineral fillers and pigments mixture.

The main paper objectives are:

– creating the mathematical model to obtain dense packing fillers and determine its impact on the performance properties of coatings;

- creating highly filled water-dispersion paints of different compositions based on Ukrainian mineral fillers;
- apply the simplex-lattice method of experiment mathematical planning to optimize the composition of the water-dispersion paints and forecasting the coatings properties;
- examine the properties of the created water-dispersion paints and coatings.

Materials and methods

Object of study – highly filled water- dispersion paints of different compositions produced using Ukrainian carbonates and kaolin. The composition of paints created with pigments/fillers volume concentration (PVC) 60 vol. %, that is close to the critical pigments/fillers volume concentration (CPVC) and promotes the formation of particles dense packing of mineral phases in the coating.

The following main components used for water-dispersion paints creating. According to prior research (Sviderskyi & Karavayev 2012; Karavayev & Sviderskyi 2012; Karavayev, Sviderskyi & Zemlianoj 2012) among carbonate fillers selected fine natural chalk produced by PSC "Novgorod-Seversky plant of building materials" brand MMC-1; LLC "Slavic chalk-lime factory" brand MMC-2, LLC "Slavic industrial union "Soda" brand carbonate filler for plastics (CFP). Among aluminum silicate fillers selected enriched kaolin from Prosyana deposit brands KC-1, KHF-86 and KBF-90 produced by Ltd. "Prosko Resources" (Karavayev & Sviderskyi 2012a; Sviderskyi & Karavayev 2013; Karavayev & Sviderskyi 2013). Titanium dioxide Crimea TiOx-230 used as white pigment.

Styrene-acrylic anionic latex dispersion Ucar DL 450 by Dow Chemical production is used as a binder in water-dispersion paints. Film formation improving was achieved by the introduction of 4 wt. % coalestsents (dipropylene glycol n-butyl ether Dowanol DPnB). Dispersion of fillers in binder was carried out using the sodium salt of polyacrylic acid Axilat 32S. Hydroxyethylcellulose Cellosize QP 30000H in concentration 0,25-0,30 wt.% was used as a paint thickener.

Simplex-lattice method of experiment mathematical planning including D-optimal Kiefer plan used to determine the optimal composition of the water-dispersion paints and influence of fillers and pigments to the coatings properties (Akhnazarova & Kafarov 1985; Zedginidze 1976). These plans are designed for the research of mixed composition, properties of which depend only on the ratio of components. The coatings properties will be determined mainly by the ratio of fillers and pigments because in water-dispersion paints with PVC 60 vol.% the content of binder is the same.

In this case realized the condition $$\sum_{i=1}^{q} x_i = 1 \quad (1)$$

where, $x_i \geq 0$ – concentration of component; q – number of components.

As a model for ternary mixtures third-order polynomial is selected:

$$y = \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_{12} x_1 x_2 + \beta_{13} x_1 x_3 + \beta_{23} x_2 x_3 + \gamma_{12} x_1 x_2 (x_1 - x_2) + \\ + \gamma_{13} x_1 x_3 (x_1 - x_3) + \gamma_{23} x_2 x_3 (x_2 - x_3) + \beta_{123} x_1 x_2 x_3; \quad (2)$$

where, x_i – concentration of components; β_i, β_{ij}, γ_{ij}, β_{jk} – corresponding polynomial coefficients, where $1 \leq (i, j, k) \leq 3$; $i \neq j \neq k$.

The created models make a possibility to identify the impact of each component of the mixture to the properties of the system. The optimal composition of the paint created by a graphical method for curves of equal values of the properties on the simplex right plane.

The properties of the created water-dispersion paints and coatings are examined according to Ukraine State Standard (SSU), European and international standards. Hiding power was examined by instrumental method according to GOST 8784; bend test (cylindrical mandrel) – according to SSU ISO 1519:2001; tensile strength - according to GOST 18299; adhesion to mineral surfaces - according to ISO 2409:2007; gloss (angle 85°) – according to ISO 2813; coatings resistance to wet abrasion – according to ISO 11998:2006. Whiteness of coatings was researched by the Berger formula (Zaribica, Miljković, Purenović & Tomić 2005), yellowness index – according to ASTM E313.

Results and discussion

Previous researchers have confirmed that mineral fillers have significant influence on the quality formation of water-dispersion paints and coatings. It is found that the most important factors in obtaining high-quality coatings is to ensure the creation of maximally filler dense packing in the coating and application of mathematical planning in calculating of paints composition.

The influence of fillers packing density on performance properties of water-dispersion coating

The influence of the particles packing density was evaluated by the carbonate fillers used in the production of water-dispersion paints using the proposed model (Fig. 1). According to model is derived mathematical formulas that allow to calculate the fillers volume and value with different particle sizes to create maximally packing density (Karavayev & Denysenko 2014).

It was found (Sviderskyi & Karavayev 2012) that the average particle size of the carbonate filler are: CFP – 1.8 microns, chalk MMC-2 – 2.0 microns, MMC-1 – 1.0 microns. Filler particles are close to spherical in shape. Calculations fulfilled by the revealed formulas allow found the following ratio of fillers that make the most particles packing density in the coating.

When combined the chalk MMC-2 (D = 2,0 microns) and MMC-1 (d = 1,0 microns) this ratio is 88,9:11,1 wt.%. In case of CFP (D = 1,8 microns) and MMC-1 (d = 1,0 microns) this ratio is 85,4:14,6 wt.%.

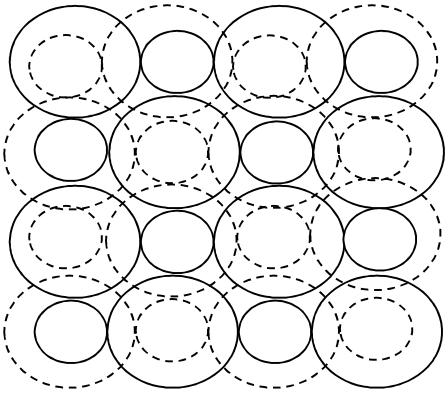

Figure 1. Schematic outline of the pyramidal package type model of different size carbonate filler particles

Source: own research.

The optimal ratio of carbonate fillers was confirmed by experimental researches. The maximum film tensile strength of 5.52 MPa at PVC 60% achieved when combined use the CFP and MMC-1 fillers in ratio of 85:15 wt.% it is allow to get. The maximum film tensile strength of 4,97 MPa at PVC 60% and 4.65 MPa at PVC 65% achieved when combined use the MMC-2 and MMC-1 fillers in a ratio of 90:10 wt.% (Fig. 2).

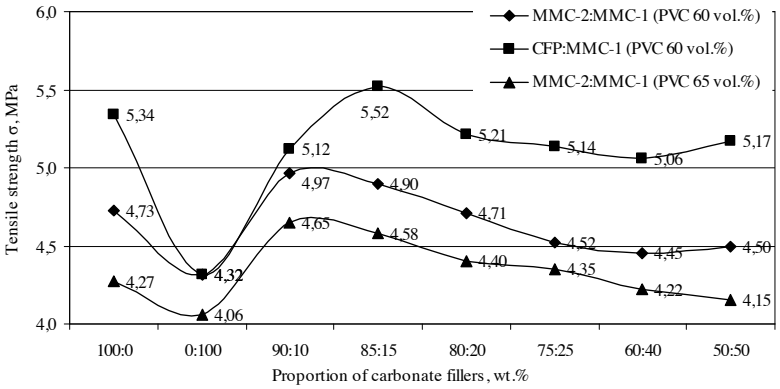

Figure 2. Dependence of tensile strength of water-dispersion coatings from the ratio of the carbonate fillers and PVC

Source: own research.

The highest resistance of coating to wet abrasion confirmed the creation a maximum particles packing density at defined ratio of fillers (Fig. 3).

It was established that the minimum coating thickness loss is 4.8 microns when using CFP and MMC-1 in a ratio of 85:15 wt.%. It is the highest level among the corresponding values in the case of use the each fillers alone and at the other ratios. This confirms the highest resistance to wet abrasion when reaching the maximum particles packing density in the coating at calculated fillers ratio.

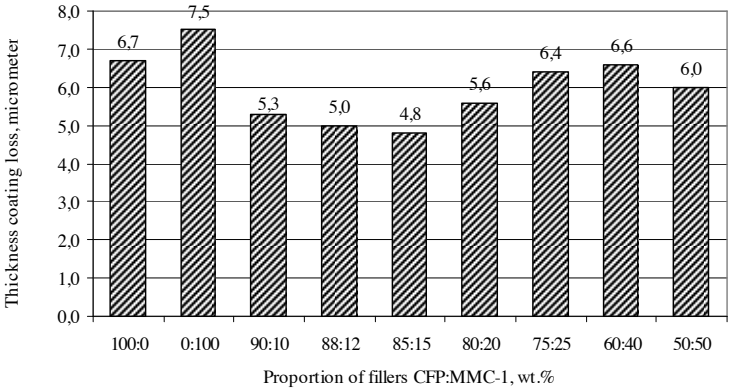

Figure 3. Dependence of resistance to wet abrasion coating from water-dispersion paints by the ratio of carbonate fillers CFP : MMC-1 (PVC 60%)

Source: own research.

Simplex-lattice method of experiment mathematical planning including D-optimal Kiefer plan used to determine the optimal composition of the water-dispersion paints and influence of fillers and pigments to the coatings properties (Akhnazarova & Kafarov 1985; Zedginidze 1976). These plans are designed for the research of mixed composition, properties of which depend only on the ratio of components. In this factor space is a proper simplex. For such systems satisfy the relation (1), where the sum of the relative concentrations of all components of the mixture equal to one. Thus, the relative concentration of each component varies from 0 to 1, i.e., in the range 0 ... 100%.

The coatings properties will be determined mainly by the ratio of fillers and pigments because in water-dispersion paints with PVC 60 % the content of binder is the same.

For mathematical planning as components use the carbonate fillers (x_1) – a mixture of CFP and MMC-1 in ratio 85.4 to 14.6 wt.%, that provides the

most dense packing of particles in the coating; kaolin Prosyana KC-1 grade (x_2) and titanium dioxide Crimea TiO_x-230 (x_3). The concentrations of these components in the studied composition varied within 0-100 wt.%, so planning the experiment and obtain its mathematical model is performed in a coordinate system of primary components. As the response functions are selected performance properties of coatings: Y_1 - tensile strength, MPa; Y_2 - resistance to wet abrasion (loss of coating thickness), microns; Y_3 - whiteness by Berger, units; Y_4 - hiding power, g/m^2. The plan of the experiment and the value of response functions are shown in Table 1.

Table 1. Characterization of experiment plan to construct a mathematical model

No of experiment	Plan			Values of response functions			
	x_1	x_2	x_3	Y_1	Y_2	Y_3	Y_4
1	1	0	0	7.95	5.1	22.3	870
2	0	1	0	9.81	8.7	12.8	1050
3	0	0	1	5.48	9.5	85.3	85
4	0.7236	0.2764	0	8.40	4.8	18.1	920
5	0.2764	0.7236	0	8.70	7.5	15.6	985
6	0.7236	0	0.2764	8.57	4.8	74.3	135
7	0.2764	0	0.7236	6.83	5.7	80.0	95
8	0	0.7236	0.2764	8.25	6.7	57.5	160
9	0	0.2764	0.7236	6.43	6.0	73.2	105
10	0.3333	0.3333	0.3333	7.30	5.0	67.4	120
11	0.22	0.22	0.56	6.40	5.3	77.3	110
12	0.22	0.56	0.22	9.25	4.2	66.5	175
13	0.56	0.22	0.22	8.42	4.7	68.0	160
14	0.44	0.12	0.44	7.12	5.5	75.1	115
15	0.44	0.44	0.12	8.83	4.3	56.4	280

Source: own research.

As a model for ternary mixtures third-order polynomial is selected (2). The resulting models of output variables have the form:

$$Y_1 = 7.95x_1 + 9.81x_2 + 5.48x_3 - 1.65x_1x_2 + 4.92x_1x_3 - 1.53x_2x_3 + 2.97x_1x_2(x_1-x_2) + 3.55x_1x_3(x_1-x_3) - 0.65x_2x_3(x_2-x_3) - 17.31x_1x_2x_3 \quad (3)$$

$$Y_2 = 5.1x_1 + 8.7x_2 + 9.5x_3 - 3.75x_1x_2 - 10.25x_1x_3 - 13.75x_2x_3 - 6.09x_1x_2(x_1-x_2) + 5.97x_1x_3(x_1-x_3) + 5.91x_2x_3(x_2-x_3) + 8.55x_1x_2x_3 \quad (4)$$

$$Y_3 = 22.3x_1 + 12.8x_2 + 85.3x_3 - 3.5x_1x_2 + 116.75x_1x_3 + 81.50x_2x_3 - 9.77x_1x_2(x_1-x_2) + 125.63x_1x_3(x_1-x_3) + 93.48x_2x_3(x_2-x_3) + 151.99x_1x_2x_3 \quad (5)$$

$$Y_4 = 870x_1 + 1050x_2 + 85x_3 - 37.5x_1x_2 - 1812.5x_1x_3 - 2175x_2x_3 + 86.6x_1x_2(x_1-x_2) - 1738.9x_1x_3(x_1-x_3) - 2105x_2x_3(x_2-x_3) - 2730.3x_1x_2x_3 \quad (6)$$

To determine the influence of the water-dispersion paints composition to coatings properties the appropriate calculations of the output variables values were made and the equal values curves of the coating performance properties were constructed on the right simplex plane in the source components coordinates (Fig. 3).

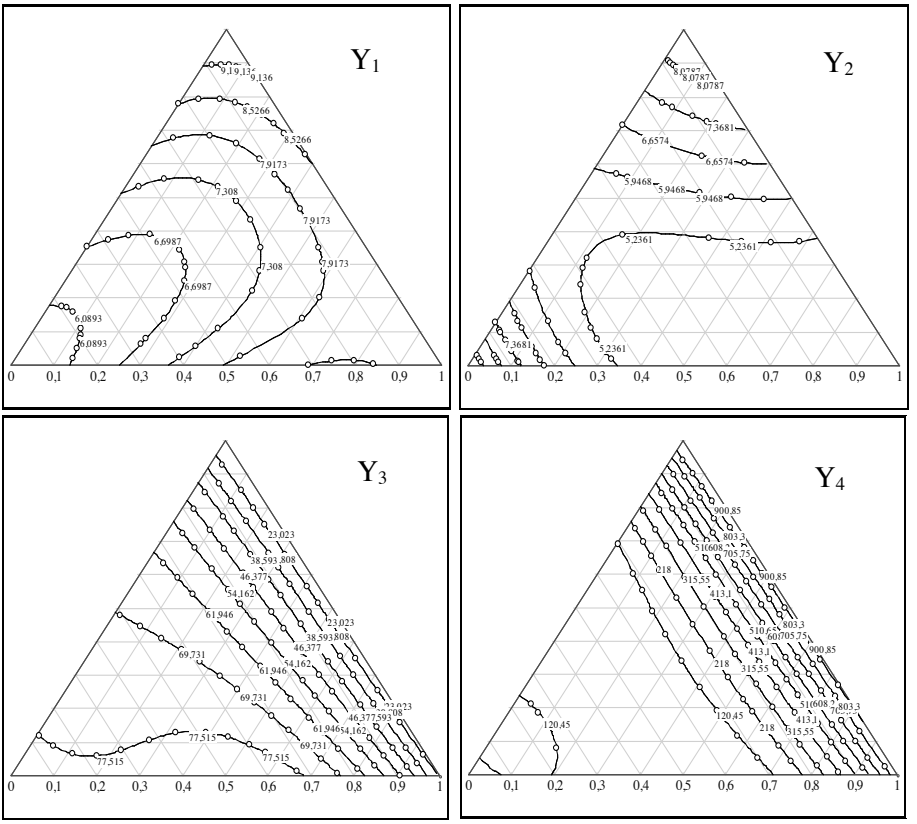

Figure 3. The equal values curves of the performance properties of water-dispersion coatings obtained by the mathematical models

Source: own research.

Practical using of graphical optimization regression models results allows to determine the compromise composition of water-dispersion paints by mineral fillers and pigments and optimal values of each output variables. By regression analysis of models (3)…(6) were obtained compromise region (Fig. 4, shaded area) with certain properties of the coating, which lies in the

following ranges: tensile strength (Y_1) - 7.50...8.50 MPa; resistance to wet abrasion (loss of coating thickness) (Y_2) - 4.5...5.0 mm; whiteness by Berger (Y_3) - 60.0...75.0 units; hiding power (Y_4) - 100...180 g/m^2.

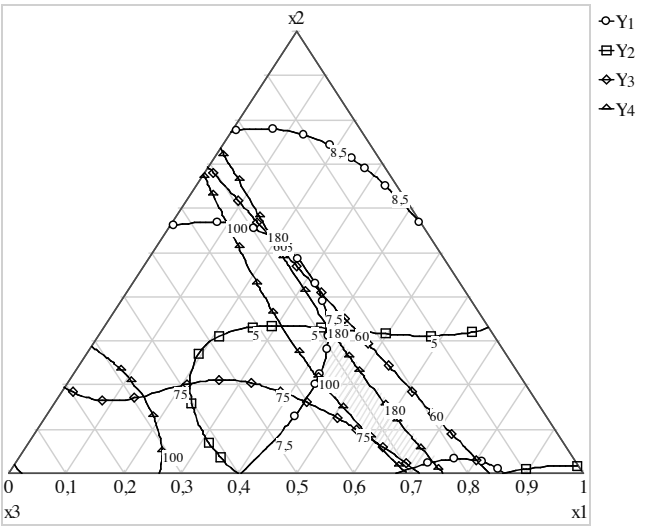

Figure 4. Compromise area of water-dispersion paints composition and coating performance property values

Source: own research.

Designated compromise range of coatings properties reached at such components content: mixture of carbonates CFP and MMC-1 (x_1) - 39.0...73.0 wt.% (by the mineral part); kaolin KC-1 (x_2) - 1.5...33.0 wt.%; titanium dioxide (x_3) - 24.5...35.0 wt.%. Optimal mineral composition of the highly filled water-dispersion paint determined by the choice of a compromise on the graphic area, will have a mixture of carbonates (CFP + MMC-1) - 56.1 wt.%; kaolin KC-1 - 15.2 wt.%; titanium dioxide Crimea TiOx-230 - 28.7 wt.%.

In this case, the contents of these components of the total composition of the paint with PVC 60 % will be next: carbonates - 25.10 wt.% (21.34 wt.% of CFP + 3.77 wt.% of MMC-1); kaolin KC-1 - 6.80 wt.%; titanium dioxide Crimea TiOx-230 - 12.83 wt.%. The water-dispersion paints with such composition will have the such compromise properties of the coating according to a regression analysis of mathematical models: film tensile strength - 7.93 MPa; resistance to wet abrasion (loss of coating thickness) - 4.6 microns; whiteness by Berger - 70.0 units; hiding power – 145.0 g/m^2.

The 7 compositions of water-dispersion paints with PVC 60% for internal and external use including calculated by regression analysis were created with the use of the received research data. The water-dispersion paints composition by the main components is shown in table 2.

Table 2. Composition of water-dispersion paints for interior and exterior use (PVC 60%)

Components	The content of the main components depending on the paint composition, wt.%						
	1	2	3	4	5 (optimal)	6	7
Carbonate filler for plastics	26.05	21.86	22.20	20.33	21.44	19.04	18.79
Chalk MMC-1	4.45	3.74	3.80	3.47	3.66	3.26	3.21
Kaolin KC-1 prosyna	7.00	–	8.00	10.00	6.80	8.00	7.00
Kaolin KHF-86	–	10.00	–	–	–	–	–
Titanium dioxide Crimea TiO_x-230	5.00	7.50	10.00	10.00	12.83	15.00	17.00
Dispersant Axilat 32S	0.20	0.24	0.27	0.27	0.29	0.33	0.37
Binder Ucar DL 450	22.00	22.00	22.00	22.00	22.00	22.00	22.00
Film preservative Polyphase 899	–	–	–	–	0.50	0.50	–

Table 3. Operational properties of coatings from water-dispersion paints

Properties	Value of coating properties depending on the paint composition						
	1	2	3	4	5	6	7
Hiding power, g/m^2	250–260	210–220	150–155	150–155	135–140	115–120	100–110
Bend test, mm	1	1	1	1	1	1	1
Film tensile strength, MPa	8.63	8.40	8.50	8.65	8.05	7.74	7.53
Adhesion to glass, concrete etc., point	1	1	1	1	1	1	1
Resistance to wet abrasion (loss of coating thickness), microns	5.8	5.6	4.8	5.0	4.8	5.5	5.7
Whiteness by Berger, units	58.2	63.0	70.5	70.1	73.5	74.1	75.0
Yellowness index	8.5	7.7	6.5	6.8	5.7	5.2	4.8
Gloss 85°, units	6.0	6.3	7.2	7.6	8.1	8.4	8.6
Water absorption, wt.% for 24 hours	10.6	12.0	11.1	12.2	10.8	11.4	11.0
Contact wetting angle, degree	88	91	90	92	89	85	87

All created water-dispersion paints with PVC 60% can be used for interior and exterior walls and ceilings of concrete, bricks, sand and cement plaster, wood, wood-based panel and plasterboard. The proposed composition of paints forming a coating resistant to repeated wet cleaning and washing using detergents and are recommended for areas with high operational loads. These paints with PVC 60% are close to CPVC, so forming the coating from

6.0 to 8.6 units level of gloss (at 85° angle), which classified as the mat according to EN 13300.

Water-dispersion paint composition nr 1 has limited use as a topcoat because the not high whiteness (58.2 units) and low hiding power (250-260 g/m2). However, high adhesion to various materials (1 point) allows the use this paint as a primer for porous surfaces in order to level the colour and reduce its absorption capacity before applying the final coating. This paint can be used to obtain a final coating after tinting in dark colours.

Water-dispersion paint of compositions numbers 1…4 are created for dry pleases where there is no significant difference in temperature and humidity. For rooms with high humidity (bathroom , kitchen, unheated porch, balcony, etc.) as well as surfaces on which condensation can occur (slopes around external windows and doors, balconies, etc.) necessary to apply paint formulations number 5 and number 6 because they contain film preservative, which protects the coating from the destruction by microorganisms that can grow on moist surfaces. The paint composition number 6 can also be outdoor use.

The optimum composition of the water-dispersion paint is number 5 obtained by the results of mathematical planning. Paint can be used to application coatings inside and outside the premises. Paint to allow application coatings with the compromise properties that have high whiteness by Berger (73.5 units), high resistance to wet abrasion (loss of coating thickness 4.8 microns), sufficient hiding power (135-140 g/m^2) and film tensile strength (8.05 MPa).

A distinctive feature of the coating is the high resistance to wet abrasion. Loss of coating thickness after 200 cycles of wet abrasion in accordance with ISO 11998:2006 is 4.8 microns. By this measure the coating refer to the 1st highest class according to EN 13300, which allows coating multiple wet cleaning and washing using detergent and makes it suitable for rooms with high operational loads.

Increase of titanium dioxide in compositions of paints number 6 and number 7 till 15.0 wt.% and 17.0 wt.% respectively, resulting in a slight increase of whiteness and hiding power but lowers resistance to wet abrasion and increases the cost of paint.

Conclusions

The obtaining maximum packing density of filler particles in the coating and application of mathematical planning in the calculation of the optimal paints composition are the most important factors in creating of high quality water-dispersion paints and coatings.

Calculations based on the developed mathematical model revealed that the maximum particles packing density in the coating will be achieved when the ratio of CFP and MMC-1 as 85.4 and 14.6 wt.% respectively.

The maximum films tensile strength (5.52 MPa) and coatings resistance to wet abrasion (4.8 micron thickness loss) got from water-dispersion paints achieved when filled by carbonates CFP and MMC-1 at ratio 85.0 wt.% and 15,0 wt.% respectively. This is higher than the corresponding values in the case of each of the fillers alone and at other ratios that confirmed of getting the densest packing of the particles in the coating.

Application of simplex-lattice method of experiment mathematical planning allowed to create the optimal composition of the water-dispersion paints with PVC 60%. Coatings based on created paint have high performance properties. Created water-dispersion paints applied in industrial production on the State Enterprise "Koloran" National Academy of Sciences of Ukraine.

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CURRENT ISSUES IN ELECTRIC AND ELECTORNIC EQUIPMENT ENERGY LABELLING

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Introduction

The principal objectives of the Energy Labelling and Ecodesign Directives (ELD and ED) include saving energy and contributing to meeting the EU target of a 20 % reduction in energy consumption by 2020. The goals for Ecodesign are wider, also encompassing the EU single market and other environmental impacts occurring along the full life-cycle of the product.

The Energy Labelling Directive foresees that the preparation of energy labels for product groups, will give clear information to consumers, enabling them to take into account the energy performance of products in their purchase decision. The Ecodesign Directive aims at reducing the environmental impacts of products by setting generic and specific 'Ecodesign requirements'. These requirements concern the following types of environmental impacts:

- Material, energy and water resources,
- Waste,
- Emissions to air, water and soil,
- Hazardous substances,
- Physical impacts in the use phase.

These impacts can occur in all life cycle phases of the product, the main phases being the manufacturing phase, the use phase and the end-of-life phase.

Even though the scope of the Energy Labelling Directive is focused on energy in the use phase, it also covers the consumption of other resources during use. Thus, some other impacts can be included in the label (such as water consumption of washing machines, noise levels of household appliances, also in the use phase).

The consumption of energy has been a focus of regulations to date, as it was the largest environmental impact. Thus, the focus of Ecodesign requirements is often on minimum energy efficiency requirements.

In terms of the product types covered by Ecodesign and Energy Labelling we distinguish the following types:

- Energy using Products (EuP) for private consumers.
- EuP for business to business (B2B) applications
- 'Product-systems'
- Energy related Products (ErP, products that have an influence on energy consumption).

Until 2009 the scope of the ED was limited to EuP. Until 2010 the scope of the ELD was limited to EuP for private consumers. The current scope of the ELD and ED is Energy related Products: any good that has an impact on energy consumption during use. A possible scope extension discusses the inclusion in the Directives scope of non ErP (extension to basically all products) and means of transport.

Ecodesign requirements are based on the least-life cycle cost principle: to set requirements at the level where life cycle costs are the lowest. This principle ensures that products are optimised with respect to energy and life cycle costs for consumers. Sticking to this principle gives an important benefit: that the energy efficiency achieved is also cost-effective. This makes it beneficial for consumers and beneficial for European economies. In the paper we will investigate current issues in Energy Labelling with focus on energy consumption reduction and lowering environmental impact.

Material and methods

The European Commission has launched a review process to evaluate the effectiveness of the Directive 2010/30/EU on energy labelling as well as specific aspects of the Ecodesign Directive 2009/125/EC. The aim of the paper is to analyse and evaluate the revision process of ELD. Findings are based on the outcome of literature research, interviews with experts from European Committee of Domestic Equipment Manufactures CECED, and case studies analyses worked out for European Commission mainly Ecofys First findings and recommendations and analyses of CECED case studies. We evaluate the existing energy labels for meeting the objectives of the Directive and new proposed label designs for future energy savings.

Results and discussion

A study that quantified the economic benefits of the ED and ELD directives estimated that, based on projected energy savings: Net savings for European consumers and businesses amount to €90 billion per year (1% of EU's current GDP) in the year 2020. This means net savings of €280 per

household per year; reinvesting these savings in other sectors of the economy would result in the creation of 1 million jobs; dependency on imports of energy would be reduced by 23% and 37% for natural gas and coal, respectively. This means the EU could lower natural gas imports from Russia by more than half and imports of coal from Russia could be stopped (Molenbroek 2012).

Table 1. Estimated energy savings in 2020 due to ELD and ED implementation

Product group	EC projected savings 2020 (TWh)	Energy consumption starting year (TWh)	BAU consumption 2020 (TWh)	Ecodesign savings (%)
Electric motors, Lot 11	135	1067	1252	10,80%
Domestic lighting (non-directional), Lot 19	39	112	134,7	29,00%
Televisions, Lot 5	28	60	132	
Tertiary Lighting, Lot 8-9	38	200	260	14,60%
Standby and off-mode losses, Lot 6[2]	36	54	90	40%
Ventilation fans, Lot 11	34	390	629	5,40%
Directional lighting, Lot 19-part2	25			
Circulators in buildings, Lot 11	23	50	55	41,60%
Vacuum cleaners, Lot 17	19	18	34	
Imaging equipment, Lot 4	15	45,1	51,9	28,90%
PCs and servers, Lot 3	12,5 to 16,3	53,1	96	
Room air conditioning appliances, Lot 10	11	30	74	
External power supplies	9	17	31	
Simple set-top boxes, Lot 18a	9	6	1	
Complex set-top boxes, Lot 18	6,5	6	10	65,00%
Domestic refrigerators and freezers, Lot 13	6	122	83	7,20%
Laundry driers, Lot 16	3,3	20,7	31,3	10,50%
Electric pumps, Lot 11	3,3	109	136	
Domestic dishwashers, Lot 14	2	26	33,7	5,90%
Domestic washing machines, Lot 14	1,2	35	37,7	3,20%

Source: Ecofys. *First findings and recommendations*. 2014. p.18

Projected total energy savings by 2020

The EC estimates from the product groups regulated to date in total approximately 460 TWh / year of energy savings in 2020 compared to business as usual (BaU). For heat the total projected savings from product groups regulated to date amounts to 2350 PJ/year in 2020. Table 1 provides an overview of energy saving estimates as provided in European Commission documents. Projected annual electricity savings by 2020 [TWh] for regulated product groups (sources: EC, preparatory studies, Impact Assessments),

electricity consumption in the starting year and year 2020, % savings for Ecodesign (the levels in the regulations). For groups in italics energy labelling also applies, savings in this case are combined Ecodesign and Energy Labelling savings (Ecofys 2014 A).

This corresponds to approximately 13% of total EU electricity consumption and 13% heat consumption in 2020. Energy savings that can be achieved by the Directives are under investigation what the full potential of savings are and how well the energy labelling and Ecodesign implementing measures are managing to capture this potential.

Current Issues in Energy Saving

Weak enforcement by Member States is a concern for energy saving, industry and consumers. The actual level of ambition of the measures is undermined by weak enforcement, with a lack of market surveillance and testing of products leading to less efficient products reaching the market or more efficient products not supported by correct labelling. This leads to reduced energy saving overall and can also have negative knock-on impacts on industry innovation and consumer behaviour and trust.

Energy savings reduced by A+++ labels are not that effective and issue of labels lacks integration with Ecodesign. The evolution of energy labels to the A+++ categories is one that has little support among stakeholders, and where there is an overwhelming recognition of the need for change. It is also becoming increasingly clear that the A+ categories are less effective at less attracting consumers to the higher classes than the A class on an A-G scale. The issue of labels including categories that are banned under Ecodesign is also identified as a key weakness of labelling that reduces potential energy savings. There is strong support for better integration of Labelling and Ecodesign in this area, potentially through removing, or otherwise identifying, banned classes on the label image (Ecofys 2014 A).

Trend to larger, but more efficient products, can lead to higher consumption. The implementing measures focus on improved energy efficiency, which, all other things being the same, will result in energy savings. However, a trend towards larger products has emerged in particular product groups, i.e. refrigerators, washing machines and TV's. It is unclear if this is solely in response to consumer demand, with increasing concerns that manufacturers are 'gaming' the labelling classes, as it is typically easier to gain higher label classes with larger products. The result is that overall efficiency improvements, as measured by the average label class of the market, may not result in total energy savings.

There are concerns that all of these issues will erode the generally high consumer trust and support for labelling and therefore there is strong need for

a more dynamic labelling system. Similarly, more regular review of Ecodesign is needed to maintain and improve energy saving potential.

Reduction of other environmental impacts from existing regulations

While Energy Labelling covers only resource consumption in the use phase, Ecodesign measures can address, and have addressed, also impacts in other life cycle phases of energy related products. We analyze reduction of other environmental impacts from actual ED and ELD measures on several examples.

Examples for Ecodesign are:

- For washing machines, limits are set on the water consumption.
- Regulations on lighting include requirements on survival factors, lumen maintenance and number of switching cycles before failure which have implications in the replacement rate and consequently on resource efficiency.
- The indication of mercury or lead content is also part of the information requirements for some products, such as lamps or televisions.
- Information relevant for non-destructive disassembly for maintenance purposes is mandatory for vacuum cleaners and for disassembly, recycling, or disposal at end-of-life for vacuum cleaners, circulators and imaging equipment.
- Durability requirements are introduced for vacuum cleaners (hose still useable after 40,000 oscillations under strain; motor lifetime at least 500 hours).
- For Room Air Conditioners, the preparatory study also identified possible refrigerant leakage as a significant environmental aspect in form of direct greenhouse gas emissions, representing on average 10-20 % of the combined direct and indirect greenhouse gas emissions. As refrigerants are addressed under Regulation (EC) No 842/2006 of the European Parliament and of the Council of 17 May 2006 on certain fluorinated greenhouse gases no specific requirements on refrigerants are set in this Regulation. However, a bonus is proposed under the ecodesign requirements to steer the market towards the use of refrigerants with reduced harmful impact on the environment. The bonus will lead to lower minimum energy efficiency requirements for appliances using low global warming potential (GWP) refrigerants.
- To help in guiding users on the best available technology for specific applications, indicative benchmarks are sometimes given on non-energy aspects. For lighting products benchmarks figures are given for a number of parameters such as lamp mercury content and light pollution from street

luminaires. Another example is water consumption benchmarks for dishwashers.

Examples for Energy Labelling are:

- Information on water consumption in the labels for dishwashers and washing machines,
- Information on noise on the labels for refrigerators and freezers, dishwashers, washing machines, tumble driers, air conditioners, vacuum cleaners, and heat-pump driven boilers and water heaters.

However, these information are always less prominent than the energy consumption and are given as absolute values only, without a scale for comparison purposes. They are therefore much less prominent and likely to guide consumer choice than the energy efficiency scale.

The respective impact assessments are not very specific on possible effects of the declaration of noise emissions. It is said that it may impact the purchasing decision, but no quantitative assessment is given.

With regard to water consumption, the impact assessment for dishwashers show that the combined effect of Ecodesign and Labelling measures will reduce the water consumption in 2020 from 389 million m^3 in the baseline scenario (+26% of 2005) to 325 million m^3, or by 16%. (Commission Staff Working Document SEC (2010).

Several policy documents state the intention to focus more on resource efficiency(Ecofys 2014 A):

- "The Commission will: … Address the environmental footprint of products, … including through setting requirements under the Ecodesign directive, to boost the material resource efficiency of products (e.g. reusability / recoverability / recyclability, recycled content, durability) …("Roadmap to a Resource Efficient Europe, Communication COM(2011) 571)
- “The Commission will, if and when introducing new or reviewing the implementing measures adopted pursuant to Directive 2009/125/EC on products also covered by the WEEE Directive, take into account the parameters for re-use and recycling as set out in Annex 1 part 1 of the Directive 2009/125/EC, and assess the feasibility of introducing requirements on re-usability, easy dismantling and recyclability of such products." Commission Statement on WEEE COM(2012) 139
- “Increased attention will be paid to the identification of ecodesign requirements on material resource efficiency in forthcoming preparatory product studies and reviews, when these aspects are found to be significant, as foreseen in Annex I of the Directive." (Commission Staff Working Document (2012) 434).

Energy Label Revision

There is strong evidence that consumers respond positively to informative energy labels using a comparative scale showing that, for the same level of service, some products consume more energy than others. In Europe, the majority of consumers recognise, understand and use the energy label in their purchasing decisions – though probably to varying degrees depending on the characteristics of specific product labels and the implementation (or not) of complementary awareness raising programs by governments, NGOs, industry and commerce. The EU energy label has raised the profile and importance of energy efficiency as a product feature and through successfully (for the most part) overcoming information barriers has made energy efficiency matter to consumers for the majority of labelled products. In so doing it has also become a very widely recognised brand for energy efficiency. The recipe for this success has been the universal application of a label design that is easy to understand at a glance, that presents information that is salient to and trusted by consumers and that can be retained throughout the procurement process so that it actively affects product purchase decisions. It is therefore a priority that the revision of the labelling Directive should continue to ensure that consumers recognise, comprehend, retain, value and trust the information conveyed in the label.

After 20 years of energy labelling in Europe the energy label still functions broadly as originally intended. It has a high rate of recognition in all European countries and is fulfilling a useful service. For many products, there is still a large potential for additional energy savings and there remain significant differences in energy consumption between products that consumers could not identify without the aid of the label. Furthermore, only 12 product groups are currently labelled and there is considerable potential to expand the labelling scheme to cover other product types. However, the effectiveness of the labelling scheme is not as high as it could be due to a number of imperfections. According to findings reported in published research and in particular those derived from consumer research, comprehension of the current label design is not as high as it could be and more importantly the design amendment that uses additional plusses to indicate higher efficiency classes beyond the A class is less effective in motivating the purchase of higher efficiency products than the original A to G scale.

Energy-related performance is a top-of-mind concern for consumers for labelled products and is often the most frequently mentioned purchasing consideration, along with price. European consumers recognise the EU energy label, with surveys confirming recognition rates up to 80 % and 95 %, and more importantly, they mostly trust the label with a large majority using it in their purchasing decisions.

The 2010 recast of the energy label has led to several significant changes from the original energy label format:

- The label's efficiency scale has been updated such that additional high efficiency classes up to the A+++ class were introduced for household refrigerators, washing machines, and dishwashers and are now being used on new labels too
- An important design change was introduced, to move from a two-part label with a language-specific background to a single, language-neutral label that is the same across the whole EU
- As a result of the decision above, illustrative icons (pictograms) were introduced in place of the former explanatory text presented in each national language.

Need for rescaling

To ensure the future relevance and effectiveness of the energy label as an informative market transformation tool the greatest necessity is to revise the energy label scale so that higher efficiency levels can be communicated in the future. All options will require a rebasing of the efficiency classes currently applied to products already subject to labelling i.e. that the designation of a product's energy performance class will necessarily change in some way following revision of the label design. This is because the class is not just defined by a letter and plusses but also by its colour within the green to red colour code scale and the length of arrow within the stacked horizontal arrow scale. The success of the current label is built upon these three mutually reinforcing mnemonics and care needs to be taken to ensure any future design is equally successful at communicating relative energy performance. Based on the need to update the label to better fit objectives in energy and resource efficiency in future European Commission published four proposed label designs that are the following:

- Label 1: Business-as-usual: A++++ to C label, representing the addition of at least one further plus to the current label when updating
- Label 2: Alphabetic A to G label, which rescales the label classes when updating
- Label 3: Numeric 40 to100 label in which classes no longer used after updating (>100) and not yet classes (0-40) are presented in grey and in which a bench marker indicates the best available technology in a certain year
- Label 4: Reverse numeric 12 to 6 label, which adds higher numbers on top and removes lower numbers on the bottom when updating. The label's starting scale would run from 7 to 1, the situation portrayed is one that is possible after the first update.

Design of proposed labels is presented in Figure 2.

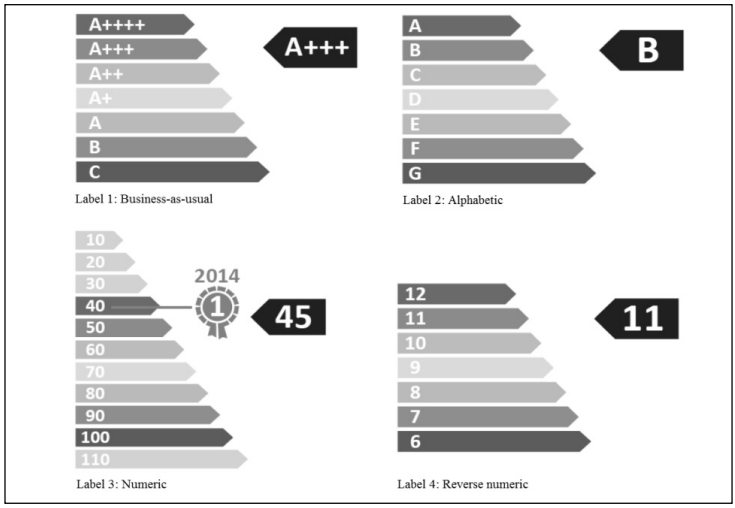

Figure 2 Design of proposed labels

Source: based on Ecofys. 2014. B. Proposed Energy labels Designs for Further Testing.

First findings and evaluation of the comprehension of the new label format is generally positive with most consumers being able to use the label to identify the most and least efficient products (though an important minority of around 25% are not) and most understanding that the objective of the label is to inform people about product energy performance. A recent study (Study on the impact of the energy label 2014) based on an on-line survey gathering over 5 000 participants from 7 European countries shows that 90% to 95% of the participants correctly identify the most energy efficient product when faced with different energy label framings. This study tested an alphabetic closed scale (the most understood), a numeric closed scale and a reverse numeric closed scale. These very high percentages may be explained by the fact that only the scale was tested, without confronting participants with a full label and in particular with an information on absolute consumption at the same time, whereas this seems to be a source of confusion for consumers who have difficulties understanding the difference between relative consumption shown on the scale and the absolute consumption, hence the lower comprehension levels that are reported in other consumer research literature are not inconsistent with these findings. Most consumers focus on the energy and energy efficiency information, which are the highest profile elements on the label. Furthermore a substantial proportion expresses a willingness to pay more for efficient models. However, comprehension and resulting positive attitude towards the label may be much less for some of the newer labels that

have not so far been analysed in consumer research (e.g. the room air conditioner label presenting "SEER" and "SCOP" parameters without explanations, and introducing regional factors).

For all labels, there are a number of challenges that need to be addressed by the forthcoming revision of the Directive. For the second phase of the study, consumer understanding and behaviour testing of four label designs in brick-and-mortar retail outlets is planned on sample of 500 respondents in four countries: Belgium, France, UK and Czech Republic with 125 interviews in each country.

CECED in their document to European Commission declares that successful testing requires that each option must be equally, fairly, comparably surveyed and different elements are tested separately The label with Business-as-usual layout foresees an update with the introduction of A++++. In some product categories, there are models already in need of more than 4 plusses (based on the current Energy efficiency Index). In alphabetic layout we assume a downgrade will occur from the start. In which case, in which class would today's best available products fit? How will the transition process be handled and look like when this layout is first introduced and for any future upgrades? Numeric layout is the only one option where new elements on top of the usual features are displayed: bench marker, empty classes on top, index figure in the black arrow and numbers instead of letters to define the classes. These layout elements are visible just in this label layout and should be tested separately and not mixed into one option (CECED comments... 2014).

Conclusions

The mnemonics used on the label are highly effective. The letters on the energy efficiency scale, the colour coding and the stacked arrows are all clearly understood, reinforce each other and are motivating to consumers. These elements and their associated use should be maintained in any future revision of the label.

Use of pluses as a complementary efficiency mnemonic is less effective. Consumer research shows the label scale is well understood, whether A-G or A+++ -D, however A+++ as the top of scale is less compelling (less motivating or appealing) than when A is at top. The difference between an A and a D is much faster for consumers to process than A+++ to A.

Highest and lowest efficiency classes are inconsistent. The current set of labels are inconsistent in the choice of end points used to rank the highest and lowest efficiency products, with some having A to G end points and others D to A+++. The fact that in some cases lower efficiency classes indicated on the

label are prohibited for sale by Ecodesign regulations is not understood nor is it communicated to consumers.

The issue whether consumption values should be expressed per year (as in the recast labels), as opposed to per cycle (as in some of the old labels) is disconcerting for many consumers and can lead them to challenge the credibility of the information on the label. This is because for appliances that are used intermittently (such as washing machines, dish washers, TV, etc.) consumers are liable to think that those designing the label cannot possibly know how frequently they use the product leading many to doubt that average values could be of direct relevance to them.

Based on the findings recommendations for future label revisions could include considering re-grading the A-to-G efficiency scale in preference to adding more plus signs; ensuring that all efficiency classes indicated on the label are still permitted for sale.

Acknowledgements

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PURCHASE DECISION CRITERIA IN PRODUCT CATEGORY OF PERFUMES: EMPIRICAL STUDY

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Introduction

Nowadays, fragrances and perfumes have become mainstream business in the cosmetics industry. Consumer demand for perfumes is largely dependent on demographics and lifestyle trends, in particular the perception of the importance of luxury and status. Perfumery industry is primarily driven by consumer. We can identify a new generation of consumers with specific consumer behavior and different approach to quality evaluation than traditional consumer. In the vision of new generation the approach to quality is done in holistic way, not only with product utility features, but with regard to brand which has the influence on personal image and social recognition. Transcendence of brand from material to symbolic level can be observed (Voinea, Pamfilie, Onete 2013). Perfumes have been transformed into "feel-good" factor, and help consumers to express their individuality and personal style.

Perfume industry growth is supported by growing demand from emerging markets. Currently, low-penetrated markets such as China and Japan, represent huge opportunities for major international players (GIA, 2011). Fragrances for women represent the largest segment of the global market. They make up 63.8% of its total value. Although women's fragrances continue to remain a leader with maximum sales, it is expected that the category of men's fragrances will grow apace.

The object of our research is to analyze purchase decision criteria in product category of perfumes with focus on the design of perfume as a purchase decision criterion. Design is the added value of any product, increasing its competitiveness and strengthening market position. Of all product categories, perfumes are one of the most known for its creative design and bottles packaging.

Estimated by Global Industry Analysts the world perfumery industry in 2017 would exceed the volume of 36 billion USD. In 2010, the fragrances and perfumes industry generated revenue of 16.3 billion USD in G8 countries (Canada, USA, Germany, France, Great Britain, Italy, Russia and Japan), and thus maintain an annual market growth rate of 1 % higher than in the four previous years. They predict fragrances and perfumes market value in 2015 of almost 18 billion USD. Leading country within the G8 fragrances and perfumes market is U.S. with 33 % market share. In 2015, the U.S. will continue to dominate the G8 market, and should reach the volume 5.7 billion USD. On top of the global fragrances and perfumes market Global Industry Analysts however place the EU which represents up to 45.1 % of the total global market. European manufacturers of fragrances and perfumes dominate the world market they carry a certain prestige of their brands worldwide (Hamrick, 2012).

International market fragrances and perfumes is highly polarized and fragmented. A leading player in the global market is Coty perfumes Inc., which generates 10.2% of the market value. Other key market participants include: Polo Ralph Lauren, Avon Products, Procter & Gamble, L'Oreal, Chanel, Estee Lauder, LVMH Group, Gucci Group, Bulgari, Puig Beauty & Fashion Group, Elizabeth Arden, Gianni Versace (GIA, 2011).

Author in the paper deals with commodity science characteristic of fragrances and perfumes and evaluates consumers buying behavior of females in the product category of perfumes with a focus on design as a criterion for purchasing decisions.

Material and methods

The object of our research is to analyze purchase decision criteria in product category of perfumes with focus on the design of perfume as a purchase decision criterion and examine the impact of various design elements The survey was conducted using a standardized questionnaire to a sample of 100 randomly selected female respondents without age limits. In subsequent analysis, we emphasized the differences and particularities of consumer behavior and purchase criteria perception of different age groups. Using Microsoft Office Excel we interpret the results in tables and graphs.

Results and discussion

Fragrances and perfumes today qualify for mainstream business of cosmetics and personal care. Due to the growing trend of emphasis on appearance and personal care, a shift of perception of fragrance as unimportant and frivolous matter towards essential characteristic, which is part of pride, self-confidence and self-esteem happened. Fragrances and perfumes transformed to a factor which constitutes a "good feeling" and helps to

strengthen the consumer's need to express individuality and personal style. A wide range of options enables consumers to choose such fragrances that complement their personal and character traits accordingly. Economic prosperity in emerging markets, along with increased demand for creating younger or celebrity impression by fragrances in developed markets is a prerequisite for the growth of the global market of fragrances.

Perfume Characteristics

The term perfume comes from the Latin, where "per fumum" means "through smoke" and refers to its earliest uses - incense in the temple sacrifices. Merriam-Webster defines perfume as a mixture of fragrant essential oils or aroma compounds, fixatives and solvents used to give the human body, animals, food, objects, and living spaces "a pleasant scent."

It is a solution of synthetic or natural odoriferous substances and combinations thereof. In a narrow sense it means only perfume extract, that scent with the highest concentration of fragrances (Pekárik, 2009).

Perfumes are divided into several types, differing from the method of preparation and concentration of fragrances (*Druhy parfumov*, 2012):

- *Extrait Parfum* is the most concentrated and most expensive type on the market. Its fragrance is most intense and longest lasting. Typically consists of a huge number of ingredients, and the proportion of essential oils in the resulting product is 15 to 30 % of the concentrated alcohol;
- *Eau de Parfum (EdP)* is a substance essential oil mixed with alcohol. Essential oils usually represent 10-14 % of the volume of such perfumes;
- *Eau de Toilette (EdT)* is lighter form of perfumes, usually with some specific scents with fewer ingredients. Essential oils are commonly represented at a concentration of 6 - 9 % and are dissolved in alcohol;
- *Eau de Cologne (EdC)* is only lighter mix of fragrance essences , at concentration 3 - 5 % of the composition;
- *Eau de solide (EdS)* has the lowest content of essential oils that make up 1 - 3 % of perfume composition.

The most practical way to start describing a perfume is according to the elements of the fragrance notes of the scent or the "family" it belongs to, all of which affect the overall impression of a perfume from first application to the last lingering hint of scent. Perfume connoisseurs speak of a fragrance's "sillage", or the discernible trail it leaves in the air when applied (Fortineau 2004).

Each perfume has 3 stages of evaporation respectively 3 core files of tones, which together form a harmonious chord of a particular perfume. *Top notes* also referred to as the "head" appear immediately after applying perfume. They are caused by small, light molecules that are released very quickly. Top notes play a key role in consumer perfume selection process in the store, as they form the first impression of the perfume. The attributes are

freshness, vigor, or sharpness. The most common top perfume tones are citrus and ginger scents. *Middle notes* are also called the "heart" of the perfume and they come after the top notes disappear. Their main task is to disguise the initial, often not so pleasant smell of perfume fundamental tones. We can smell the fragrance in about two minutes to an hour after applying perfume. Attributes of the middle tone tend to be softness and roundness. Typical middle tones include rose and lavender. *Base notes* emerge just before the fading of middle tones and only these constitute the main idea of the perfume. The ingredients of base notes are usually strong and to make full unfoldment, they need up to 30 minutes. Heavy molecules from the base notes evaporate very slowly some can be scented even 24 hours after application of perfume. Attributes of base tone is saturation and depth (Edwards, 2006).

The number of perfume compositions, now estimated to be 800, of which more than half are feminine fragrances. For their segmentation H & R (Haarmann and Reiner) grading system is used, which divides the fragrances by type for males and for females and maps their presence in different areas of the world market. Experts who draw up this system were guided by principle that each perfume has its peculiar fragrance base. The classification is based on the scents, which are most dominant in European, American and Japanese markets in the 20th century. The exception are the oldest citrus aromas and fragrances Foughre Royale/Houbigant from 1882 and Jicky/Guerlain from 1889 , which are still in circulation today , as well as some famous perfumes which are no longer in production as Foughre Royale from 1917, Chypre/Coty or Bois de Iles/Chanel from 1926. The reputation of fragrance was a significant criterion. Particular emphasis was put on the "cult" variations such as Chanel N'5 or Chypre, indicating new directions in the development of perfume. Each major category is divided into several sub-categories (Poriadok 2009).

According to their perception of the composition there are 3 major women's fragrances, which are divided into several subcategories (Rodokmeň, 2009):

I. Flower bouquet:

- floral - green: for this creation smell of fresh leaves and resin is typical;
- floral - fruit: floral fragrances are tinged with a hint of flavors of black currant, pineapple, apricots, peaches, and apples;
- floral - fresh: light fragrance, aroma reminiscent of spring hyacinths, lilies of the valley, and orange blossom;
- floral - floral: the chief ingredient is rose and jasmine, but ylang - ylang, narcissus, tuberose, iris and cloves often are often added;
- floral - aldehyde: fatty aldehydes affect the dispersion of odor;

- floral - sweet: the heaviest floral fragrance, a transitional stage to the oriental direction;

II. Oriental fragrance:

- oriental - amber: a citrus scent is admixed with sweet vanilla amber;
- oriental - spicy: besides spicy fragrance of clove, nutmeg and cinnamon it has bitterish, oriental fragrance, like the smell of dry wood and ambergris;

III. Cypress fragrance: cypress and citrus cultivation is widespread in the Mediterranean areas due fleshy, juicy fruits. Cradle of lemon, which belongs to the citrus plants are southern slopes of the Himalayas. In Europe has been known since Roman times. Tangerine and sweet orange come from Indo-China. Fruit grapefruit has a bitter taste.

Cypress and lemon scent are not quite identical with cypress and citrus plants – which are specific compositions. Cypress fragrance is typical of feminine as well as for masculine fragrances, while citrus fragrance is more a masculine scent.

Name Chypre or Cyprus, comes from Francois Coty, Grandmaster of 20th century perfumery, who composed the fragrance of Cyprus in 1917 and he produced it mainly from material originating from the Mediterranean area. The name is probably derived from the island of Cyprus:

- Cypress - fruit: heavy, strongly aromatic fruity fragrance which main component is a peach;
- Cypress - floral - animal: it is equally effectual with men and with women;
- Cypress - floral: base tone is indicated by the scent of rose, blends also with patchouli;
- Cypress - fresh: this subgroup includes cypress pure fragrance compositions;
- Cypress - green: the lightest variant of Cypress scents.

Perfumes are one of the product categories that are most famous for its creative design of packaging and bottle.

Perfume Packaging Design

Design with its visual representation role is to effectively establish a relationship between perfume and its target group. It must be consistent with the language and expectations of the target group that the product addresses. Perfumes not only should evoke the flavor, but also emanate a certain personality type and feelings.

Many components contribute to the success of the design, but all can be classified into two main categories: a) graphic design elements such as colors, lettering, logos and b) product design elements such as shape, size and material. Consumers associate package design elements such as color and shape, to human qualities and then assign them to the product. The first thing consumers will notice is the color of the packaging, as it penetrates into their subconscious mind the best and fastest and thus have the power to influence consumers' emotional responses. Like the color, shape is also an important design attribute. It raises the images of product features and its performance.

Packaging design develops gradually, as new technologies, material, budget and market needs evolve. Gone a long way and today, in addition to various shapes, we can discern a variety of materials from which the package is made. (*Obalový dizajn*, 2008).

The importance of purchase decision criteria when buying perfumes

Female respondents rated the criteria as scent, brand, design, price, own experience, advertising campaign, recommendations form others, sales personnel, and samples in magazines according to the importance assigned to them when buying perfume. The rating scale was from 1 to 5, while 1 meant very little importance and 5 very high importance. Their evaluation is shown in Figure 1.

On the basis of the respondents' declaration, we found the order of importance of perfume purchase criteria, which is as follows: scent of the perfume, their own experience, price, brand, design, samples in magazines, recommendations form others, sales personnel and ultimately advertising campaign.

Scent of the fragrance gained a clear lead in importance when choosing a perfume. 96 % of respondents attributed very high importance to scent, and the remaining 4 % attributed high importance. It was of highest importance in all age groups of female respondents.

The second most important criterion in the selection of perfume, according to respondents is their *own experience*. 41 % assigned very high importance, 33 % great importance, 20 % average importance and only 6 % assigned low importance to their own experience. Own experience was valued most in the category of ladies in their forties (57 %) followed by ladies in their thirties (54 %).

Price was posted in the third place. 37 % of respondents considered price of very high importance. For 26 % of women price has high importance, for 29 % average importance. 8 % of respondents claimed price has only a low importance for them. Higher age groups are the most cost sensitive. 83 % of ladies over sixty and 50 % of ladies in their fifties identified price as very important factor.

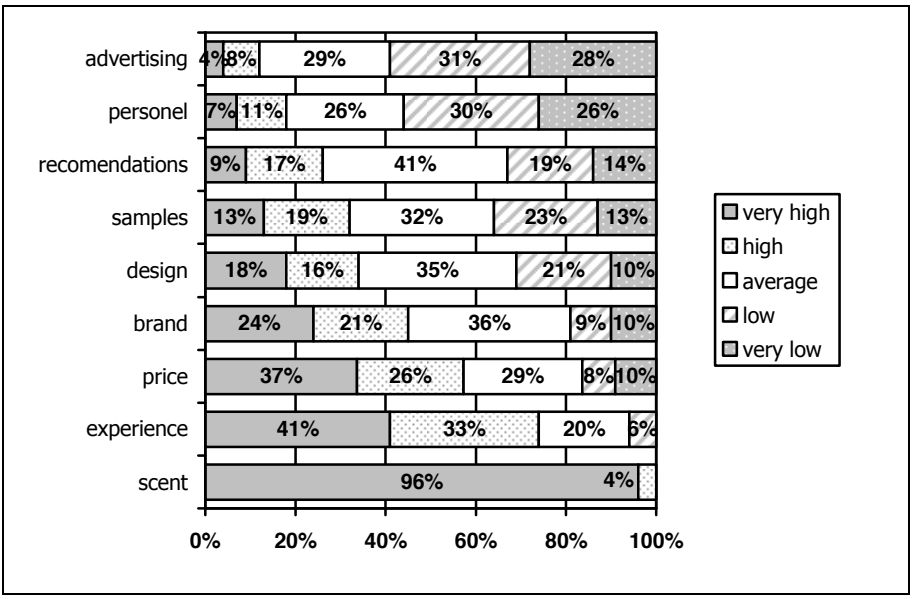

Figure 1. Importance of purchase decision criteria when buying perfumes

Source: own research.

The fourth most important criterion was *brand*. Most respondents (36 %) attributed average importance to brand. A significant proportion (24 %) is of those who attributed very high importance, but also of those who attributed high importance (21 %). Very low importance was attributed by 10 % of respondents, low by 9 % of them. The youngest generation is affected by brands most of all generations. 35 % of teenagers attribute very high importance to brands, 29 % high importance, and none of them low or very low importance.

Design as a decision criterion in perfume category was placed to the fifth position of the nine criteria. Most respondents (35 %) perceived perfume design only average importance. 18 % of respondents admitted that design for them has very high importance, 16 % attributed high importance. 21 % attribute low importance to design, and 10 % very low importance. Perfume design affects most the age group of teenagers (29 % attribute very high importance, 24% high importance to design) and age group in their twenties (30 % attribute very high importance , 8 % high importance). To much lesser extent it affects the age group in their thirties (12 % attribute very high importance, 19 % high importance), and age group in their forties (14 % attribute very high importance, 7 % high importance). Importance of design rose dramatically in age group of ladies in their fifties (40 % declared high

importance, 40 % average importance). Has the least impact on women over sixty (67 % low importance, 17% of very low importance).

Sixth are *perfume samples* in magazines. Very high importance was ascribed to them by 13 % of respondents, high importance by 19 %. Most of respondents (32 %) attribute average importance to samples, for 23 % it is criterion with low importance, for 13 with very low importance. The lowest importance is to samples attributes by women over sixty (33 % very low importance, 50 % low importance).

Recommendations gained seventh place in the ranking. 41 % of respondents attributed average importance to recommendations, 17 % high importance and only 9 % very high importance. On the other side 19 % attributed low importance, and very 14 % low importance. This criterion is rated the most positively by women over sixty (50 % high importance).

Sales staff support occupied penultimate position. 30 % respondents assessed sales staff support with low importance, 26 % with very low importance. For more than a quarter of women 26 % it has an average importance. 11 % attributed high importance, and only 7 % attributed very high importance. Sales staff support was valued most in age group of women over sixty (50 % high or very high importance) and in their fifties (40 % high or very high importance). Sales staff support was the least important factor in their decision making for teenagers (47 % very low importance) and in their twenties (30 % very low importance).

Advertising occupied the last position in ranking of all criteria. 28 % of respondents claimed that in their decision it does not play the slightest role. For 31 % of them it has a low importance and for 29 % the average importance. Just small proportion of respondents (8 %) attributed high importance to advertising, and only (4 %) rated it with very high importance. Young age groups are affected by advertising most of all age groups, especially teenagers. 30 % of them attributed high to very high importance to advertising. On the contrary, the least importance is attributed to advertising by women over sixty (50 % very low importance, 50 % low importance) and by women in their fifties (80 % very low, 20 % low importance).

The importance of individual design elements on purchase decisions

Respondents rated the elements of perfume design based on how much importance they attach to them. Individual design elements were evaluated by points from 1 to 5, when one means very low importance and five means very high importance. Based on the results, we created order of elements from strongest to weakest impact, as follows: color of the perfume, shape and material of the bottle, the name of the perfume, packaging, the shape of cap, and finally shape, and color of the font. Evaluation of design elements is shown in Figure 2.

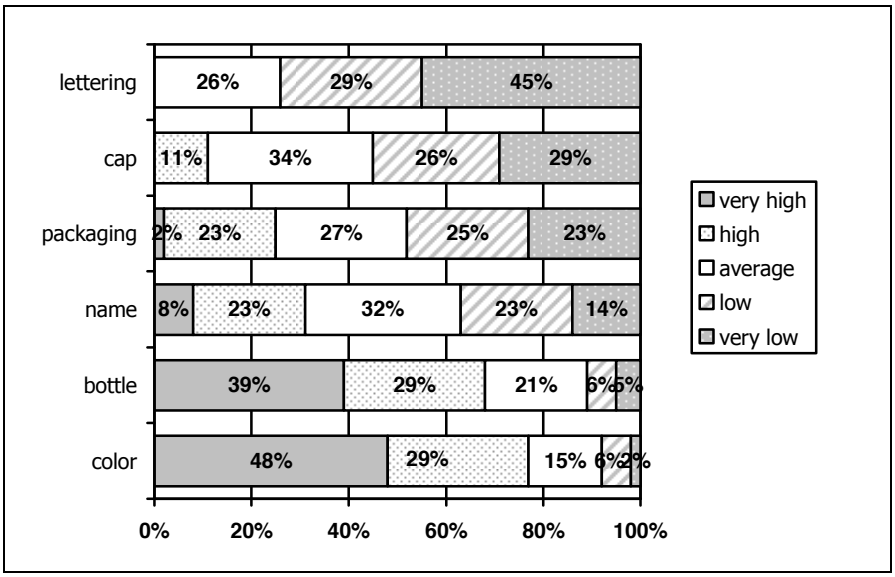

Figure 2. The importance of individual design elements on purchase decisions

Source: own research.

According to the respondents, the strongest influence on their purchasing decision from all design elements is attributed to the *color* of the perfume. Nearly half (48 %) of respondents described it as an element with a very strong, and more than a quarter of respondents (29 %) with strong impact. 15 % of respondents attribute average impact, 6 % small, and 2 % very small impact to color.

The shape and material of the bottle is the second most important element of perfume design. It has very strong influence to 39 % of respondents and strong influence to 29 %. Color of the perfume as an element with an average influence was rated by more than 21 % of women. Weak (6 %) or very weak effect (5 %) was attributed to it by only a small percentage of respondents.

Name of the perfume occupied the third position among design elements. It has very strong influence among design elements only to 8 % of respondents, strong influence to 23 %. Most respondents perceived it as a design element with an average influence (32 %). It was considered to be an element with little effect by 23 % of respondents, and very weak influence by 14 %.

Packaging of the perfume occupied the fourth place. His influence among design elements was assessed as strong by 23 % of respondents, very strong by few just 2 %. Average effect to packaging was attributed by 27 %. A quarter of respondents (25 %) perceived packaging as an element with a

weak influence among design elements, and the remaining 23 % perceived it as an element with a very small impact.

The *shape of cap* was evaluated as penultimate design element. 29 % of give the cap very low importance, 26 % low importance, 34 % average importance 11 % strong importance, and no one saw the cap as very impactful element.

Design element with the smallest impact on the purchasing decisions among all design elements was the *shape and color of the font*. No respondent perceived it as an element with a strong or very strong influence. Most respondents (45 %) ascribed only a very small impact, another 29 % weak impact, and the remaining 26 % average impact to shape and color of the font used on the perfume.

Even if respondents in the research expressed difficulties to predict scent of perfume by color, in the next part of the questionnaire they attributed specific scents to colors.

Conclusions

On the basis of respondents rating design occupied fifth position from all the nine purchase decision criteria such as scent of a fragrance, brand, design, price, own experiences, advertising, recommendations, sales personnel, and samples. Clear leadership in importance when choosing a perfume, was achieved by scent of the perfume. 96 % of respondents attributed very high importance to scent, and the remaining 4 % attributed high importance. It was of highest importance in all age groups of female respondents. The second most important criterion in the selection of perfume, according to respondents is their *own experience*. 41 % assigned very high importance Own experience was valued most in the category of ladies in their forties (57 %) followed by ladies in their thirties (54 %). *Price* was posted in the third place. 37 % of respondents considered price of very high importance. Higher age groups are the most cost sensitive. 83 % of ladies over sixty and 50 % of ladies in their fifties identified price as very important factor. The fourth most important criterion was *brand*. Most respondents (36 %) attributed average importance to brand. The youngest generation is affected by brands most of all generations. 35 % of teenagers attribute very high importance to brands, 29 % high importance, and none of them low or very low importance. *Design* as a decision criterion in perfume category was placed to the fifth position of the nine criteria. Most respondents (35 %) perceived perfume design only average importance. 18 % of respondents admitted that design for them has very high importance, 16 % attributed high importance. 21 % attribute low importance to design, and 10 % very low importance. Perfume design affects most the age group of teenagers (29 % attribute very high importance, 24% high importance

to design) and age group in their twenties (30 % attribute very high importance , 8 % high importance). To much lesser extent it affects the age group in their thirties (12 % attribute very high importance, 19 % high importance), and age group in their forties (14 % attribute very high importance, 7 % high importance). Importance of design rose dramatically in age group of ladies in their fifties (40 % declared high importance, 40 % average importance). Has the least impact on women over sixty (67 % low importance, 17% of very low importance).

Although the respondents in assessing the impact of design on their buying decisions were rather skeptical, several studies clearly show that design has the power to influence our emotional reactions (Ch. Fiell – P. Fiel, 2004, Demirbilek – Sener, 2003, Griffin, 1999, Alessi 1998), while the consumer is not aware of its impact. The greatest emphasis should be put on the color scheme of perfumes. The colors transmit certain signals towards consumers therefore they should be used by manufacturers when designing perfume consciously and purposefully. Like the color, perfume bottle shape also raises specific consumer's expectations about its characteristics.

This study has several limitations. First is the sample size that does not allow generalization. Second it does not follow real shopping process and it uncovers what people think or what they believe and declare it is important for then in shopping process. It does not measure the difference between consumer beliefs and their behavior. In future it should be complemented by quantitative study and consumer shopping process observation which can highlight discrepancies between consumer declarations and real shopping behavior.

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THE ROLE OF CONSUMERS IN COMMODITY SCIENCES – THE CASE OF ENVIRONMENTALLY AND SOCIALLY SUSTAINABLE TEXTILE AND CLOTHING PRODUCTS

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Introduction

The literature produced in the framework of commodity sciences (CS) and most recent research clearly point to the growing role of consumer behaviour analysis.

CS is increasingly perceived as a field of research dealing with the quality of commodities, where both the producer's and consumer's perspectives are taken into account. More and more importance is given to shaping and analysing product quality in terms of the external and internal customers' expectations, and to accounting for these expectations by defining specific qualitative and technological parameters of products (Korzeniowski, Chochół & Foltynowicz 2006)

R. Zalewski (2013) also points to the crucial role of consumers in commodity sciences of the future called CS 2.0.

Because product quality analysis performed from the consumer perspective and the analysis of relationships between consumers and manufacturers attract more and more attention, factors shaping consumer behaviour should also be examined more in depth, particularly those explaining how consumers perceive and differentiate products.

Consumers behave differently towards particular groups of products, which increases the usefulness of the analyses investigating individual markets or market segments. The outcomes of the analyses are also applicable to everyday business operations.

This article concentrates on a very special group of products, i.e. environmentally and socially sustainable textile and clothing products. The

research was undertaken in response to challenges arising from sustainable development in the 21st century, corporate social responsibility and new consumption trends, but also out of the belief that users and consumers must be given a greater role in creating innovative textile and clothing products. The worldwide increase in ecological and social awareness, one of the most pronounced phenomena observed in the sphere of consumption, is another challenge for the present-day CS. This challenge arises from the fact that consumers pay more and more attention to the environmental, social and ethical characteristics of the products they choose.

The article provides an analysis of the behaviours of Polish consumers towards sustainable textile and clothing products and of the factors that determine them, giving special attention to factors explaining how consumers perceive and differentiate sustainable textile products from others.

Sustainable textile and clothing products

Together with food products, textiles and clothing are counted among the basic groups of consumer goods. Textiles accompany people "from cradle to grave", ensuring comfort and protecting their health. Even so, the textile and clothing industry in Poland is a grossly underutilised sector of her economy, almost at the edge of negligence, although the European Commission's reports point out that Poland owes her considerable share in the European industry to the production of innovative textiles, including those meeting strict environmental and social standards.

The question of sustainable production of clothing is very complex, because the clothing industry's supply chain is one of the longest, most complicated, fragmented and globally expanded. Compared with food production, its manufacturing processes are also less transparent.

As a result, the understanding and definition of sustainability as applying to textile and clothing products is ambiguous and fairly problematic. Most people associate sustainability with the environment, although its two other aspects – economy and society – are equally important. From the perspective of the social impacts of textile and clothing products, the sustainable ones are those that are made in good working conditions and without child labour, and respect fair trade rules.

Blackburn (Blackburn, 2009) points to misunderstandings about what is "good" and "bad" in the context of sustainability. Terms like "organic", "natural" and "biodegradable" are generally perceived to be "good", whereas "GM", "synthetic" and "chemical" are considered to be "bad". Many of those terms are used cleverly to market claimed sustainability benefits, but a product can only be sustainable when the whole "cradle-to-grave" life cycle is sustainable. From the consumer perspective, the most efficient way to find out

about product sustainability is to look for ecological and social labels attached to textiles and clothing as a proof of their being sustainable.

One of the most respected is The Global Organic Textile Standard (GOTS) which confirms that the status of textiles is consistently organic from the harvesting of raw materials through environmentally and socially responsible manufacturing and labelling, thus providing credible assurance to the consumer (more about social and ecological labels in Koszewska 2011, Koszewska 2013).

Factors determining consumer behaviour towards sustainable textiles and clothing

Consumer behaviour is determined by a number of factors that can be put into two categories. The first category consists of internal factors described as individual characteristics (Engel et al. 1986) or consumer's attributes-predispositions (Nicosia, 1968). These are demographic factors (gender, language, age, income and occupation, educational attainment, etc.), socio-cultural factors (e.g. family status, social class, lifestyle, preferred style of dressing), psychological factors (the pace of learning, being open to novelties, propensity to take risks, sensitivity, knowledge and consciousness, etc.).

Consumer behaviour towards sustainable products is primarily determined by the socio-cultural and psychological factors, among which several interrelated factors are the most significant.

The first of them is the knowledge of environmental and social threats involved in the production of textiles and clothing. This knowledge is stressed in many articles on environmentally and socially sustainable products (Thøgersen, 2000; Moisander et al. 2010; Kang et al. 2013). But knowledge alone does not suffice. (Brosdahl & Carpenter 2010). Ecological and social sensitivity is also widely covered in the literature. This sensitivity is much more than knowledge alone, because it makes consumers take specific actions.

One of the main reasons for the disinterest in sustainable textile and clothing products seems to be the lack of awareness of the problems and risks associated with the use of conventional products which often contain carcinogenic substances, etc., or the lack of awareness of social or/and ecological fast fashion implications (Pookulangara & Shephard 2013). Only the combination of knowledge, the awareness resulting from it, and individual predisposition of a particular person produces a category referred to as concern (Butler & Francis 1997; Brosdahl & Carpenter 2010; Pino et al. 2012; Balderjahn et al. 2013), which determines consumers' attitudes and motivations for seeking and purchasing sustainable textiles and clothing (STC).

All these factors – knowledge, awareness, concern and the resulting attitudes and motivations – are influenced by internal factors (individual's predispositions) and external factors called environmental influences (Engel et al. 1986), which include the family, reference groups, and the media.

A study conducted with a representative sample of Polish consumers confirmed that their knowledge of ecology, awareness and concern significantly differentiate their behaviour towards STC products (Koszewska 2012)

Their shopping routines and habits and the criteria they apply to select these products are also of importance (Koszewska 2013). The factors are frequently related to consumers' past experiences or their loyalty to a store or a brand, which are called the consumer interaction variables (Du Preez 2003; Du Preez & Visser 2003).

One of the research aims of this article is to find the key factors determining the purchase of sustainable textile and clothing products.

Material and methods

A review of the literature allowed identifying a range of factors that the customers perceive as driving their purchases of textile and clothing products (fashion, brand and style, price, quality, wearability, comfort of wear, fit, the shop, etc.). The range was extended to ecological and social criteria that other studies omit or rarely address. The final set of 18 different opinions (variables) on why particular clothing products are chosen and bought with a 7-grade scale attached to it was presented to respondents to measure their support for the opinions.

An exploratory factor analysis was applied to determine which factors determined the purchase of STC products the most strongly, as well as and their rankings. First the rationality of applying a factor analysis model to the collected data was evaluated by constructing a matrix of correlations between particular variables. The relatively high value of KMO (0.814) and the result of the Bartlett's test (4687,28 at p=0.00) showed that the model was an appropriate solution. In the next step, the principal component method was used.

In the factor analysis, factor loadings were subjected to orthogonal varimax rotation. To identify the principal components, the variables with the highest factor loadings and the component data were separated from each other. The scree method, the eigenvalue and the percentage of variance pointed out that five principal components were suitable for further analysis. These five principal components in a set of eighteen accounted for almost 62% of the variance (for the purpose of this article the principal components are equivalently called factors).

Results and discussion

After analysis, 18 observable variables were aggregated into 5 factors responsible for consumers choosing sustainable clothing products: „fashion", „ecology", „ethics", economy", and „utility". The loadings of the 5 factors are presented in table 1.

The factors have the following compositions. Factor 1 consists of variables explaining why buyers pay more attention to clothes' brand-name, originality, fashion, and good quality than to their price. Because all these variables have to do with fashion trends, factor 1 was arbitrarily called „fashion".

Factor 2 incorporates variables such as raw material composition, a known country of production, and ecological labelling. All the variables meet under the heading of ecology, and so factor 2 was named.

Table 1. The structure of the principal components (factor loadings) after rotation

Observable variables	Factors (principal components)				
	fashion	ecology	ethics	economy	utility
Global or European brand	.828				
Original, unique design	.813				
Importance of the brand	.743				
Fashion, new trends	.692				
Frequency of buying new clothes	.647				
Quality/price	.525				
Raw materials composition		.799			
Country of production		.783			
Natural raw materials		.763			
Ecological labelling		.605			
Workers' rights			.886		
Child labour			.880		
Buying at the sales				.793	
Buying in second-hand stores				.764	
Price				.435	
Period of wear					.713
Wearability					.705

Source: developed by the author

Factor 3 is made of variables relative to the social aspects of production, such as a system of production infringing or not workers' rights, the use of child labour, **etc**. Because all these variables have to do with the ethical aspect, factor 3 was called „ethics".

Factor 4 consists of variables such as product prices, buying at the sales, second-hand stores, which can be summarised as economic. Hence factor 4 was called „economy".

Factor 5 encompasses variables concerning the utility characteristics of clothing, such as period of wear and wearability. This one was called „utility".

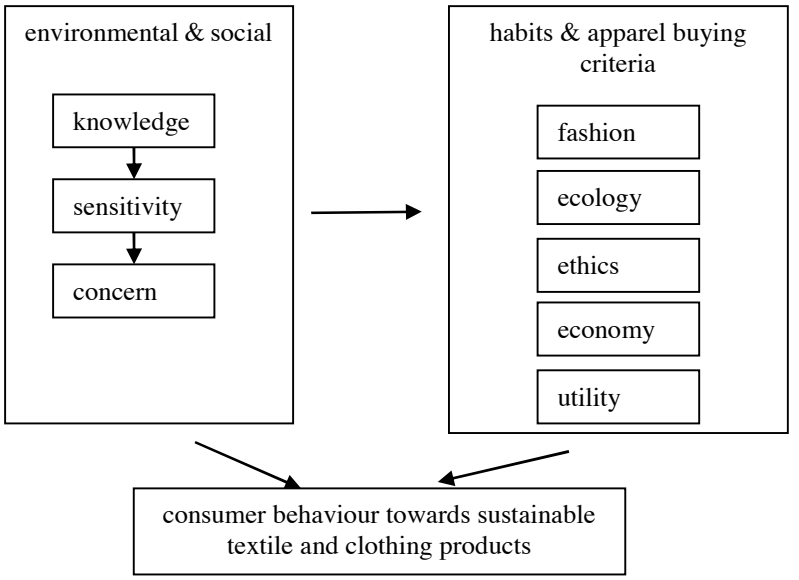

Figure 1. Factors affecting consumer behaviour towards sustainable textile and clothing products

Source: developed by the author.

As far as sustainable textile and clothing products are concerned, two groups of factors appear to be crucial to consumer behaviour. One consists of environmental and social knowledge, sensitivity and concern, and the other is represented by buying habits and apparel selection criteria, including „fashion", „ecology", „ethics", economy", and „utility".

Consumers' role in solving the ecological and social problems caused by the textile and clothing industry

In analysing consumers' contribution to the solving of environmental and social problems caused by the textile and clothing industry the whole "cradle-to-grave" product life cycle must be considered. The focus of the above analysis is on the buyer's decision-making process, but environmental and social problems occur in the later phases of the cycle too. It is also noteworthy

that consumers' capacity to help solve the problems varies depending on the phase.

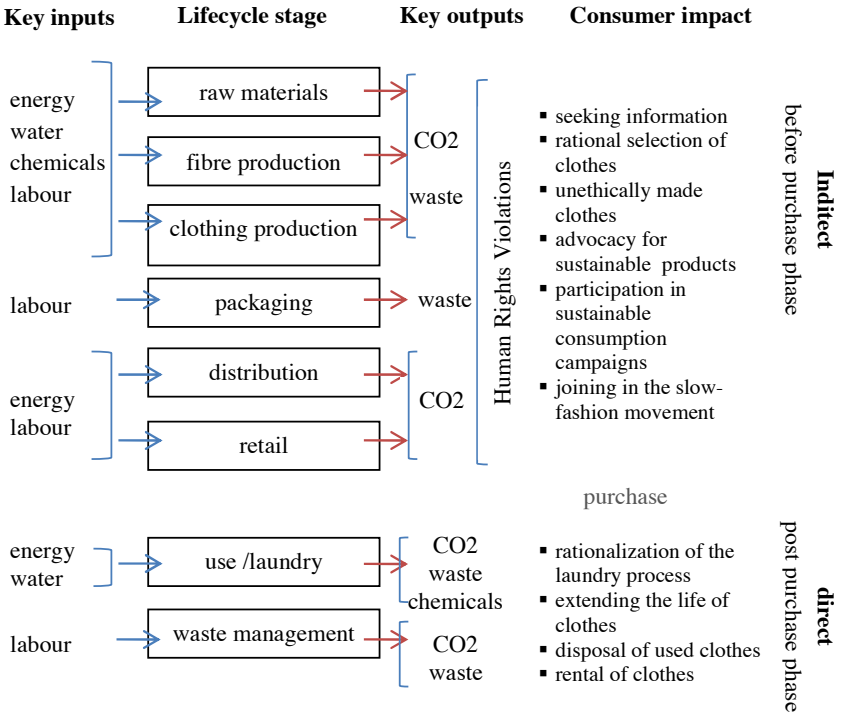

Figure 2. The consumer impact on solving the ecological and social problems in life cycle stages

Source: developed by the author

In the before-purchase phase, consumers can only indirectly mitigate the negative impacts of the modern textile and clothing industry, for instance by making buying decisions in a conscious and mindful manner. In the post-purchase phase, their contribution may take the following forms:

- active seeking of information on the producer's environmental and ethical attitudes,
- choosing clothes based on the information about manufacture methods and conditions (checking the raw materials composition, producer's country, eco- and social labelling, etc.)
- giving up the purchase of products made by unethical manufacturers (environmentally unfriendly, abusing workers, etc.)

- talking with friends and acquaintances about companies' protection of the environment and support for local communities
- encouraging friends to buy products made by a producer committed to environmental protection or supporting local communities
- participating in events/campaigns promoting responsible consumption and fair trade
- becoming part of the slow-fashion movement (buying as many clothes and as frequently as it is really needed; choosing products for their quality and wearability; renting clothes for special occasions such as weddings and maternity rather than buying them; buying second-hand clothes, etc.).

When the consumers' capacities and responsibilities are discussed, the later phases of product life cycle such as wear and disposal are frequently omitted. However, in these later phases consumers can make contributions that are equal in importance but more direct.

A case in point is extracted energy consumption, where consumer use is identified as the most significant life cycle stage; transport and packaging are notably insignificant contributors to the total burden. Figure 3 presents a percentage breakdown by life cycle stage calculated for total extracted energy consumption associated with the lifetime of a three pack of men's cotton briefs. (Collins & Aumônier 2002).

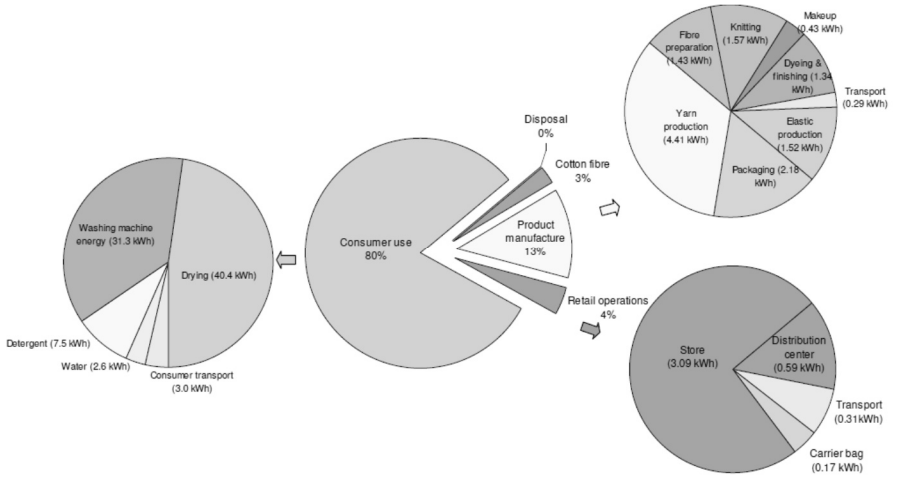

Figure 3. Analysis of life cycle energy consumption for a pack of men's cotton briefs (104.9 kWh)

Source: Collins M., Aumônier S., 2002, Streamlined Life Cycle Assessment of Two Marks & Spencer plc Apparel Products, Environmental Resources Management

In the post-purchase phase, the socially responsible consumer is expected to show the following behaviours (Allwood et al. 2006).

Rationalization of the laundry process (segregation according to the raw materials, washing at lower temperatures with eco-detergents, hang-drying, avoiding ironing where possible;

- extending the life of clothing and textile products through repair;
- disposal of used clothing and textiles through recycling firms that return them for second-hand sale wherever possible, but otherwise extract and recycle the yarn or fibres.
- renting clothes that will not be worn to the end of their natural life.

Conclusions

I can be concluded, that there are two groups of factors that seem to be crucial in determining consumer behaviour towards sustainable textile and clothing products. One consists of consumers' environmental and social knowledge, sensitivity and concern, and the other is formed of buying habits and apparel purchase criteria, i.e. of „fashion", „ecology", „ethics", economy", and „utility".

Consumers' contribution to the solving of environmental and social problems caused by the textile and clothing industry may take very different forms. In the before-purchase phase, consumers can only indirectly mitigate the negative impacts of the modern textile and clothing industry. In the post – purchase phrase their impact has much more direct nature. In both cases it can be hindered by various barriers and restrictions that take time and efforts to overcome. A change in the attitudes of firms and consumers towards a more responsible behaviour is a gradual process that needs appropriate knowledge and awareness, and which frequently makes organisations and individuals modify their routines and long-standing habits. It is however important to start it however small the first improvements might seem, and to believe that contrary to the widespread opinion consumers have considerable power and that even individual decisions they take may make a difference.

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BRAND MARKETING STRATEGIES OF INTERNATIONAL SMARTPHONE MARKET

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Introduction

The mobile phone industry is the one of global businesses shaped by the trend toward globalization and technological innovation. The mobile phone companies are making effort to build up their global marketing strategy, and heavily investing in R&D and design in order to compete over the globe (Chalporn 2002).

The global mobile phone market has grown rapidly in recent years. In 1991, only one percent of the world's inhabitants had a mobile phone. Ten years later at year-end 2001, almost one in every six, or 948 million, of the world's inhabitants had mobile phone (Smartphone Market in China 2014).

This phenomenal growth of mobile phones has surpassed even the most optimistic projection and many economies now have more mobile phones than fixed lines. This is true not only in developed economies, but also in developing ones. Silicon India recently reported, the number of active cell phones will reach 7.3 billion by 2014 (Pramis 2013).

Smartphone has penetrated the mobile phone market in many countries, further changing the way people communicate. China seems to be one of the biggest markets. In fact, 23.9 million smartphones shipped in China during the third quarter of 2011, slightly above the 23.3 million shipments in the U.S. Now China is already the world's largest smartphone market based on shipment volumes and device activation numbers (*Smartphone Market in China* 2014).

In 2012, China's smartphone market is still in its growing stage. According to China Internet Network Information Center (CNNIC), the user attention for smartphone in China's mobile phone market has exceeded 90 percent in March 2012. As the figure 1 shows, the top five vendors are SAMSUNG (22.1%), HTC (16.5%), MOTOROLA (11.3%), NOKIA (10.4%) and APPLE (9.5%).

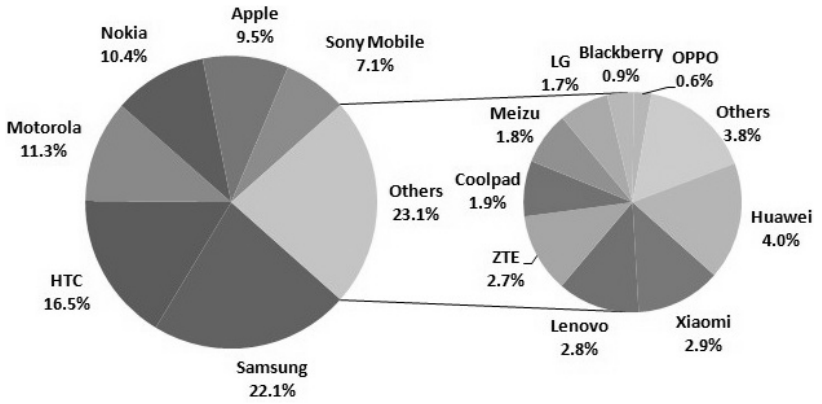

Figure 1. The Brand Attention Ratio for China Smartphone Market in 2012

Source: Smartphone Market in China 2014.

This research intends to identify the effective global marketing strategy for global smartphone manufacturers to investigate how smartphone's brands develop their marketing strategy to comply with different conditions in both Korea market and international markets. Most popular smartphone brands in Korea are SAMSUNG and LG. For international brands, Apple and HTC is the one who dominate smartphone market.

The results of this study will be useful to marketers currently operating in the smartphone industry to develop their international marketing strategy and new products. Also, they will be contributed to the academic world by illustrating theoretical issues of global marketing strategy in the real-world case study.

Material and Methods

This study will be conducted mainly through the secondary data collection because of the difficulty in collecting the primary data and it will be based on several sources such as business articles, magazines, news report, and smartphone company's website.

Results and discussion

World trade and investment have grown rapidly, with many attractive markets opening up. The number of global companies also grows dramatically. To compete in foreign market, companies that operate in global markets need to broaden the sources of competitive advantage relentlessly over time. However, careful assessment of current competitive position is also required.

Table 1. The Results of SWOT Analysis

	SAMSUNG	LG	APPLE	HTC
LOGO	SAMSUNG	LG	iPhone	htc quietly brilliant
STRENGTH	Super AMOLED Noncoding System Android Removable Battery DMB High Quality A/S	More than 1400 patent related to LTE accumulated Know-How from CYON High Quality Management High LED Tech.	Continuous R&D Large Application Market (more than 22m Apps.) Brand Power Easy to Use	Good Design New Service Differentiated User Interface New Products Accumulated Tech. Strengthened Collaboration Work
WEAKNESS	Lack of Brand Power Less Attractive Design Last Mover Disadvantage - Less Loyal Customers	Less Competitive in the Market Cheap Price Phone Image Lack of International Network	Integral Battery Complicated Domestic A/S System No DMB Function Apple Application (Face Time and iMessage) which only available for iPhone users	Low Brand Awareness Intellectual Property Issues Low Number of Products
OPPORTUNITY	High Hardware Tech. to provide better Hardware than any other companies. Brand image is getting stronger every year.	More than 1400 Patent related to LTE	Loyal Customers Many Number of Global Users High Brand Power Customers see Apple and an innovative and developed company	Touchscreen Tech. Many Strategic Alliance Broadened 3G Tech.
THREAT	Competition Increasing Android O/S	SAMSUNG LTE Market Share Low Brand Image	Black Market for Application Market High Competition of Application Market Higher Threat of Other Company's products	Weak Barrier to Entry Entrance of New Companies from China
PRODUCT' IMAGE				

Source: own research.

Based on this SWOT framework, marketing executives can construct alternative strategies (table 1).

As the table 1 shows, SAMSUNG's strengths are high technologies (such as super AMOLED, noncoding system, Android O/S), high functions (such as removable battery, DMB function) and high quality A/S. On the other hand, weaknesses are lack of brand power and less loyal customers than APPLE and last mover disadvantage. In the effort to revitalize the smartphone business, SAMSUNG recently launched flagship "Galaxy S" series to compete with iPhone 5G, and the initial market response is positive. In transition to 4G (4^{th} generation) smartphone market, SAMSUNG is challenging the incumbent smartphone leaders such as APPLE (*Samsung, LG dominate*...2014). In LG's case, the strengths are more than 1400 patent related to LTE and high LED technology but weaknesses are cheap price phone image. APPLE's greatest strengths are brand power and large application market. On the other hand, weaknesses are complicated domestic A/S system. Finally, HTC's strengths are accumulated technology and strengthened collaboration work but weaknesses are low brand awareness and intellectual property issues.

Most of all, the explosive growth of global smartphone market gives a great chance to expand business globally.

In SAMSUNG's case, it has high hardware technology to provide better hardware than any other companies. On the other hand, the most powerful thing in Apple is that it has the most loyal customers for now.

Cutthroat competition in smartphone market is key barrier for new rivals. Since smartphone market growth rate skyrocketed, this led the new competitors into the market. However, in 2013, SAMSUNG accounted for 35.2% of the market, selling 12 million handset units, and LG took up 10% with APPLE securing a 32.3% market share in global market. With the combined market shares of the two Korean mobile brands and Apple reaching almost 80 percent, it is said that the global market is now overtaken by the big three (*Samsung, LG dominate*... 2014).

As the table 2 shows, for segmentation and targeting, as the lifestyle of smartphone are workers and students. Also, propensities to consume are focusing more on design and features.

For positing, SAMSUNG strongly focuses on loyal customers to the brand but positioning in market is image of substitution products of iPhone as the table 2 and figure 2 shows. SAMSUNG needs to develop premium marketing strategy to be the best brand for smartphone in the global market.

Table 2. The Results of STP Strategy

	SAMSUNG	LG	APPLE	HTC
O/S	- Android	- Android	- iOS	- Android
SEGMENTATION & TARGETING	Age: - 20~50 Life Style: - Workers & Students - Loyal to SAMSUNG Propensity to Consume: - Conspicuous Consumption Tendency	Age: - 18~30 Life Style: - Workers & Students - Better Use & Develop for Application Propensity to Consume: - Additional Tech. - - Personal System	Age: - 20~30 Life Style: - Workers & Students - Focused on E-mail /Work - Better for Work Propensity to Consume: - Broad Features - Good Design	Age: - 18~34 Life Style: - Workers & Students - Focused on E-mail / Work Propensity to Consume: - More Search to Purchase - Focus More on Design & Features
POSITIONING	- Emotional Design - Creating Culture - Image of Substitution Products of iPhone - - Premium Strategy	- Focus on Display & Screen → Best Company for Display	- Differentiated Design - More Features than Other Products	- Solid Tech. - HTC Contents → Theater on Hands

Source: own research.

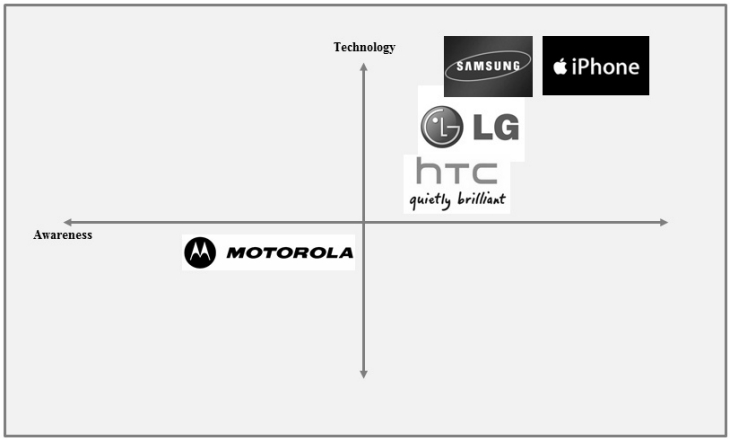

Figure 2. Positioning of Smartphone Brands in Market

Conclusions

The competitive quality and innovative technologies are the prerequisites for the success in this industry. Quality is strategic differentiator for products and services. Because of the vital link to customer satisfaction and quality

must ultimately be defined by the customers. Innovative technologies are crucial to the mobile phone industry. Accordingly, the global mobile phone producers should advance in the level of quality and technology through the continuous research and development activities. Also, another important success factor is collecting of foreign market information in a rapid and correct way. By this information, companies can analyze the industry's current situations, formulate the strategic direction, and respond to consumers and competitors more effectively.

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LASER PULSE METHOD FOR INVESTIGATING THE THERMAL DIFFUSIVITIES OF INSULATING MATERIALS

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Introduction

Thermo-physical characterization of materials is of great importance in materials sciences and technology. Heat transfer parameters, i.e. thermal conductivity, thermal diffusivity and the thermodynamic parameter – the heat capacity, have an impact on the optimal use of materials. Structure and its stability is the main object of the thermo-physical study where temperature and the heat transfer play a leading role in the behaviour of materials. Differences in thermo-physical parameters can be found between materials prepared under various conditions that are induced by technology. The flash laser method is the most used popular technique to measure the thermal diffusivity of solid samples. It consists of heating the front face of an opaque slab by a short pulse and detecting the temperature evolution at its rear surface, from which the thermal diffusivity is obtained.

Theoretical model

The laser flash method is based on the comparison of the measured temperature with the temperature obtained from mathematical solution of the pertinent heat conduction problem.

The formulae needed for the data reduction procedure can be derived from solutions of the heat conduction equation, together with appropriate initial and boundary conditions corresponding to the thermal flash test. In the case in which the heat flux in the sample is one dimensional, the heat conduction equation is:

$$\frac{\partial T}{\partial t} = \alpha \frac{\partial^2 T}{\partial x^2} \tag{1}$$

where t is time, α is the thermal diffusivity, x is the space coordinate, L is the sample thickness, and $T = T(x, t)$ is the temperature at the space-time point (x, t). In the ideal thermal flash experiment, the initial and boundary conditions are

$$T(0)=(x,0) \tag{2}$$

$$\frac{\partial T}{\partial x}\Big|_{x=0} = -\frac{q}{\lambda}\phi(t) - \frac{k}{\lambda}T(0,t) \tag{3}$$

$$\frac{\partial T}{\partial x}\Big|_{x=L} = -\frac{k}{\lambda}T(L,t) \tag{4}$$

where: λ - is the thermal conductivity of the sample,
q - is the amount of heat absorbed through unit area of the sample face,
k - is the heat transfer coefficient and $\varphi(t)$ is the flash pulse shape function.

By neglecting the heat loss effect ($k = 0$) and assuming instantaneous pulse heating,

$$\varphi(t)=\delta(t) \tag{5}$$

where $\delta(t)$ is the Dirac delta function (Gembarovič and Taylor 1993, Opara and Chruściński 1986),

$$\delta(t) = \left\{ \begin{matrix} 0 & dla\ t \neq 0 \\ +\infty & dla\ t = 0 \end{matrix} \right\} \qquad \text{and} \qquad \int_{-\infty}^{+\infty} \delta(t)dt = 1 \tag{6}$$

the rear surface temperature of the sample is given by the solution at $x = L$

$$T(L,t) = T_m\left[1 + 2\sum_{n=1}^{\infty}(-1)^n \exp\left(-\frac{n^2\pi^2 a t}{L^2}\right)\right] \tag{7}$$

where

$$T_m = \frac{q}{\rho c_p L} \tag{8}$$

is the steady state temperature in the sample after the pulse, ρ is the density, and c is the heat capacity of the sample material.

In the method developed by Parker et al. 1961, a small and thin specimen is subjected to a high intensity short-duration radiant energy pulse. The energy of the pulse is absorbed on the front surface of the specimen and the resulting

rear surface temperature rise is recorded, as illustrated in Fig.1. Parker et al. 1961 calculated the thermal diffusivity value from the specimen thickness and from the time $t_{0.5}$ (9) required for the rear surface temperature rise to reach 50% of its maximum value Fig. 2. Generally, the temperature rise in the specimen is small, so that the physical properties can be assumed constant during the test.

$$\alpha = \frac{0.1388\,L^2}{t_{0.5}} \tag{9}$$

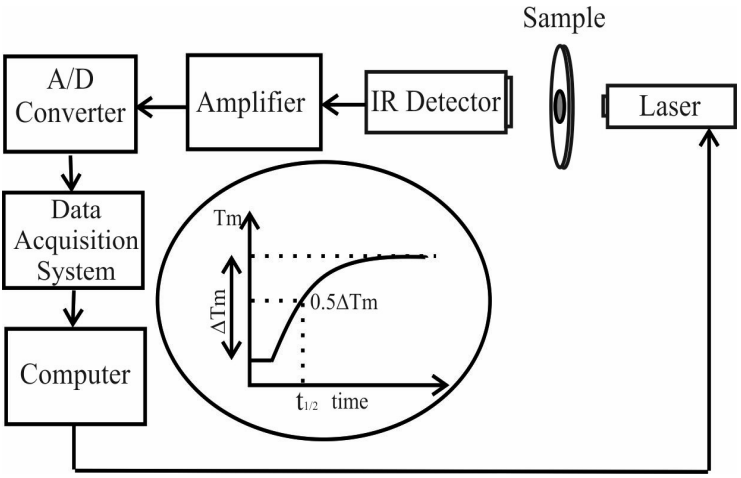

Figure 1. Schematic of flash diffusivity experimental setup

Source: own research.

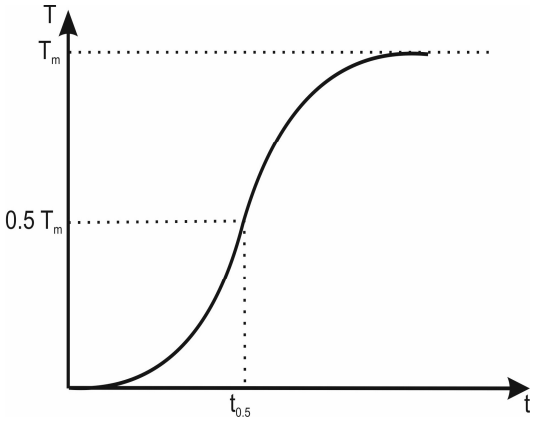

Figure 2. Theoretical curve of temperature rise at the rear surface of the sample.

Source: own research.

The original laser pulse method of measuring thermal diffusivity proposed by Parker et al. 1961 assumes ideal boundary and initial conditions, i.e. zero heat loss, infinitely short laser pulse, and uniform heating of the sample face. Simplicity of the method is marred in practice by difficulties of realizing these idealized conditions. Thanks to theoretical works of many researchers, the original concept has been gradually improved to account for real experimental conditions. Methods to correct the apparent thermal diffusivity for heat radiation losses have been given by Cowan 1963, Donaldson 1972, Clark and Taylor 1975, and Gembarovič and Taylor 1993. Procedures for finite pulse time correction have been developed by Cape and Lehman 1963, Taylor and Cape 1964, Larson and Koyama 1967 and Heckman 1973.

The thermal diffusivity may be calculated from the equation:

$$\alpha = \frac{K_0 L^2}{t_{0.5}} \tag{10}$$

where τ - the duration of the pulse
t_c - the characteristic rise time $t_c = L^2/\alpha$
$K_0 = t_{0.5}/t_0$ and t_0 is a parameter which depends on the values of τ and t_c.

In the case of no heat loss from the sample, the values of K_0 can be evaluated as a function of τ/t_c, by resolving analytically the thermal diffusion equation.

Tested materials and results

The materials used for shoe uppers and soles (see Table 1) were tested, including those of very small thickness and very low thermal resistance as well as thick materials of low density and expected high thermal resistance. The selected materials included thin calfskin lining and cattle leather (chrome tanned leather), and nubuck for shoe uppers as well as rubber used for shoe soles were tested. Specimens of disk shape and 49,2mm in diameter were taken. The specimen thickness and density are listed in Table 1.

Thermal resistance of materials was measured using step response method, whereas thermal diffusivity was determined by means of the Parker method, allowing for the shape and duration of the pulse heating. The measurements were made using an 18-bit NI PCI-6281 multifunction data acquisition board (Table 2) with an IR laser of 808nm wave length and 5 mm^2 heating pulse area (Table 3). Depending on the material tested, a thermocouple (Fig. 3) or thermopile infrared sensor (Fig. 4) was used for radiation detection. The measuring device shown in Figure 5 Software for controlling the

computer and temperature measurement was created in LabView environment (Fig. 6). The results of the thermal tests are listed in Table 4.

Table 1. Thickness and density for materials under examination

Material	Thickness, mm	Density, kg/m^3
Nubuck	2.16 ± 0.04	605 ± 6
Cattle leather	1.29 ± 0.04	627 ± 3
Calfskin lining	0.71 ± 0.02	588 ± 17
Sportan B-015	1.70 ± 0.07	372 ± 12
Lining J-055	0.81 ± 0.01	382 ± 4
Rubber	1.08 ± 0.03	900 ±20

Source: own research.

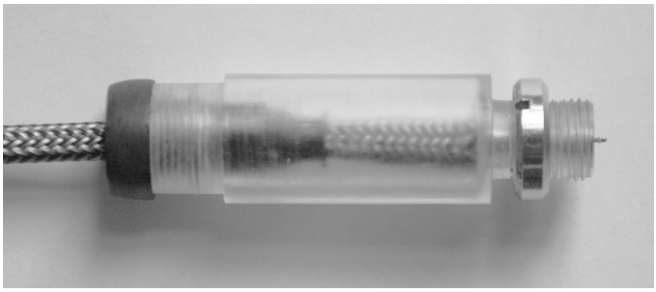

Figure 3. Thermocouple radiation detection

Source: own research.

Table 2. NI PCI-6281 multifunction data acquisition board specifications summary

Name	Value
Signal Conditioning	Low-pass filtering
Differential Channels	8
Resolution	18 bits
Sample Rate	625 kS/s
Max Voltage	10 V
Maximum Voltage Range	-10 V - 10 V
Maximum Voltage Range Accuracy	980 μV
Maximum Voltage Range Sensitivity	24 μV
Minimum Voltage Range	-100 mV - 100 mV
Minimum Voltage Range Accuracy	28 μV
Minimum Voltage Range Sensitivity	0.8 μV
On-Board Memory	4095 samples

Source: National Instruments Corporation 2009, NI 628x Specifications.

Table 3. Laser Specifications

Lp.	Parameter	Value
1	Wavelength λ	808nm;
2	Output power	~800mW;
3	Power	5V/1A;
4	Acrylic two spherical optics	f=4,6mm; NA=0,4cylindrical lens correction φ8mm; AR;
5	Diameter of the output beam	~4mm
6	Focusing the laser spot	~2x2mm na odległości 15mm
7	Laser switch-off time t_{on}	~15μs;
8	Laser switch-off time t_{off}	~5 μs;
9	Modulation depth	100%
10	Maximum frequency modulation	50kHz;
12	Safety class	4 wg PN-EN 60825 1:2005

Source: Documentation laser module ML-33PM-808-800, firm AMECAM, W-wa, 2010.

Table 4. Thermal resistance, thermal diffusivity, corresponding relative expanded uncertainty

Material	Thermal resistance m^2K/W		Thermal diffusivity m^2/s	
	R	%	$\alpha\ 10^{-6}$	%
Nubuck	0.0301±0.0007	2.3	0.105±0.004	3.8
Cattle leather	0.0192±0.0002	1.1	0.086±0.002	2.3
Calfskin lining	0.0124±0.0005	4.0	0.087±0.003	3.4
Sportan B-015	0.0296±0.0008	2.7	0.113±0.002	1.8
Lining J-055	0.0149±0.0005	3.4	0.165±0.005	3.0
Rubber	0.0060±0.0001	1.6	0.215±0.005	2.3

Source: own research.

Figure 4. Thermopile infrared sensor

Source: own research.

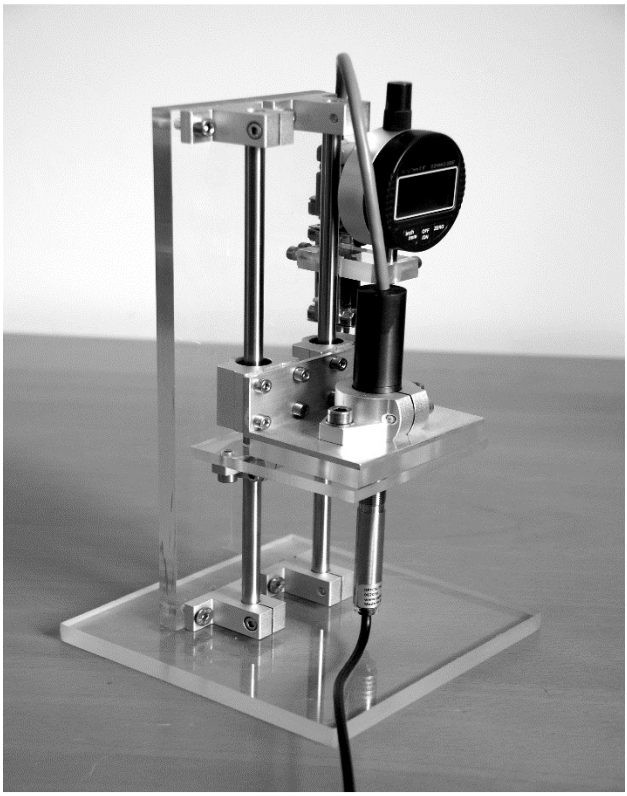

Figure 5. The measuring device

Source: own research.

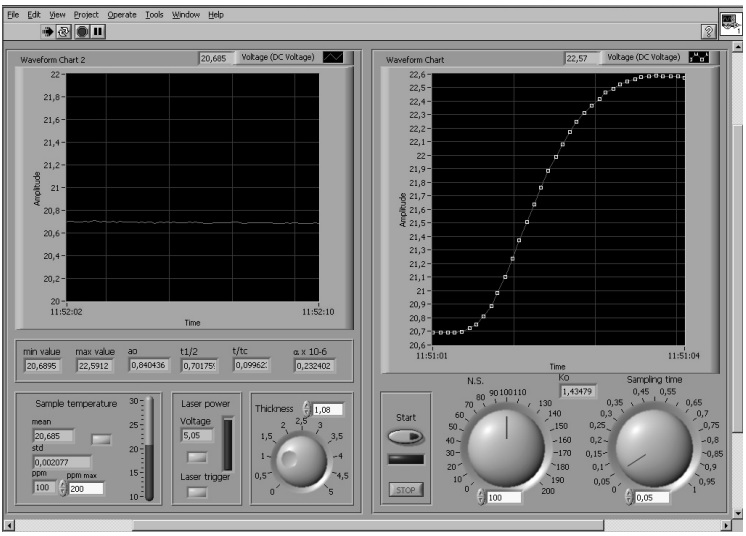

Figure 6. Control panel windows in the LabView program

Source: own research.

Uncertainty of estimated thermal diffusivity

The main possible errors of this measurement method are due to:

- thickness measurement of the sample,
- calculation of the time constant $t_{0.5}$,
- shape and duration of the pulse heating,
- heat loss.

Since it is difficult to directly calculate the error associated with the heat loss, only the first three errors have been investigated in this paper. From equation (11) we can conclude that, if there is 1 % error in the measurement of $t_{0.5}$, it will introduce roughly 1 % error to the thermal diffusivity of the sample. The accuracy of the measurement of $t_{0.5}$ depends largely on the sampling frequency and signal to noise ratio of the IR-detector.

$$u_{\max}(\alpha) = \left| -\frac{0.1388L^2}{t_{0.5}^2} dt_{0.5} \right| + \left| \frac{0.2776L}{t_{0.5}} dL \right| \tag{11}$$

Sample thicknesses are measured by an automatically operating micrometer. The accuracy of the micrometer is 10 μm. According to the calculation for leather, which has a thickness of about 1 mm, the measurement of thickness introduces 1 % error thus resulting in a 2 % error in thermal diffusivity. To avoid the error introduced by the thickness measurement error,

other accurate thickness measurement methods such as optical methods may be used.

When the duration of the pulse τ is comparable to the characteristic rise time t_c of the rear face temperature the increase of that temperature will be delayed and the coefficient equal 0.1388 in equation (9) will be greater. Such a situation takes place when the sample are thin or when their thermal diffusivity has a high value. The coefficient 0.1388 ($1.37/\pi^2$) in equation (9) is accurate within about 1 % for $t_c > 50\ \tau$ (Taylor and Cape 1964).

Uncertainty of the thermal diffusivity measurement using the laser pulse method of natural materials does not exceed 4% and leatherlike materials 3%.

Conclusions

To fully assess the inconclusiveness of the measurement of insulating materials thermal diffusivity, it is necessary to check heat loss impact on the measurement results. Using a more powerful laser with short, right-angle pulse laser will decrease the inconclusiveness of low-thickness material measurements (less than 1 mm). A high coefficient of variation of the thickness of materials causes the inconclusiveness of their thermal diffusivity measurements.

Of the tested materials, leather used for shoe uppers is characterized by the lowest thermal diffusivity ($0.86 \div 1.05\ x10^{-7}$ m^2/s), whereas rubber displayed the highest thermal diffusivity (2.15×10^{-7} m^2/s).

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EXPANDING OF RAW MATERIAL BASE OF MINERAL FILLERS FOR WATER-DISPERSION PAINTS IN UKRAINE

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Introduction

Paint industry makes a significant contribution to the economy of Ukraine and it is a reliable and stable sector of the domestic chemical industry. More than 60% of raw materials, which used in paint manufacturing, are produced in Ukraine including titanium dioxide, alkyd resins, varnishes, fillers, etc.

Ukrainian paint industry puts significant investment in new technologies to minimize the negative impact of paints on the environment. New production facilities for more than 60 thousand tons of water-dispersion paints and varnishes per year were introduced in Ukraine over last five years. At the end of 2013 about 50% of the paints total annual production is eco-friendly water-based materials. And this trend will continue further.

Scientists and Ukrainian Paint and Coatings Association are working together to ensure in Ukraine production of paints which have minimal impact on the environment and human health. They have been conducting researches in Ukraine in order to expand the raw material base for water-dispersion paints. Special attention is gived to white mineral fillers, using of which in paints considerably reduces production costs (Merezhako 2000; Merezhako 2001; Myronyuk, Sikorskyi & Karavaev 2013; Salnik 2009; Sikorskyi 2013; Sviderskyi 2013).

The purpose of the paper is the study of possibility of expansion the raw material base for water-dispersion paints at the expense of kaolins and carbonates of Ukrainian deposits.

Analysis of recent research and publications

Papers of such Ukrainian scientists us Karavaev T., Myronyuk A., Salnik V., Chernyak L., Tkach N. are devoted to researches of mineral fillers (Myronyuk, Sikorskyi & Karavaev 2013; Salnik 2009; Sikorskyi 2013; Swiderskyi, Salnik & Chernyak 2010; Swiderskyi, Salnik & Chernyak 2012; Swiderskyi, Salnik & Tkach 2010). We also have been researching the properties of mineral fillers and coatings based on them.

These papers continues a series of publications devoted to the development of water-dispersion paints with domestic mineral fillers. Modification estimate of kaolin, chalk, and precipitated calcium carbonate as plastomer and elastomer fillers also was investigated by polish scientists Domka L., Malicka A., Stachowiak N. (2008, 2008a).

Material and methods

Kaolins and carbonates of Ukrainian deposits were selected as objects of the study. We selected next kaolins: KC-1 (Glukhovetske deposit); KC-1 (Prosianivske deposit); raw kaolin (Turbivske deposit); E2013 (Katerynivske deposit); KO-1 (Oboznivske deposit) and next carbonates: MTD-2 (Sumy region), MMC-1 (Chernigiv region), MMC-2 (Donetsk region), KH-5 (Luhansk region). These fillers have different chemical compositions and physic-chemical properties of the surface. This fact makes possible to establish the basic regularities of modification of kaolins and carbonates varieties.

Following surfactants were selected to modify fillers: methacrylate-functional silane, bifunctional silane, oligomeric propyl silicate concentrate.

Contact angle, wetting by polar (water) and nonpolar (benzene) liquids, filtration coefficient and specific surface area were determined to evaluate the efficiency of surfactants activating action. The methodology of determining these parameters is based on the thermodynamic theory of capillary dripping.

Results and discussion

Kaolins and carbonates may become the basis of raw materials for water-dispersion paints with improved properties. In order to obtain kaolins and carbonates with optimal for water-dispersion paints characteristics we changed the hydrophobic-hydrophilic properties of mineral fillers. It was achieved by modifying the surface of the mineral fillers when grinding in the presence of the abovementioned surfactants (Merezhako 2000; Swiderskyi, Salnik & Chernyak (2012).

Studies have shown that all fillers have low values of wetting by water after modification. The values of wetting by water for studied fillers is within the range from 0,02 to 0,06. Kaolins and carbonates wet much better by nonpolar liquids. The values of wetting by benzene increase in 3,5-8 times. The effect of maximal wetting by test liquids is fixed for Prosianivskyi kaolin and minimal wetting is fixed for Katerynivskyi kaolin. This can be explained by the differences of chemical and mineralogical composition of the studied kaolins and carbonates (Merezhako 2001; Swiderskyi & Karavaev 2012).

Wetting process is also depends upon particles shape, size and degree of compaction of fillers. The influence of these parameters may be evaluated taking into account such indicator as filtration coefficient of dispersion systems. Quantitative values of filtration coefficient, unlike wetting, vary over a wide range. Filtration coefficient ranges from 0,19 to 2,08· 10–6 for water and from 1,03 to 6,27· 10^{-6} for benzene. But the value of filtration coefficient is not always essential for the development of the surface kaolin wetting process. Specific surface area characterizes a development of filler's surface, it's adsorption capacity and activity.

Specific surface area of the fillers is a parameter that uniquely allows us to estimate the contribution of the wetting factor, their macrostructure and degree of compaction. Values of the specific surface area of carbonates ranges from 24,1 m^2/g (MTD-2) to 35,9 m^2/g (KH-5). Besides, smaller particles' sizes are also inherent for these brands – 3,2 and 2,5 microns, respectively.

Values of the specific surface area of kaolins ranges from 49,6 m^2/g (Prosianivskyi KC-1) to 18,0 m^2/g (Katerynivskyi E2031) for water, and from 34,7 m^2/g (Oboznivskyi KO-1) to 13,5 m^2/g (Turbivskyi raw kaolin) for benzene. Values of the specific surface area of riched kaolins are in 2 times higher as enriched kaolins. Oboznivskyi and Prosianivskyi kaolins have the most developed specific surface area and Katerynivskyi kaolin has the smallest one.

Lyophilic-lyophobic balance of surface of kaolin and carbonates as fillers depends on their ability to interact with water. This property is characterized by contact angle of wetting by water. The value of contact angle can determine the degree of hydrophilicity of fillers (Swiderskyi & Milotskyi 2012; Swiderskyi, Salnik & Tkach 2010). Turbivskyi raw kaolin and carbonate MTD-2 brand are the most hydrophilic. This is confirmed by the highest water absorption of these fillers. Katerynivskyy kaolin and carbonate MMS-2 are the least hydrophilic. Values of the contact angle of wetting by water of kaolins ranges from 42 to 72 degrees. Values of the contact angle of wetting by water of carbonates ranges from 21 to 35 degrees. According to hydrophilicity studied carbonates can be placed in a range MTD-2 – KH-5 – MMC-1 – MMC-2. Moreover, carbonate KH-5 brand has the same contact angle

as carbonate filler MTD-2 brand. But the surface of carbonate MTD-2 brand is more hydrophilic due to a greater concentration of OH-groups on the surface.

Surface condition of fillers such as hydrophobic properties was changed by modification. Values of the contact angle of wetting by water increased to 10-13 degrees. So physical and mechanical properties of the finished composite materials based on studied fillers are improved due to increasing of fillers' activity to polymer resins (Domka, Malicka & Stachowiak 2008).

Conclusions

In order to expand the raw material base for water-dispersion paints was studied and changed surface state of kaolins and carbonates. Kaolins and carbonates of Ukrainian deposits are typical hydrophilic fillers. This is a weak for their use in water-dispersion paints. This disadvantage was eliminated by modification.

Modification of studied fillers by surfactants at concentrations of 0.75 - 3% gives both, kaolin and carbonate, pronounced hydrophobic properties. It also leads to a decrease of agglomeration and aggregation of the fillers particles. As a result, dispersions of modified fillers and polymers are more stable in the water.

So it makes possible to use kaolins and carbonates of Ukrainian deposits in water-dispersion paints due to increasing of fillers' activity to polymer dispersions.

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QUALITY ASSESSMENT OF FEATHER-DOWN RAW MATERIALS AS FILLERS FOR BEDDING PRODUCTS

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Introduction. Problem Formulation

The ability of bedding goods to provide comfortable conditions for people's adequate rest and protect their bodies from hazardous influence of environment determines the necessity of expanding the range of feather-down fillers made of valuable natural raw materials.

Historically feather-down raw materials were traditional fillers for blankets and pillows as they had desirable consumer properties. The down blanket has been one of the warmest blankets, in which feathers and down of waterfowl were used as fillers.

None of other well-known fillers has such softness and elasticity. The feathers and down of waterfowl have the best consumer properties. Due to the possibility of air circulation inside those goods, such filler adsorbs moisture which is produced by a person during their sleep, and then it gradually returns that moisture outward.

The feather-down raw materials are known to be plumage, received after dead or alive birds' plucking (SSTU 4609:2006). Plumage is the total amount of quills on a bird's body, and a feather is horny covering on skin with empty core and light fluffy sprouts on each side, which covers the bigger part of birds' bodies. The down is small tender fluff on birds' bodies (*Contemporary Ukrainian Language* ... 2004).

The duck down, as a rule, is of lower quality, each bit of fluff has a hard awn, due to this fact the down becomes heavier and lumps together in finished goods. The goose down has no hard awns in each bit of fluff. A bit of fluff, as opposed to a quill, is composed of thin fibers without central trunk. Such a

structure provides a great number of "air chambers", thereby the excellent thermal insulation from environment is guaranteed.

Therefore the bedding goods are softer and lighter. The goose down is distinguished by soft tender barbs, which are fixed in one point on a short core and are not joined together (*Down Blanket* 2014).

Undoubtedly, the most valuable feather-down raw materials are the eider duck down. Eider ducks live on the rocks of Greenland, Canada and Iceland. The high cost of this material is explained by the complexity of its collection and processing. The birds and their nests are safeguarded by the law, and bits of fluff are collected manually in the nests which were left. Every year nearly 4000 kg of the eider ducks' pure down is collected, therefore these bedding goods manufacturing is by the piece rather than a massive one.

Nowadays the limited liability company "Herd Billirbeck HmbX", the Ukrainian leading company which is well-known in many European countries, produces a large range of bedding products with different bulking fillers – the blankets made of waterfowl down; sheep, camel and cashmere wool: cotton, natural silk and bamboo fibers, as well as silicon synthetic fibers; the feather-down pillows, as well as the orthopedic pillows with anti-allergic fibers; mattress covers; bed linen; plaids of different fibrous structure, special bed linen for children, products for hotels and sanatoriums, exclusive bed items (Mykhailova & Domres 2013).

Research Aim is to assess the quality of feather-down raw materials as fillers for bedding products.

Materials and methods

The research objects are presented by the feather-down raw materials that are used as traditional fillers for bedding goods (blankets, pillows). These products are manufactured by the limited liability company "Herd Billirbeck HmbX" (Ukraine). The physicochemical characteristics of the feather-down fillers' quality have been investigated by employing the standard methodology (SSTU 4609:2006).

Investigation Results

The feather-down raw materials' classification is given in Figure 1.

Moreover, the covering quills are distinguished by size:

- small feathers: chicken – length up to 25mm inclusive, goose and duck feathers – up to 35 mm inclusive;
- average feathers: chicken – length from 25 mm to 85 mm inclusive, goose and duck feathers length from 35 mm to 95 mm inclusive;

- big feathers: chicken – length more than 85 mm, duck and goose feathers – more than 95 mm (SSTU 4609:2006).

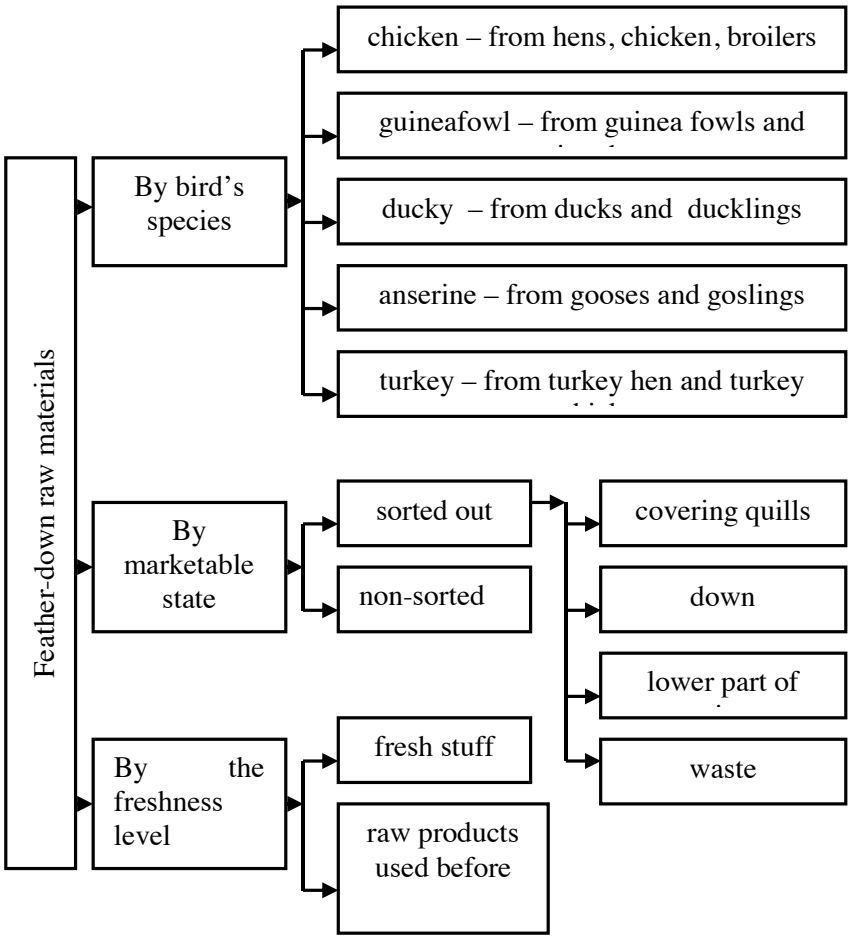

Figure 1. Feather-down raw materials' classification

Source: own research.

In State Standard Specification SSTU 4609:2006 the requirements given for the raw materials' quality are divided into the requirements by organoleptic and physicochemical characteristics of the sorted-out and non-sorted-out fresh raw materials. Therefore, it is important to define properly these notions.

The fresh feather-down raw materials are the stuff, which is obtained after the dead or alive birds plucking and which has never been used. The non-

sorted-out feather-down raw materials are the mixture of feathers and down of farm birds' similar type in natural proportion.

The quality of feather-down raw materials is defined according to the results of organoleptic and physicochemical research. As a rule, the following indices are estimated: external appearance, smell, mass moisture content, mass components content, mass waste content, mass down content.

The organoleptic and physicochemical characteristics of the sorted-out fresh feather-down raw materials are presented in Table 1.

Table 1. Requirements for the sorted-out fresh feather-down raw materials' quality

Indicator name	Characteristics and norms					
	down		Covering plumage			
	goose	duck	goose	duck	chicken, guineafowl turkey	chicken, broilers
external appearance	clean, without yellowness		clean, safe, elastic			
smell	natural, without putrefactive, mouldy and other side smells					
mass moisture content, %, not more than	12					
mass components content, %, not more than						
- lower part of wing	Not permitted		3.0	3.0	5.0	16.0
-small feathers	15.0	15.0	Not regulated			
mass waste content, %, not more than						
-brocken feathers	Not permitted		1,0	1,5	2,0	2,0
- premature feathers	Not permitted		1,5	2,0	2,0	30
- clogging	6,5	6,5	6,5	6,5	6,5	6,5

Source: SSTU 4609:2006 Feather-down raw materials. Technical requirements.

The organoleptic and physicochemical characteristics of the non-sorted fresh feather-down raw materials are shown in Table 2.

Table 2. Requirements for the non-sorted fresh feather-down raw materials' quality

Indicator name	Characteristics and norms	
	Goose feather-down stuff obtained by the method of intravital plucking	Goose, duck, chicken, guineafowl, turkey raw materials
external appearance	clean, safe, elastic	
smell	natural, without putrefactive, mouldy and other side smells	
mass moisture content, %, not more than	15	15
mass components content, %, not more than		
- lower part of wing	Not permitted	5,0
-small feathers from necks	Not permitted	Not regulated
mass down content, %, not more than	25	Not regulated
mass waste content, %, not more than		
-brocken feathers	1,0	2,0
- premature feathers	5,0	2,0
-clogging	6,0	6,5

Source: SSTU 4609:2006 Feather-down raw materials. Technical requirements.

Using the selected raw materials, the company "Herd Billirbeck HmbX" reaches high indices of quality during the process of feather-down fillers manufacturing. For the production to be competitive on the market, the sorted-out raw materials of the best quality are selected – goose down and feathers, which are characterized by the high thermal insulation and lightness. Having been selected heavily during the raw materials purchasing, the down is subjected to the delicate processing and its quality is checked. The investigation results of the feather-down raw materials quality are given in Table 3.

Table 3. Investigation results of the sorted-out fresh feather-down raw materials quality

Indicator name	Investigation results	
	Goose down	Goose feathers
1	2	3
External appearance	clean, without yellowness	clean, safe, elastic
Smell	natural, without putrefactive, mouldy and other side smells	
mass moisture content, %, not more than	9	10
mass components content, %, not more than - lower part of wing - small feathers	Not permitted 12.0	2.8 Not regulated

Source: own research.

Conclusion

Thus, the information given confirms that feather-down raw materials for the bedding goods fillers are valuable stuff due to their properties and meet the requirements of current normative documents.

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ON FIRE SAFETY OF PORTIERE FABRICS

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Introduction

Nowadays, textile materials, in particular tapestries, are widely used for interior decoration in residential houses and in places of mass gathering of people (hospitals, hotels, hostels, health centers, educational establishments, theatres, cinemas etc.) (Osipenko & Kolcheva 2011, Perepelkin 2001). It is important that these materials are flammable due to the increased ability to ignite easily even from low-calorie sources of ignition and quickly spread fire, especially if applied for products that are operated in a vertical form (Baratov & Konstantinova 2006, Zubkova & Antonov 2002).

The analysis of literature has shown that it is possible to improve fire-retardant properties of textile materials using nonflammable and heat-resistant fibres or flame retardants (Baratov & Konstantinova 2006, Moryganov & Kolomeytseva 2002). Study of scientific works in relation to fire protection of textile (Baratov & Konstantinova 2006, Zublova & Antonov 2002, Moryganov & Kolomeytseva 2002, Barylo 2005, Tyuganova, Kapyev & Kocharov 1981, Syrbu, Burmistrov, Samoylov & Salikhova) revealed that a perspective and effective method of giving fireproof properties to textile materials, including tapestries of different fibre composition is their processing by flame retardants on the equipment of decorative production of textile enterprises.

On the basis of the conducted researches concerning the range of flame retardants for the treatment of textile materials, presented on the Ukrainian market, it has been found out that about 97 % of it is formed due to arrival from abroad (Kolcheva & Osipenko 2012). Foreign flame retardants vary in purpose and chemical composition. It is known that today special attention should be paid to flame retardants made on the basis of the phosphoprous- and nitrogen-containing compounds. Therefore, it is possible to improve fireproof properties of textiles due to the polymer destruction in the direction of increasing the quantity of coke, which prevents combustion, reduces the

output of combustion products to the gas phase, reduces the flow of combustible gases in the flame.

The indexes of fireproof properties of textile materials have been studied both by foreign and domestic scientists: Einsele U. (1972), Horrocks A.R. & Price D. (2008), Weil E.D. & Levchik S.V. (2009), Baratov A.N. & Konstantinova N.I. (2006), Barylo O.G. (2005), Zubkova N.S. & Antonov S.Iu. (2002), Moriganov A.P. & Kolomeyceva E.A. (2002), Perepelkin K.E. (2001), Tyuganova M.A. (1981) and others. However, the issue of fire protection of tapestries remains relevant and requires new effective flame retardants, processing by which will ensure the compliance of fabrics with the complex of the specified requirements.

The aim of the research is to identify indexes of tapestries flammability before and after the flame retardant treatment.

Material and methods

The objects of the research are portiere fabrics, which account for almost two-thirds of the total assortment of tapestries. Description of the researched specimens of portiere fabrics is given in table 1.

Table 1. Description of the researched portiere fabrics

Number of the fabric specimen	Fibre content, %	Kind of weave	Density surface, g/m^2	Thickness mm
1	polyester – 53, cotton – 30, flax – 17	double-layer	317	0,76
2	polyester – 52, cotton – 30, flax – 18	combined	174	0,48
3	polyester – 57, cotton – 30, flax – 7, lycra – 6	combined	242	0,58
4	polyester – 60, viscose – 32, flax – 8	linen	218	0,56
5	polyester – 53, cotton – 28, flax – 17, viscose –2	linen	178	0,47
6	polyester – 100	jacquard	176	0,30
7	cotton – 100	rib fabric	210	0,48

Determination of flammability indexes of portiere fabrics before and after fireproof processing and after the chemical cleaning was carried out in accordance with the requirements of DSTU 4155-2003, which corresponds to the IMO Res. A.471 (XII) «Recommendation on test method for determining

the resistance to flame of vertically supported textiles and films» in the part of a test method, under accredited research laboratory conditions. Thus, according to mentioned standard the textile material is characterized as flammable, if the results of tests correspond such terms: afterflame time makes more than 5 seconds at any of specimens which were tested from a surface; any of specimens which were tested from the surface have burnings at one of edges; the surface flash is more than 100 mm from the point of setting fire in any specimens that were tested from the surface or from an edge; the length of char makes more than 150 mm in any of the specimens which were tested from the surface or from an edge. If during the tests all the above-mentioned terms were not executed, the fabrics are classified as inflammable. Processing of experimental data was carried out through mathematical and statistical methods with the help of the program SPSS (Statistical Package for the Social Sciences). There has been established that the error of the experience ranged from 1 to 2 %.

Results and discussion

The results of testing portiere fabrics specimens without fireproof processing concerning flammability indexes are shown in table 2.

Table 2. Flammability indexes of portiere fabrics without fireproof processing

Number of the fabric specimen	Value of flammability indexes, unit of measurement			
	afterflame time, seconds	burnout to one of edges	surface flash, mm	length of char, mm
1	75	burns out	237	206
2	76	burns out	300	220
3	67	burns out	208	185
4	69	burns out	311	219
5	44	burns out	315	217
6	36	burns out	36	196
7	74	burns out	334	212

On the basis of the obtained data analysis it has been found out that specimens of portiere fabrics do not meet the requirements of DSTU 4155-2003, are flammable and need fire protection. It should be noted that the fabric made of 100 % polyester (specimen № 6), is significantly smaller than the length of surface flash compared with the indexes of other specimens and the specified norms (≤ 100 mm). However, according to other flammability indexes this fabric does not meet the requirements (DSTU 4155-2003).

To improve flame retardant properties of portiere fabrics of different fibrous structure there was used a new flame retardant Flame Stop (Osipenko, Polishhuk & Kolcheva 2012) with the concentration of the active substance – aminotrimethylenphosphonic acid (ATMP) 75÷300 g/l. It has been proved that neutralized with ammonia ATMP contains 23,2 % of phosphorus and 24,5 % of nitrogen, which in total is higher than in the acid form of ATMP, which includes 31,2 % of phosphorus and 4,7 % of nitrogen. The choice of such a composition is caused by the high content of phosphorus and ammonia, which are able to improve fireproof properties of textile materials. In addition, there was paid attention to the fact that the new flame retardant should not worsen the specified indexes of processed fabrics properties, and must have a reasonable price.

Flame retardant processing of portiere fabrics has been carried out on padding equipment in the accredited research laboratory in accordance with the developed regimes, taking in account the fibrous structure of cloth specimens.

To determine the optimal concentration of ATMP in the new flame retardant Flame Stop there have been studied the flammability indexes for specimens № 2, 6, 7 (table 3).

Table 3. Flammability indexes of portiere fabrics, processed by the new retardant Flame Stop with the concentration of ATMP equal to 75, 100, 125, 150 g/l

Number of the fabric specimen	Value of flammability indexes, unit of measurement			
	afterflame time, seconds	burnout to one of edges	surface flash, mm	length of char, mm
Concentration ATMP 75 g/l				
2	65	does not burn out	250	185
6	13	does not burn out	22	140
7	0	does not burn out	125	125
Concentration ATMP 100 g/l				
2	0	does not burn out	55	120
6	0	does not burn out	20	48
7	0	does not burn out	32	63
Concentration ATMP 125 g/l				
2	0	does not burn out	50	80
6	0	does not burn out	15	45
7	0	does not burn out	30	60
Concentration ATMP 150 g/l				
2	0	does not burn out	45	63
6	0	does not burn out	15	41
7	0	does not burn out	28	57

According to the results of researches it has been established that the specimens of portiere fabrics, impregnated with Flame Stop with the concentration of ATMP acid 75 g/l, demonstrate lower flammability indexes in comparison with the corresponding indicators identified for unprocessed specimens. But fabrics with such a treatment do not meet the specified requirements and according to DSTU 4155-2003 are classified as flammable.

The increase in the new flame retardant of ATMP concentration up to 100÷150 g/l has led to a considerable decline of flammability indexes of all investigated specimens that enables us to say the fabric is hardly inflammable. However, in our opinion, to increase the concentration of ATMP in the new retardant to more than 150 g/l is not reasonable, because there have not been revealed any significant improvements of fireproof properties of fabrics specimens.

After that there was determined the impact of the new retardant Flame Stop on the performance of the tensile strength of portiere fabrics by carrying out appropriate tests before and after the fire-retardant treatment. According to the results of the research it has been found out that the indexes of the tensile strength correspond to the established standards (GOST 23432-89 - 1990) (not less than 147 N), and for fabrics before fireproof processing they vary on warp from 708,2 to 1692,1 N, on weft – from 261,7 N to 1368,3 N, and for fabrics processed by Flame Stop, respectively, on warp – from 672,9 to 1685,3 N, on weft – from 259,7 to 1367,1 N. Therefore, the obtained results show that the indexes of the tensile strength after fireproof processing of portiere fabrics worsened somewhat: on warp – 0,5÷5 %, on weft – 0,1÷1 %, which is within allowed deviation (not more than 5 %).

Table 4. Flammability indexes of portiere fabrics processed by Flame Stop with the concentration of ATMP acid 125 g/l before and after chemical cleaning

Number of the fabric specimen	Value of flammability indexes, unit of measurement			
	afterflame time, seconds	burnout to one of edges	surface flash, mm	length of char, mm
1	1/1[1]	does not burn out	72/85	103/115
2	0/0	does not burn out	50/66	80/84
3	1/1	does not burn out	87/90	109/119
4	1/1	does not burn out	77/86	117/125
5	0/0	does not burn out	73/85	118/128
6	0/0	does not burn out	15/15	45/57
7	0/0	does not burn out	30/35	60/55

Note. In the numerator of conditional fractions there are flammability indexes before chemical cleaning, in the denominator – after chemical cleaning.

At the next stage of our research we found out the resistance of portiere fabrics treated with Flame Stop with the concentration of ATMP 125 g/l, to the chemical cleaning according to the methods (DSTU 4182-2003). Experimental data are presented in table 4.

The analysis of the flammability indexes of portiere fabrics treated with Flame Stop with the concentration of ATMP acid 125 g/l, certifies that the duration of the residual flame burning and burning out to one edge after chemical cleaning has not changed. It should be noted that in all seven specimens there is a deterioration of surface flash length and length of char in comparison with the specimens, which were not exposed to chemical cleaning. However, the evaluation of portiere fabrics after chemical cleaning shows their conformity to the specified requirements (Osipenko, Polishhuk & Kolcheva 2012), therefore, fabrics are hardly flammable.

Conclusions

Research results of flammability indexes of portiere fabrics with different fibrous composition showed that they do not meet specified requirements, are flammable and need fire protection.

To improve the flame retardant properties of portiere fabrics there has been proposed the new retardant Flame Stop, made on the basis aminotrimethylenphosphonic acid. On the basis of experimental studies there has been found out the optimal concentration of this acid in Flame Stop to make portiere fabrics of different fibrous composition hardly flammable.

It is shown that the indexes of tensile strength of portiere fabrics before and after processing by Flame Stop almost do not differ and correspond to the specified requirements.

There has been proved the possibility of using chemical cleaning to care about portiere fabrics processed with Flame Stop, preserving their flame retardant properties.

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DIFFERENCES BETWEEN INTERNATIONAL AND RUSSIAN REQUIREMENTS RELATED TO TEXTILE SAFETY

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Introduction

Safety is the most important issue for all customer goods. Loosing those characteristics leads disfunctionaling. Overscoaring of safety characteristics turns products into dangerous group. As for textiles chemical safety is the most important one, because of chemical composition of a textile.

It's worth noticing that any textile material is a complicated mixture, mainly made of textile fiber. Rate of fiber may differ and reach a peak at 90-95 per sent. Other components are auxiliary, dyes, finishing, components, implementing at the finishing stage of textile production. So, all components may influence safety factors.

Material and methods

We try to make a comparative analysis of some safety factors limits that are established by different documents. Safety's factors of textiles are listed by different documents both international and nationals. Sanitary Norms and Rules (SanPiN) 2.4.7/1.1.1286-03 "Hygiene request for clothing for children, teenagers and adults" is the most important document regulating the safety of textiles in Russian Federation.

Besides, from July 1, 2012, mandatory requirements set by the Customs Union Technical Regulation (CU TR 017/2011) "About Safety of Consumer Goods of light industry" that are applied to consumer goods within the common customs territory of Belarus, Kazakhstan, and Russia.

The transition period for the said Technical Regulation has been established until July 1, 2014. Parameters of biological and chemical safety are issued according to this standard.

Mentioned Technical Regulation also sets safety requirements to underwear items, including hygroscopic index that should reach at least 6 per cent.

It's worth noting that consumers' anxiety about possible risk of disappearing of lace underwear from circulation is groundless, since the mentioned requirement shall apply, regardless of design features of underwear and materials it is made of 6 per cent hygroscopic index was defined with respect to scientifically-proved hygienic standards. Since 2010, it was incorporated in the Customs Union Common Sanitary, Epidemiological, and Hygienic Requirements to Goods subject to the Sanitary and Epidemiological Supervision (Monitoring). This index was formalized in the legislations of three states (the Russian Federation Sanitary Regulations and Norms (SanPiN 2.4.7./1.1.1286-2003), the Republic of Belarus Standard (STB 1049-97), and the Republic of Kazakhstan Technical Regulation "Requirements to the Safety of Consumer Goods" effective from 2008). Besides, from 2003 this norm was incorporated in two interstate standards GOST 25296-2003 and GOST 31228-2004.

Hygroscopic is the capacity of a fiber to absorb liquid, which is the essential condition for underwear. Hygroscopic index depends on the composition of the materials underwear is made of (normally, a gusset made of natural fibers is enough for hygroscopic to conform to the Technical Regulation requirements).

The Eurasian Economic Commission has established an efficient mechanism of amending technical regulations. It enables to consider substantiated proposals of Member-States particularly in regard to modification of indices. Any proposals submitted shall be subject to consideration in accordance with the established procedure.

Another Customs Union Technical Regulation "About Safety of Production for Kids and Teenagers" (CU TR 007/2011) approved by the Customs Union Commission Decision No. 797 dated September 23, 2011 applies to production intended for kids and teenagers, that have not been in operation (new), commercialized in the territory of the CU Member-States regardless of the country of origin. The CU TR 007/2011 does not cover production designed and manufactured for medical purposes, baby food products, perfumes and cosmetics, sport products and equipment, study guides, textbooks, electronic study publications, toys, printed table games, furniture, made-to-order products. Assessment (confirmation) of compliance with the CU TR 007/2011 requirements shall be performed by way of state registration with subsequent declaration of compliance or certification.

Allowed rate of dangerous substances are noticed by many international corporations, like Mark & Spencer or IKEA but Oeko-tex Standard 100 is more annually used worldwide. Oeko-tex 100 is ecological and chemical rate

for productions. That is not a law, but list of professional requests where a company may choose the most appropriate issues. The thing of ecology is as important in the modern world, as thing and quality.

Results and discussion

The comparative characteristic of safety factors is shown in table 1.

Table 1. Safety's parameters of textile, normalized by different documents

SanPiN 2.4.7/1.1.1286-03	CU TR 007/2011	CU TR 017/2011	Oeko-tex 100
Hygroscopicity Permeability to air Static characteristic Migration of dangerous components in water and air space Maximum concentration limit of free formaldehyde Smell	Hygroscopicity Permeability to air Colour stability to washing, perspiration and dry friction Free formaldehyde	Hygroscopicity Permeability to air Intensity of electrostatic field on the surface Mass fraction of free formaldehyde	pH value Formaldehyde Extractable heavy-metals Heavy metals in digested sample Pesticides Pentachlorofenol Colorants Colour fastness (staining) Determination of odours

Source: own research.

According to these data the most serious requirements of safety is given by Oeko-tex-100, then followed by Sanitary Norms and Rules and then goes Technical Regulate. Oeko-tex-100 includes requirements for smell, pH, stain ability for friction, waterproof and so on.

Let us analyze safety factors of textiles from the point of view of maximum concentration limit of free formaldehyde. Toxicity of formaldehyde is well-known. It is being the 2nd class-danger substance for a human's body. Also it's concerned as carcinogen. Formaldehyde is included in appret that are used to make material dimensional stability, wrinkle resistance etc. Formaldehyde apprets consists of formaldehyde in chemical linking forms and such forms may establish polymer compound on the fibre or establish chemical connects with it. The textile material with such appret may evolve formaldehyde which may penetrate in environment and even to the body's skin and throw it, that shows its toxicity action.

Comparative characteristic parameters of concentration limit of formaldehyde in adult and child clothing is shown in Table 2. I used some regular documents which establish the limits of formaldehyde in different kinds of clothing for different users: kids, children and adults. These documents are: Oeko-tex Standard 100, Customs Union Technical Regulation "About Safety of Production for Kids and Teenagers" (CU TR 007/2011) and valid in Russian Federation State Standard GOST R 50729-95 «Textiles. Maximum permissible concentrations of free formaldehyde".

Table 2. Comparative characteristic of concentration limit of formaldehyde in adult and child clothing`s parameters (mg/kg)

	GOST R 50729-95			CU TR 007/2011			Oeko-tex 100		
	1 class	2 class	3 class	1 class	2 class	3 class	1 class	2 class	3 class
For kids up to the age of one	-	-	-	-	20	20	-	-	-
From one up to the age of three	75	300	1000	20	75	300	-	-	-
From three up to fourteen	75	300	1000	75	300	300	75	75	300
From fourteen up to eighteen	75	300	1000	75	300	300	75	75	300
For adults	75	300	1000	75	300	300	75	75	300

Source: Own research based on mentioned documents.

It`s worth to notice that textiles and clothing are devoted into several classes depending on contact with the skin: the more intensively a textile comes into contact with the skin (and the more sensitive the skin), the higher the human ecological requirements to be met. Accordingly, successfully tested textile products are allocated to four different product classes:

Product class I: Textiles and textile toys for babies and small kids up to the age of three, e.g. underwear, romper suits, bed linen, bedding, soft toys etc.

Product class II: Textiles which have a large part of their surface in direct contact with skin, e.g. underwear, bed linen, terry cloth items, shirts, blouses etc.

Product class III: Textiles which have no or only a little part of their surface in direct contact with skin, e.g. jackets, coats, facing materials etc.

Product class IV: Furnishing materials for decorative purposes such as table linen and curtains, but also textile wall and floor coverings etc.

Then I have analyzed the formaldehyde's concentration limit in clothing of products from 1st to 3rd classes. The comparative characteristic of concentration limit of formaldehyde in adult and child clothing`s parameters, which are set by different documents, is shown in Table 2.

Conclusions

Conclusion based on my analyses is that the hardest requirements of the concentration limit of formaldehyde are established by Oeko-tex Standard 100, the next goes Customs Union Technical Regulation "About Safety of Production for Kids and Teenagers" (CU TR 007/2011) and third place has GOST R 50729-95 «Textiles. Maximum permissible concentrations of free formaldehyde".

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POTENTIAL ANTIRADICAL ACTIVITY OF *PRUNUS SPINOSA* EXTRACTS

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Introduction

Free radicals are atoms, groups of atoms or molecules with an odd number of unpaired electrons. They can exist as independent species and are mostly stable for a relatively short time. Free radicals are probable everywhere in nature, in the air, our bodies, and the materials around us. They are responsible for aging related illnesses, and can contribute to heart attacks, stroke and cancers. They can be formed as a result of oxygen interaction with certain molecules. Free radicals are very highly reactive species. They initiate a chain reaction with other molecules. Free radicals cause a deterioration of plastics, a fading of paint, a degradation of works of art. The main danger comes from the damage they can do when free radicals react with important cellular components such as DNA, or the cell membrane (Aruoma 2001).

Each organism has a defense system of antiradical species (known also as natural antioxidants) to prevent damage caused by free radicals. The antiradical species are molecules that are able to neutralize the free radicals by donating a hydrogen atom or electron to produce a relatively more stable radical with very poor ability in propagation of the chain reaction leading to the interruption of autoxidation process. Some antioxiadants are also supplied with a diet, especially in a form of natural polyphenolic compounds. Their antiradical activity seems to be one of the most important properties utilized not only in food but also in farmaceutical products. It was reported in literature that a number of plant extracts exhibit a very significant antiradical properties. It is reasonable to suppose that the antiradical activity of plant extracts should strongly depends on the solvent composition used in the extraction processes.

In recent literature one can find a number of paper dealing with antiradical properties of plant extracts as well as infusions. Antiradical activity of plant extracts and infusions is attributed mainly to polyphenolic compounds, especially to flavonoids. Such compounds can be found in

number of vegetables, fruits, nuts, seeds, roots, leaves as well as in some beverages like tea and wine, especially red wine. Some literature data (Morel., Cillard & Cillard 1998; Mira *et al*. 2002) indicate that the antioxidant activity of isolated polyphenolic compounds depends mainly on their molecular structure while antioxidant activity of plant is related not only to structural characteristics of certain polyphenols but also to the concentration of a species in plant.

One can expect that the antiradical activity of plant extracts or infusions should strongly depend on the solvent composition used in the extraction or infusion processes. Therefore it would be very interesting to determine experimentally the antioxidant activity of plant extracts. The total polyphenolics content and especially flavonoids concentration in plant extracts seems to be one of the most important parametes describing quality of commercial products based on plants. Such a descriptor can quantitatively characterize the sources of natural antioxidants, which can improve quality of food, cosmetic, pharmaceutical and herbal formulations.

Plant extracts are often rich in polyphenols. They have potential application in cosmetology and pharmacology. Recently they are frequently used also as food supplements. In most papers on application of plant extracts the first priority is given to the antioxidant properties of polyphenols. It is known that many polyphenols can act as cofactors for almost all kinds of enzymes. It is also important that polyphenols are present in anti-cellulite, anti-couperosis anti-aging and skin lightening products. Some authors describe also other important forms of activity of polyphenols such as: antiseptic, strengthening capillaries, anti-inflammatory effect, protective against radiation, moistening, softening, soothing, styptic and many other It is generally accepted that scientifically proven skin benefits of polyphenols as cosmetic ingredients refer, for example, to prevention of lipid oxidation (Glinka *et al*. 2002; Kim *et al*. 1997; Schmid & Zulli 2002; Hiipakka *et al*. 2002), stimulation of fibroblast proliferation (Kim *et al*. 1997), reduction of collagen breakdown (Schmid & Zulli 2002) or 5α-reductase (Hiipakka *et al*. 2002).

During last few years we have published several papers showing results of our measurements on the total content of phenolic compounds and flavonoids as well on the antioxidant capacity of solutions of active single chemical species, infusions as well as extracts prepared using various plant materials (Kończal & Zieliński 2008; Malinowska, Zieliński & Szymusiak 2010; Zygmanowska & Zieliński 2011; Kluj & Zieliński 2012; Śledziński, Kwaśniewska & Zieliński 2013; Swat & Zieliński 2013; Kończal & Zieliński 2014). We have found that for a given plant or product in each case the antiradical activity of plant extracts strongly depends mainly on the solvent

composition used in the extraction or infusion processes and elongation of the extraction procedure.

In this work we deal with blackthorn (*Prunus spinosa*) which is a genus of trees and shrubs, which includes the cherries, peaches, plums, nectarines, apricots and almonds. The specific name *spinosa* is a Latin term indicating the pointed and thornlike spur shoots characteristic of this species.

This plant is easy to grow in a form of native shrub or small tree, that can be used for hedging. *Prunus spinosa* grows in any moist well-drained soil in full sun. *Prunus spinosa*is a large deciduous shrub or small tree growing to 5 metres (16 ft) tall, with blackish bark and dense, stiff, spiny branches. The leaves of *Prunus spinosa* are oval, 2–4.5 centimetres (0.79–1.77 in) long and 1.2–2 centimetres (0.47–0.79 in) broad, with a serrated margin. *Prunus spinosa* is in flower from March to April. The flowers of *Prunus spinosa* are 1.5 centimetres (0.59 in) diameter, with five creamy-white petals; they are produced shortly before the leaves in early spring, and are hermaphroditic and insect-pollinated. The fruit, called a "sloe", is a drupe 10–12 millimetres (0.39–0.47 in) in diameter, black with a purple-blue waxy bloom, ripening in autumn, and harvested – traditionally, at least in the United Kingdom, in October or November after the first frosts. Sloes are thin-fleshed, with a very strongly astringent flavour when fresh is a deciduous (Rushforth 1999). The flowers of *Prunus spinosa* are usually white to pink, sometimes red, with five petals and five sepals. According to literature reports (Wikipedia 2014) around 430 species are spread throughout the northern temperate regions of the globe. Many members of the genus are widely cultivated for fruit and ornament. The fruit from this genus are commonly called the stone fruit. According to FAOSTAT (FAOStat 2014) the annual producion of the stone fruit of *Prunus spinosa* in 2012 was as follows (in thousands tonnes): Iran - 205; China - 138; Afghanistan - 46; Uzbekistan - 34; Turkey - 17; Hungary - 14; Algeria - 13 and Georgia - 13.

Species such as blackthorn (*Prunus spinosa*), are usually grown for hedging, game cover, and other utilitarian purposes. The wood of some species (notably cherry) is a specialised timber. Many species produce a very aromatic resin from wounds in the trunk. This resin is sometimes used medicinally. Other minor uses of *Prunus* species include dye production. Pygeum, a herbal remedy containing extracts from the bark of *Prunus africana*, is used as to alleviate some of the discomfort caused by inflammation in patients suffering from benign prostatic hyperplasia. Because of their considerable value as both food and ornamental plants, many *Prunus* species have been introduced to parts of the world to which they are not native, some becoming naturalised. *Prunus* species are food plants for the larvae of a large number of Lepidoptera species both butterflies and moths.

Many species of *Prunus* are cyanogenic; that is, they contain compounds called cyanogenic glucosides, aspecially amygdalin. Amygdalin is found in bitter almonds and in the kernels of peaches, cherries, plums, apples, etc. On hydrolysis, amygdalin yields hydrogen cyanide, usually in the plant leaves and seeds (Armstrong 1913). Although the fruits of *Prunus spinosa* some may be edible by humans and livestock (in addition to the ubiquitous fructivory of birds), seeds, leaves and some other parts of the plant may be toxic (Cook & Callow 1999).

In the present work we study the variation of antiradical activity of extracts obtained from *Prunus spinosa*. The main purpose of our experimental research desribed in this work is to find the optimum solvent composition applicable to extraction process of active compounds present in flowers of *Prunus spinosa*. We are looking for effective extrahent able for preparation of extract with high polyphenols content of potential use as a cosmetic ingredient.

Experimental

Materials

Flowers of *Prunus spinosa* were purchased from Flos company. All chemicals used in this work were of analytical grade. The following chemicals: Folin-Ciocalteu's phenol reagent (Merck), caffeic acid (Sigma), sodium carbonate, (POCH S.A., Poland), 96% ethanol, $KMnO_4$ (Chempur, Poland) were used as supplied without any purification before use. In all experiments we have used a redistilled water which was additionally purified by means of a further boiling with alkaline $KMnO_4$ solution and finally fractionally distilled.

We have investigated antiradical properties of *Prunus spinosa* flowers. All samples were used as supplied without any purification before use.

Methods

We have performed the extraction process of *Prunus spinosa* plant for a period of 1, 5 and 24 hours. In each experiment the 1 g sample of *Prunus spinosa* flowers were placed in dark bottle and stirred at room temperature for 5 minutes with 200 ml of the designed solvent. After that the samples were kept without sirring in a dark room during all the period of maceration. After the designed period of time each sample was filtered through a paper filter under a slightly reduced pressure. The filtrate obtained in such a way was analysed.

In our extraction experiments we have used five water – ethyl alcohol mixtures as solvents. The composition of the water – ethyl alcohol mixtures based on volume ratio of the solvents was as follows 0:1, 1:3, 1:1, 3:1 and 1:0. In order to characterize the *Prunus spinosa* flowers extracts obtained in such a way and to determine the antiradical activity of them we have carried out spectrophotometric determination of various parameters for freshly obtained extracts.

The total content of the phenolic compounds present in the extracts was determined by means of standard spectrofotometric method using Folin–Ciocalteu reagent following the procedure described by Singleton and Rossi (Singleton & Rossi 1965) with caffeic acid. Briefly, 0.1 ml of diluted solution of the extract sample obtained from *Prunus spinosa* flowers or an appropriate amount of gallic acid was mixed with 6 ml of distilled water in 10 ml volumetric flask. Then, to the resulting mixture, 0.5 ml of Folin-Ciocalteu reagent was added and finally, the content of the flask was intensively mixed for 3 minutes. Next, 1.5 ml of 20% (w/v) Na_2CO_3 was added the mixture and volume was made up to 10 ml with double distilled water. The resulting mixture was allowed to stand for 2 hours in the dark at room temperature. After that time the absorbance of the sample was determined at 765 nm against the blank. The standard curve was prepared using up to 7 mg/L of caffeic acid in ethanol : water (1:9, v/v). The total phenolic content was expressed in mg of caffeic acid equivalents per gram of the air dried *Prunus spinosa* flowers.

We have determined the content of flavonoids present in the *Prunus spinosa* flowers extracts spectrophotometrically by means of a method proposed by Karadeniz *et al*. (Karadeniz *et al*. 2005) with (-)epicatechin as the reference compound (Re *et al*. 1999). In our procedure a sample of 1.0 ml of the extract, 5.0 ml of water was mixed with 0.3 ml of 5% aqueous solution of sodium nitrate(III). The resulting solution was stired and left for 5 minutes. Then 2.0 ml of 1 M aqueous solution of aluminium was added and the mixture was again stirred. After keeping the sample for 5 minutes 2 ml of 1M aqueous solution of NaOH was added, the resulting mixture was diluted with double distilled water to the final volume of 10 ml and the absorbance was measured at 510 nm against blank solution.

All spectrofotometric measurements described in this work were carred out using Genesis II spectrophotometer (Milton Roy, USA) connected with the personal computer *via* RS232 interface. Statistical analysis of the numerical data presented in this work was performed using the statistical tools incorporated in the Microsoft Excel spreadsheet equipped with XNumbers macro developed by Volpi (Volpi 2007). Errors of numerical parameters of nonlinear equations used in this work were estimated by means of SolverAid macro as developed by De Lisi (De Lisi 1999; De Lisi 2012).

Results and discussion

Figure 1 shows the absorpction spectra of extracts obtained from *Prunus spinosa* using aqueous solutions of ethanol at various voume ratios of the solvents. As can be seen the shape of each spectra strongly depends on the solvent composition. As can be seen in Figure 1 each spectrum recorded for the extracts obtained from *Prunus spinosa* exhibits a absorption band maximum located at *ca*. 264 nm. Moreover, one can observe also several other signals with maxima located between *ca*. 330 and 370 nm. As can be seen in Figure 1 the intensity of the spectum is the lowest for the extracts obtained using pure solvents: water or ethanol. It is evident that ethanol itself exhibits the lowest extractive properties among extrahent mixtures tested in this work.

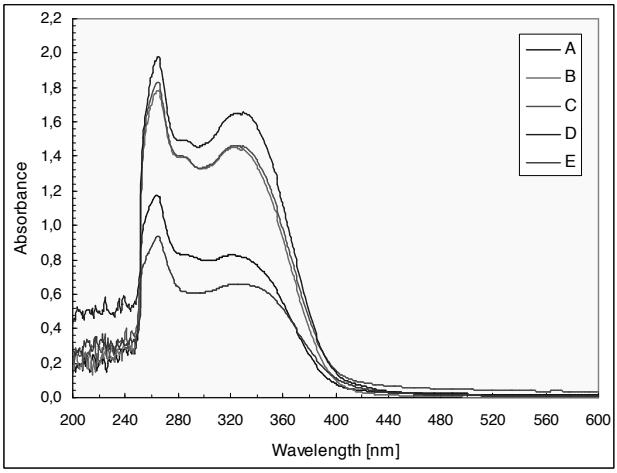

Figure 1. Absorption spectra for extracts in various solvents. Concentration of ethanol: A – 0%; B – 24%; C – 48%; D – 72%; E – 96 %

Source: own research.

Figure 2 presents changes in the absorbance of several extracts obtained from *Prunus spinosa* flowers at two wavelengths: 264 nm and 330 nm which are attributable for phenolic compounds. As can be observed in Figure 2 the intensity of the bands located at 264 nm and 330 nm strongly depends on the extrahent composition. As can be seen in Figure 2 that the bands with the lowest intensities are recorded for extracts obtained using ethanol.

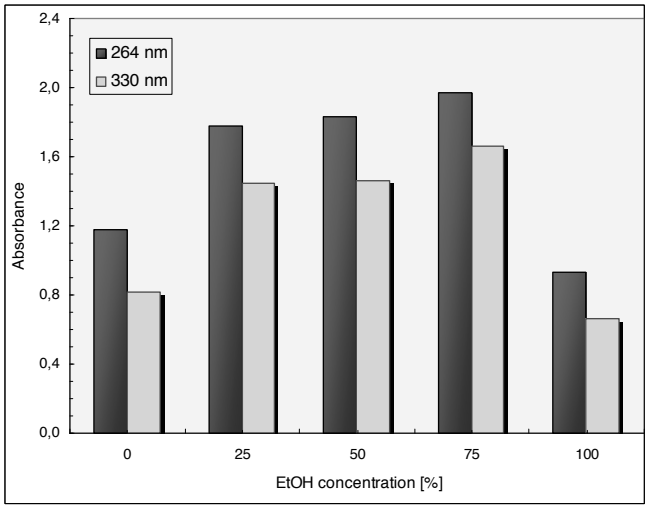

Figure 2. Effect of ethanol concentration on intensity of absorption bands for aqueous-ethanolic extracts obtained from *Prunus spinosa* flowers using various solvents composition as registrated at 264 nm and 330 nm.

Source: own research.

Figure 3 shows the results of our determinations of the total phenolic compounds content (expressed in mg of gallic acid used as standard compound) in the extracts obtained from *Prunus spinosa* flowers after 1 hour of extraction process using ethanol–water mixtures with variable ethanol content. It is seen in Figure 3 the plot of the total phenols content in the extracts obtained from *Prunus spinosa* flowers strongly depends also on the composition of the solvent used during the extraction process. As can be seen in Figure 3 the maximum total content of phenols in the extracts of *Prunus spinosa* flowers can be obtained in the extrahent containing *ca*. 48% of ethanol.

Figure 4 shows the results of our determinations of the flavonoids content (expressed in mg of (-)epicatechin used as standard compound) in the extracts obtained from *Prunus spinosa* flowers after 1 hour of extraction using ethanol–water mixtures with variable ethanol content. It is seen in Figure 4 the plot of flavonoids content in the extracts obtained from *Prunus spinosa* flowers strongly depends also on the composition of the solvent used during extraction process. The maximum total content of flavonoids in the extracts of *Prunus spinosa* flowers can be obtained in the extrahent containing *ca*. 50% of ethanol.

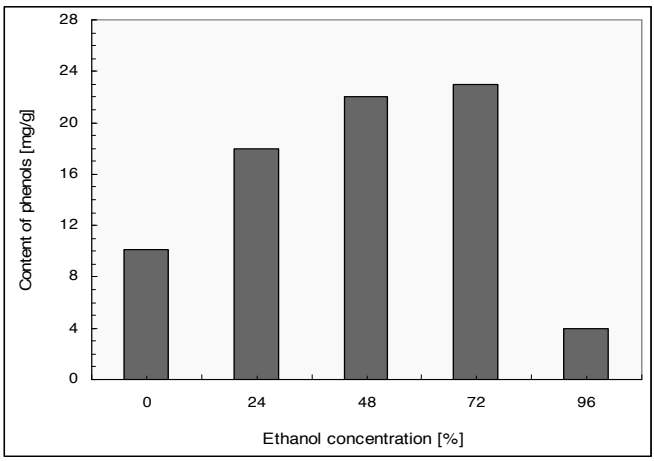

Figure 3. Effect of ethanol concentration in extrahent mixture on the total phenolics concentration (in mg of caffeic acid) in extracts obtained from *Prunus spinosa* flowers after 1 hour extraction time

Source: own research.

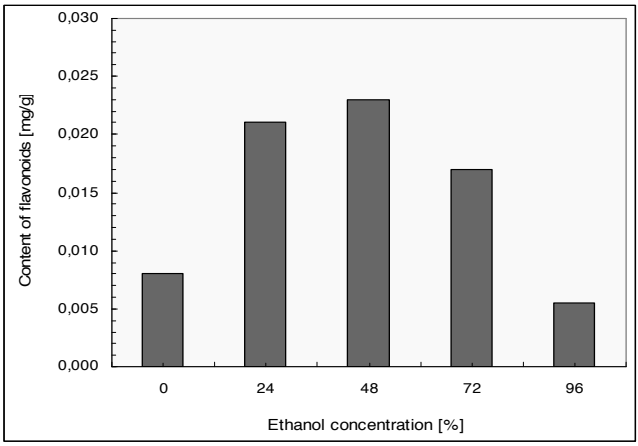

Figure 4. Effect of ethanol concentration in the extrahent mixture on flavonoids Concentration (in mg of (-)epicatechin) in the extracts obtained from *Prunus spinosa* flowers after 1 hour extraction time

Source: own research.

Figure 5 is a representative example of flavonoids change in the extracts obtained from *Prunus spinosa* flowers during the extraction process performed using various ethanol – water mixtures. It shows a variation in the flavonoids content as a function of the extraction time performed using

aqueous solutions of ethanol at different concentrations of ethanol. The content of flavonoids concentration shown in Figure 5 is given in mg of (-)epicatechin per 1 g of *Prunus spinosa* flowers used in extraction process. As can be seen in Figure 5 each experimental curve has a nonlinear shape concave downward approaching gradually some equilibrium value. The antiradical activity of the *Prunus spinosa* flowers extracts evaluated in such a way strongly depends on the duration of the extraction process. It is seen in Figure 5 that the plot of the flavonoids content in the extracts obtained from *Prunus spinosa* flowers strongly depends also on the composition of the solvent used during the extraction process.

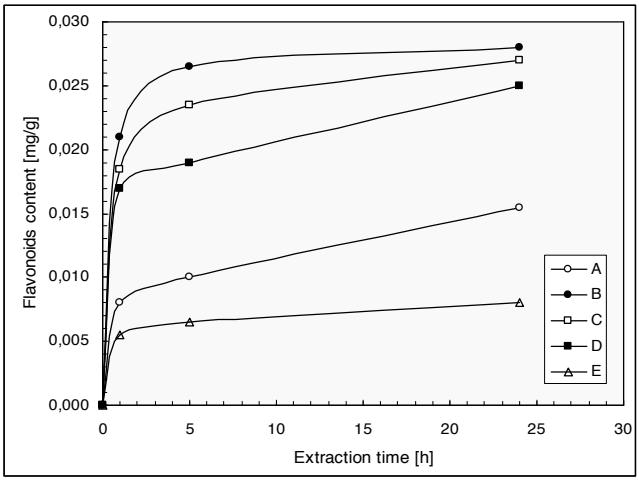

Figure 5. Effect of extraction time on flavonoids concentration i n extracts obtained from *Prunus spinosa* flowers using aqueous solutions of ethanol.
Concentration of ethanol: A – 0%; B – 24%; C – 48%; D – 72%; E – 96 %

Source: own research.

Conclusions

In this work we have experimentally found that extracts from the flowers of *Prunus spinosa* contain a huge amount of phenols including flavonoids. We can state that the flowers of *Prunus spinosa* can be redarded as a very valueable source of antiradical species, such as flavonoids and other polyphenols. Based on our experimental data one can conclude that the content of antiradical species in the extracts obtained using aqueous solutions

of ethanol with 50% ethanol concentration is always higher than that found in the extracts obtained using water or ethanol.

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INTERDISCIPLINARY STUDY OF COLOURED COTTON FIBRES FOR FORENSIC PURPOSES

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Introduction

Textiles and fragments of single fibres can constitute an important role as forensic evidence, especially if they could come from the victim's or suspect's clothing (Robertson & Roux 1999, Wąs-Gubała 2009). Fibres transferred from an assailant's clothing to that of a victim, and vice versa, as well as fibres present on a victim's body, e.g. under the fingernails, are most often required in order to establish whether or not physical contact took place between individuals, as in cases of murder, sexual abuse, fights, etc. The driver's and passengers' seats, as well as other elements of the vehicle's interior, are also checked for fibre evidence for determining who may have been driving a vehicle during a road accident. Fragments of the single fibres from victims' clothes are frequently found on the knives, scissors, axes used by a perpetrator.

A fragment of a single fibre, often a few millimetres long and with a diameter of 20 μm to 25 μm, doesn't acquire any features to allow for the identification of an exact textile product because it may have come from a set of similar products. Due to the mass production of garments, household furnishings and car interiors, it is now very difficult to narrow the origin of fibres to a limited number of sources. The analytical research allows ascertaining that evidential fragment of fibre can originate from known source (e.g. suspect' clothes) but never confirming that it dates from concrete product.

Cotton fibres are one of the most prevalent in the consumer market (Basra 1999), and therefore are often the object of research in the forensic science, as so-called contact traces or microtraces. Many kinds of textile products as textiles clothing, underwear, bed linen, towels, medical textiles are manufactured from cotton fibres only or cotton fibres blended with other fibres types.

The general classification and comparison of cotton samples for the cotton producers and merchants based on the commercial quality parameters, such as: colour grade, leaf, Micronaire, and fibre length (http://www.gca.org.pl/). For cotton processing sector the following parameters are to be known: breaking strength, maturity, linear density, length non-uniformity, short fibre content, neps and dusts. Such kinds of analyses can be made with instrumental methods by means of HVI, AFIS, MDTA and similar systems. A large part of the cotton crop is still classed manually – by means of comparison of fibre to standards established by individual cotton producers.

Methods of cotton testing used in commodity and textile sciences generally may not be adapted to forensic science, because it does not give the possibility of examining the fragments of the single fibres. To identify or to compare a small fragment of cotton fibre, different varieties of optical microscopy are available (e.g. comparison, polarised, fluorescence) as well as a standard spectroscopic techniques connected with a microscope e.g. microspectrophotometry UV-Vis (UV-Vis MSP) or Raman spectroscopy (Robertson & Roux 1999, Wąs-Gubała 2009). These methods provide information on cotton physical and chemical features as: colour, longitudinal view, surface morphology, thickness, fluorescent properties, and type of dye used.

Colour plays a crucial role in the case of comparative cotton studies in forensic science and it differentiates the cotton fibres derived from different textile products, first and foremost. Numerous colour models have appeared over the years, which make possible to establish the colour of an investigated object by assigning it a specific numerical value. Some attempts have been made to use CIE coordinates in forensic science, nowadays in the field of textile examinations the CIE and CIEL*a*b* system are widely accepted (Hunt & Pointner 2011).

MSP is a means of measuring the interaction of radiation from different wavelengths of light, across the ultraviolet and visible regions (UV-Vis), in terms of absorption or transmission (Starczak, Wąs-Gubała & Kościelniak 2013). This technique has the capability of measuring the physical result of this interaction between the radiation and the substance being examined (containing chromophores) as fibre dyes, but does not provide information on the types of dyes present in the fibres.

It is theoretically possible to identify the types of fibre dyes using thin-layer chromatography, capillary electrophoresis or liquid chromatography but, because of their destructive nature, these methods are not widely used in forensic practice. Raman spectroscopy, however, is a technique used with increasing frequency in the identification of dyes and comparison of dyed fibres, and it has been deemed the only technique, through which molecular

structural information concerning the dye present in a fibre may be obtained in a virtually non-destructive manner (Chalmers, Edwards & Hargreaves 2012, Lepot, De Wael, Gason & Gilbert 2008, Massonnet 2012, Wąs-Gubała & Machnowski 2014).

Reactive dyes, characterized by their excellent washfastness, can react with the hydroxyl groups of cellulose and form, through esterification or etherification, covalent bonds between the dye molecules and cotton (Wąs-Gubała & Machnowski 2014).

The study presented herein was dedicated to the selected aspects of colour assessment of cotton fibres dyed with single reactive dye based on Vis MSP results. The research aimed to determine the possibility of identifying each of the binary or ternary dye mixtures' components using Raman spectroscopy, thereby verifying the practicability of dye type identification in actual cases of forensic fibre studies.

Material and methods

Single fibers, selected from 43 knitted cotton fabrics (1 ready to dye, 42 dyed) (Table 2 and Table 3), as well as 14 individual reactive dyes used for fabric coloring, in powdered form (Table 1), were used in the study.

Table 1. Summary of the dyes used for fabric coloring with binary or ternary mixtures

Group of dyes	Symbol of dye	Commercial name of dye
Reactive	R1	Intracron® Gelb BF-3R 150%
	R2	Intracron® Rot BF-3B 150%
	R3	Intracron® Turkus VG
	R4	Intracron® Dark Blau CDX-ST
	R5	Polactiv® Yellow E-7GL
	R6	Novacron® Brillant Red FN-3GL
	R7	Novacron® Ocean SR
	R8	Bezactiv® Blau SGLD 150%
	R9	Bezactiv® Blau SFR 150%
	R10	Bezactiv® Rot S3B 150%
	R11	Bezactiv® Grun S4B 150%
	R12	Synozol® Gelb HB
	R13	Synozol® Marine HB
	R14	Synozol® Rot HB

Source: own research.

All of the samples dyed with single reactive dye were provided by Ciba (nowadays BASF Schweiz AG). The cotton fabrics were dyed using one-compound reactive dyes with the commercial name Cibacron® (at present Novacron®), in different combination of concentration from 0.18% to 6.0%. Knitted cotton fabrics dyed with binary or ternary mixtures of reactive dyes, at a mass concentration of 0.1% to 3.0%, were prepared in laboratory conditions at the Faculty of Material Technologies and Textile Design of Lodz University of Technology, using a UGOLINI Redkrome dyeing apparatus, equipped with infra-red heating. Dye concentrations in the fabric samples were calculated based on the absorbency values of the dye-bath samples, taken at the beginning and end of each dyeing process, using a UV-VIS-NIR Jasco V-670 spectrophotometer. It was concluded, through visual color assessment, that all of the woven and knitted fabric samples tested differ from one another. The cotton fabrics used in this study contained no auxiliary additives or optical brightening agents.

Table 2. Summary of examined cotton fibers dyed with single reactive dye

Type of fibre	Group of dyes	Symbol of dye	Commercial name of dye	Approximate concentration of dye [%]					
				0.18	0.75	1.50	3.00	4.50	6.00
Cotton	Reactive	R15	Novacron® Blue	✓	✓	✓	✓		
		R16	Novacron® Brilliant	✓	✓	✓	✓		
		R17	Novacron® Navy		✓		✓	✓	✓
		R18	Novacron® Navy		✓		✓	✓	✓
		R19	Novacron®	✓	✓	✓	✓		
		R20	Novacron®	✓	✓	✓	✓		
		R21	Novacron® Red	✓	✓	✓	✓		
		R22	Novacron® Red	✓	✓	✓	✓		

Source: own research.

The study of research material presented here was carried out using two spectroscopic techniques: Raman spectroscopy and microspectrophotometry in the visible range (Vis MSP). All of the fabrics were dyed in their entirety – however, measurements were performed separately for fibers extracted at random from the weft and warp of each fabric.

Experiments on cotton fibres dyed with single reactive dye were performed using a 20/20 PV™ microspectrophotometer from CRAIC Technologies, equipped with a Xenon lamp and Ultrafluar 40x Zeiss objective**.** The transmittance spectra were recorded in the visible range, between 380 nm and 800 nm. Measuring conditions were: aperture size – 6.0 μm x 6.0 μm, scans to average – 25.

Table 3. Summary of examined cotton fibers dyed with binary or ternary mixtures of reactive dyes

Type of fibre	Symbol of sample	Macroscopic colour of sample	Composition of dye mixture
Cotton	Co0	white	without dyes
	Co1	red	3.0 % R2; 1.0 % R1
	Co2	red	3.0 % R6; 0.5 % R1
	Co3	red	2.0 % R6; 0.1 % R1
	Co4	green	1.5 % R1; 1.0 % R11 0.1 % R2
	Co5	green	2.0 % R5; 0.5 % R1 0.5 % R8
	Co6	green	1.5 % R5; 0.1 % R3 0.1 % R9
	Co7	blue	0.5 % R9; 0.3 % R7 0.1 % R10
	Co8	blue	1.5 % R7; 0.3 % R2
	Co9	blue	1.0 % R4; 0.5 % R2 0.5 % R1
	Co10	brown	2.5 % R12; 1.0 % R13 1.0 % R14

Source: own research.

The examined fibres were mounted between quartz microscope slides and cover slips, using glycerine (Sigma-Aldrich Chemie GmbH, Germany) as a mounting medium. Reference data were taken exclusively from an area immediately adjacent to the mounted fibre; this was directly followed by measurements of the fibre sample.

From at least ten spectra measured for single fiber, a mean spectrum was calculated. Finally, the average spectrum of all 50 measurements representing a particular fabric sample was calculated. Mean spectra were calculated using CRAIC MSP Data Acquisition Software.

Raman spectra were collected only for cotton fibres dyed with binary or ternary mixtures of reactive dyes and for dyes in powdered form. In those experiments Renishaw inVia spectrometer equipped with a confocal Leica microscope, and three types of excitation sources – Ar ion (514 nm), He-Ne (633 nm), and a near infrared semiconductor laser (785 nm) was used.

Examined fibers were passed through a hole in the aluminum spectral plate, drawn tight and affixed to the plate by their ends while an individual dye was prepared by dissolving a solid dye in deionized water and putting a small amount of this solution on the microscope slide covered with aluminum foil; after evaporation Raman spectra were recorded. The laser beam was

focused on the samples with a 50x objective lens, and the signal recorded using a Peltier-cooled charged coupled device (CCD). Spectra were acquired in 5 accumulations, with the most suitable scanning times and laser power levels determined separately for each examined sample, through experimentation, thanks to which the spectra obtained were of the best possible quality in terms of intensity of the bands, degree of separation and signal-to-noise ratio. All of the spectra presented in this paper were acquired within a range of 200–1800 cm^{-1}, and baseline corrected and smoothed using Wire 3.2 software.

Results and discussion

*Prediction of the changes of the CIEL*a*b* values with concentration of dye based on the MSP results for fibre dyed with single reactive dye*

From the raw spectral data obtained for each of the measured cotton fibres, the colorimetric coordinates were calculated: L* – lightness, a* – green/red, b* – blue/yellow (Table 4). The following criteria for colour measurements were used: illuminant D65 – represent natural daylight with a correlated colour temperature of 6500K, standard observer 10° CIE 1964, spectral range 380-770 nm, sample averaging – 50.

Those parameters could be defined as:

L* – lightness value is a measure of white-black scale in CIEL*a*b* colour space;

a* – red/green value is a measure of the coordinate of colour on the red-green axis in CIEL*a*b* colour space. Positive coordinates represent a red shade and negative coordinates represent a green shade in colour terms, while coordinates near zero represent a gray shade;

b* – yellow/blue value is a measure of the coordinate of colour on the yellow-blue axis in CIEL*a*b* colour space. Positive coordinates represent a yellow shade while negative coordinates represent a blue shade in colour terms. Coordinates near zero represent a gray shade.

The colorimetric coordinates were calculated from the raw transmittance spectral data using the appropriate CIE formulae in a CRAIC MSP Data Acquisition software.

For cotton fibres coloured with dye from the blue sub-group it was noticed that average value of red/green coordinates and yellow/blue coordinates decreased as the concentration of dye in fibre increased. The colour of those fibers appeared much greener and bluer as the concentration changed to a higher value.

When dyes from the red sub-group were considered, it was observed that the average value of the red/green coordinates increased gradually, while the mean value of the yellow/blue coordinates decreased – the colour of cotton fibres dyed with the red dye moved to red and to blue at the same time as the concentration was rising.

Table 4. Colorimetric data

Symbol of dye	Concentration of dye [%]	L* aver.	a* aver.	b* aver.
R15	0.18	94.45	-0.25	-0.45
	0.75	91.14	-2.81	-5.03
	1.50	85.95	-5.15	-9.78
	3.00	78.07	-7.64	-17.88
R16	0.18	90.10	-1.05	-1.35
	0.75	85.10	-5.66	-6.91
	1.50	83.84	-	-
	3.00	82.46	-	-
R17	0.75	90.06	-1.95	-5.04
	3.00	75.04	-6.87	-
	4.50	69.13	-7.26	-
	6.00	66.32	-7.63	-
R18	0.75	87.49	-2.86	-7.79
	3.00	71.46	-6.58	-
	4.50	66.73	-6.06	-
	6.00	61.96	-6.58	-
R19	0.18	95.73	1.61	3.04
	0.75	93.24	3.52	8.70
	1.50	88.50	5.77	13.94
	3.00	85.03	12.21	22.30
R20	0.18	96.32	3.63	3.77
	0.75	85.55	9.47	10.56
	1.50	86.64	14.26	16.73
	3.00	80.04	21.36	24.96
R21	0.18	92.65	1.61	0.26
	0.75	89.72	5.86	-1.24
	1.50	87.76	11.06	-3.40
	3.00	83.12	21.03	-8.78
R22	0.18	96.74	2.42	0
	0.75	92.45	8.26	-2.50
	1.50	88.56	13.65	-5.89
	3.00	83.50	24.54	-

Source: own research.

In the orange sub-group it was noticed that while the concentration of the dye in the fibre increased both the average values of the red/green coordinates and yellow/blue coordinates increased. The colour of the cotton fibres dyed with the orange dye appeared yellower and redder while the concentration increased.

In every case, the average value of the lightness coordinates decreased as the concentration of dye in fibre increased; consequently, the colour of cotton fibers appeared darker.

Colour uniformity on a microscopic level based on the MSP results for fibre dyed with single reactive dye

To express colour uniformity in tested cotton fibres, sample standard deviations were calculated for every colorimetric coordinates. All statistical data in relation to the concentration of dye in the dye bath were presented in graphical form – an example of such a relation is shown on Figure 1.

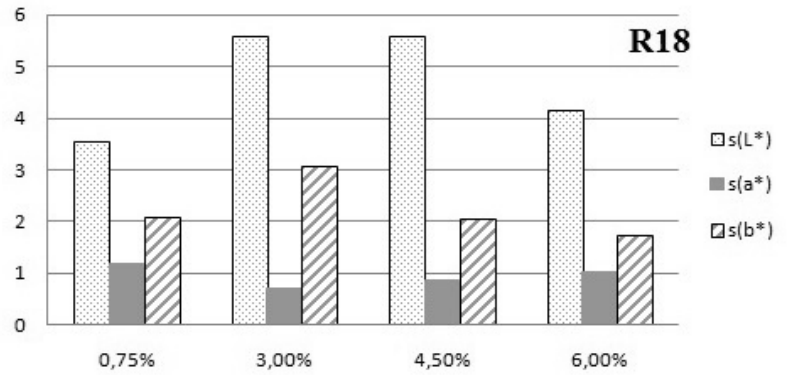

Figure 1. Sample standard deviation for colour parameter L*, a*, b* in relation to concentration of dye R18 used in dyeing process of cotton textile

Source: own research.

On the basis of the results obtained for each cotton sample dyed with single reactive dye, it can be concluded that there is no correlation between colour uniformity in the cotton fabric (taking into consideration changes in lightness, red/green and yellow/blue colour) and concentration of this type of dye. The dispersion of chromaticity coordinates in CIEL*a*b* colour space did not show a permanent upward/declining trends during increasing of the concentration of reactive dye used in the dyeing process.

Identification of dyes in fibres dyed with binary or ternary mixtures based on the Raman spectroscopy results

Comparing the spectra of colored cotton fibers with the spectrum of an uncolored fiber and the spectra of dyes used for coloring a given fabric, it was assessed whether identification of every component of a dye mixture is possible. In Fig. 2, example Raman spectra which were obtained using a 785 nm laser are shown, for standard cotton fiber (Co0), green-colored cotton fiber (Co5) and dyes R5, R8, and R1. Analysis of the obtained results indicated that low-intensity bands coming from the remaining dye R8 and R1 were observed; however, the presence of bands characteristic for the main component of the dye mixture, R5 was not confirmed.

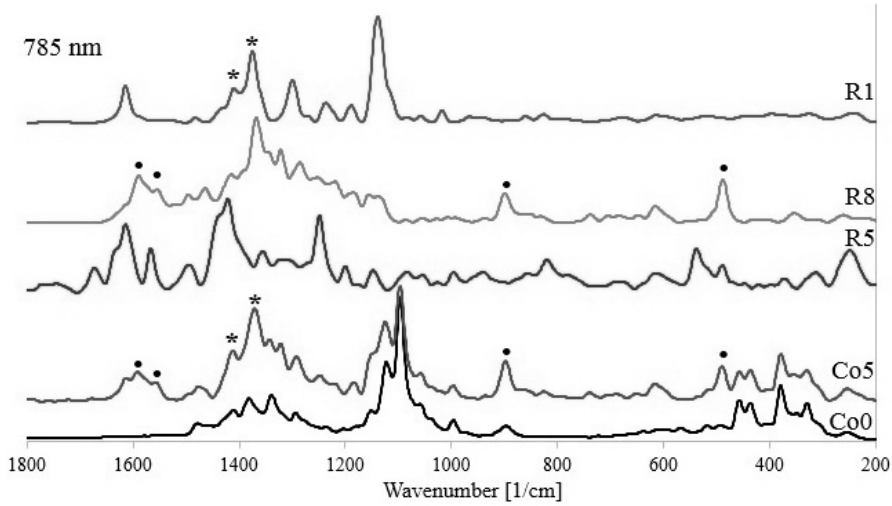

Figure 2. Juxtaposition of Raman spectra from cotton fibers and reactive dyes, obtained using a 785 nm wavelength laser; standard cotton fiber - Co0, green cotton fiber - Co5, dyes R5, R8, R1; * bands from dye R1, • bands from dye R8

Source: own research.

Recapitulating the results obtained for dyed cotton fibers, using all accessible lines of excitation, it was determined that:

1. in the case of all fibres coloured with a binary dye mixture, only one dye was detected, which was the main component of the mixture, and this pertained to 56% of these samples,
2. in the case of fibers coloured with ternary dye mixtures: three components were not detected in none coloured cotton fiber sample; in 61% of fibre samples, only one component was identified; in 11% of colored fibre

samples, two dye mixture components were identified, while in half of these cases the dyes identified weren't the ones of the highest concentration.

Conclusions

The results of the presented study demonstrate that when the concentration of dye rose, the colour of the cotton fibres dyed with blue dye appeared much greener and bluer. For orange fibres – they appeared yellower and redder whilst for red fibres the colour moved to red and to blue.

No correlation was observed between the concentration of reactive dye used in the dyeing process and the colour uniformity inside a cotton fibre. These preliminary findings are based on a limited number of known reactive dyes.

The studies conducted evinced the difficulty of identifying coloring components in cotton fibres which came from fabrics dyed with mixtures of reactive dyes - only one of the colouring components was most often identified, and in about 3/4 of cases this was the dye of the highest concentration. Identification of all dyes used in the dye mixtures was not successful in any of the Raman spectra obtained for cotton fibres.

The results of the presented study might find the practical use mainly in the examination of very important forensic traces such as the fragments of single cotton fibres.

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A COMPARISON BETWEEN INSTRUMENTAL TEST RESULTS AND SENSORY ANALYSIS OF SELECTED PROPERTIES FACILITATING GLOBAL EVALUATION OF COSMETIC EMULSION STABILITY

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Introduction

Because of the direct impact of cosmetics on human body and potential side effects that can be caused by the wrong composition of cosmetics or production in inadequate conditions, the process of making cosmetics is subject to detailed and strict legal regulations.

The European Union Cosmetics Directive and the regulations of the Minister of Health in Poland thoroughly describe all requirements and methods of testing the composition of cosmetic products. However, there are no standardized methods of testing other properties of cosmetics. Mandatory requirements that have to be met are in case of moisturizing cosmetic emulsions focused on ensuring the safety of their use, but do not stipulate the quality levels of the product, which is particularly important for the customers, who generally look for not only safe in use, but also high quality products.

Moisturizing cosmetic emulsions are distributed in sealed packaging insulating the products from the impact of microclimate conditions such as humidity and air movement that is why the tests could be conducted with the focus on the analysis of the impact of temperature and storage time on the speed of changes in these emulsions.

On the basis of practical tests and reference work review, the following hypotheses were posed:

- the use of sensory analysis allows to specify the properties with the highest dynamics of changes occurring during storage

- the results of sensory analysis of cosmetic emulsion consistency shows strong correlation in relation to the instrumental tests results, provided the correct selection of sensory testing methods.

Stability of cosmetic emulsion

The product's stability is characterized by its ability to maintain shelf life under specified conditions, which means that the product is fit for use and is in line with all requirements. The product's lifespan is defined as the time in which all quality properties of the product are maintained and do not exceed the critical value (maximum or minimum). The end of the product's lifespan is marked by its expiry date, beyond which the product becomes unfit for use. For obvious practical reasons, it is vital to determine the product's expiry date accurately. If the shelf life is too long it might lead to consumer's loss (the product bought will already be unfit or barely fit for use), if it is too short – it might lead to the manufacturer's loss (the product which still retains its high quality might be withdrawn from the market).

The physical changes in emulsions are usually relatively slow. It is, therefore, important to use accelerated stability tests. Their main goal is to determine the storage time in standard conditions. In general, however, the exact kinetic equations describing the course of ongoing changes are not developed. That is why, based on observation in artificially intensified conditions it is possible to forecast product's stability in standard, normal conditions of storage. The tests of accelerated aging are used to determine the relative stability of emulsion and to estimate the useful lifespan. The general method of accelerating the chemical products' lifespan tests is to determine their pace of aging in elevated temperatures and analyze the speed of changes with temperature. The obtained data is then extrapolated to a temperature at which the product is stored or used. The accelerated aging process used for the purposes of this study was conducted at 45 ± 2 ºC.

In order to determine direction and intensity of changes of selected properties of moisturizing cosmetic emulsions, and then to identify the property which is characterized by the highest dynamics of changes, three stages of sensory analysis were carried out.

The analysis of the market share of individual manufacturers and the results of interviews with the employees of the distribution network of cosmetic emulsions allowed for the selection of fifteen products that were tested. In the selected group of emulsions were the products offered by market leaders, as well as the products of companies with small market share. Products were marked with special two-letter codes.

Consumer evaluation

In the first stage of sensory analysis the consumer evaluation was performed. It was carried out by 518 individuals who had not been previously trained in terms of sensory analysis and proper selection considering sensory sensitivity. Every assessor received three sets, each of them containing two coded samples (a fresh sample and an accelerated aging sample – storage in 45 ºC for four weeks). The assessors' task was to determine the preferences by using the paired comparison test and to point out which of the properties (scent, color, consistency) influenced their choice. It was possible to select all three properties or not to select any of them. The selection of the above mentioned properties as the markers of the changes in quality of cosmetic emulsions is the result of the previously conducted research on consumer preferences in terms of the quality of cosmetic emulsions (Szakiel 2012).

According to PN-ISO 5492, the preference is defined as an emotional attitude towards the product or the assessor's reaction leading to the final evaluation of the product as a better than another one (or several other products). Before the evaluations started, all samples were stored for 24 hours in normal conditions, similar to those in which the actual evaluation was later carried out.

Table 1. Consumer preferences results

Sample symbol	„Fresh" sample	Accelerated aging sample
AA	71	33
DH	95	9
GI	75	29
JB	74	28
KA	89	13
KC	72	30
LB	83	22
LN	82	23
NH	48	57
NR	66	38
SB	93	11
SI	78	26
VL	94	9
WH	83	20
ZH	66	37

Source: own research.

On analyzing the results (see: table 1) it can be observed that the assessors preferred the fresh samples to the ones which were subject to accelerated aging. The only exception here was the preference of emulsion with the code NH. It was the only case in which the assessors actually preferred the accelerated aging sample to the fresh one. Also, in cases of products coded with NH, NR and ZH - the preferences in pairs were not statistically significant.

The obtained results allow to measure scientifically the impact of changes in scent, color and consistency on the choice of samples. As shown in table 2, in case of as many as twelve products – the most critical property influencing the assessors' choice was the consistency of emulsions. Three remaining products were selected based on their scent; however, it has to be mentioned that there was no significant difference here between the scent and consistency.

Table 2. The impact of changes in scent, color and consistency on the choice of "fresh" and aged samples

Sample symbol	Color	Consistency	Scent
AA	3	65	37
DH	12	69	41
GI	20	56	37
JB	12	46	33
KA	10	65	29
KC	18	54	37
LB	21	64	42
LN	9	71	34
NH	14	62	43
NR	16	79	42
SB	19	49	54
SI	11	63	38
VL	8	62	69
WH	14	48	51
ZH	31	67	33

Source: own research.

According to research results, it seems that the key property strongly influencing the general evaluation of the product, and which is characterized by a high dynamic of changes during accelerated aging, is the emulsion's consistency. Consistency is understood as a degree of cohesion and density as well as viscosity of the product. Due to the form and chemical character of cosmetic emulsions, the dynamic viscosity was chosen as the best factor describing consistency. Therefore, the remainder of this paper focuses on the

study of dynamic viscosity changes as an indicator of unfavorable changes in moisturizing cosmetic emulsions during the process of aging.

Dynamic viscosity is dependent on the internal structure of the emulsion, which is macroscopically decisive in terms of the product's properties. From the thermodynamic point of view, all emulsions are unstable (Brud & Glinka 2001; Marcinkiewicz – Salomonowiczowa 1995). However, in practice, relatively stability and stable emulsions can be easily produced. In order to achieve success and to retain the position on the market it is vital to minimize the unfavorable changes in the quality of manufactured goods, and here in terms of cosmetic emulsions – it is as important on the level of distribution as when the product is already purchased by the customer. Here the most common mistakes are made in terms of the conditions of storage.

The conditions of storage are understood as the microclimate factors such as air temperature and humidity, influence of solar radiation, and intensity of air movements. The stability of cosmetic emulsions may be threatened by the quantitative and qualitative changes in their composition, as well as internal changes in their structure. Quantitative changes in the composition are associated with the processes of releasing volatiles and evaporation. The intensity of these changes in strongly correlated with air movements and storage temperature (Gajewski & Kaniewski 2005). This can lead to the disorder in the ratio of the disperse and dissipated phase, which eventually brings unfavorable changes in physical properties of cosmetic emulsions and a decrease in product's quality.

The qualitative changes are due to chemical changes and can be the result of the impact of solar radiation and temperature. Chemical changes can be particularly harmful to human health and therefore all cosmetic products need to contain stabilizers such as preservatives and antioxidants, whose main goal is to prevent or minimize such changes. The effectiveness of such substances, however, decreases depending on how far the real storage conditions are from the ones recommended by the manufacturer.

The main role in minimizing the unfavorable impact of microclimate factors is the proper selection of product's packaging. A properly selected packaging, apart from insulating moisturizing cosmetic emulsion from the adverse effects of external factors, should also allow for the convenience of use i.e. dosage, storage, which influences the final evaluation of the product by the consumer.

In case of cosmetic emulsions available in retail, the most commonly used is tight sealed packaging made of polyethylene, polypropylene, and sometimes of polyethylene terephthalate. Such packaging isolates the product from the influence of some of the microclimate conditions such as humidity, air movements and to some extent – solar radiation. In order to minimize the unfavorable changes in moisturizing cosmetic emulsions due to storage

temperature, producers usually recommend the storage of the product in tightly closed packaging, in room temperature and in places not exposed to direct sunlight.

Bearing in mind the fact that the packaging made of plastic effectively isolates the product from generally all microclimate conditions except from the temperature, the considerations on the impact of storage conditions on the quality of moisturizing cosmetic emulsions were limited to the study of the influence of temperature on the changes in product's quality.

Sensory evaluation

In order to verify the results of consumer evaluation – the participants had no previous training in the field – and to be able to perform selection based on sensory sensitivity, it was decided to form a team from among the assessors and that team carried out the sensory evaluation in laboratory conditions.

The consumer evaluation presented in chapter two, despite having used appropriate methods and techniques, cannot be classified as sensory analysis per se. It was carried out in non-standardized conditions by individuals who had not been previously trained in sensory analysis and no selection in terms of sensory sensitivity was conducted (Baryłko-Pikielna & Matuszewska 2009; PN-EN ISO 5492).

There are precise rules and requirements set out by (PN-EN ISO 6658) that have to be met while conducting sensory analysis. The aim of which is to minimize the fluctuations in the indications of human senses; in case of sensory analysis human senses serve as measuring instruments. It has to be noted, however, that due to the use of senses as measuring instruments the results can be affected by many errors resulting, for example, from the psychophysical condition of the assessors. The tests aiming at the selection of sensory team have been carried out on the basis of all rules and requirements in the field of sensory analysis.

Given the fact that the sensory team was supposed to evaluate the color, scent and consistency of cosmetic emulsions, detailed sensitivity tests were restricted to the sense of smell, sight and touch (PN-EN ISO 5496 & PN-EN ISO 8586).

The analysis of results obtained by individual assessors, allowed to qualify as many as 38 individuals, out of 45 previously pre-qualified, to the assessment team.

Assessment of acceptability of emulsion's scent, consistency and color

The team of assessors carried out two rounds of tests: during the first one, the accelerated aging samples were assessed (at 45 degrees Celsius for 4

weeks); in the second one the accelerated aging samples (at 45 degrees Celsius for 8 weeks). In both rounds the accelerated aging samples were then compared with fresh samples. Before the evaluations started, all samples were stored for 24 hours in normal conditions, similar to those in which the actual evaluation was later carried out.

At each stage two evaluations were performed: the evaluation of color, scent and consistency in nine-point hedonic scale, and the evaluation of viscosity using a linear scale. The hedonic scale used in evaluation of color, scent and consistency involved assessing the samples by giving them marks from 1 to 9, with 1 being highly unacceptable and 9 particularly acceptable. According to (PN-EN ISO 5492), the acceptability is understood as the emotional attitude of the assessor to the product or the product's properties, and the level of acceptability can be measured as a degree to which the consumer might like or dislike that product or its properties.

Table 3. Evaluation results of color, scent and consistency in hedonic scale for fresh and 4-weekk aged samples

Sample symbol	„Fresh" sample			Accelerated aging sample		
	Color	Consistency	Scent	Color	Consistency	Scent
AA	5.05	5.91	6.16	4.78	5.46	5.84
DH	6.11	5.84	4.65	5.53	4.67	3.97
GI	6.14	5.59	5.51	6.26	4.91	5.23
JB	5.70	6.43	5.30	5.23	5.49	4.71
KA	5.87	5.36	6.18	5.00	4.23	5.71
KC	6.05	4.87	5.82	5.68	4.32	5.39
LB	6.34	6.29	6.17	5.91	5.46	5.62
LN	6.06	5.36	5.08	6.19	4.83	5.21
NH	5.97	4.71	5.61	5.83	4.47	5.32
NR	6.24	5.73	6.03	6.13	5.33	5.97
SB	6.26	5.82	5.97	5.84	4.91	5.66
SI	5.66	6.16	5.92	5.29	5.65	5.52
VL	6.08	6.35	6.08	5.93	4.87	5.47
WH	5.90	4.62	4.77	5.44	3.98	4.38
ZH	6.26	5.42	5.55	5.88	4.95	5.68

Source: own research.

On analyzing the results as shown in tables 3 and 4, it can be observed that there is a distinct difference in average scores of the properties of fresh samples obtained during the second round of tests in relation to the results obtained in the first round of tests. Such difference might arise from a so called contrast effect (Szakiel & Turek 2005). It is a type of error that occurs when

dissimilar objects of the same kind are being compared. The contrast effect highlights the differences between the objects and that might have been the reason why the average scores of emulsions' properties were slightly higher in the second round of tests. The members of the sensory team of assessors were informed about potential errors that might occur during evaluation, which might have contributed to minimizing differences that can be observed.

Table 4. Evaluation results of color, scent and consistency in hedonic scale for fresh and 8-weekk aged samples

Sample symbol	„Fresh" sample			Accelerated aging sample		
	Color	Consistency	Scent	Color	Consistency	Scent
AA	5.15	6.10	6.34	4.58	5.10	5.67
DH	6.26	5.99	4.70	5.00	3.38	3.52
GI	6.27	5.67	5.60	6.46	4.30	4.96
JB	5.84	6.62	5.40	4.90	4.63	4.11
KA	5.90	5.37	6.28	4.14	3.12	5.29
KC	6.09	5.07	5.98	5.28	3.91	5.05
LB	6.50	6.48	6.27	5.63	4.60	5.16
LN	6.19	5.42	5.26	6.38	4.34	5.47
NH	6.10	4.88	5.63	5.77	4.32	5.13
NR	6.31	5.74	6.22	6.07	4.87	6.08
SB	6.45	5.99	6.11	5.59	4.17	5.44
SI	5.80	6.26	6.11	4.96	5.07	5.23
VL	6.16	6.54	6.11	5.80	3.66	4.89
WH	6.02	4.76	4.79	4.98	3.43	3.98
ZH	6.44	5.47	5.74	5.41	4.46	5.76

Source: own research.

Assessment of viscosity of the emulsion by means of linear scale

The analysis of the results of consumer preferences and acceptability of selected properties of cosmetic emulsions allows to draw conclusions that the property which is affected to the greatest extent by the time of accelerated aging is consistency. It can be therefore inferred that the emulsion's property most prone to changes and strongly affecting the product's evaluation is its consistency. Consistency is understood as a degree of cohesion and density as well as viscosity of the product. Due to the form and chemical character of cosmetic emulsions the dynamic viscosity was chosen as the best factor describing consistency. Therefore, the remainder of this paper focuses on the study of dynamic viscosity changes as an indicator of unfavorable changes in moisturizing cosmetic emulsions during the process of aging.

The last stage of sensory analysis was the assessment of viscosity of moisturizing emulsions, at which the assessors were to estimate the level of viscosity by the means of non-structured, bi-polar linear scale. First, the fresh samples were assessed. The next round of tests was carried out with the accelerated aging samples after 28 days. The final round was carried out after 56 days for both types of samples. In order to facilitate the assessment a 100mm bi-polar scale was used and reference samples were also introduced: water at zero and at maximum – an emulsion with the following composition: Aqua, Paraffinum Liquidum, Mineral Oil, Glycerin, Stearic Acid, Cetearyl Alcohol, Ceteareth-20 with dynamic viscosity of 3000 mPas and constant shear rate D = 50 s-1 (Glinka 2001; Malinka 1999).

Separate scores were expressed as a distance (measured in millimeters) from the zero point on the scale. Such value reflects the intensity of the property (in percentage) in relation to the maximum point of the scale used. The average scores for the samples stored in room temperature conditions are presented in table 5, and the average scores for accelerated aging samples can be found in table 6.

Table 5. Viscosity evaluation results for samples stored in 20 ºC

Sample symbol	Aging period [days]		
	0	28	56
AA	57	61	61
DH	21	23	28
GI	43	43	46
JB	48	49	49
KA	54	58	58
KC	23	25	25
LB	44	43	48
LN	28	31	30
NH	26	26	28
NR	32	32	33
SB	66	65	68
SI	70	71	71
VL	26	26	28
WH	37	36	39
ZH	69	69	76

Source: own research.

Table 6. Viscosity evaluation results for samples stored in 45 ºC

Sample symbol	Aging period [days]		
	0	28	56
AA	57	65	65
DH	21	26	27
GI	43	44	52
JB	48	52	53
KA	54	60	61
KC	23	26	35
LB	44	44	50
LN	28	36	35
NH	26	26	32
NR	32	33	37
SB	66	68	80
SI	70	77	78
VL	26	28	38
WH	37	47	50
ZH	69	84	86

Source: own research.

Instrumental evaluation

In order to investigate the precision level of subjective assessment results of viscosity levels obtained during sensory evaluation, the same samples were subject to the measurements of the dynamic viscosity at low shear rate. Viscosity is defined in physics as a property of fluids characterizing their resistance to streamline flow under the influence of external forces. The resistance of the liquid is caused by the internal friction occurring during the movement of fluid layers. A modern rotary viscometer Rheotest RN 3.1 produced by RHEOTEST Medingen GmbH was used for measurements. The instrument operates at the torque level between 0.1 ÷ 160 mNm and rotational speed of 0.1 ÷ 1000rpm. The S1 measuring system used here allows for measuring the viscosity at shear rate of 0.13 ÷ 1300 s-1. The measurement system consists of a rotor and a movable outer cylinder coaxially arranged. For measurement purposes, 35 cm3 of the investigated sample were put into the outer cylinder and then the measuring rotor was placed. The outer cylinder was then placed in the thermostat which maintained a stable temperature of

20 ºC (with accuracy up to0.1 ºC) during entire test. All tests were conducted at a constant shear rate D = 50 s-1. The results are presented in tables 7 and 8.

Comparison of the results of sensory and instrumental evaluation

Due to the fact that in the course of instrumental evaluation a linear scale with reference samples (of which the viscosity is generally known) was used, it was possible to properly analyze the obtained results of sensory evaluation and corresponding values of dynamic viscosity. In order to compare the consistency of the results between the evaluation with the use of instrumental methods and sensory analysis, a correlation coefficient was calculated.

Table 7. Comparison between sensory evaluation of viscosity and corresponding instrumental results for samples stored in 20 ºC

Sample symbol	Instrumental measurements			Sensory evaluation			Correlation coefficient
	Aging period [days]			Aging period [days]			
	0	28	56	0	28	56	
AA	1912	1972	2022	1710	1830	1830	0.891
DH	789	830	858	630	690	840	0.937
GI	1391	1445	1492	1290	1290	1380	0.847
JB	1354	1389	1416	1440	1470	1470	0.904
KA	1733	1776	1802	1620	1740	1740	0.932
KC	791	846	882	690	750	750	0.921
LB	1189	1230	1265	1320	1290	1440	0.727
LN	827	865	891	840	930	900	0.729
NH	756	804	830	780	780	840	0.770
NR	933	973	1011	960	960	990	0.860
SB	1817	1892	1944	1980	1950	2040	0.574
SI	2195	2271	2335	2100	2130	2130	0.890
VL	731	774	812	780	780	840	0.846
WH	1237	1285	1337	1110	1110	1170	0.876
ZH	2010	2072	2119	2070	2070	2280	0.825

Source: own research.

Table 8. Comparison between sensory evaluation of viscosity and corresponding instrumental results for samples stored in 45 ºC

Sample symbol	Instrumental measurements			Sensory evaluation			Correlation coefficient
	Aging period [days]			Aging period [days]			
	0	28	56	0	28	56	
AA	1912	2068	2219	1710	1950	1950	0.871
DH	789	891	998	630	840	960	0.986
GI	1391	1541	1675	1290	1320	1560	0.898
JB	1354	1461	1564	1440	1560	1590	0.948
KA	1733	1868	2003	1620	1800	1830	0.924
KC	791	942	1086	690	780	1050	0.956
LB	1189	1298	1391	1320	1320	1500	0.842
LN	827	939	1038	840	1080	1050	0.824
NH	756	837	928	780	780	960	0.882
NR	933	1057	1143	960	990	1110	0.906
SB	1817	2029	2183	1980	2010	2400	0.852
SI	2195	2368	2541	2100	2310	2340	0.917
VL	731	859	992	780	840	1140	0.937
WH	1237	1428	1619	1110	1170	1500	0.928
ZH	2010	2208	2359	2070	2520	2580	0.944

Source: own research.

Conclusions

The results of the study show that there is a high consistence in the results of the tests carried out with the use of sensory analysis and instrumental methods. The calculated correlation coefficients were all in the range of 0.57 and 0.99 and the median value was 0.86 which proves a strong correlation between these two methods. However, despite the fact that the correlation of the results is so strong, a particularly low resolution of this method (1 mm on the scale equals 30mPas) significantly limits the possibility of using it to assess the stability of cosmetic emulsions (based on the evaluation of the emulsion's viscosity).

As shown in tables 1-4 some assessors were able to observe the difference in the properties of the emulsion at different stages of its accelerated aging, therefore the future research will attempt at changing the uniform scale 0 - 3000 mPas to another one with the range of values suitable to the viscosity of

investigated emulsion samples. With such a narrowed scale, the assessors will be required to present a higher sensory sensitivity, which of course will lead to the development of a brand new, more restrictive, participant selection method.

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THE USE OF BLIND TESTS IN SENSORY EVALUATION OF COSMETIC PRODUCTS ON THE EXAMPLE OF EYE CREAMS

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Introduction

The global cosmetics industry is now growing dynamically. The cosmetics market in Poland reached the level of 3.3 billion euro in 2011 and was ranked 6th in Europe. Market analysts from Euromonitor International estimate that, despite the possible slowdown on the cosmetics market, the situation in Poland will be quite the contrary and the Polish market should be growing much faster than any other leading one, thus reaching the revenues of well over 3.5 billion euro by 2016. An ever increasing complexity of the market and a growing number of cosmetic products available in Poland make the consumer's purchase decision much more difficult than only a couple of years ago. The authors of a very successful promotional campaign of Polish cosmetics (the project was commissioned by the Ministry of Economy in 2012) point out that the growing diversity of the cosmetics market in Poland is a result of its particularly good flexibility. Both small and medium-size manufacturers easily and quickly respond to changes in consumer needs and are able to address them effectively within a shorter period of time than the big, international players. Such manufacturers have relatively small production lines and are able to apply changes in the production process without having to face with extremely high costs. However, those times when Polish products could successfully compete with the foreign ones only in terms of their low price tag are over and, most likely, will never return again. Nowadays, in order to gain a competitive edge over the big players, Polish manufacturers have to invest in modern production lines, research and development programs and they have to be able to offer innovative products. The main focus is, however, not only on the products but on the packaging and marketing communication as well (*Cosmetics industry* 2014). As a result, modern consumers are oftentimes faced with extremely aggressive and almost

omnipresent cosmetics advertising. A particularly wide range of products available on the market does not facilitate the choice of the best one.

Commodity Science, which puts the product and its quality in the center of research, strives to provide the consumers with accurate and objective information about these products. Based on such information, a consumer should then make a good purchase decision (Turek 2013). Undoubtedly, the purchase decision is a result of several factors coming to play such as: the product's brand, packaging and price. Consumers, according to Iwasiewicz, generally tend to choose the cheapest product from among the best ones offered within their financial possibilities (Iwasiewicz 1999). Considering all of the above it should be also remembered that the most basic features of the product, and maybe even the most important of all, are the properties that arise from the product's primal purpose.

The analysis of independent tests of cosmetic products conducted by certified laboratories prove that there is no close relationship between the quality of the product and its price. The fig. 1 shows the empirical distribution of the tests where the classes were determined based on the Spearman's rank correlation coefficient. As shown in the histogram, most of the results are located between 0,2-0,4. It proves that there is no strong correlation between the parameters: quality – price (for more information on the relationship quality and price can be found (Turek 2013)). Thus, there is no linear relationship between high price and high quality of the product. In case of cosmetic products, high price does not necessarily ensure higher quality.

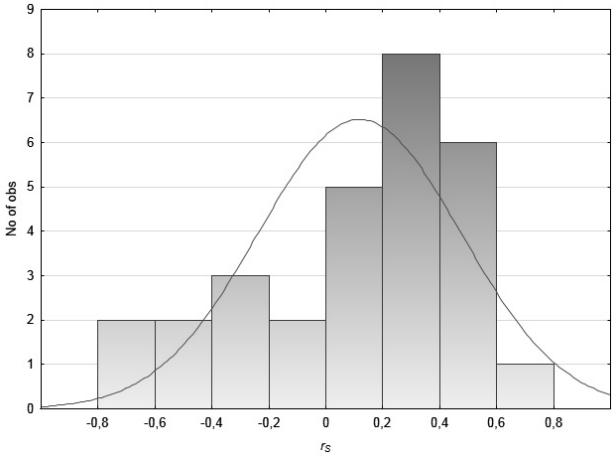

Figure 1. Spearman's rank correlation coefficient in cosmetic product tests

Source: (Turek 2013).

The aim of this study was to show the use of blind tests in sensory evaluation of cosmetic products. Based on the results of conducted tests, the product's brand and price were also examined in relation to their sensory properties. From among dozens of different cosmetic products available on the market, the eye creams were chosen for the purpose of this research. The manufacturers of each analyzed product hailed their creams for their amazing effects such as wrinkle reduction, dark circles removal and so forth. The study aimed to verify what the real effects of the eye creams are. In order to eliminate confounding variables such as the brand image or the price, the blind test was introduced. Blind tests ensure that the assessor's opinion is unbiased by any external or internal factors.

Materials and methods

The study was conducted in two stages. The first phase consisted of a survey whose main aim was to find out the general opinion of respondents regarding eye creams and the knowledge of products and brands available on the market. The research was performed among 150 women (feedback level – 83%) of different ages, residing in different areas and with different level of education. The survey posed questions about the sources of information regarding cosmetics, the popular brands and general knowledge of brands, as well as whether there is any relationship between the product's price and quality. Based on the results of this survey, the products and assessment criteria were selected for the second stage of the research. The next phase consisted of sensory evaluation which was conducted in home conditions ("Home Use tests" H-U). Such tests have a higher success rate and give more complex results since they are performed in a normal use conditions, and the assessors have more time to test the products than during the Central Location tests "C-L" (Baryłko-Pikielna & Matuszewska 2009, Meilgaard, Civille & Carr 1999). Eight eye creams were tested. Seven of them were brand products purchased in retail shops, and one of them was made by own recipe especially for the purpose of the study. The eye creams were selected from different price range and from among different brands. The table 1 shows the products' brand names and their average price.

Selected ingredients and their percentage composition (per 15ml of the product) are shown in table 2. The ingredients were chosen in a way as to create O/W emulsion. Skin around eyes is particularly delicate and sensitive. This area contains small amount of subcutaneous fat, and the skin is very thin there. There are also fewer sebaceous glands than in other parts of face, which leads to a very common skin problem: over-drying, and of course, to the appearance of wrinkles. Therefore, the eye cream ingredients should boast such selection that smoothes and/or prevents formation of wrinkles and

alleviates the signs of fatigue (Bender 2001; Brud & Glinka 2001; Glinka & Glinka 2008).

Table 1 Selected products

Brand	Prices in EUR 10ml	Code number in the blind test
Bielenda Professional Ideal Skin	1.9	471
Mary Cohr - New YouthEyeContour	34.8	357
Ziaja Sopot Rozświetlenie	1.1	699
Sensai/KanebоEyeContourBalm	74.7	357
L'Oreal Kod Młodości	11.4	102
CliniqueAllAboutEyeRich	27.5	510
OriflameAqua-Rhythm	8.1	133
Eye cream - own recipe	1.7	873

Source: own work.

All eye creams were given separate codes, which are shown in table 1. Four test groups were created. Each group consisted of 15 assessors in the following age combination: 5 people under 30 years of age, 5 people between 30 and 50 years of age, and 5 people over 50. The eye creams were put into 25ml containers and divided into 4 sets. Each set consisted of two different creams. In each pair the main and immediately observed properties were tested first. Such characteristics can be evaluated even after the first use. They were: scent, consistency, homogeneity, application, absorption, hydration and moisturizing properties (*Laboratorium podstaw syntezy i technologii związków biologicznie czynnych* 2012). Then the properties observed in the long-run were tested – the ones whose aim is to optimize the cosmetic effect of the product. The evaluation of such properties is only possible after a considerably long period of use. The following effects were tested: smoothing of the under eye skin area, dark circles reduction, improvement of skin appearance, skin firmness. Each of the eye creams was also given its general quality grade. All selected features were also assessed on verbally structured 5-point hedonic scale. Moreover, eye cream assessors were asked to choose the cream they prefer in each pair and to estimate how much they believed such a cream might cost (10 ml container). To determine statistically significant difference in preference among each pair of creams, the two-tailed test was used. The null hypothesis stated that there was no significant difference between the creams in each pair, the alternative hypothesis – on the contrary – that there was a difference between two creams. The level of statistical significance was α=0,05 (ISO 5495: 2007). The eye creams were

applied twice a day (in the morning and evening) for a period of two weeks, with each cream used on one side of face only.

Table 2. Eye cream ingredients – own recipe

Ingredients	Percent composition (%)	Composition by mass (g)
Phase A (61.5%)		
Cornflower hydrolate	28.0	4.20
Water	12.0	1.80
Glycerol	5.0	0.75
D-panthenol	3.5	0.53
Niacinamide	3.0	0.45
Lemon extract	3.0	0.45
Allantoin	2.0	0.30
Elderberry extract	2.0	0.30
Pine bark extract	1.5	0.23
Caffeine	1.5	0.23
Phase B (31,5%)		
Cocoa butter	5.0	0.75
Tucuma butter	5.0	0.75
Shea butter	5.0	0.75
Cetyl alcohol	4.5	0.68
MGS	4.0	0.60
Strawberry seed oil	1.0	0.15
Green coffee oil	1,5	0.23
Squalane	1.0	0.15
Chestnut oil	1.5	0.23
Almong oil	1.0	0.15
Coenzyme Q10	1.0	0.15
Vitamin E	1.0	0.15
Phase C (6%)		
Vitamin A	2.5	0.38
Vitamin C	2.0	0.30
Argan oil	1.5	0.23
Phase D		
Hyaluronic gel	1.0	0.15
Mica	q.s	q.s

Source: own work.

Results and discussion

The survey

No significant differences were observed between the groups of respondents in terms of age, residence and education, that is why the results from all groups were analyzed together. According to the respondents, the most reliable source of information about the cosmetics (fig.2) was own experience (74%). Personal recommendation was also very important (44%). The experts' opinion, information available on the Internet or the product's label came close – at almost 30%.

The study revealed that the cosmetics most often used by the respondents were the products manufactured by: Ziaja (77,60%) and Nivea (76%). These cosmetics had the lowest figures in terms of being known from the commercials only – Ziaja (8.8%) and Nivea (6.8%) respectively. The least popular cosmetics producer was Dr Nona. Only 4.8% of the respondents had ever used this brand of cosmetics and only 20.8% ever heard of it. The respondents also used the products of Bielenda, Olay, Eveline. From among more expensive products, the most popular were the following brands: Chanel, Dior, Yves Saint Laurent, Lancôme. But generally speaking, the respondents usually knew these products from commercials and advertising campaigns rather than personal use (a particularly high price of these products might be a barrier here) although as many as 20% of women in the survey claimed that they had already used the products of these brands.

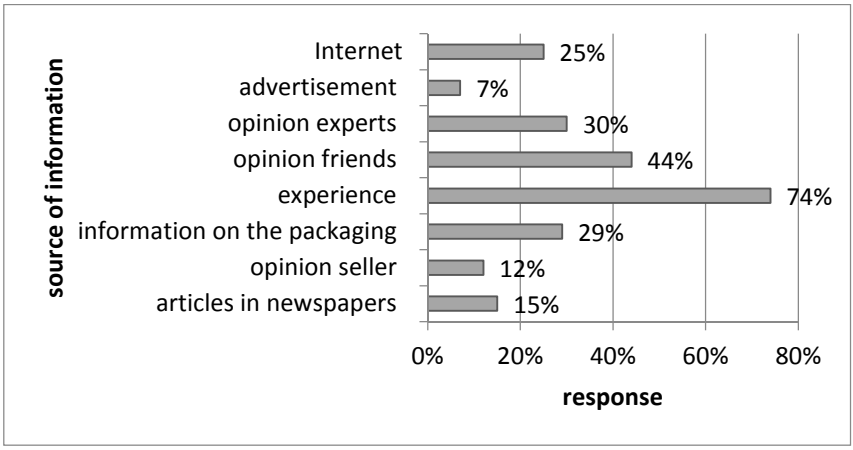

Figure 2. The most reliable sources of information about cosmetic products according to the respondents

Source: own work.

Table 3. Knowledge of cosmetics brands (%)

D*	R**	Brand	D	R	Brand
77.6%	8.8%	Ziaja	18.4%	40.0%	Chanel
62.4%	16.0%	AA	28.0%	28.0%	La Roche-Posay
48.8%	28.8%	Dr Irena Eris	18.4%	29.6%	Avène
8.0%	19.2%	Kwiaty Polskie	26.4%	24.0%	Iwostin
48.0%	29.6%	Vichy	4.8%	20.8%	Dr Nona
20.8%	31.2%	Biotherm	14.4%	30.4%	Yves Saint Laurent
51.2%	21.6%	L'Oreal	12.0%	18.4%	SVR
30.4%	27.2%	Bielenda	7.2%	20.8%	Celia
28.8%	36.8%	Olay	15.2%	26.4%	Farmona
36.0%	23.2%	Eveline	16.8%	17.6%	FlosLek
31.2%	26.4%	Dermika	28.0%	28.8%	Kolastyna
44.8%	30.4%	Soraya	52.8%	16.0%	Garnier
76.0%	6.4%	Nivea	18.4%	41.6%	Dior
30.4%	29.6%	Clinique	19.2%	33.6%	Lancôme
13.6%	0%	Other			

*D – a brand, whose products have been used by the respondents
**R – a brand known only from advertising campaigns or other people's recommendations

Source: own work.

It is worth noticing that none of the respondents mentioned any of the "private labels". This segment of the cosmetics market has been recently growing and there has been a gradual increase in sales of such products. In 2013, the overall share of private label sales among FMCG (fast moving consumer goods) amounted to 18.2% which was 1.5% more than in 2012. Moreover, in terms of value, the annual sales of private label products increased by almost 9%, while sales of branded products fell by over 2%. A whooping figure of 22% stands for the consumers who have bought more private label products this year than in the previous one. And although almost 50% of respondents claimed that the main reason why they choose private labels is their lower price, well over 25% of them believes that the quality of such products is equal to branded products. These results might serve as a basis for further research with the use of blind tests, comparing private label products with branded products available on the market. Almost 38% of respondents believe that there is no relationship between the quality and the price of the product. Only 28% claims that more expensive products are of higher quality. 34% of respondents answered: "I don't know". Based on the survey results it can be concluded that almost a third of respondents believes that the quality of the product corresponds with its price. The second stage of the research (sensory evaluation) aimed at determining whether such belief has any scientific grounds.

Sensory evaluation

In order to determine whether the samples evaluated in each pair have a differing level of significance the Mann-Whitney test was used. The results are shown in table 4. The values that differed significantly (at the level of 0.05) are in underlined (Mynarski 2003).

In the first pair, the cream with code no. 471 received the best grades in all evaluated characteristics. Statistically significant differences in favor of the cheaper cream were demonstrated in consistency, application, absorption, moisturizing effect, dark circles and swelling reduction and in overall grade. In case of other characteristics such as: scent, hydration, smoothness of the skin, improvement of skin appearance and firmness there were no statistically significant differences. The general price of the product estimated by the assessors was 6 euro. The real price was around 1.9 euro per 10ml of the product. In case of the cream no. 357 the average price was estimated at 4.5 euro whereas the market price was 35 euro per 10ml of the product. The final comparison between the creams in this pair was more favorable for the cream no. 471. Based on the obtained results in pair 1, the null hypothesis had to be rejected in favor of the alternative hypothesis. It should be noted that the cream which was evaluated as the better one, was in fact over 17 times cheaper than the other.

In the second pair the creams with code numbers 699 and 357 were tested. The market price of the cream no. 699 is 1.1 euro and of no. 357 is 75 euro. The cream number 699 had better scores in consistency, application and absorption. However, the cream no. 357 achieved better scores in reduction of dark circles and swelling and the improvement of skin appearance. The cream no. 357 had a statistically significant difference in overall grade. It was therefore evaluated as a better product. However, the assessors' task to directly select the better product fell through due to inconsistent responses. Generally, the price of cream no. 699 was estimated at 3.5 euro and the cream no. 357 – 4.8 euro.

In the third pair the creams with code numbers 102 (market price ca. 11.4 euro) and 510 (27.5 euro) were assessed. Based on the results of conducted study, there is no significant difference in the quality of these two products. The characteristics of both creams received similar scores. From among immediately observed characteristics, the cream no. 102 had better scores in consistency and application. The cream no. 510 had better scores in moisturizing effect. In terms of choosing a better product, the assessors' responses were inconsistent in this pair as well. The cream no. 510 was chosen by 8 respondents and the cream no. 102 – by 7. The estimated product price was at the level of 6.7 euro for the cream no. 102 and 5.6 euro for the cream no. 510.

Table 4 The results of the comparison of four pairs of creams

	code number							
	471	357	699	357	102	510	133	873
	pair 1		pair 2		pair 3		pair 4	
Immediately observed characteristics								
scent	3.5	3.9	3.8	3.2	3.4	3.3	4.0	2.7
consistency	4.9	2.9	4.1	2.3	4.2	2.9	3.7	3.8
application	4.3	3.7	4.4	2.7	4.1	3.1	3.9	3.4
absorption	4.3	3.6	4.3	3.3	3.9	3.5	3.3	3.2
hydration	4.0	3.7	4.0	4.0	3.7	3.7	3.5	4.1
moisture	4.1	3.2	3.4	3.9	3.1	4.1	3.1	4.4
Characteristics observed in the long run								
smoothing of the skin	3.9	3.4	3.3	3.8	3.7	3.5	2.8	3.9
dark circles reduction	3.7	3.1	2.9	3.5	3.3	3.2	2.5	4.2
reduction of swelling	3.5	2.8	2.9	3.8	3.1	3.2	2.8	4.3
improvement of skin appearance	3.7	3.4	3.1	3.7	3.6	3.5	2.9	4.1
skin firmness	3.5	3.3	2.9	3.4	3.2	3.6	2.5	3.9
overall grade	4.2	3.2	2.9	3.7	3.3	3.2	2.7	3.9

Source: own work.

The last pair of creams in the test was the set of code numbers: 133 and 873. The first cream was a branded product with the market price of ca. 8.1 euro per 10ml and the second one was a homemade cream based on own recipe (production cost ca. 1.7 euro per 10 ml). The cream no. 133 had a much better score in terms of the product's scent (4.0 vs. 2.7). However, the homemade cream obtained better scores in moisturizing effects (4.40 vs. 3.1) and almost all other categories. The estimated value of the product was 3 euro for the cream no. 133 and 4.2 euro for the homemade one.

Although all participants claimed that the homemade cream left a visible layer after application, it was generally considered as a positive factor (concealing dark circles). According to the assessors, the cream was also particularly effective in dark circles reduction. The only shortcoming of the homemade cream was apparently its scent. In two-tailed test the recipe cream was selected as a better one. Of course, given a very limited number of assessors it is impossible to claim that the recipe cream is better and would be preferred by the consumers. The test would have to be conducted on a much larger group of participants.

In order to determine whether there is statistically significant difference in overall grade among the creams in the study, the Kruskal-Wallis test was used. The null hypothesis was that, on average, there were no differences in the overall grades, the alternative hypothesis was that at least two average results would be different. The adopted level of significance was $\alpha = 0{,}05$. The test probability value was less than 0.05, therefore there are grounds for rejection of the null hypothesis (Mynarski 2003). It, of course, follows that the alternative hypothesis should be accepted. Taking into account the average scores of cream samples, the sequence of products was as follows: Bielenda cream achieved the best scores, then the own recipe cream, then Sensai/Kanebo, L'Oreal, Clinique, Mary Cohr, Ziaja. The Oriflame product had the worst score.

Conclusions

The results of blind tests in sensory evaluation have proved that branded products are not necessarily better in terms of their quality and sensory properties. There is no linear relationship between the high price and high quality; more expensive products did not receive better scores than the cheaper ones. Bielenda cream, which costs less than 2 euro, topped the ranking, the second best product was the own recipe homemade cream.

The final price of the product depends on several factors such as technological processes, product tests etc. On the other hand, it should be considered that the price of majority of expensive products is shaped by other factors as well, not directly related to the actual quality and purpose of the cream. That is why, a cheaper product might oftentimes boast similar or even better quality than much more expensive ones. It is therefore important to properly select the information about the product and see through the purely advertising slogans while making the purchase decision. This study proves that consumers generally rely on personal recommendation or own experience when choosing cosmetics goods. It is important to understand the role played by independent research institutions such as the International Consumer Research & Testing or consumer institutions like Consumer Federation. Such research organizations usually use blind tests in their studies. Eliminating external factors, like brand loyalty, attractive packaging or price leads to obtaining more accurate information about the product's real value in use. Sample coding is also slowly becoming a new research standard thus eliminating the most immediate external factors. Blind tests have been used for years and are now oftentimes used in promotional and advertising campaigns. The most famous example of this type of campaign is "The Pepsi Challenge". Nowadays, blind tests are also frequently used by bloggers. Unfortunately, it is usually forgotten that in order to organize a proper blind test several requirements have to be met. The samples have to be of similar

size, they have to be stored and applied in similar temperature and conditions, applications have to be measurable and the results have to be accurately interpreted. It is, however, certain that with the increase of competition on the food and cosmetic products market, blind tests will be more frequently used in research.

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CORRELATIONS BETWEEN PERFORMANCE PROPERTIES OF TEXTILES AND CONCENTRATION OF FABRIC SOFTENER IN RINSING BATH

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Introduction

Fabric softeners are household chemical products which are used in the washing process. They are added to the final rinsing bath in order to modify the fibre surface of the laundered fabric. Generally, fabric softeners reduce negative effects of washing, static cling and difficulties with fabric ironing, and smooth out the roughness of fabric fibres.

Fabrics rinsed in softener solutions have an improved "hand". In everyday terms, this quality is referred to as fabric softness. The majority of fabrics are made of fibres which have negative active centres on their surfaces. Cationic surfactant molecules introduced into the final rinsing bath can be easily adsorbed on fabrics, creating a kind of deposit on the surface of fibres. The presence of the deposit results in smoothing-out of the fibre surface and neutralization of the negatively charged active centres. In addition, the deposit facilitates fabric ironing due to a decrease in the coefficient of friction between individual fibres, and between the fibres and the surface of the iron (Kuo-Yann 1997, Levinson 1999, Mohammadi 2006, Przondo 2007, Wasilewski & Bogdańska 2007, Wasilewski & Ogorzałek 2009).

In addition to cationic surface active agents, commercially available fabric softeners also contain up to several percent of a fragrance composition. A pleasant scent is supposed to attract the interest of consumers during shopping. Moreover, fragrance compositions are adsorbed on fabric fibres, giving users an additional argument in favour of using softening agents. Manufacturers are constantly on the lookout for new, unique fragrance notes to appeal to prospective consumers. Fragrance compositions should last long enough, and should have a minimal skin irritation potential. From the point of

view of an average user, it is essential for fabric softeners to contain an appropriate amount of a fragrance composition.

The presence of fragrance compositions in fabric softeners and, consequently, the nice scent of laundered fabrics are usually very important factors for consumers. Not uncommonly, however, users adding a fabric softener to the rinsing bath fail to comply with the manufacturer's guidelines, and use increased amounts of the product. There is a risk, though, that an excessive amount of a softener added to the rinsing bath may lead to a number of adverse effects including the yellowing and excessive hydrophobization of fabrics which prevents effective water absorption (Lindhal 2006 & Zielinski 2013). Studies published to date do not provide precise information on the degree of fabric softener overdose which triggers a deterioration in parameters of the laundered fabric that are unfavourable for consumers.

The present study seeks to determine the effects that arise from using excessive amounts of a fabric softener in the final rinsing bath. Because the properties of rinsed fabrics depend primarily on the cationic surfactant (the main active ingredient of products of this type), solutions of a cationic surfactant were prepared using the following concentrations: 0.0001%, 0.001%, 0.01%, 0.1% and 1%. The solutions thus prepared correspond to rinsing baths containing both deficient and excessive amounts of a fabric softener.

The solutions represented reference baths in which samples of a cotton fabric were rinsed. After that, the softness of individual fabrics and their rewettability were assessed. To obtain additional information about the properties of different solutions, surface tension measurements were carried out.

Material and methods

Test material

The tests were performed with the material called Dehyquart AU 46 (Cognis, Germany), containing ca. 90% of bis-acyloxyethyl-hydroxyethyl methylammonium methosulphates and 10% of isopropanol.

Preparation of cotton fabric for tests

A cotton fabric with dimensions adjusted to needs was boiled in a bath containing 3 g of sodium alkyl benzene sulphate expressed as 100% of the active substance, 2 g of sodium hydrogen carbonate and 1 l of distilled water. The ratio between the weight of the fabric and the weight of the bath was maintained at 1:20. The fabric was boiled for 15 minutes in order to remove

interlinings and fabric finishers. After boiling, the fabric was manually rinsed five times in room-temperature water.

Softening effect

Tests assessing the effectiveness of softening were conducted in accordance with guidelines set out in the Polish Standard (PN-86/C-04833/02). The principle of the method is based on a comparative evaluation of fabric rinsed in a rinsing bath containing the test product with reference standards, a system for fabric hand assessment. The assessment is performed by a team of 10 testers, each of whom is tasked with comparing pairs of samples. Based on their own perception, the testers determine which of the two samples in a pair is softer. The softer fabric is then assigned one point. If a tester perceives both samples to be equally soft, each of them is assigned half a point. Each sample is compared with all the other samples, which means that a sample can be assigned a maximum of five points. The maximum score that can be obtained for the test product is 50, which corresponds to the maximum softening effect in a given test series.

Rewettability of rinsed fabric

The test was performed in accordance with the Polish Standard (PN-96/C-04833/03). The method involves a measurement of relative wetting height in samples of cotton fabric rinsed in a solution of the test product compared to a control sample, i.e. a piece of fabric rinsed in distilled water. The final result is the arithmetic mean calculated for three parallel tests.

Surface tension

Surface tension tests were carried out in the temperature of 22°C, and were based on the ring removal method. The tests were performed with a Lauda TD1 tensiometer. Values represented in the chart are average values determined for five independent measurements.

Results and discussion

Softening effect

The ability to soften fabrics is one of the key performance properties of fabric softeners. The effectiveness of softening depends both on the type and concentration of cationic surfactants which are contained in softeners (Kuo-Yann 1997, Levinson 1999, Wasilewski & Bogdańska 2007, Wasilewski & Ogorzałek 2009). Commercial fabric softeners are formulated with ca. 10%

of cationic surfactants. The amount of softener added to a rinsing bath is not more than 50 ml per 10-20 l of water. It follows that the concentration of surfactants in the rinsing bath is usually very low, between 0.01 and 0.1%.

Results of softness tests performed for fabrics rinsed in different baths are shown in Table 1 and in Figs. 1 and 2.

Fabric rinsed in a rinsing bath containing 0.0001% of cationic surface active agent received the softness score of 17. The result is 12 points lower than distilled water and 15 points higher than model fabric H. Looking at soft model fabric (S) and intermediate model fabrics (I1 and I2), it is evident that the test sample has a much lower score. For fabric rinsed in a rinsing bath with 0.001% of the cationic surfactant the score was 16, i.e. 12 softness points higher than the value recorded for model fabric H. The other scores obtained for distilled water, intermediate model fabrics (I1 and I2) and soft model fabric (S) exhibit the following differences in relation to the test sample: 13, 16, 19 and 18. The softness score of the fabric rinsed in a rinsing bath containing 0.01% of the cationic surface active agent is 19. The other scores obtained for different model fabrics demonstrate the following differences in comparison to the test sample: soft model fabric (S) – 14 points higher, intermediate model fabric (I1) – 14 points higher, intermediate model fabric (I2) – 17 points higher, hard model fabric (H) – 17 points lower. The softness score of the fabric rinsed in a rinsing bath containing 0.1% of the cationic surfactant is 32. Distilled water and hard model fabric (H) reach 24 and 2 points, respectively, i.e. values which are 8 and 30 points lower than the test sample. Values determined for the other model fabrics are equal to the test sample – with the exception of value obtained for the intermediate model fabric (I2) which is 2 softness points higher. The fabric rinsed in a rinsing bath containing 1% of the cationic surface active agent was assigned the value of 37, which is higher than distilled water and the model fabrics under discussion.

Table 1. Listing of results obtained in measurements of the fabric softening effect induced by aqueous solutions of cationic surfactants

Concentration of cationic surfactant [%]	Softening effect [%]					
	Sample	Fabric rinsed in water (W)	Model fabric - hard (H)	Model fabric - soft (S)	Model fabric – intermediate (1) (I1)	Model fabric – intermediate (2) (I2)
0.0001	17	29	2	34	33	35
0.001	16	29	4	34	32	35
0.01	19	27	2	33	33	36
0.1	32	24	2	30	30	32
1	37	26	2	28	28	31

Source: own research.

The tests demonstrated that an increase in the content of the cationic surfactant in the rinsing bath increased the effectiveness of fabric softening. Fabrics rinsed in solutions with surfactant concentrations ranging from 0.0001 to 0.001% have a low softness level – their point scores represented between 32 and 34% of the maximum possible score. The 0.1% and 1% presence of the cationic surface active agent in the rinsing bath has a major influence on the effectiveness of softening: fabrics rinsed in them achieved 64% and 74% of the maximum score, respectively.

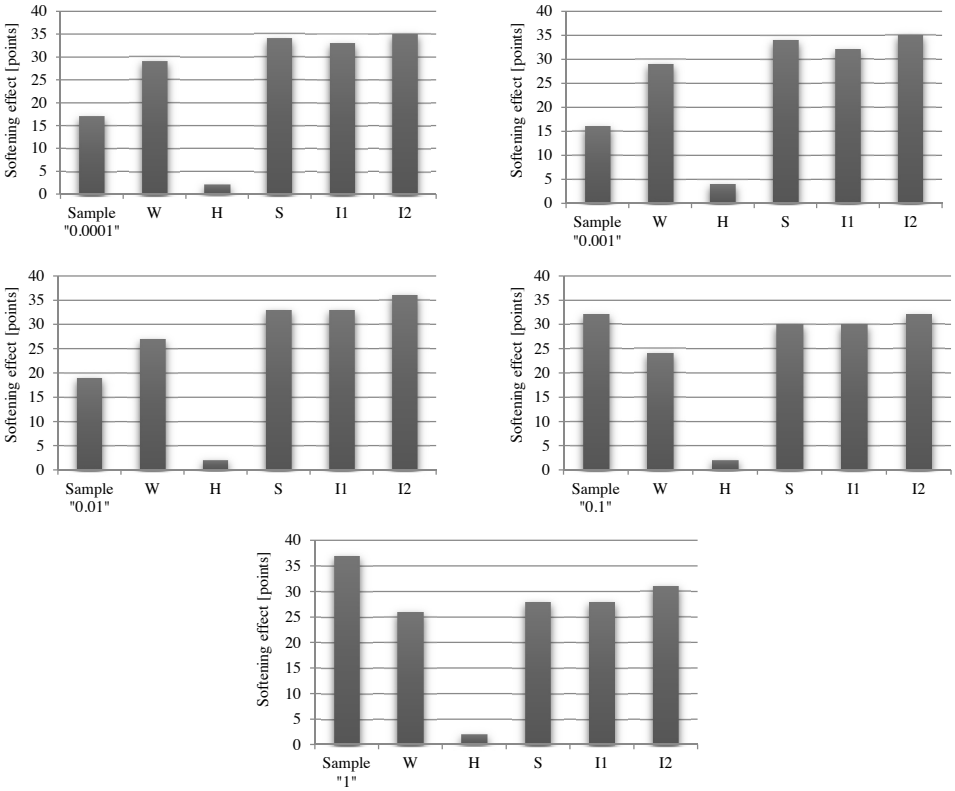

Figure 1. Fabrics softening by aqueous solutions containing various concentrations of cationic surfactants. W - fabric rinsed in water, H - model fabric - hard, S - model fabric - soft, I1 - model fabric - intermediate (1), I2 - model fabric - intermediate (2)

Source: own research.

Figure 3 illustrates changes in the degree of the softening effect observed for fabrics rinsed in rinsing baths in relation to two selected model fabrics: hard and soft.

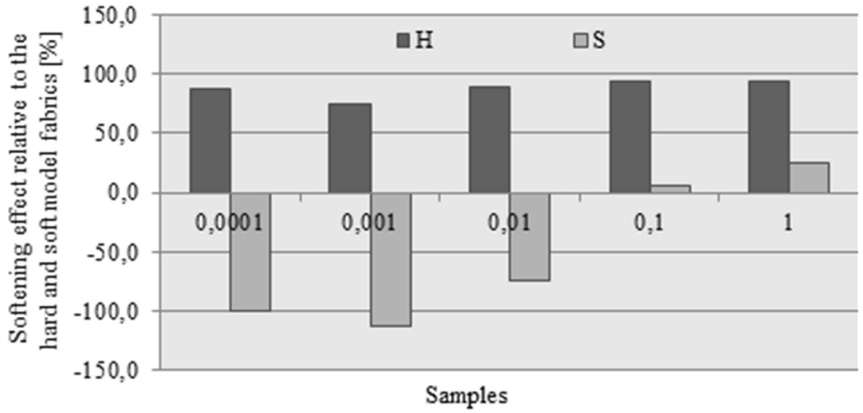

Figure 2. Softening effect relative to the hard and soft model fabrics

Source: own research.

Fabrics rinsed in baths containing the cationic surfactant at a concentration from 0.0001 to 0.01% were found to be softer (by ca. 80%) than the hard model fabric (H), however no favourable effect in properties was noted in relation to the soft model fabric (S). The values recorded are up to 112% lower. In contrast, fabrics rinsed in rinsing baths containing 0.1 and 1% of the cationic surface active agent had a higher softness score than both investigated model fabrics (H and S).

Rewettability of rinsed fabric

An assessment was performed to determine the rewettability of fabrics rinsed in aqueous solutions of the cationic surfactant. Results are listed in Figure 3.

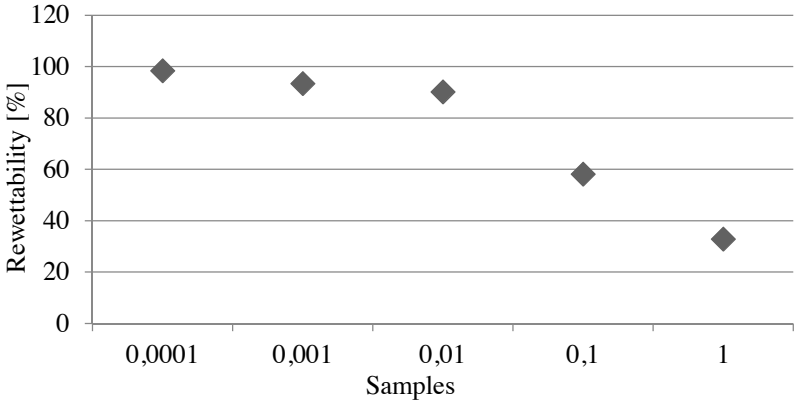

Figure 3. Rewettability of fabric rinsed in aqueous solutions of cationic surfactant

Source: own research.

Based on results of the assessment it was concluded that an increase in the content of the cationic surfactant in the rinsing bath causes a decrease in rewettability. For the surfactant's concentrations between 0.0001% and 0.01% the level of rewettability varies from 90% to 98%. A significant deterioration in rewettability (down to 58%) was observed for the 0.1% concentration. Also, fabric rinsed in the 1% solution had a very low water absorbability of just 33%.

The results indicate that already at the concentration of 0.1% cationic surfactants significantly saturate the fibre surface. Using a higher concentration of active ingredients in the bath may lead to a significant decline of hygienic properties of fabrics. The data show unambiguously that an overdose of fabric softener significantly decreases the comfort of use of clothes.

Surface tension

Cationic surface active agents display a tendency to accumulate near the interface, which supports the adsorption of these substances on the fibre surface, ultimately leading to the formation of a specific kind of deposit. The observed changes in surface tension of solutions as a function of concentration may be a premise for determining the concentration at which cationic surface active agents cause saturation of the interface (Zieliński 2013). If the content is further increased, various types of aggregates (micelles) are formed in the bulk phase.

Results of surface tension tests performed for aqueous solutions of cationic surface active agents at different concentrations are presented in Fig. 4.

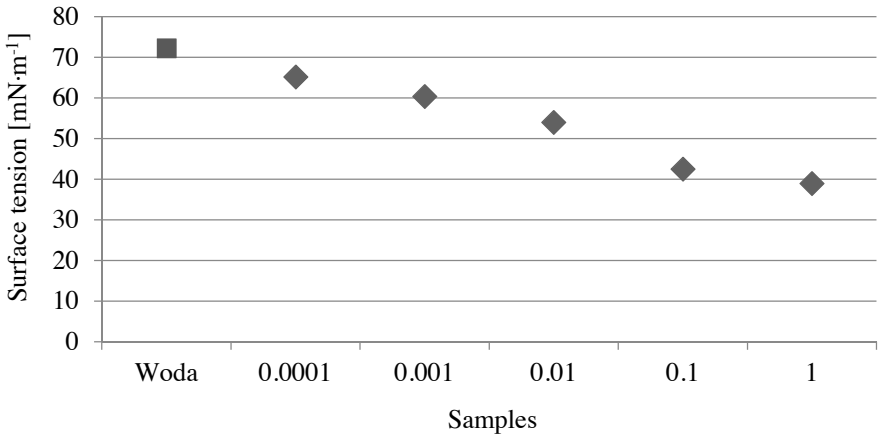

Figure 4. Correlation between surface tension and concentration of aqueous solutions of cationic surfactants

Source: own research.

It was observed that an increase in the concentration of the cationic surfactant, as expected, triggers a decrease in surface tension of solutions. The value of surface tension for water is 72 [mN·m^{-1}]. For a solution containing 0.0001% of the surfactant, σ is over 10% lower than for water. A rise in concentration brings about a drop in surface tension. For the highest of the test concentrations (1%), the value of 39 [mN· m^{-1}] was noted. It is nearly by half smaller than values recorded for water. Crucially, above the concentration of 0.1% there were no significant changes in the measured parameter. Therefore, it can be assumed that above that concentration level the surfaces are already completely saturated and a variety of micelles are formed in the volume phase of the rinsing bath.

Conclusion

The study reported above sought to examine the effect of a cationic surface active agent on the properties of fabrics rinsed in solutions of that agent. A range of laboratory tests were carried out for solutions with increasing concentrations of the cationic surfactant. One of the key properties that should be present in fabric softeners is the ability to lower the level of interface tension. Test results demonstrated that an increase in the content of the cationic surfactant had an impact on lowering the level of surface tension of solutions. However, above the concentration of 0.1% there are no significant changes in the measured parameter. The results were correlated with data describing the degree of softness of fabrics rinsed in different solutions. It was observed that the fabrics became softer along with increasing concentrations of the cationic surface active agent in a rinsing bath. The tendency is considered very desirable by consumers.

A limitation in the use of rinsing baths containing 0.1% of cationic surfactants are results of tests investigating fabric rewettability. In this case, the value of the measured parameter was found to decrease along with increasing concentrations of the cationic surfactant. From this point of view, the most beneficial concentration (ensuring the highest softness level while preserving the fabric's ability to absorb water) was 0.01%.

Summing up, it can be concluded that a rise in the concentration of cationic surfactants contained in fabric softeners has a significant impact on performance properties of these products. The finding is especially important in view of the fact that using disproportionate amounts of fabric softeners, and thus excessive amounts of cationic surfactants, yields negative outcomes. The fabric has a very low ability to absorb water, i.e. high hydrophobicity. To recapitulate, the use of rinsing baths with appropriately selected concentrations of cationic surfactants guarantees that the fabric will maintain proper quality.

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EVALUATION OF MONGOLIAN CASHMERE CLOTHING: COMPARISON BETWEEN MONGOLIAN WORKERS AND FOREIGN TOURISTS

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Introduction

Deemed one of the most luxurious materials obtained from animal, cashmere is largely used in expensive clothing. The global annual production of cashmere is 11,000 – 14,000 tons; 85% of them come from Mongolia and the plains of China's Inner Mongolia. Being the world's second largest cashmere producer after China, Mongolia supplies 7,000 to 8,000 tons of cashmere a year (*Mongolian Cashmere and Wool Report* 2012).

Mongolia spent 700 years under the Chinese control and 70 years under the Soviet Union as a satellite state. By 1989, it put an end to its socialist system and introduced the market economy in 1990. Its population density is the lowest in the world – approximately 2.8 million over the area of 1.56 million km^2 (Orth 2011). Thanks to the rich mineral resources such as copper, coal and gold, Mongolia has enjoyed rapid economic development in the recent years. In 2004, its per capita income was $400, which quickly rose to $3,575 by 2012 (*Report on Mongolia* 2013). However, mining accompanied environmental degradation, concentration of population in urban areas and other social issues.

The Mongolian cashmere industry can be divided into two: nomadic herding and manufacturing which includes washing, spinning, knitting and clothes-making. Since the start of the market economy in 1990, the demand for cashmere rose in the US and Europe and the herders quickly increased the number of cashmere goats they raised. Consequently, the grazing by the goats left the plains desolate, disrupting the habitat of wild animals and posing a grave threat to the ecosystem (Carrington 2013). Nonetheless, the Mongolian government offers a wide range of benefits (i.e., income tax exemption, low

tax rate, free supply of water) to the herders who are mostly nomads earning low income since herding is the foundation of the traditional Mongolian culture. While the rise of the cashmere goats brings more income to the individual herders, it inflicts severe damage on the ecosystem and results in the whopping social cost.

Furthermore, the production of cashmere fiber is highly unpredictable and cannot be controlled (Westhuysen 2005). For instance, the natural disaster that once hit Mongolia in 2010 killed a substantial number of cashmere goats. The cashmere produced in 2010 dropped to 3,000 tons but was quickly restored to its usual production level by 2011. Then in late 2000, the demand for cashmere products and their prices plummeted, following the global economic downturn (Mattis 2009). The unstable cashmere price is a matter of great concern to the suppliers in Mongolia. That cashmere is significantly affected by the market demand, climate and other external factors mainly due to the fact that the herders raising the goats and supplying the raw fibers account for a significant part of the Mongolian cashmere industry.

In Mongolia, the cashmere processing industry began in earnest with the inflow of the foreign capital in the 1990s. As of 2013, 50% of cashmere businesses in Mongolia deal with washing, 40% do both washing and combing, and only 10% carry out the whole process including the production of finished goods (Mongolian 2013). In Mongolia, washed and combed cashmere fiber is exported to China, Japan, Europe and more. Cashmere products can be divided into two: low/mid-priced and high-priced. The former is produced in China and Mongolia and the latter as the Italian or UK brands. The cashmere fiber market in Europe is relatively stable. While China is one of the main cashmere producers, it also imports 50% of the Mongolian cashmere fibers and has enormous influence on the Mongolian industry. The changes in the Chinese cashmere industry are closely linked to the Mongolian counterpart, especially because the growth of the cashmere market is driven by the low/mid-priced products mostly manufactured in China. In addition, bordered by China and Russia, the conflicts over cashmere with China not only affect the industry itself but also the political situation.

There are about 20 cashmere clothing brands in Mongolia. Gobi, a state-run company established in 1981, is one of the most well-known Mongolian cashmere companies. Ever since Gobi emerged, other companies also followed, such as Altai Cashmere or Goyo.

While the market demand, global economy, natural disasters and competition with China all affect the Mongolian cashmere industry, it is still the largest and most promising industry, next to mining. The Mongolian government has planned to assist the development of the industry, with a particular focus on the finished goods production and the shift to a high value-added industrial structure. From this perspective, this paper aimed to compare

the awareness on the Mongolian cashmere products by the local workers at the Mongolian cashmere companies to the evaluation by foreign tourists, in an effort to provide the guidelines that may help the Mongolian cashmere industry to develop.

Material and Methods

Instruments

For the purpose of the study, the surveys consist of two types. The Survey I was designed to conduct a research on the local workers at the Mongolian cashmere businesses, and the questions were on the evaluation of the Mongolian cashmere products, the current and future competitiveness, and the characteristics of the companies and respondents. The questions regarding the product evaluation were based on the research by Kim (2006). The questions on the current and future competitiveness were prepared by the researchers, such as "What do you think of the competitiveness of the Mongolian cashmere products in the global market?" or "How do you expect the competitiveness of the Mongolian cashmere products to change in the global market in the next five years?"

The Survey II was designed for foreign tourists visiting Mongolia. The questions asked the tourists how they evaluate or if they intend to purchase the Mongolian cashmere products, and about the demographic characteristics of the respondents. The instruments evaluating the Mongolian cashmere products were the same as the ones used on the local workers as mentioned above. The questions about the purchase intention were taken from the research by Anderson & Littrell (1995). All questions were measured on the 5-point Likert scale. The questionnaire was first phrased in Korean and then translated into Japanese, English and Russian by the bilingual experts. Then the third party experts, who are proficient in Korean and each of the four languages, were asked to translate the questions back into Korean, to be compared with the primary translation. The questions were then revised and finalized.

Data collection and analysis

To conduct a research on the local workers of the cashmere companies in Mongolia, the researchers visited the companies in Ulan Bator, the capital of Mongolia. Ninety sets of questionnaire were distributed to the local workers from July to December, 2012. Excluding insufficient responses, seventy nine questionnaires were used for final analysis.

Survey II was conducted on the foreign tourists from Korea, Japan, Russia and English-speaking countries, also in Ulan Bator from July to September, 2012. The questionnaire was distributed at department stores, restaurants, museums, galleries, tourist attractions and accommodations near Ulan Bator. A total of 626 surveys were collected. Ten questionnaires with inadequate answers were excluded and 616 questionnaires were used in the final analysis. 149 responses were from Koreans; 128 from Japanese; 220 from the English speaking countries; and 119 from Russians. SPSS 18.0 was used and the analysis was by descriptive statistics, t-Test, one way ANOVA, and Duncan's test.

Characteristics of Respondents

In the Survey I, there were more female local workers (68%) than male (32%) respondents. 47.4% of the respondents were in their 20s, 30.3% in their 30s, and 22.4% in their 40s. The job titles of the respondents were: CEO (9.1%), manager (18.2%), engineer (15.6%), administrative and sales (18.2%) and others (39%). In terms of work experiences, 35.9% worked between two to five years, 32.1% between five to ten years, and 23.1% less than two years. Those who worked ten or less years accounted for 91% of the total and those who worked longer were only 9.0%. 12.2% of the respondents were employed in material processing, 57.1% in knitted clothing manufacturing, and 30.6% were working in vertically integrated companies.

In the Survey II dealing with foreign tourists, 24.2% of the respondents were from Korea, 20.8% from Japan, 35.7% from English speaking countries, and 19.3% from Russia. 62.7% of the respondents were male, and 33.9% were married. The occupation of the respondents varied widely from government employees, teachers, military personnel, self-employed, housewives, salaried workers to those in the service industry. Respondents were relatively evenly spread in income distribution: 21.8% earned less than 2 million KRW (Korean Won) per month (approximately 1700 US dollars), 21.3% earned between 2 to 3 million KRW, 20.8% between 3 to 5 million KRW, 16.9% between 5 to 6 million KRW and 19.2% KRW 6 million or more.

Results and Discussion

Mongolian cashmere products evaluation by local workers

First, the researchers had the local workers evaluate the Mongolian cashmere products. As seen on Table 1, the workers thought highly of the products in terms of "Luxurious Brand", "High-end", and "Uniquely Mongolian", followed by "Trendy", "Sophisticated Design", "Distinctiveness" and "Excellent Quality". However, they evaluated low on

"Price Low for High Value" and "Low Price". It can be interpreted that the workers regard the Mongolian products as the luxurious brand items and do not consider them to be low-priced.

Foreign tourists thought most highly of the Mongolian cashmere products being 'Uniquely Mongolian', followed by 'High-end', 'Distinctiveness' and 'Excellent Quality'. As Mongolian workers, foreign tourists also rated relatively low on 'Price Low for High Value' and 'Low Price'.

Table 1. Evaluation of the Mongolian Cashmere Products by Mongolian Workers

Product Evaluation Category	Average	Standard Deviation
Luxurious Brand	4.25	0.94
High-end	3.95	1.02
Uniquely Mongolian	3.88	1.18
Trendy	3.67	0.93
Beautiful Color	3.60	0.95
Sophisticated Design	3.58	0.93
Distinctiveness	3.57	1.18
Excellent Quality	3.46	1.12
Price Low for High Value	2.86	1.24
Low Price	2.64	1.28

Source: own research.

Evaluation of the Mongolian Cashmere Products by Foreign Tourists

Table 2. Evaluation of the Mongolian Cashmere Products by Foreign Tourists

Product Evaluation Category	Average	Standard Deviation
Uniquely Mongolian	3.49	0.80
High-end	3.44	0.88
Distinctiveness	3.43	0.81
Excellent Quality	3.42	0.88
Beautiful Color	3.38	0.84
Luxurious Brand	3.31	0.91
Sophisticated Design	3.27	0.78
Trendy	3.25	0.81
Price Low for High Value	3.18	0.77
Low Price	3.07	0.99

Source: own research.

Differences in the Evaluations by Mongolian Workers and Foreign Tourists

Differences between the evaluations by Mongolian workers and foreign tourists were examined. The results of t-test showed that in a majority of categories, except for 'Distinctiveness', 'Excellent Quality' and 'Beautiful Color' as seen on Table 3, there were significant differences. Mongolian workers thought more favorably on the products in the following categories: 'Uniquely Mongolian', 'High-end', 'Luxurious Brand' and 'Sophisticated Design' (t=2.85, p<.01; t=4.68, p<.001; t=8.30, p<.001; t=2.74, p<.01; t=4.02, p<.001). With regard to 'Price Low for High Value' and 'Low Price', foreign tourists rated higher than Mongolian workers did (t=-2.14, p<.05; t=-2.67, p<.01). These results indicate that Mongolian workers believe that the Mongolian cashmere products are quite uniquely Mongolian having luxurious brands, and not low priced.

Table 3. Difference between the Evaluations by Mongolian Workers and Foreign Tourists

Product Evaluation Category	Mongolian Workers Mean(SD)	Foreign Tourists Mean(SD)	*t* -Value
Uniquely Mongolian	3.88 (1.18)	3.49 (0.80)	2.85**
High-end	3.95 (1.21)	3.44 (0.87)	4.68***
Distinctiveness	3.57 (1.18)	3.43 (0.81)	0.98
Excellent Quality	3.46 (1.21)	3.42 (0.88)	0.29
Beautiful Color	3.60 (0.85)	3.38 (0.84)	1.96
Luxurious Brand	4.25 (0.94)	3.31 (0.91)	8.30***
Sophisticated Design	3.58 (0.93)	3.27 (0.78)	2.74**
Trendy	3.67 (0.93)	3.25 (0.81)	4.02***
Price Low for High Value	2.86 (1.24)	3.18 (0.77)	-2.14*
Low Price	2.64 (1.28)	3.08 (0.99)	-2.67**

*significant at p<0.05 ** significant at p<0.01
Source: own research.

Differences between the evaluations by Mongolian workers and foreign tourists from different countries were also examined. The results show that Mongolian workers rated high on most categories except on 'Price Low for High Value' and 'Low Price'. Among the foreign tourists, Russians rated the products high on most categories, similar to the Mongolian workers. But they

were different on 'Luxurious Brand' and 'Trendy' from the workers. Russian respondents rated higher on 'Price Low for High Value' and 'Low Price' than the Mongolian workers. After Russians, the tourists from English-speaking countries rated the products high, followed by Japanese and Korean tourists.

Table 4. Difference between the Evaluations by Mongolian Workers and Foreign Tourists by Country

Product Evaluation Category	Mongolian	Foreign Tourists				*F*
	Workers (n=79)	Korea (n=149)	Japan (n=128)	English Speaking Countries (n=220)	Russia (n=119)	
Uniquely Mongolian	3.88 A	3.40 B	3.31 B	3.54 A	3.69 A	7.35 ***
High-end	3.95 A	3.21 C	3.26 C	3.50 B	3.81 A	14.99 ***
Distinctiveness	3.57 A	3.30 B	3.11 B	3.57 A	3.67 A	10.16 ***
Excellent Quality	3.46 A	3.15 B	3.20 B	3.60 A	3.66 A	9.82 ***
Beautiful Color	3.60 A	3.11 B	3.41 A	3.46 A	3.56 A	6.91 ***
Luxurious Brand	4.25 A	3.23 C	2.88 D	3.50 B	3.52 B	30.41 ***
Sophisticated Design	3.58 A	3.05 C	3.40 AB	3.29 B	3.38 AB	6.96 ***
Trendy	3.67 A	3.01 C	3.41 B	3.24 B	3.37 B	9.10 ***
Price Low for High Value	2.86 B	3.23 A	3.09 A	3.23 A	3.15 A	3.12 *
Low Price	2.64 B	2.95 A	3.03 A	3.09 A	3.23 A	3.98 **

*significant at $p<0.05$ ** significant at $p<0.01$
Source: own research.

Different alphabet characters indicate significant differences at $p<0.05$.

Conclusions

This study compared the product evaluations of the Mongolian cashmere – one of the most promising industries in Mongolia – by Mongolian workers

and foreign tourists in an effort to present the direction for the development of finished cashmere product industry. The major results of the study are as follows:

First, there were significant differences between the evaluations by Mongolian workers and foreign tourists. Overall, the workers thought more highly of the products than foreign tourists, indicating a gap between the perception of the producers and customers. The workers thought more favorably on 'Luxurious Brand' than on any other categories, contrary to the foreign tourists. In terms of the price and value, the workers and tourists had also different ideas. The tourists thought more highly of the price advantage than the workers did. These differences regarding key competitive factors of Mongolian cashmere products should be taken seriously. From the consumer's perspective, current competitiveness of Mongolian cashmere clothing seems largely based on low price and their brand power or luxury image are not recognized as the producers think.

Second, the product evaluations differed by the nationality of the tourists. Russian tourists in general thought more favorably of the products than other tourists had, closer to the ratings given by the Mongolian workers. Russian tourists were followed by those from the English-speaking countries, whereas the ratings by Koreans and Japanese were lowest. The differences in customers' evaluation by nationality should also be considered in the marketing strategies of the cashmere products.

There is a great need for the in-depth studies on what causes such difference in evaluations by nationality. By identifying the factors that affect the evaluation of the Mongolian cashmere products and addressing the findings, the products could be improved to meet the needs of consumers and to develop the marketing programs that stimulate demand for Mongolian cashmere products.

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