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Consumer behavior management influenced by laundry detergent quality

Abstract: The study aims to assess the quality of laundry detergents sold on the Ukrainian market and to determine their competitive advantages for consumers. The study is based on official materials from the State Customs Service of Ukraine and the scientific works of domestic and foreign scientists in this field. The article examines the state of the synthetic detergents market in Ukraine, including laundry detergents, during 2020-2024. The results of a study of the market saturation with domestic and foreign products are presented. The dynamics of export-import operations of the studied product are characterized. The current requirements for the quality of laundry detergents are analyzed, and a comparative characteristic of different classifications is given. A sociological survey of consumers was conducted, which determined the main brands in the highest demand among the latter. A study of the organoleptic and physicochemical quality indicators of selected samples (based on the consumer survey results) of laundry detergents was conducted. General scientific methods – a collection of information, its analytical processing, and theoretical generalization; statistical methods – for quantitative assessment of the volumes of export-import operations of the studied product; graphical – for illustrating the dynamics of the studied indicators were used. It was established that consumers prefer relatively inexpensive goods among the variety of laundry detergents. An assessment of the quality of the studied samples showed that they all meet the requirements of the current regulatory documents.

Keywords: laundry detergent, import, export, quality, classification.

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Управління споживчої поведінки під впливом фактору якості пральних порошків

Анотація. В статті розглянуті питання стану ринку синтетичних мийних засобів України, включаючи пральні порошки, протягом 2020-2024 рр. Наведено результати дослідження насиченості ринку вітчизняної та закордонної продукції. Охарактеризовано динаміку експортно-імпортних операцій досліджуваного товару. Проаналізовано чинні вимоги до якості пральних порошків та наведено порівняльну характеристику різних класифікацій. Проведено соціологічне опитування споживачів, яке визначило основні торговельні марки, що користуються найвищим попитом серед останніх. Проведено дослідження органолептичних та фізико-хімічних показників якості обраних зразків (за результатами опитування споживачів) пральних порошків. Використано загальнонаукові методи – збір інформації, її аналітичне опрацювання та теоретичне узагальнення; статистичні методи – для кількісної оцінки обсягів експортно-імпортних операцій досліджуваного товару; графічний – для ілюстрації динаміки досліджуваних показників. Встановлено, що серед різноманіття пральних порошків споживачі надають перевагу відносно дешевим товарам. Оцінка якості досліджуваних зразків показала, що всі вони відповідають вимогам чинних нормативних документів.

Ключові слова: пральний порошок, імпорт, експорт, якість, класифікація.

Abbreviations:

EACH is registration, evaluation, authorization, and restriction of chemicals;

UCGFEA is Ukrainian Classification of Goods for Foreign Economic Activity.

Introduction

The rapid development of scientific and technological progress in the chemical industry leads to a constant expansion of the capacity and assortment of the laundry detergent market. This allows consumers to use various products to facilitate washing and achieve cleanliness and freshness of things at home. For modern people around the world, laundry detergents have become an integral part of a high quality of life, including environmental quality, living conditions, safety, physical comfort, sleep quality, and rest (*Voloshyna, 2017*). Consumers use laundry detergents almost daily. Each homemaker chooses different washing products depending on the manufacturer, volume, composition, and price category. Both domestic and imported goods are present in household use. Consumers prefer products that can provide the expected result, but it is important not to forget about the quality of these detergents, as it has a direct impact on health and the environment. According to the Resolution of the Cabinet of Ministers of Ukraine No. 717 of August 20, 2008, "On Approval of the Technical Regulation of Detergents" (*2008*), a detergent is any substance or preparation containing soap and/or other surfactants intended for washing or cleaning and used in households and industry, in the form of a liquid, powder, paste, bar, tile, tablet, etc. Laundry detergent is a synthetic detergent (SD) as a powder or granules that provides a washing effect (*Synthetic Detergents…, 1995*).

Before the full-scale invasion, the Ukrainian laundry detergent market could be considered entirely developed. Several factors confirmed this. Firstly, almost all international brands were represented in Ukraine. Secondly, there was a variety of price and functional offers: consumers could choose products in any price range and purchase detergent designed for different types of laundry or clothing of a specific color. Thirdly, the share of contraband goods, which could reach

20-25% of all supplies ten years ago, had significantly decreased to acceptable levels due to regulatory changes, increased border control, and a larger share of legal trade in total sales. Fourthly, more and more Ukrainians were showing interest in the environmental safety of detergents, which is a progressive indicator even for the European market.

The supply of the Ukrainian market with high-quality laundry detergents is influenced by several factors: consumer needs, market demands, technological advancements, and environmental safety standards. As Ukraine integrates into the European Union, the domestic laundry detergent market is increasingly filled with foreign-made products. Therefore, improving the assortment of the latter by enhancing their quality is extremely important. The relevance of the research topic is determined by the fact that in modern conditions, new substances, groups, and classes of compounds are being actively developed and introduced into production. These substances find wide application in many sectors of the economy as both intermediate and final products and require hygienic regulation. Thus, the quality of laundry detergents is critical for further developing this market segment and meeting consumer needs.

The issue of assessing the quality of synthetic detergents (including laundry detergents) has been addressed in the works of many domestic and foreign scientists. T. Kolomiets and L. Chernyak (*2017*) evaluated the quality of phosphate-free laundry detergents. I.S. Ilchuk (*2015*) determined the impact of synthetic detergents on human health by studying the components of these products. A.Yu. Chernyavska (*2023*) conducted a study on the impact of chemical compounds in synthetic detergents on the environment using bioindication. T.M. Cherevata (*2014*) studied laundry detergents' assortment and consumer properties.

In addition, the problems of the quality of synthetic detergents were also highlighted in the works of foreign scientists. A. Ferri (*2016*) studied the impact of detergents and additives on consumer satisfaction. Irshad N. Shaikh and M. Mansoor Ahammed (*2024*) researched the impact of the washing method and the type of detergent on the characteristics of the water after washing. Abdal-Rhman Magdy Abdullah Youssef (*2019*) researches and improves the main components of laundry detergents that increase their washing ability. However, the publications of these scientists containing an assessment of the quality of synthetic detergents (including laundry detergents) are pretty limited in number and highly specialized. Thus, there is a need for current research on other aspects of the quality assessment of laundry detergents in the Ukrainian market.

Under war conditions, companies producing laundry detergents require constant improvements and the ability to respond quickly to risks associated with large-scale missile strikes on Ukraine's infrastructure. However, manufacturers must understand that precisely the quality of laundry detergents is the key determinant of consumer choice.

The study aims to assess the quality of laundry detergents sold on the Ukrainian market and to determine their competitive advantages for consumers.

The study is based on official materials from the State Customs Service of Ukraine and the scientific works of domestic and foreign scientists in this field.

A survey was conducted using a questionnaire among respondents. Since laundry detergents are mass-consumption goods, consumers of various categories and social groups participated in the survey. The main criteria for dividing consumers were age, gender, and monthly income. The survey involved 136 respondents living in different regions of Ukraine.

Labeling research was conducted according to the requirements of the Technical Regulations for Detergents (*2008*).

The quality of the laundry detergent samples was assessed based on organoleptic and physicochemical indicators. The appearance of the powders was determined visually at an ambient temperature of (20±2)°C and under natural daylight. The washing ability was determined by the ratio of the degree of soil removal by the test detergent solution to the ideal degree of soil removal on one type of fabric according to DSTU 2665:2012 "Synthetic detergents. Method for determining washing ability" (*2012*). pH, foaming, and foam stability were determined according to DSTU 2972:2010, "Powder Synthetic Detergents. General Technical Requirements and Test Methods" (*2010*).

The results of the study

Trends in the laundry detergent market

Ukraine is an attractive market for household chemicals, primarily due to its large population and favorable geographic location. However, the percentage of domestic industrial production of surfactants such as sodium alkylbenzenesulfonate, higher alcohol sulfates, alkyl ether sulfates, nonionic, and other types of surfactants, which form the basis of synthetic detergents, including laundry detergents, is relatively low (*Ternova, 2021*).

The assortment of laundry detergents on the Ukrainian market is diverse, but their chemical composition is quite similar. Most are laundry detergents based on synthetic anionic surfactants, while laundry detergents based on other surfactants, particularly natural surfactants, are represented in small volumes.

The leading producers of laundry detergents are transnational companies: "Procter & Gamble" (brands "Ariel," "Tide," "Tix Bonux"); "Henkel" (brands "Persil," "Rex," "Perwoll," "Pur," "Bref," "Silan," "Losk"); "Cussons" (TME); "Unilever" (TM OMO), "Reckitt Benckiser" ("Dosia," "Lanza") (*Figure 1*) (*Economic Truth, 2024*).

Ukrainian-produced laundry detergents include brands such as "Vukhastik," "Alles GUT!," "WASCHKONIG," and those manufactured by "Procter & Gamble Ukraine" (*Nakonechna, 2024*). Next, we examine the overall characteristics of imports and exports of laundry detergents (*Figure 2*). An analysis of the data presented below shows that Ukraine has had a negative trade balance for this type of product over the past few years, indicating that it imports significantly more synthetic detergents than it produces and sells on the foreign market. Over the past 5 years, imports have exceeded exports by a factor of 15-30, which significantly impacts the economy. Despite a decline in 2022 due to the full-scale Russian invasion, imports of this product have been rapidly growing. The peak of imports for this period was reached in 2021 at $303,105 thousand. Export volumes fluctuate, with the lowest figure in 2022 at $8,675 thousand and the highest in 2023 at $14,758 thousand. This allows for hope in developing domestic production, increased volumes on the Ukrainian and foreign markets, and a gradual trade balance improvement (*Statistics and Registers…, 2024*).

An analysis of data from the State Customs Service of Ukraine (*2024*) indicates that in 2019, the largest share of imports originated from Poland (22,97%), Germany (13,37%), and the Czech Republic (7,86%), with other countries accounting for 55,80%. Exports were primarily directed to Moldova (20,41%), Italy (15,49%), and Bulgaria (14,98%), with the remaining 49,12% going

to other countries.

In 2020, the largest share of imported laundry detergents came from Poland (24,97%), Germany (11,23%), and Hungary (7,9%), with the remaining 55,90% from other countries. Exports were primarily directed to Moldova (25,57%), Bulgaria (18,91%), and the Czech Republic (6,93%).

In 2021, Moldova (26,89%), Bulgaria (21,33%), and Georgia (7,39%) were the top export destinations for laundry detergents, while Poland (24,20%), Germany (11,58%), and France (7,13%) were the primary import sources.

In 2022, Poland (29,70%), the Czech Republic (11,23%), and Germany (10,04%) were the primary exporters of laundry detergents to Ukraine, and Moldova (22,67%), Poland (11,91%), and Latvia (10,40%) were the main import destinations.

In 2023, significant volumes of laundry detergents were imported from Poland (22,52%), the Czech Republic (14,21%), and Germany (8,84%), with the remaining 54,42% from other countries. The largest export markets were Moldova (20,98%), Poland (19,03%), and Romania (12,27%).

An analysis of Figure 3 indicates that a similar trend persisted in 2024. Most laundry detergents were imported from Poland, the Czech Republic, and Germany, while exports were primarily directed to Romania, Moldova, and Poland.

Consequently, the most significant quantities of laundry detergents were imported from Poland, Germany, and the Czech Republic, with Hungary and France also emerging as leading sources in other years. Exports were primarily directed to Moldova and Bulgaria, as well as to the Czech Republic, Georgia, Romania, Latvia, and Italy.

The analysis of the laundry detergent market revealed that foreign-produced products dominate it. However, the emergence of new domestic brands that have gained significant consumer demand is worth noting. The study found that imports significantly exceeded exports of laundry detergents. The product range includes international brands such as "Procter & Gamble," "Henkel," "Cussons," "Unilever," and "Reckitt Benckiser." However, domestic brands like "Vukhastik," "Alles GUT!," "WASCHKONIG," and "Procter & Gamble Ukraine" have recently gained considerable market share. Most of the products studied were imported, primarily from Poland, Germany, and the Czech Republic. In contrast, Ukrainian products were mainly exported to neighboring countries, with Moldova and Bulgaria being the leading destinations.

Classification and quality requirements for laundry detergents

At this stage of the research, it would be beneficial to consider the classification of laundry detergents based on various criteria and compare the classification of the studied product according to the Harmonized System (HS) and scientific classification.

According to the scientific classification (*Merezko et al., 2019*), laundry detergents, including powders, are divided into the following groups based on their intended use for:

- washing wool and silk fabrics (pH 7-8,5);
- washing cotton and linen fabrics (pH 10-11,5);
- washing various fabrics, including synthetic fibers (pH 9-9,5);

- washing children's clothes;
- washing coarse and heavily soiled fabrics, including workwear.
- based on consistency, laundry detergents are divided into:
- powdered;
- liquid;
- washing capsules (*Merezko et al., 2019*).

Powdered detergents have a higher pH level, making them more effective at tackling tough stains like clay. However, they can be challenging to dose: too little may not clean effectively, while too much can be hard to rinse. They dissolve less well in cold water and can leave stains on clothes, making pre-treatment with a stain remover beneficial. The undissolved powder can form clumps that clog washing machines. On the positive side, powdered detergents can help prevent mold growth in washing machines if used at least once a week (*Merezko et al., 2019*).

Liquid detergents are more manageable to dose, with measuring cups for precise amounts. They do not clog washing machines because they dissolve well, even in cold water. Liquids can also be used for pre-treating stains, especially greasy ones (*Merezko et al., 2019*).

Laundry capsules offer both advantages and disadvantages. They are compact, easy to store, and highly concentrated, making them efficient for machine washing. However, their concentrated formula can irritate the skin, so they should not be used for hand washing.

According to the scientific classification, the main characteristics for classifying laundry detergents are their intended use and consistency (*Merezko et al., 2019*).

According to the Ukrainian Classification of Goods for Foreign Economic Activity (UCGFEA), as approved by the Law of Ukraine "Customs Tariff," laundry detergents are classified under Section VI, "Products of the chemical and related industries" (*2022*).

This section is divided into 10 groups, with laundry detergents falling under group 34: "Soap, organic surface-active agents, washing preparations, lubricating preparations, artificial waxes, and prepared waxes, polishing or scouring preparations, candles, and similar articles, modeling pastes, "dental wax" and dental preparations with a basis of gypsum" (*UCGFEA, 2020*).

Commodity code 3402 "Organic Surface-Active Agents (Other Than Soap); Preparations for Washing, Cleaning (Including Auxiliary Washing Preparations) and Scouring, with or without Soap, but not Including Preparations of Heading 3401" covers laundry detergents (*UCGFEA, 2020*).

A complete classification of laundry detergents, depending on their composition and characteristics, is presented in the appendix (*Table 1*).

The main component of laundry detergents is organic surfactants, characterized by wetting, emulsifying, peptizing, and foaming abilities. The combination of these properties determines their cleaning action. Synthetic detergents are supplemented with alkaline and neutral electrolytes, alkylolamides, carboxymethylcellulose, and other substances to enhance this action. For example, bleaching agents are functional additives (*Merezko et al., 2019*).

Anionic surfactants are paramount for laundry detergents. They dissociate in aqueous solutions into anions, negatively charged hydrophobic parts of the molecule (long hydrocarbon chains), and cations, small, positively charged ions, usually sodium and sometimes potassium.

The larger anion, similar in size and properties to the hydrophobic part of a fat soap molecule, is responsible for the surfactant properties (*Merezko et al., 2019*).

According to the UCGFEA, the main classification features of laundry detergents, including laundry powders, are chemical composition, the presence of certain types of acids, intended use, and the type of surfactants.

It is necessary to note that the scientific classification of laundry detergents differs from the UCGFEA classification. The UCGFEA classification is primarily used for customs purposes. However, a common feature of both classifications is the intended use of laundry detergent (including laundry powders).

An integral part of the research is analyzing Ukraine's quality requirements for laundry detergents and comparing them with EU requirements.

The requirements for the quality and safety of laundry detergents are specified in the normative documents established for this product in Ukraine, such as technical regulations and state standards. Laboratory indicators of the quality of laundry detergents include the pH of an aqueous (1%) solution, the content of surface-active substances (alcohol-soluble) and unsulfonated compounds, the content of alkaline salts, moisture, carboxymethylcellulose, optical brighteners, etc.

According to the "Technical Regulations for Detergents", approved by the Cabinet of Ministers of Ukraine on August 20, 2008, No. 717, a detergent is any substance or preparation containing soap and/or other surfactants intended for washing or cleaning and used in households and industry, in the form of a liquid, powder, paste, bar, tablet, etc. A surfactant is any organic substance and/or preparation used in detergents, having surface-active properties and consisting of one or more hydrophilic groups and one or more hydrophobic groups of such a nature and size that they can reduce the surface tension of water, form monomolecular layers that spread or are adsorbed at the interface between water and air, emulsions and/or microemulsions, and/or micelles, and can also be adsorbed at the interface between water and a solid surface.

The introduction of detergents and surfactants into circulation is possible only if they do not pose a threat to the safety of the environment and meet the requirements for:

- the level of biodegradability of surfactants;
- the labeling of detergents;
- information provided upon request by the executive authorities specified by law;
- restrictions on the content of phosphates and other phosphorus compounds in detergents.

The complete biodegradability of surfactants included in the detergent must be at least 60% (in terms of carbon dioxide) or 70% (in terms of total organic carbon) within 28 days.

In cases where the level of complete biodegradability of surfactants contained in a detergent is less than 60% (based on carbon dioxide) or 70% (based on total organic carbon), the requirement for primary biodegradability of surfactants contained in the detergent shall apply to industrial detergents.

The primary biodegradability of surfactants in detergents shall be at least 80% (*On the Approval…, 2008*).

Detergents, including laundry powders, are subject to restrictions on the content of

phosphates and other phosphorus compounds (*Table 2*) (*On the Approval…, 2008*).

According to DSTU 2972:2010, "Synthetic Powdered Detergents. General Technical Requirements and Test Methods" (*2010*), laundry powders must meet the following requirements (*Table 3*).

According to DSTU 2972-2010 and the "Technical Regulations for Detergents" (*2008*), the labeling must include:

- name and trademark of the detergent;
- name, trademark, complete address, and telephone number of the manufacturer;
- information on the composition of the detergent;
- address, e-mail address (if available) and telephone number;
- rules and conditions of use and special precautions, if necessary;
- purpose of the powder;
- information on confirmation of conformity;
- net weight:
- date of manufacture and expiry date;
- designation of the regulatory document according to which the detergent is manufactured;
- EAN barcode.

In the EU, the safety and quality of detergents are regulated by Directive 648/2004 of the European Parliament and of the Council of 31 March 2004 on detergents. The hygienic safety of detergents in the EU is governed by the new chemicals' legislation REACH – a regulation of the European Union No 1907/2006, which defines the production and marketing of all chemical substances, including their mandatory registration. Since 2012, the EU has banned the sale of detergents for washing with a total phosphorus content of 0,5 g or more per wash in a standard washing machine (*Regulation…, 2006*).

Therefore, the requirements for the quality and safety of laundry detergents are established in the "Technical Regulations for Detergents," approved by the Cabinet of Ministers of Ukraine on August 20, 2008, No. 717, and DSTU 2972:2010 "Synthetic Powdered Detergents. General Technical Requirements and Test Methods" and are carefully monitored by the state. Requirements for the labeling and quality of laundry detergents are also outlined in the aforementioned regulatory documents. Laundry detergents must meet the latest organoleptic (appearance, color, odor) and physicochemical parameters: detergency, foam stability, foaming, and pH level.

A sociological survey of consumer preferences regarding laundry detergents

Laundry detergents are an integral part of household chemistry. While they simplify the washing process, they also raise concerns about their environmental and human health impact. Growing consumer awareness of environmental issues drives demand for safer and more effective laundry detergents. The purpose of this study is to examine consumer preferences regarding laundry detergents. Specifically, we aim to determine the key criteria for choosing laundry detergent, how consumers assess the environmental characteristics of products, and their willingness to pay more for environmentally friendly products. A survey was conducted among 136 respondents using Google Forms to achieve the research goal.

The sociological survey involved consumers of laundry detergents, of which 67% were women (92) and 33% were men (44). By age, they were divided into three categories: 18-30 years – 68% of the total, 31-60 years – 23%; 61 years and older – 9%. Regarding average monthly income, 16% of respondents earn up to 10,000 UAH/month, 58% – up to 25,000 UAH/month, and 26% – more than 25,000 UAH/month.

The sociological survey revealed that laundry detergents from brands such as "Ariel," "Persil," "Gala," "Sila," "Sarma," and "Grunwald" received the highest rating on a 5-point scale (*Figure 3*). Consumer survey results also showed that laundry detergents from brands like "Losk" and Savex were in high demand, receiving a rating of 4,3 from consumers. Additionally, the survey found that 62% of consumers pay attention to the composition of laundry detergents, indicating consumer awareness when choosing a laundry detergent.

One key factor when choosing a laundry detergent is the type of fabric. Different fabrics have different structures and require different care. Therefore, laundry detergent manufacturers conduct numerous studies to determine which components and technologies are best suited for each type of fabric. In this regard, the questionnaire included questions regarding the importance of choosing the fabrics most frequently soiled. The survey results are presented in the appendix (*Figure 5*).

The survey found that consumers most frequently encounter stains on silk, flannel, cotton, and calico. Therefore, at this research stage, it is appropriate to present the results of a sociological survey regarding the most common types of stains on the aforementioned fabrics among consumers. The survey results are presented in the appendix (*Figure 6*).

Analysis of the survey results allowed us to identify the most common types of stains for different types of fabrics. Cotton fabrics most often have food stains (coffee, tea, juices, grease), grass, blood, and wine stains. This is due to the widespread use of cotton products in everyday life, particularly for cooking and outdoor activities. For synthetic fabrics, characteristic stains include cosmetics (mascara, lipstick), deodorants, as well as ink and marker stains. Such fabrics are often used for sportswear and everyday wear, which explains the specific nature of the stains. For woolen fabrics, the main problems are greasy stains, sweat stains, and moth damage. These stains require delicate removal to preserve the structure and appearance of woolen products. In addition to the main types of stains, color fading and graying after washing are a common problem for colored fabrics.

The survey results showed that Ukrainian consumers prefer laundry detergents in the middle price range. "Ariel," "Persil," "Gala," "Sila," "Sarma," and "Grunwald" were the most popular brands. Respondents appreciated the effectiveness of these detergents' stain removal and their hypoallergenic properties. Consumers face a wide range of stains, depending on the fabric type, lifestyle, and other factors. This indicates that modern laundry detergents should be universal and effectively cope with various types of stains. At the same time, about 30% of respondents noted that they would like to see more natural and environmentally friendly laundry detergents on the market. An analysis by age group showed that young people are more likely to choose laundry detergents online, while older people prefer traditional formats. Social media and recommendations from friends were the primary sources of information about laundry detergents for most respondents.

A comparative study of the performance characteristics of different laundry detergents

According to the results of a sociological survey, it was established that consumers prefer the following brands, which were chosen among other samples for quality assessment (*Figure 7*):

- sample 1 – TM "Ariel" (Aqua powder. Bright colors);
- sample 2 – TM "Persil" (Expert color. Freshness);
- sample 3 – TM "Sila" (Spring Garden);
- sample 4 – TM "Sarma" (Active);
- sample 5 – TM "Gala" (Aqua powder. French aroma);
- sample 6 – TM "Grunwald" (Sapfir).

For the convenience of conducting research, samples of laundry detergents from brands "Ariel," "Persil," "Sila," "Sarma," and "Grunwald" were chosen as universal, meaning they can be used for both hand washing and machine washing. Laundry detergent from the brand "Gala" was selected in two different types (separately for machine washing and hand washing). This is due to the fact that the manufacturer does not produce a laundry detergent that can be used for both hand and machine washing simultaneously.

In the first stage of the research, the compliance of the laundry detergent labeling with the Technical Regulations for Detergents (*Table 4*) was determined.

Analyzing *Table 4*, it can be stated that all the studied laundry detergent samples meet the requirements of the Technical Regulations regarding labeling (*2008*). The packaging indicates the name and trademark, manufacturer and its address, composition, purpose, conditions of use, weight, date of manufacture, expiration date, and storage conditions.

The following research stage involved conducting an organoleptic evaluation of the laundry detergent samples according to DSTU 2972:2010 (*2010*). The evaluation was conducted at a room temperature of 20°C and under natural lighting. Thus, the obtained results can be considered reliable. The research results are presented in the appendix (*Table 5*).

The next step was to study the physicochemical indicators and compare them with the requirements of DSTU 2972:2010 (*Table 6*).

It was established that all the studied samples meet the requirements of DSTU 2972:2010. Samples 1 and 6 had the best solubility in hot water. The pH level was the same except for sample 6.

Samples 2 and 3 showed the best foam stability, and sample 5 had the best foaming ability.

Based on the results of a sociological survey, the following types of stains were selected for the study of laundry detergents' detergent properties: lipstick, grass, wine, blood, and deodorant (*Figure 8*).

An expert group of four individuals specializing in the evaluation of non-food products was formed to assess the cleaning performance of the selected laundry detergent samples. These experts were research associates from the Department of Commodity Science and Customs Affairs at the State University of Trade and Economics (SUTE). The removal of various types of stains by the tested laundry detergent samples was evaluated using a developed 5-point scale:

5 – excellent stain removal without pre-soaking;

4 – leaves slight traces;

3 – requires pre-soaking;

2 – leaves visible stains;

1 – do not remove the stain.

When assessing the cleaning performance of the laundry detergent samples, the average score of all experts for each indicator was used.

The cleaning performance was evaluated after hand and machine washing at 30°C, a temperature selected according to each fabric type's recommendations.

The results of the cleaning performance assessment of laundry detergents on silk fabric are presented in the appendix (*Figure 9*).

The research results demonstrated that "Persil" was the most effective laundry detergent, regardless of the washing method or type of stain. However, it should be noted that for hand washing, "Persil" was most effective at removing deodorant from silk, while for machine washing, it excelled at removing blood and deodorant. Additionally, "Ariel" and "Gala" laundry detergents were quite effective for hand washing.

On the other hand, "Sarma" laundry detergent proved to be the least effective, performing poorly on all types of stains and fabrics. The results of the cleaning performance assessment of the tested samples on flannel are presented in the appendix (*Figure 10*).

It was established that Persil laundry detergent was the most effective at removing stains from flannel. All types of stains were completely removed when washing the tested samples in a washing machine. After washing (both by hand and in a washing machine) with "Ariel," "Sila," and "Gala" detergents, slight traces of stains remained on the fabric sample, which also indicates a fairly high cleaning performance. "Sarma" laundry detergent did not remove stains at all when hand washing, and visible stains remained after machine washing. This suggests that this laundry detergent is ineffective for washing flannel fabrics.

The results of the cleaning performance assessment of the tested samples on cotton are presented in the appendix (*Figure 11*).

The research results showed a trend similar to that observed for silk and flannel fabrics. For cotton, Persil proved to be the most effective detergent.

It completely removed grass, wine, blood, and deodorant stains from cotton fabric after machine washing. Lipstick stains were barely noticeable after washing. Additionally, Ariel detergent removed most of the aforementioned stains. "Sarma" detergent was the least effective, barely removing lipstick, grass, wine, and blood stains during hand washing.

However, when using this detergent in a washing machine, the stains were almost completely removed, although slight traces remained. "Sila," "Gala," and "Grunwald" laundry detergents also demonstrated fairly good cleaning performance. While they did not completely remove all stains, they were quite effective in both hand and machine washing.

The results of the cleaning performance assessment of the tested samples on linen are presented in the appendix (*Figure 12*).

It was established that "Persil" detergent was also the most effective for washing linen in a washing machine. When hand washing, it completely removed grass, wine, and deodorant stains. In this case, "Ariel," "Sila," and "Gala" detergents were also effective. Similarly, "Sarma" was the least effective detergent. It barely removed any type of stain, except for deodorant.

As a result of the conducted research, the most significant factors enhancing the effectiveness of laundry detergents were identified in the appendix (*Figure 13*). It was established

that foaming ability and foam stability are interrelated indicators. Foam creates a soft abrasive environment that helps to detach dirt from fabric fibers. Foam also contributes to the uniform distribution of detergent on the fabric surface, improving its interaction with contaminants. Additionally, foam creates a barrier between the metal parts of the washing machine and the fabric, reducing the risk of damage.

Another crucial factor directly influencing a laundry detergent's cleaning performance is solubility. Surfactants are primarily responsible for the detergent's cleaning action. The better they dissolve, the more effectively they wet the fabric, surround dirt particles, and detach them from the fibers. Dissolved surfactants form micelles – spherical structures that capture fat molecules and other contaminants, transforming them into an emulsion that can be easily rinsed off with water. Highly soluble detergent components ensure more efficient mixing with water, creating a homogeneous solution that promotes better stain removal. The dissolution rate of the detergent affects the speed at which the cleaning process begins. The faster the detergent dissolves, the faster stain removal starts.

Most surfactants in laundry detergents work best in an alkaline environment. Many stains (such as proteins and fats) dissolve better in alkaline conditions. This facilitates their removal from the fabric. An alkaline environment helps preserve bright colors and prevents yellowing of white fabrics. At low pH (acidic environment), the effectiveness of surfactants decreases, which can lead to insufficient stain removal. Additionally, an acidic environment can damage certain types of fabrics. An excessively high pH can damage fabrics, especially colored and delicate ones. Furthermore, excessive alkalinity can leave alkaline residues on the fabric, which can irritate the skin. The optimal pH for washing is usually in the range of 8-11. However, the specific optimal pH may vary depending on the type of fabric, the type of stain, and other factors.

One of the main factors directly influencing the enhanced effectiveness of laundry detergents is their composition. The optimal ratio of different components ensures effective removal of various types of stains. The choice of surfactants depends on the type of fabric, the type of stain, and the water temperature. Enzymes allow for the effective removal of complex organic contaminants but may be ineffective at low temperatures. Bleaches can damage colored fabrics, so their use is worth limiting. Water softeners improve the effectiveness of surfactants, while anti-scale agents prevent scale formation in the washing machine.

When choosing a laundry detergent, it is necessary to consider the type of fabric, the degree of soiling, the water temperature, and other factors. Some components of laundry detergents can cause allergic reactions, while others can negatively impact the environment. Based on the conducted research, the following recommendations have been formulated:

- Manufacturers are recommended to expand the range of laundry detergents, in particular, to develop products for the specific needs of consumers (e.g., for children's clothing, sportswear, delicate fabrics);
- The growing interest of consumers in environmentally friendly products requires manufacturers to develop laundry detergents based on natural ingredients;
- The introduction of innovative technologies can allow for the creation of more effective and safe laundry detergents;
- An active marketing campaign that emphasizes the unique properties of the product and its

advantages over competitors will help win over consumer loyalty.

Discussion

Promising directions for future research include a detailed study of the global laundry detergent market, specifically analyzing trends, innovations, and consumer preferences. Simultaneously, a comprehensive study of the quality and safety of phosphate-free detergents should be conducted, including an assessment of their cleaning ability, environmental impact, and human health effects, as well as a comparison with traditional detergents.

Particular attention will be paid to studying the composition of phosphate-free detergents, including the use of new, more environmentally friendly surfactants and enzymes. Additionally, the impact of various factors, such as water hardness, washing temperature, and fabric type, on the effectiveness of phosphate-free detergents will be evaluated. The research results will enable the development of recommendations for manufacturers and consumers aimed at improving the efficiency and safety of using laundry detergents.

A component of future research in this area will be the development of mathematical models for forecasting the development of the laundry detergent market, as well as studying consumer behavior and the factors influencing consumer choice.

Conclusions

The Ukrainian laundry detergent market is characterized by a significant presence of international corporations such as "Procter & Gamble," "Henkel," and "Unilever." While domestic producers are increasing their presence, they still occupy a smaller market share.

Most laundry detergents on the Ukrainian market have a similar chemical composition, based on synthetic anionic surfactants. This indicates general trends in the industry and a limited variety of offerings for consumers with specific needs (such as allergy sufferers or those who prefer environmentally friendly products).

A sociological survey revealed that the typical laundry detergent consumer in Ukraine is a woman aged 18-30 with a middle income. The most popular brands among respondents include "Ariel," "Persil," "Gala," "Sila," "Sarma," and "Grunwald."

Consumers primarily encounter food stains on cotton fabrics and cosmetic stains on synthetic materials. Laboratory tests have shown that Persil laundry detergent demonstrated the highest effectiveness in removing various types of stains from different fabrics.

Other popular brands also showed good results, especially "Ariel" and "Gala." "Sarma" laundry detergent proved to be the least effective.

Despite the dominance of international brands, there is potential for developing domestic manufacturers, who can meet the specific needs of consumers, such as offering more natural and hypoallergenic laundry products.

Conflict of interest

The author declares that there is no conflict of interest.

References:

Abdal-Rhman Magdy Abdullah Youssef (2019). Detergents Heavy-Duty Powder. https://www.researchgate.net/publication/331732053_Detergents_Heavy-Duty_Powder

Cherevata, T. M. (2014). Assortment and consumer properties of washing powders. *Scientific works of the Odessa National Academy of Food Technologies*, *46*(1), 291-295.

Chernyavska, A. Yu. (2023). Study of the impact of chemical compounds in the composition of synthetic detergents on the environment by the method of bioindication. *Ecology (Ecology and Environmental Protection)*. https://er.chdtu.edu.ua/handle/ChSTU/4706

Customs Tariff of Ukraine. Law of Ukraine No. 2697b-IX, dated October 19, 2022. https://zakon.rada.gov.ua/laws/show/2697%D0%B1-20#Text

Economic Truth. The Great Ukrainian Laundry (2024). *Epravda*. https://www.epravda.com.ua/publications/2023/08/17/702882/

Ferri, A. (2016). Laundry performance: Effect of detergent and additives on consumer satisfaction. *Tenside Surf. LAUNDRY/CLEANING AGENTS*, *53*. 375-386.

Ilchuk, O. S., Podguska, I. O. (2015). Impact of synthetic detergents on human health. https://ela.kpi.ua/server/api/core/bitstreams/f406101a-2a9d-4295-9635-e078efbc3b77/content

Kolomiets, T. M., & Chernyak, L. V. (2017). The quality of phosphate-free laundry powders. *Goods and markets*, *1*, 50-57.

Merezhko, N. V., Mokrousova, O. R., Koptyukh, L. A., Kolomiets, T. M., Karavaev, T. A., Osievska, V. V., Glushkova, T. G., Mykhailova, H. M., Sirenko, S. O., Chernyak, L. V., Andrievska, L. V., Marchuk, N. B., Kaluga, N. V., Shulga, O. S., Zolotaryova, O. G., Stretovich, S. S. & Komaha, V. O. (2019). Commodity science. Vol. 1. Non-food products. Kyiv National University of Trade and Economics.

Nakonechna, A. (2017, February 25). Analysis of the household chemicals market in Ukraine. *Conferences*. http://oldconf.neasmo.org.ua/node/726

On Detergents. (2004). Directive No. 648/2004 of the European Parliament and the Council of the EU, dated March 31, 2004. https://zakon.rada.gov.ua/laws/show/994_961#Text

On the Approval of the Explanations to the Ukrainian Classification of Goods of Foreign Economic Activity. (2020). Order of the State Customs Service No. 256, dated July 14, 2020. https://customs.gov.ua/documents/pro-zatverdzhennia-perekhidnikh-tablits-vid-uktzed-versiyi-2012-r-do-uktzed-versiyi-2017-r-142

On the Approval of the Technical Regulations for Detergents. (2008). Resolution of the Cabinet of Ministers of Ukraine No. 717, dated August 20, 2008 https://zakon.rada.gov.ua/laws/show/717-2008-%D0%BF#Text

Registration, Evaluation, Authorization and Restriction of Chemicals. (2006). Regulation of the European Union No. 1907, dated 2006. https://www.reachinfo.eu/service/reach-registration-certification

Shaikh, Irshad N. & Mansoor Ahammed, M. (2024). Effect of washing method and detergent type on laundry greywater characteristics. *Journal of Water Process Engineering*. https://www.sciencedirect.com/science/article/abs/pii/S2214714424013357

Statistics and Registers. Statistical Export and Import of Goods. (2024, November 19). State Customs Service of Ukraine. *Goods Country*. https://customs.gov.ua/statistika-ta-reiestri

Synthetic Detergents. Method for Determining Detergency (DSTU 2665:2012). (2012). Technical Committee "Synthetic Detergents". Ministry of Economic Development of Ukraine.

Synthetic Detergents. Terms and Definitions. (DSTU 3126-95). (1995). Research and Design Institute of the Chemical Industry (VNDIKHIMPROEKT). State Standard of Ukraine.

Synthetic Powdered Detergents. General Technical Requirements and Test Methods (DSTU 2972:2010). (2010). Technical committee "Synthetic Detergents". State Consumer Standard of Ukraine.

Ternova, A. S., & Verinkin, O. M. (2021). Evaluation of the economic and ecological brand of the enterprise on the detergent market of Ukraine. *Economics and Management of the National Economy*, *56*, 54-61.

Voloshina, S., & Kozlova V. (2017). The state and prospects for the development of the market of synthetic detergents in Ukraine. *Economy and Society. Economics and Enterprise Management*, *10*, 222-225.

Appendix

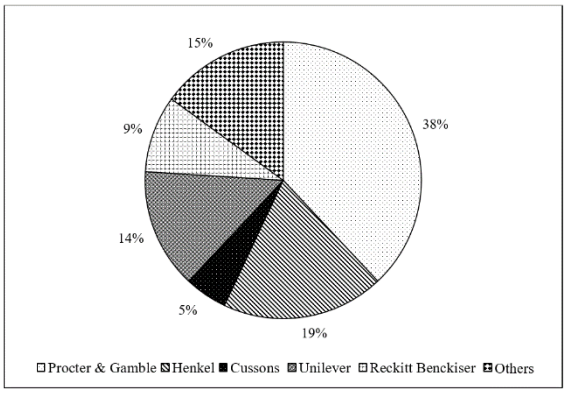

Figure 1. The share of the volume of imported manufacturers of washing powders in comparison with domestic ones on the Ukrainian market, 2024

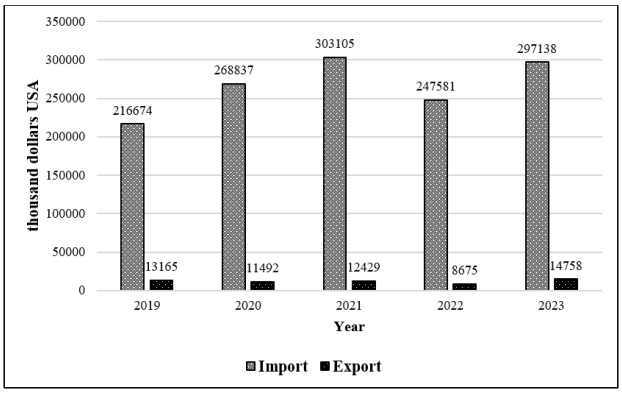

Figure 2. Dynamics of volumes of export-import transactions with laundry detergents in 2019-2023, thousand dollars USA

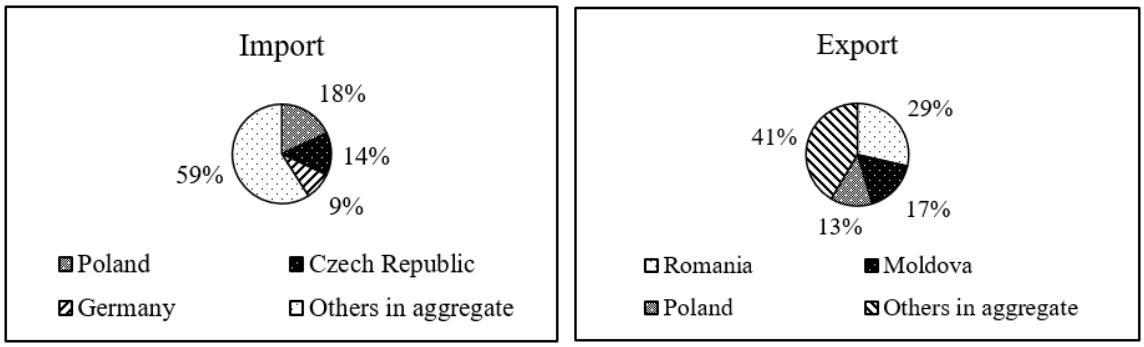

Figure 3. The share of the main importing and exporting countries of laundry detergents in Ukraine, 2024

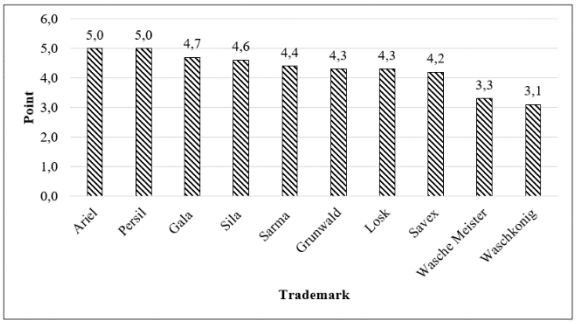

Figure 4. Rating of laundry detergent brands among surveyed consumers, 2024

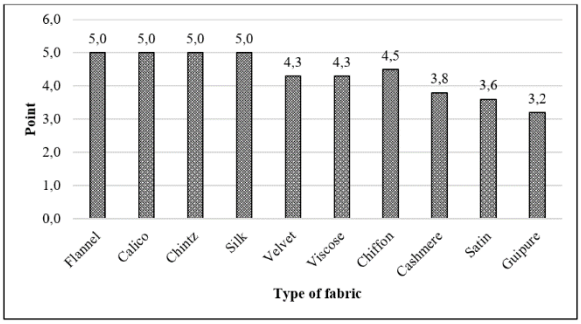

Figure 5. Rating of types of fabrics that are most often exposed to pollution, among surveyed consumers, 2024

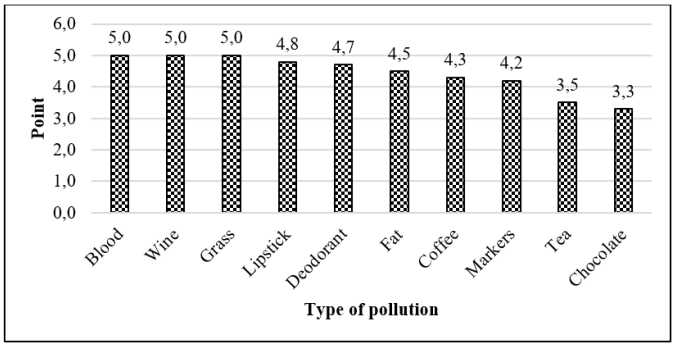

Figure 6. Rating of the most common types of pollution for different types of fabrics, among surveyed consumers, 2024

Figure 7. The appearance of selected investigated samples of washing powders

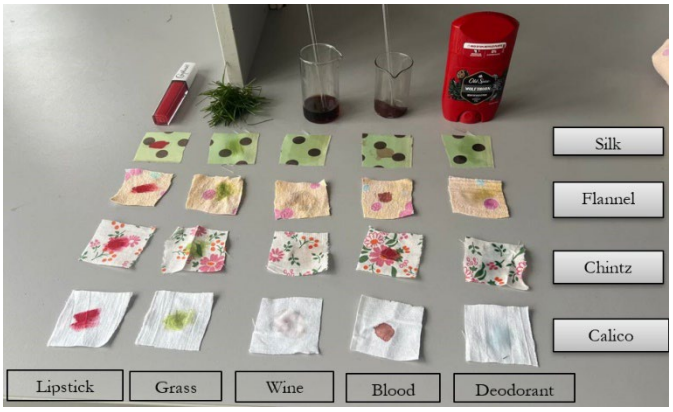

Figure 8. The appearance of selected types of stains for studying washing ability of laundry detergent

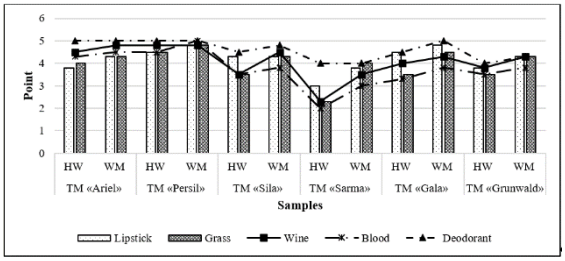

Figure 9. The results of the evaluation of the examined silk samples after HW and WM
* WM – washing in a washing machine
HW – hand washing

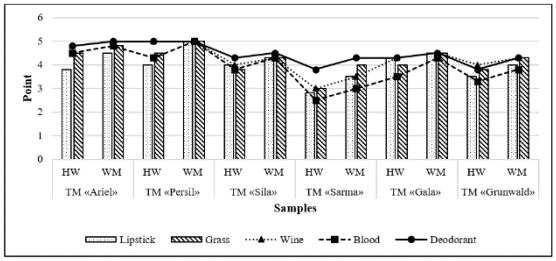

Figure 10. Results of evaluation of the tested flannel samples after HW and WM
* WM – washing in a washing machine
HW – hand washing

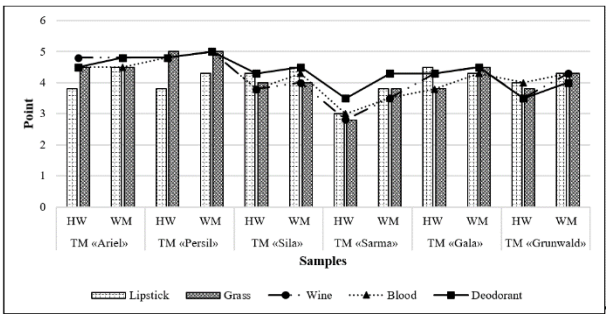

Figure 11. Evaluation results of the tested chintz samples after HW and WM
* WM – washing in a washing machine
HW – hand washing

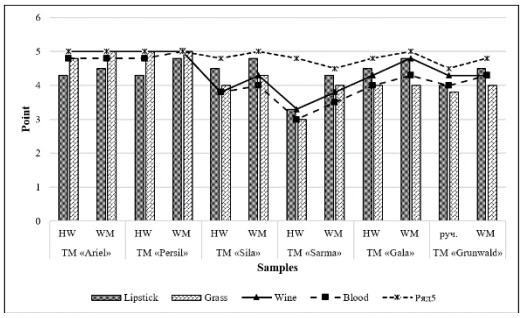

Figure 12. Evaluation results of the studied calico samples after HW and WM
* WM – washing in a washing machine
HW – hand washing

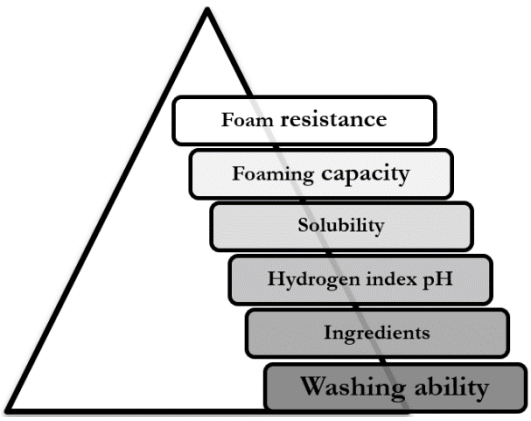

Figure 13. The significance of the main indicators of increasing the effectiveness of laundry detergent

Table 1. Classification of laundry detergents according to UCGFEA

Product code	Product description
3402	Surface-active organic substances (except soap); surface-active preparations, preparations for washing, washing (including auxiliary detergents) and cleaning preparations, whether or not containing soap (except preparations included in heading 3401):
[3402 3]	- anionic organic surfactants, whether or not put up for retail sale:
3402 31 00 00	- linear alkylbenzene sulfonic acids and their salts
3402 39	- others:
3402 39 10 00	- an aqueous solution of disodium alkyl [oxides (benzene sulfonate)] with a concentration of 30 wt.% or more, but not more than 50 wt.%
3402 39 90 00	- others
[3402 4]	- other surface-active substances, whether or not put up for retail sale:
3402 41 00	- cationic:
3402 41 00 10	- benzalkonium chloride (benzalkonium chloride INN)
3402 41 00 90	- others
3402 42 00 00	- non-ionic
3402 49 00 00	- others
3402 50	- means packaged for retail trade:
3402 50 10 00	- surfactants
3402 50 90 00	- detergents and cleaning products
3402 90	- others:

3402 90 10 00	- surfactants
3402 90 90 00	- detergents and cleaning products

Table 2. Restrictions on the content of phosphates and other phosphorus compounds in detergents

Name of the detergent	Restriction	Date of application of the restriction
1. Detergent for washing in household washing machines	- the total phosphorus content should not be equal to or exceed 0?2 grams in the recommended amount and/or dosage of the detergent for use in the main cycle of the washing process in hard water for the standard load of the washing machine for normally soiled fabrics in the case of using powerful detergents for lightly soiled fabrics in the case of using detergents for delicate fabrics	90 days after the termination or cancellation of martial law in Ukraine*
2. Detergent for washing in industrial washing machines	- the mass fraction of total phosphorus in the detergent should not amount to or exceed 0,1%	90 days after the termination or cancellation of martial law in Ukraine*
	- the mass fraction of total phosphorus in the detergent should not be equal to or exceed 0,05%	from December 31, 2026*
3. Detergent for hand washing, washing and cleaning	- the mass fraction of total phosphorus in the detergent should not be equal to or exceed 0,05%	90 days after the termination or cancellation of martial law in Ukraine*
4. Detergent for household dishwashers	- the total phosphorus content should not be equal to or exceed 0,1 grams in a standard dose of detergent for use in the main wash cycle for loading a dishwasher with a table set for 12 people	90 days after the termination or cancellation of martial law in Ukraine*
5. Detergent for industrial dishwashers	- the mass fraction of total phosphorus in the detergent should not be equal to or exceed 0,25%	90 days after the termination or cancellation of martial law in Ukraine*
	- the mass fraction of total phosphorus in the detergent should not amount to or exceed 0,1%	from December 31, 2026*
6. Another detergent	- the mass fraction of total phosphorus in the detergent should not be equal to or exceed 0,05%	90 days after the termination or cancellation of martial law in Ukraine*

* Voluntary application of established restrictions is possible before the date of their application.

Table 3. Indicators of the quality of laundry detergents

Name of the indicator	*Norm*	*Control method*
Appearance	Granules or powder	According to Clause 5.1 of DSTU 2972:2010
Washing ability, %, not less than	85	According to DSTU 2665
Indicator of the concentration of hydrogen ions, pH: - for washing products made of cotton and linen fabrics;	10,5-11,5	According to DSTU 2207.1
- for washing products made of mixed fabrics;	9,0-10,7	
- for washing products made of wool, silk, artificial and synthetic fabrics	7,5-9,0	
Foaming capacity: foam height, cm	20	According to DSTU 2207.1

Table 4. Conformity of labeling of washing powders to the Technical Regulation of detergents

Indicator	Sample					
	№1	№2	№3	№4	№5	№6
Trademark	Ariel	Persil	Sila	Sarma	Gala	Grunwald
Appointment	For washing products made of mixed fabrics	For all types of fabrics, except silk and wool	For all types of fabrics, except silk and wool	For all types of fabrics, except silk and wool	For all types of fabrics, except silk and wool	For all types of fabrics, except silk and wool
Ingredients	5-15% Anionic surfactants, <5% nonionic surfactants, bleaches, phosphonates, polycarboxylates, zeolites, enzymes, flavors	5-15% anionic surfactants, < 5% nonionic surfactants, phosphonates, polycarboxylates, zeolites, flavors, enzymes	>30%: sodium sulfate; 5-15%: anionic surfactants, sodium carbonate, sodium silicate, antiresorbents; <5%: fragrance, optical brightener	> 30%) sulfates; (5-15%) carbonates, anionic surfactants, silicates, oxygen-containing bleach; (< 5 %) polycarboxylates, defoamer	5-15% anionic surfactants, <5% nonionic surfactants, polycarboxylates, enzymes, optical brighteners, flavors, hexylcinnamic aldehyde	>30% sodium chloride; 15-30% sodium carbonate; 5-15% sodium silicate; <5% sodium percarbonate, anionic surfactants
Address	Procter & Gamble-Rakona, s.r.o.., Ottova 402, 269 32 Rakovnik, Czech Republic	"Henkel Poland Operations ", 02-672, m. Warsaw, str. Domanievska, 41, Poland	LLC "Slobozhansky Mylovar", 62371, Kharkiv Region with. Yards. St. Sumy Shlyach, 53, Ukraine	"ATHENA GROUP" LLC, 37 Zaporizhia Highway, m. Dnipro, 49000, Ukraine	Procter & Gamble Ukraine LLC, 08304, Kyiv region, m. Boryspil, str. Zavokzalna, 2, Ukraine	TPP "Velvet Bis" LLC, 85-825, m. Bydgoszcz, str. Voyska Polskigo, 65, Poland
Terms of use	Avoid contact with eyes, use personal protective equipment. In case of contact with eyes, rinse with water for 10-15 minutes. Protect from children					
Net mass, g	300	300	350	400	300	350
Date of manufacture	07.10.24	07.10.24	18.09.24	09.09.23	10.10.24	15.05.24
Expiry date, months.	24	36	60	36	24	60
Storage conditions	at a temperature no higher than 35ºC and a relative humidity of no more than 95%					

Table 5. Organoleptic evaluation of laundry detergent

Sample	Appearance	Color	Odor
Standard according to DSTU 2972:2010	The powder is coarse-grained or fine-grained, the presence of colored granules is allowed	Corresponds to the color indicated on the package, usually white	Corresponds to the smell indicated on the package, not sharp
№1	The powder is coarse-grained, multi-colored granules are present	White	Pleasant odor of freshness, not sharp
№2	The powder is coarse-grained, multi-colored granules are present		Pleasant odor of flowers, not sharp
№3	Powder with granules of different sizes, blue granules are available		A pleasant odor of a spring garden, not sharp
№4	The powder is fine-grained, lumps are present		A sharp unpleasant odor

№5	The powder is fine-grained, blue granules are present		Pleasant odor of perfume, not sharp
№6	The powder is fine-grained, green granules are present		Pleasant odor of flowers, not sharp

Table 6. Research of physico-chemical indicators of the quality of laundry detergent

Indicator	Sample					
	№1	№2	№3	№4	№5	№6
Solubility in hot/cold water, min	1,5 / 8	3 / 9	1,5 / 6	3 / 7	1,5/ 7	1 / 6
Hydrogen index pH	10	10	10	10	10	11
Foam resistance, %	72,7	76,9	76,6	61,5	72,7	72,7
Foaming capacity, см	2	3	5	4	7	5