Quality assessment of textile products as a basis for responsible production and consumption

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Abstract. The purpose of this study is to investigate the aspects of responsible production and consumption of Ukrainian semi-linen napkins for the hospitality industry. The quality of textile products is a prerequisite for efficient consumption and prolonged service life. One of the elements of responsible production is information support for finished textile products. The article analyzes standards that regulate the requirements for textile products regarding safety and environmental friendliness. The mass fractions of the components of the raw material composition were determined using burning tests, microscopy, and sample dissolution. The wipes are made of linen fibres (58.59%) and cotton fibres (41.41%), which differs from the information on the label. The pH was determined by the electrometric method and was 5.3 units. The pesticide content was determined by gas chromatography and did not exceed the instrument's sensitivity limit. An atomic emission spectrophotometer determined the content of extractable heavy metals. The levels of lead, cadmium, arsenic and cobalt did not exceed the sensitivity limit of the instrument. The content of extractable heavy metals, nickel – 1.0 mg/kg, chromium – 0.5 mg/kg, and copper – 0.34 mg/kg did not exceed the limits set by the standard.

1 Introduction

Textiles are the basis of people's well-being all over the world. Textile materials have a wide range of uses: clothing, footwear, interior decoration (bed and table linen, towels, carpets, curtains), furniture, transportation, construction, medical and protective equipment. Textile production is a source of economic growth for countries. However, [1] the linear economy based on the principle of irresponsible production and consumption ("take-make-throw away") no longer works effectively for businesses, consumers, and the environment.

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This will make it possible to use knowledge and tools to build a new economy for sustainable resource management, production and use of materials after the end of the product life cycle.

The EU Strategy for Sustainable and Circular Textiles [2] recognizes the importance of the textile sector. It implements the commitments of the European Green Deal, the Circular Economy Action Plan, and the European Industrial Strategy. One of the points of this strategy is to set requirements for the design of textile products, which determines the service life, maintainability, recycling and disposal conditions. Thus, the strategy considers the entire life cycle of textile products and proposes coordinated actions for responsible production and consumption, which aligns with the UN Sustainable Development Goal 12.

Textile production in Europe is regulated by EU and national legislation, including production methods and working conditions, fiber names, appropriate labeling and marketing, fiber composition of textile products [3].

According to [4], textile manufacturers need to improve their quality to ensure responsible production and consumption. It will allow consumers to use textile products for a long time instead of sending them to landfills, thus polluting the environment.

The study aims to assess the quality, safety and environmental performance of textile products for the hospitality industry, enabling manufacturers to achieve sustainable development goals through responsible labelling.

To achieve this goal, the following tasks were performed: analysis of regulations and requirements for linen textile products used in the hospitality industry; testing samples of Ukrainian-made linen wipes according to selected safety indicators; and assessing the responsible production and consumption of linen textile products through their labelling.

2 Material and methods

Linen napkins produced by Gallery of Linen LLC (Ukraine) were chosen as the object of research. Modern methods were used to conduct the research, namely:

- mass fraction of raw material components – according to DSTU 4057-2001 [5], combustion characteristics and microscopic studies, by the method of sample dissolution;
- pH level – according to DSTU ISO 3071:2015 [6], electrometrically using a pH meter;
- pesticide content – by gas chromatography;
- the content of extractable heavy metals – using an inductively coupled plasma atomic emission spectrophotometer AES ICP Avio 200 manufactured by Perkin Elmer (USA).

A wide range of methods was used to conduct the research, which will allow solving the tasks.

3 Theory

One of the areas of SDG 12 is to improve the quality of textile products, which will allow them to use their full life (second-hand, the library of things, repair, redesign, patchwork, recycling, upcycling, freecycling, downcycling). The longer a product lasts, the more profitable and efficient its consumption is. If a textile product is high quality, the social labor invested in it is not lost and is used to good effect [4].

Information support is a prerequisite for the responsible use of textile products. Many countries use environmental labelling, the main purpose of which is to encourage manufacturers to produce and consumers to buy environmentally friendly textiles; to compare textile products; and to reduce environmental impacts by minimising adverse effects during use and disposal [7].
To establish the level of responsible production and consumption of the object of study to be used for the hospitality industry, it is necessary to select a nomenclature of quality indicators. It is known [8] that woven garments are divided into groups according to the type of raw materials used. During the preparatory stage of the study, it was found that the type of raw material used in the object of study is indicated on the label. For this purpose, the data was analyzed and a group was established based on the mass fraction of the raw material components. According to the national standard, the names of the groups of fabrics and single products containing linen fiber are presented as follows: 100 % – pure linen; at least 92 % – linen; at least 30 % – semi-linen; at least 15 % – mixed. In addition, the subject of the study is included in the group "linen and table cloths", a subgroup for rolling pins and napkins. The product label indicates the raw material used – 100% linen (Fig. 1).

![Fig. 1. Label with labeling details on a napkin.](image)

Notes: 1 – name of the manufacturer, 2 – its trademark; 3 – location of the manufacturer; 4 – name of the product; 5 – article; 6 – designation of the regulatory and technical documentation in accordance with which the product is manufactured; 7 – composition of raw materials, %; 8 – nominal size of the product, cm; 9 – care symbols, 10 – date of manufacture; 11 – expiration date; 12 – bar code of the product.

During the processing of textile materials, there is a problem of the lack of sorting and fractionation technologies based on the components of the fiber composition [9]. For the responsible production and consumption of textile products, information on their operation (indicated on the label) and subsequent disposal (not on the label) is important. Therefore, it is important for manufacturers to develop a label indicating the fiber composition of materials, the place of production, and the environmental impact. In Ukraine, textile manufacturers use national standards for labeling their products, which do not regulate such requirements.

Therefore, for the further selection of quality indicators, a group was identified by the type of raw materials used and purpose. At the preparatory stage of assessing the quality level of linen napkins, a nomenclature of indicators was selected. The mandatory indicators of linen products include: surface density, linear density of yarn, number of threads per 10 cm on the warp and weft, size, mass fraction of raw material components [10]. In addition, the mandatory quality indicators for linen products include indicators for linen and table fabrics, namely: the degree of dyeing resistance to various physical and chemical influences, compliance of the artistic and coloristic design and structure of the product with the reference sample.
However, not all of these indicators affect the safety and environmental friendliness of textile products. It is therefore possible to use the OEKO-TEX® STANDARD 100, which establishes a nomenclature of quality indicators for textiles in contact with the skin: pH, formaldehyde content, extractable heavy metals, pesticide content [11].

As a result of the analytical search, the nomenclature of quality indicators for linen napkins was analyzed, which will make it possible to evaluate them in terms of responsible production and consumption.

4 Results

Identification of the components of the raw material composition of a textile product involves qualitative and quantitative analysis. Although according to the labeling (Fig. 1), linen napkins made in Ukraine are made of 100% linen fibers, during the preparatory stage of research on the appearance, fabric structure, and stiffness to the touch, it was found that the samples of textile products are made of heterogeneous (mixed) threads (Fig. 2).

Fig. 2. Appearance of the fabric of a sample napkin made of Ukrainian flax: 1 – warp yarns, 2 – weft yarns.

The analysis data confirmed the assumption that the samples were made from fabrics that were not homogeneous in terms of raw material composition. Initially, the combustion characteristics of samples of Ukrainian-made linen wipes were studied, which revealed the following:
- when brought to the flame – they do not melt or change shape;
- in the flame – burns without melting;
- when removed from the flame – it continues to burn without melting;
- appearance of the residue after combustion – light gray ash, easily crushed by fingers;
- odor during burning – burnt paper [5].

The identification results identified the samples as cotton and linen fibers. To confirm the fiber composition of the textile product, a microscopic examination of samples of napkins made of Ukrainian flax was carried out (Fig. 3).
The study results showed that the mass fraction of raw material components is as follows: flax – 58.59%, cotton – 41.41%. In accordance with DSTU 3047-95 [8], samples of Ukrainian-made flax wipes are classified as semi-flax wipes with a flax fiber content of at least 30% by the content of the raw materials used.

The pH of the water extract of the samples of semi-flax wipes produced in Ukraine was 5.3 units, which meets the safety requirements for textile products [11].

The results of studies of the pesticide content are presented in Fig. 4.

According to the chromatogram data, the pesticide content in the samples did not exceed the sensitivity limit of the device and corresponds to the regulatory values [11].

The content of extractable heavy metals in the samples of semi-flax wipes of Ukrainian production is shown in Fig. 5 and Table 1.
Examine Spectra - Analyte

Cr 267.711

Wavelength (nm)

Intensity

267.59
267.830

P

Examine Spectra - Analyte

Ca 327.393

Wavelength (nm)

Intensity

327.244
327.537

P

Examine Spectra - Analyte

Cd 228.802

Wavelength (nm)

Intensity

228.699
228.901

P

Examine Spectra - Analyte

Pb 220.353

Wavelength (nm)

Intensity

220.255
220.448

Examine Spectra - Analyte

Ni 231.604

Wavelength (nm)

Intensity

231.51
231.704

Examine Spectra - Analyte

Co 228.616

Wavelength (nm)

Intensity

228.513
228.716

6
Fig. 5. Heavy metal content in samples of Ukrainian-made semi-flax wipes: a – Chromium; b – Copper; c – Cadmium; d – Lead; e – Nickel; f – Cobalt; g – Arsenic.

Table 1. The results of the study of toxic elements in samples of semi-flax wipes produced in Ukraine.

<table>
<thead>
<tr>
<th>Name of the indicator</th>
<th>Levels of toxic elements</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>maximum permissible</td>
<td>maximum permissible</td>
</tr>
<tr>
<td>Lead</td>
<td>1,0</td>
<td>0,2</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0,1</td>
<td>0,1</td>
</tr>
<tr>
<td>Arsenic</td>
<td>1,0</td>
<td>0,2</td>
</tr>
<tr>
<td>Cobalt</td>
<td>4,0</td>
<td>1,0</td>
</tr>
<tr>
<td>Nickel</td>
<td>4,0</td>
<td>1,0</td>
</tr>
<tr>
<td>Chromium</td>
<td>2,0</td>
<td>1,0</td>
</tr>
<tr>
<td>Copper</td>
<td>50,0</td>
<td>50,0</td>
</tr>
</tbody>
</table>

Note: * limit of sensitivity of the method.

The study results show that the content of extractable heavy metals does not exceed the standardized values.
5 Discussion

According to [12], the use of the eco-label indicates a high level of chemical management, environmental efficiency, functioning of the environmental management system, social responsibility, quality management, health and safety by OEKO-TEX® STANDARD 100.

The analysis of the study results showed that the labeling details are not always suitable for identifying the components of the fiber composition of textile products. However, it is positive that the labeling of samples of napkins made from flax and cotton fibers has symbols for their care.

Natural fibers are innovative, sustainable and environmentally friendly, produced from natural sources. In the textile sector, these fibers are the way to a clean and green environment, are easily recycled, are the reinforcement for composite materials, and are the basis for responsible production and consumption. They also have a positive impact on human health [13]. This is because they are a product of agricultural production, where chemicals are used to protect plants and increase their productivity [14]. As a result, natural plant fibers can contain pesticides and heavy metals.

Studies [15] have shown that the pH level of the environment of textiles is assessed due to the fact that textile materials undergo chemical treatment (bleaching, dyeing, and sizing) during the production process [16]. Chemicals are fixed on the fibers and affect the safety of finished textiles. Paper [17] also shows the importance of controlling the pH of the dye on the pulp. The factors that influence the resistance of finished dyes to different acidity or alkalinity conditions are described. The article [18] presents the results of studies of the pH levels of various textile products and finds that most of these products fall within the recommended range of 4.0 to 7.5 units.

In addition, it is also important to use bast fibers, which can provide significant benefits due to their lower environmental impact [19].

Testing for heavy metals and pesticides is a prerequisite for monitoring the safety and environmental friendliness of textiles for responsible production and consumption. Since the components of the raw material composition of a textile product are products of plant origin, the study of pesticide content is an urgent issue [16]. It was established [20] that pesticide residues were found in cotton fiber textiles in the concentration range from 0.01 to 0.416 mg/kg. The pesticides belonged to different chemical groups, most of which are regulated by OEKO-TEX® STANDARD 100. The monitoring of harmful substances (heavy metals and pesticides) in the textile products in the study [21] showed that the concentration of these substances did not exceed the levels permitted by the OEKO-TEX® STANDARD 100.

Heavy metals in textiles are regulated by mandatory environmental standards that establish the presence of 11 extractable heavy metals [11].

This problem was discussed by scientists [22] who studied the content of heavy metals in textiles that were subjected to dyeing. It was found that the concentrations of heavy metals in various textiles of different colors from local markets exceed the permissible limits: for nickel (from 3.8 to 6.5 mg/kg), chromium (from 0.5 to 7.6 mg/kg), copper (from 3.4 to 88.3 mg/kg). In support of this, the paper [23] presents the results of tests on textile products for the content of heavy metals: arsenic 0.002 mg/kg, cadmium 0.0008 mg/kg, copper 8.6 mg/kg, lead 0.0009 mg/kg, zinc 48.6 mg/kg.

The authors [24] emphasize the importance of studying metals and metal compounds in textiles and characterize the sources of their occurrence. It was found that samples of textiles contain arsenic, lead, chromium, mercury, etc. Traces of metals such as copper, cadmium, zinc, manganese, iron, and nickel were also found [25].
In contrast to the previous study, the concentrations of extractable heavy metals in the wipes samples were found to be too low, which proves compliance with international and national regulations and the responsibility of Ukrainian manufacturers.

6 Conclusions

Responsible production and consumption are decisions we must make for future generations. To do this, producers and consumers must realize their responsibility to society, be able to trace the origin of raw materials, a sustainable technological process of manufacturing products from environmentally friendly recyclable raw materials, constantly improve the quality of textile products, etc.

The life cycle of textile products made of cellulose fibers allows for a certain level of quality, safety, and environmental friendliness to be incorporated into their design and reflected in their labeling.

The study showed that the fiber composition of the Ukrainian-made semi-flax wipes indicated on the labeling does not correspond to the actual content of the components. This indicates that it is impossible to establish the product's compliance with the procedure for further use, recycling and disposal. To achieve sustainable development goals, Ukrainian producers need to prepare for changes in European legislation and introduce environmental labelling for textile products.

Research into raw material composition has revealed a discrepancy in labelling that does not allow consumers to make responsible choices. The study of safety indicators of Ukrainian-made semi-flax wipes showed compliance with the requirements of OEKO-TEX® STANDARD 100 in terms of pH, pesticide content and extractable heavy metals. This proves the responsibility of the napkins manufacturer and makes them safe for use and the environment.

Choosing high-quality, durable, safe, environmentally friendly textiles helps to reduce waste and natural resources, as consumers are less likely to replace their clothes due to their rapid wear and tear. Such textiles, manufactured in accordance with ethical and environmental principles, support the concept of responsible production and consumption, where products are chosen that do not harm health, the environment or society.

Textile assessment is not only a means of guaranteeing product quality, but also a way to support responsible production and consumption, which is essential for sustainable development.

Ukrainian textile manufacturers should monitor raw materials according to the requirements of the OEKO-TEX® STANDARD 100, which will enable them to produce safe and environmentally friendly textile products, analyse material supply sources and introduce environmental labelling of their products, not only to promote their own products but also to encourage responsible consumption. The current requirement is to develop 'green' passports for textile products, indicating the composition of the fabric (recycled fiber content), the origin of the material and the processing methods available.

The research was carried out within the framework of research topics 0121U110650 "Quality and safety of products in domestic and foreign trade and trade entrepreneurship: modern vectors of development and prospects" (2021) and 0117U001582 "Research and development of properties, assortment and quality of innovative non-food products" (2017).
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