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Assessment of the Quality and Authenticity of Pesto Sauces Available on the Polish Market

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Abstract

Aim: The aim of this study was to assess the quality of pesto sauces available in Poland on the Tri-City market (Gdańsk, Gdynia and Sopot). Three pesto sauces were tested: Grand'Italia pesto alla genovese (GI), SACLA Italia pesto alla genovese (SI), Baresa Pesto alla Genovese (BP).

Methodology: The correctness of labelling of selected sauces was assessed in accordance with the requirements of the Regulation of the European Parliament and of the Council (EU) of 25 October 2011. The acidity of the sauces was tested using the acid-base titration method with NaOH solution against phenolphthalein. The content of NaCl salt in pesto sauces was determined using the Mohr method. The colour of pesto sauces was determined using the CIELab method using the Konica-Minolta CR 400 colourimeter. The fat content in the tested sauces was determined using the Gerber method.

Results: The tested sauces contained all the information that should appear on the packaging, including the name of the product, the name and address of the manufacturer, the composition and nutritional value, the production batch number and the expiry date. The acidity of the tested pesto sauces was in the range of 2.4-3.6% in terms of acetic acid. The salt content was in the range of 2.3-2.9%, and the fat content was in the range of 38.0-42.5%. The value of the L* parameter in the analysed pesto sauces remained in a narrow range of 41.91-42.72. The value of the a* parameter was in the range of –1.83 to –2.37, the value of which depends on the degree of decomposition of chlorophyll contained in basil, which is the main component of pesto sauce. In turn, the value of the b* parameter was in the range of 22.45-26.78. The results of the study showed that the quality of the

analyzed pesto sauces differed from the literature data on the production of pesto alla genovese sauces. The presence of ingredients such as simple saccharides and glucose-fructose syrup, the presence of thickening agents and the low content of Pecorino Romano or Grana Padano cheese raise concerns.

Implications and recommendations: Further research on pesto sauces is necessary to ensure their quality and authenticity due to the growing interest of consumers in Italian food products.

Originality/value: The conducted research is one of the few in Poland and is a contribution to the assessment of quality and ensuring the authenticity of selected pesto sauces available on the Polish market.

Keywords: pesto sauces, quality and authenticity, product market, Polish market

1. Introduction

Numerous factors influence the change in the model of nutrition and eating habits, which include population growth, globalisation, urbanisation, economic pressure, climate change, population migration, changing lifestyle and quality of life, which are altering food consumption around the world (Berkemeyer & Wehrmann, 2022; Chen & Antonelli, 2020; Owino et al., 2022). Italian and French cuisine are the two most popular European types of food with a global reach and the strong influence the eating habits of consumers. The popularity of Italian cuisine is caused by many factors, but the most important are the geographical location and Mediterranean climate of Italy, beneficial to growing vegetables and fruit. The traditional products in the culinary culture of Italy include olive oil, cheese, pasta, and wine. However, the term 'Italian cuisine' should not be used, as it is very diverse and one actually deals with the cuisines of Italian regions, and even the cuisines of Italian cities, such as Naples, Milan, and Genoa (Sert, 2017). The northern Italian cuisine is very different from the southern one. Fish and seafood dominate the menu on the Italian coasts and islands. Italian dishes use herbaceous plants such as basil, oregano, mint, sage, celery, and fennel. Italian cuisine is most often associated with pizza and pasta by consumers around the world. There are dozens of types of Italian pasta, served with sauces such as: *pomodoro e basilico*, *carbonara*, *aglio olio e peperoncino*, *arrabiata*, *pesto alla genovese*, *al tartufo*, and others. The aim of this paper was to present one of the most commonly used pasta additives, i.e. pesto sauce, and to assess the quality of ready-made pesto sauces available on the Polish market.

2. Characteristics of Pesto Sauce

Classic pesto sauce is made by grinding, usually in a mortar, fresh basil with olive oil, salt, garlic, parmesan and/or pecorino cheese, and pine nuts. The sauce originates from Genoa and is a specialty of Liguria, the region of which Genoa is the capital. Unlike other pasta sauces, pesto is a sauce prepared and served cold, which preserves its organoleptic characteristics, such as colour and flavour (Turrini et al., 2022; Zunin et al., 2009). The Liguria pesto has unique organoleptic properties resulting from the characteristic sensory attributes of Genoese basil (*Ocimum basilicum* L.). The product possesses the P.D.O. (Protected Designation of Origin) mark (Commission Regulation (EC) No 1623/2005).

The basis of pesto sauce is basil *Ocimum basilicum* L. cv. *Genovese*. Basil as a spice and fresh herb is ideal for seasoning and enriching various types of dishes, such as meat, fish, soups, and salads (Spence, 2024), and plays an important role in Italian cuisine, the cradle of the famous Mediterranean diet. Genovese basil, known for its exceptional aromatic and sensory properties, is not only an indispensable decorative element of iconic Italian dishes (spaghetti with cherry tomatoes, pizza Margherita, Caprese salad), but also the main ingredient of the famous green sauce known as pesto (Ciriello et al., 2023). Numerous studies have shown that basil leaves (*Ocimum basilicum* L.) are a rich source of bioactive

compounds with high antioxidant potential (Bajomo et al., 2022; Fedoul et al., 2022; Romano et al., 2022; Sęczyk et al., 2022; Shahrajabian et al., 2020).

Studies have also shown that the variety of *Ocimum basilicum* L. used to prepare the pesto sauce is of great importance. The evaluation of the production, quality, and physiological performance of three Genovese basil varieties ("Aroma 2", "Eleonora", and "Italiano Classico") showed that "Aroma 2" produces the highest yield and is characterised by the highest photosynthesis rate with the lowest nitrate content (Ciriello et al., 2021a).

The quality of *O. basilicum* cv. *Genovese* is also influenced by the temperature at which the plant grows. Short-term exposure to mild and severe temperature stresses of cold (4 and 10°C, respectively) or heat (30 and 40°C) affects the biochemical and physiological characteristics of basil leaves and roots. It has been shown that episodic exposure to both heat and cold stress increases the content of chlorophyll a, chlorophyll b, and carotenoids in basil leaves (Jakovljević et al., 2021).

Another ingredient in pesto is olive oil, which has long been known to have many health benefits when consumed as part of the Mediterranean diet. However, it is only in the last decade that epidemiological studies confirmed its protective role against the development of several chronic diseases, and this is particularly true for extra virgin olive oil. Olive oil from Ligurian *Taggiasca* olives is recommended, but unfortunately the harvests of this variety of olive are not large and therefore it is often adulterated (Buckland & Gonzalez, 2015; Gaforio et al., 2019; Senizza et al., 2023).

In Italy, sea salt is used for grinding basil, however it should be remembered that the salt should be obtained in a way ensuring its appropriate quality. Unfortunately, significant contamination of sea salt with macro, micro, and nanoplastics has been recently observed (Renzi & Blašković, 2018; Śmiechowska, 2018).

The next ingredient of pesto is cheese, which should be Parmigiano Reggiano and/or Pecorino Fiore Sardo, and ideally the saltier, more piquant, and more accessible Pecorino Romano. Unfortunately, cheese is very often adulterated, especially Parmigiano Reggiano, which means that the original and authentic cheese should be protected by, for example, electronic chipping (Popping et al., 2017).

The last of the main ingredients of pesto are pine nuts. The benefits of consuming pine nuts are due to their polyunsaturated fatty acids (PUFA) content. Previous studies have shown the potential benefits and anti-inflammatory effects, as well as the beneficial metabolic changes resulting from consuming pine nuts (cf. Takala et al., 2023).

Garlic is not a standard addition to pesto, but is added optionally. Common garlic, *Allium sativum* L., a member of the *Amaryllidaceae* family, is cultivated worldwide as a vegetable and spice plant (Netzel, 2020; Singh & Singh, 2019). However, the properties of garlic and its effects on the human body have been generating increasing interest in this vegetable not judt as a spice (Ansary et al., 2020; Shang et al., 2019; Tudu et al., 2022). Garlic added to pesto not only affects its sensory values, but also acts as a preservative. Research on the application of the properties of garlic continues and leads to the production of new medicinal and food products (Verma et al., 2023).

3. Materials and Methods

The study material consisted of ready-made pesto sauces available on the Polish market: Grand'Italia pesto alla genovese (GI), SACLA Italia pesto alla genovese (SI), and Baresa pesto alla genovese (BP). All physicochemical analyses were performed in triplicate, and the data shown in the tables are the average of the three examinations.

The assessment of the correctness of the labelling consisted in checking whether the label contained all the required information, i.e. product name, manufacturer's name, manufacturer's address, production batch number, expiration date, product weight, as well as information on storage conditions,

composition, and nutritional value. The labelling should meet the requirements of the Regulation of the European Parliament and of the Council (EU) of 25 October 2011 (Regulation (EU) No 1169/2011…).

The acidity of the pesto sauces was determined by titrating the analysed sample with a sodium hydroxide solution of a precisely defined titer in the presence of phenolphthalein as an indicator.

The total acidity was expressed in percentages in terms of acetic acid. The sodium chloride (table salt) content in the sauces was determined using the Mohr method.

The colour of the pesto sauces was determined using the CIELab method. The instrumental determination of their colour was performed using a Konica-Minolta CR 400 colorimeter (Konica Minolta, Japan) for the standard 2° observer and D65 illuminant. The colour measurements were made in a CIELab colour space, where L* determines the brightness of raw materials and extrudates (on a scale of 0-100), the a* colour index is the balance of green (–100) and red (+100), while the b* colour index is the balance of blue (–100) and yellow (+100).

The fat content of the examined pesto sauces was determined using the Gerber method.

The organoleptic evaluation of the sauces was performed immediately after opening the packages.

The acidity, sodium chloride and fat content were determined according to the generally accepted analytical methods included in the standards and described in the literature. The calibration of the Konica-Minolta CR 400 apparatus for determining colour using the CIE LAB method was carried out in accordance with the procedure provided by Konica Minolta, Japan.

4. Results and Discussion

The general profile of the analysed products is presented in Table 1. The information provided on the packaging and on the manufacturers' websites was used.

Table 1. Characteristics of the research material

Product code	Product name	Ingredients
GI	Grand'Italia pesto alla genovese	Sunflower oil, basil (29.8%), potatoes, glucose syrup, cashew nuts, Grana Padano cheese (4.5%) (with hen egg white), Pecorino Romano cheese, salt, extra virgin olive oil (1.5%), pine nuts, (1%), acidity regulator: lactic acid, garlic.
SI	SACLA Italia pesto alla genovese	Sunflower oil, Italian basil (36%), Grana Padano cheese (contains egg lysozyme as preservative), cashew nuts, sea salt (3.3%), glucose, Pecorino Romano sheep cheese, pine nuts, flavors, potato flakes, acidity regulator: lactic acid, extra virgin olive oil.
BP	Baresa pesto alla genovese	Basil (38%), sunflower oil, olive oil (11%), cashew nuts (5%), hard cheese (4.7%) (cow milk, salt, preservative: egg lysozyme), yoghurt (4%), flavoring substances, salt (2%), sugar, Pecorino Romano cheese (1.3%), pine nuts (1%), garlic (1%), acidity regulator: lactic acid.

Source: own study.

The analysis was preceded by an assessment of the correctness of the labelling. The studied sauces contained all the information that should be shown on the packaging, including the product name, the name and address of the manufacturer, the composition and nutritional value, the production batch number, and the expiration date. The labelling met the requirements of the Regulation of the European Parliament and of the Council (EU) of 25 October 2011 (Regulation (EU) No 1169/2011…).

The declared composition of the pesto sauces was very diverse with respect to the basil content, in the range of 29.8-38%. In two of the analysed products, the presence of pine nuts was declared in the amount of 1%. Only one sauce, SACLA Italia pesto alla genovese, contained sea salt in the amount of 3.3%, and the Baresa pesto alla genovese sauce contained 2% of salt, but no information was given whether this was sea salt (Table 1).

All the analysed sauces contained cashew nuts, at 5% in the Baresa pesto alla genovese sauce according to the manufacturer's declaration. All the sauces contained also pine nuts according to the information on the labels, but the SACLA Italia pesto alla genovese sauce did not specify their content. The primary source of fat in the sauces was sunflower oil with a variable addition of olive oil, while the original Italian pesto is made only with olive oil (Table 1).

An important ingredient of pesto sauce is proper cheese. All the examined sauces contained Pecorino Romano, but only in the case of Baresa pesto alla genovese sauce its content was specified as 1.3%. In addition, the Grand'Italia pesto alla genovese sauce contained 4.5% of Grana Padano, and the Baresa pesto alla genovese sauce contained an unknown amount of hard cheese of an unspecified variety. The SACLA Italia pesto alla genovese sauce also contained a thickening agent in the form of potato flakes. In all the pesto sauces, saccharides were added in the form of glucose, glucose syrup, or sugar (Table 1).

Studies of pesto sauces available on the Dutch market also confirmed the diverse composition and content of the main ingredients (Al-Malahmeh et al., 2017). In 31 pesto sauces from the Dutch market, the basil content ranged from undeclared to 79%. In 20 pesto sauces from this market, sunflower oil was also used instead of olive oil. The amount of other ingredients such as olive oil, pine nuts, and salt, also varied. Several labels declared the presence of thickening agents, while one specified guar gum and xanthan gum. In two sauces, the composition was not given, only the information that they were prepared according to a secret recipe.

The overall sensory evaluation of pesto sauces in this study was based on their appearance after opening the glass containers. The sauces were found to be green in color with varying degrees of color saturation. The smell was also characteristic and resulted from the ingredients used. The consistency of the sauces was not uniform, and a layer of oil was visible on the surface of the sauces. In this study, no consumer sensory evaluation of the pesto sauces was performed.

Taste and smell have a major impact on the consumption of pesto. Sensory quality is one of the decisive factors in consumers' choice after production and during storage, and many factors influence the sensory sensations. The research conducted by Altay et al. (2024) showed that the type of cheese used to produce the sauce has a major impact on the sensory properties of pesto sauces. The authors used Beyaz peynir, Tulum, and Kashar cheeses produced in Turkey to obtain pesto sauces. Based on the sensory results, it was found that the sauces were highly appreciated by consumers (Altay et al., 2024). In turn, the research conducted by Sordini et al. (2024) demonstrated that higher values of the "cheese", "pine nuts", and "green colour" attributes determined the choice of pesto sauces by consumers.

Table 2 presents the results of the sodium chloride (salt) content, fat content, and acidity in the analysed pesto sauces.

Table 2. Acidity, sodium chloride content, and fat content in pesto sauces*

Parameter \ Product	GI	SI	BP
Acidity (expressed as acetic acid) [%]	3.0	2.4	3.6
NaCl content [%]	2.8	2.3	2.9
Fat content [%]	42.0	38.0	42.5

* results in the table are the average of three determinations

Source: own study.

In all three pesto sauces analysed by the authors, lactic acid was declared as an acidity regulator, but the amount of its addition was not given. Their acidity varied from 2.4 to 3.6% in terms of acetic acid. In the study by Naelga & Ihong (2019), it was found that the pH of pesto sauces from Asian, North American, and Australian markets was slightly acidic and averaged 5.2. Nicosia et al. (2021) found

a varying acidity of commercial pesto sauces from the Italian market in a wide range of pH 4.00-5.64. Pesto sauces produced in Turkey also had a varied acidity ranging from 5.30 to 5.77 (Altay et al., 2024). According to these authors, the acidity of pesto sauces was influenced by the acidity of the cheeses used to make the sauces. Sordini et al. (2024) measured acidity in the pH range of 5.26 to 5.37 in freshly prepared pesto sauces intended for delivery to stores.

The pesto sauces analysed in this study contained salt in the range of 2.3-2.9%. Altay et al. (2024) found an average salt content of 1.5% in pesto sauces, whereas inspections in the British market found a salt content in the pesto sauces served in the McDonald's chain in the range of 1.5-3.3%. According to research conducted by Consensus Action on Salt and Health (Cash), two products from Sacla, the best-selling British pesto brand, contained 30% more salt than sea water, and two and a half times more salt per 100 g than peanuts (The Guardian, 2017).

The fat content in the studied pesto sauces from different producers ranged from 38.0 to 42.5% (Table 2). Studies on industrially produced Italian pesto showed that most of the sauce samples had a lipid content in the range of 46-49%, with only a few samples showing higher values (Tanzilli et al., 2023). Similar results of the fat content in pesto sauces were found by Nicosia et al. (2021). The highest fat content of 60% was determined by Sordini et al. (2024) in pesto sauces produced by a local company in Perugia.

Colour is one of the main characteristics of food and a major factor influencing the choice of food products. The food industry uses natural and synthetic dyes to enhance food colouring to meet the needs and expectations of consumers. In recent years there has been a growing interest in natural dyes as they are perceived as healthier than synthetic ones (De Mejia et al., 2020; Koop et al., 2023). Pesto sauces are among the food products that owe their colour primarily to basil leaves, which is the main ingredient of the sauce that determines it (Zunin et al., 2009). The colour of pesto measured in the CIELab system is characterised by three parameters: L* – lightness, a* – green-red pigment vector, and b* – blue-yellow pigment vector. The results of the colour measurements of pesto sauces performed in this study are presented in Table 3.

Table 3. Analysis of the colour of pesto sauces using the CIELab method*

Colour parameter \ Product	GI	SI	BP
L*	41.91	42.72	42.01
a*	–2.61	–1.83	–2.37
b*	22.88	26.78	22.45

* results in the table are the average of three determinations

Source: own study.

The value of the L* parameter in the analysed pesto sauces remained in a narrow range of 41.91-42.72 (Table 3). Nicosia et al. (2021) reported a range of the L* parameter from 44.34 ± 0.59 to 47.98 ± 0.62 with a basil content of 30%. Turrini et al. (2022) indicated the great importance of the a* parameter, because it can be an indicator of chlorophyll degradation. Therefore, Nicosia et al. (2021) analysed only the a* parameter, which remained in the range of –3.0 ± 0.13 to –3.82 ± 0.12. In this study, the a* parameter remained in the range from 1.83 to 2.61. The large variability of colour parameters is explained by the influence of many factors such as basil variety, type and cultivation conditions, industrial processing factors, and preservation techniques (Sordini et al., 2024). The colour of pesto and its long life are some of the most important features of this unique sauce, and for this reason new ways of ensuring colour stability are being sought. Studies have been conducted using other plant raw materials, such as spinach and coriander (Ciriello et al., 2021b; Kim et al., 2016; Sowmya et al., 2022), as well as on the use of herbs from different cultivation systems. Hydroponically grown coriander and basil showed better colour stability than coriander and basil grown in soil, together with better sensory

properties and better storage qualities. Pesto prepared from hydroponically grown herbs proves to be a higher quality option on commercial scale (Sowmya et al., 2022). Klug et al. (2018) showed that process and product innovations in obtaining pesto made from fresh broad bean seeds using microwaves also have a positive effect on colour stability, as well as chlorophyll and carotenoid content. Microwave treatment improved the sensory quality of the sauce and reduced the content of condensed tannins.

5. Summary and Conclusions

Italian cuisine is one of the most popular in the world and is based on olive oil, fresh vegetables, cheese, pasta, and wine. Many processed foods previously available only on the Italian food market have become global products, and pesto is one of them. Studies on the quality of pesto sauces available on the Polish market have shown that they vary in quality.

- The basil content in pesto sauces ranged from 29.8% to 38.0% and was lower than the content in sauces available on the EU market.
- Low a* parameter values from 1.83 to 2.87 indicate low chlorophyll content corresponding to low basil leaf content.
- Pesto sauces were prepared with sunflower oil with a varying addition of olive oil from an undeclared amount up to 11%.
- The analysed sauces contained 2.3-2.9% salt, which was lower than the salt content in pesto sauces available on other markets, e.g. the British one.
- The information on the sauce labels indicates that the addition of Pecorino Romano or Grana Padano cheese did not exceed 1.5%. The producers also used other cheeses, the names of which were not specified on the packaging.
- Two sauces contained thickening agents in the form of potato flakes, while all of them contained added sugars in the form of sucrose, glucose, or glucose syrup.
- Due to economic reasons or the lack of availability of pine nuts, they were replaced with cheaper cashew nuts.

The results of this study showed that the quality of the analysed pesto sauces differed from the literature on the production of *pesto alla genovese* sauces. Therefore, it is necessary to conduct further research on pesto sauces in order to ensure their quality and authenticity due to the growing interest of consumers in Italian food products.

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Ocena jakości i autentyczności sosów pesto dostępnych na polskim rynku

Streszczenie

Cel: Celem niniejszego badania była ocena jakości sosów pesto dostępnych w Polsce na rynku trójmiejskim (Gdańsk, Gdynia i Sopot). Przebadano trzy sosy pesto: Grand'Italia pesto alla genovese (GI), SACLA Italia pesto alla genovese (SI), Baresa Pesto alla Genovese (BP).

Metodologia: Dokonano oceny prawidłowości oznakowania wybranych sosów zgodnie z wymaganiami Rozporządzenia Parlamentu Europejskiego i Rady (UE) z dnia 25 października 2011 r. Przeprowadzono badania kwasowości sosów metodą miareczkowania alkacymetrycznego roztworem NaOH wobec fenoloftaleiny. Określono zawartość soli NaCl w sosach pesto metodą Mohra. Barwę sosów pesto określono metodą CIELab przy użyciu kolorymetru Konica-Minolta CR 400. Zawartość tłuszczu określono metodą Gerbera.

Wyniki: Badane sosy zawierały wszystkie informacje, które powinny znaleźć się na opakowaniu, w tym nazwę produktu, nazwę i adres producenta, skład i wartość odżywczą, numer partii produkcyjnej oraz datę ważności. Kwasowość badanych sosów pesto zawierała się w przedziale 2,4-3,6% w przeliczeniu na kwas octowy. Zawartość soli pozostawała w zakresie 2,3-2,9%, a zawartość tłuszczu kształtowała się w zakresie 38,0-42,5%. Wartość parametru L* w analizowanych sosach pesto utrzymywała się w wąskim zakresie 41,91-42,72. Wartość parametru a* pozostawała w zakresie od –1,83 do –2,37, którego wartość uzależniona jest od stopnia rozpadu chlorofilu zawartego w bazylii, która jest głównym składnikiem sosu pesto. Z kolei wartość parametru b* kształtowała się w zakresie 22,45-26,78. Wyniki badania wykazały, że jakość analizowanych sosów pesto odbiegała od danych literaturowych dotyczących produkcji sosów *pesto alla genovese*. Zastrzeżenia budzi obecność składników takich jak sacharydy proste i syrop glukozowo – fruktozowy, obecność substancji zagęszczających i niska zawartość sera Pecorino Romano or Grana Padano.

Implikacje i rekomendacje: Konieczne jest prowadzenie dalszych badań nad sosami pesto w celu zapewnienia ich jakości i autentyczności ze względu na rosnące zainteresowanie konsumentów włoskimi produktami spożywczymi.

Oryginalność/wartość: Przeprowadzone badania należą do nielicznych w Polsce i stanowią wkład w ocenę jakości i zapewnienie autentyczności wybranych sosów pesto dostępnych na polskim rynku.

Słowa kluczowe: sos pesto, jakość i autentyczność, produkt rynkowy, rynek polski