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PUMPKIN AND FLAX BY-PRODUCTS - INGREDIENTS FOR BETTER SENSORY CHARACTERISTICS OF COOKIES

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Abstract

Animal feed is the primary application for waste generated by the cold oil industry. However, this by-product is also a valuable source of proteins, fats, dietary fiber, polyphenols, and antioxidant activity, making it an attractive functional ingredient for the development of healthy food products. Sensory acceptability is a crucial factor to consider when creating new food items. The objective of this paper is to incorporate by-products from the cold pressing of pumpkin and flax oils into cookies production and assess their sensory acceptability.

The official American Association of Cereal Chemists (AACC) 10-50D method was employed to produce the cookies. In addition to the control cookies (made with 100% wheat flour), variations were also prepared by replacing 30% and 60% of wheat flour with flour derived from pumpkin and flax by-products. To evaluate the sensory characteristics of the cookies, 19 semi-trained panelists conducted a sensory analysis in Veles (Macedonia) and Pristina (Kosovo). The sensory parameters including color, shape, texture, smell, and taste, were evaluated using a hedonic scale (ranging from 1 to 9). Analysis of variance (ANOVA) and Fisher's Least Significant Difference test (LSD) at $p < 0.05$ were performed with the software XLSTAT 2019 and Microsoft Office Excel 2016.

A statistically significant ($p < 0.05$) impact of pumpkin and flax by-products on the sensory quality of the cookies was revealed. Pumpkin by-product cookies received a higher overall acceptability score (5.65 points) compared to those containing flax by-products (5.57 points) as a replacement for wheat flour. Furthermore, cookies with 60% by-product content were rated higher than those with only 30% by-product substitution.

Incorporating by-products into cookie production presents an innovative, cost-effective, and easy approach to minimizing environmental waste and creating new healthy products. However, due to the novelty of these cookies, consumers may not be familiar with them. The sensory analysis revealed that the control cookies received the highest ratings. Further investigation is needed to determine the ideal quantity of by-products that can be utilized in cookie production.

***Key words**: By-products, Cookies, Flax, Pumping.*

1. Introduction

In developed countries, more than 10 million tons of food waste are produced yearly. The costs associated with the management of this waste are several million euros [1]. A challenge in the food industry, on one hand, is the creation of safe and quality products for consumption, and on the other hand, is the proper management of the generated waste. Food security is particularly important due to the lack of natural resources, population growth, high food prices, climate change, etc. [2]. The sustainable management of waste from the food industry is an area that has grown tremendously in recent years. All aspects (environmental, economic, and social) should be included in the sustainable management itself [3].

The oil production industry is a part of the food sector which, like all others, undergoes changes both in the way of obtaining the oil and in improving its nutritional quality. Cold pressing of oils is a method of oil extraction in which oil is obtained from raw materials of plant origin with high nutritional value, primarily because no organic solvents are used during the extraction [4].

Flax seeds (*Linum usitatissimum*) together with chia and sesame have become popular in recent years and are increasingly being used in the daily diet. They are known as "superfoods" because of their rich nutritional composition (excellent source of protein, dietary fiber, polyphenols, antioxidant properties, and polyunsaturated fatty acids (omega 3) [5, 6]. Flaxseed oil is primarily used for its health benefits such as preventing coronary heart disease, preventing some types of cancer as well as neurological and hormonal disorders [7].

During the extraction of flaxseed oil, a significant amount of by-product (defatted cake) is produced, and its disposal can be costly. In addition, this by-product contains a significant amount of protein and other nutrients, which have potential functional properties [8]. Due to its high nutritional value, this cake can be dried and ground into flour and used as a functional ingredient, additive, addition for certain biotechnological processes, or mostly as animal feed. As one of the reasons for the insufficient use of this type of flour is the insufficient awareness of the benefits of the potential use and the presence of cyanogenic compounds and biologically active substances in this type of flour [9].

In the last few years, attempts have been made to incorporate the cake, which is obtained as a secondary product after the production of flaxseed oil, into the recipe compositions of various bakery-confectionery products. According to Krupa-Kozak *et al.*, [10], with the addition of 75% of this type of by-product, gluten-free bread with improved nutritional characteristics is obtained. Sanmartin *et al.*, [11], used defatted flaxseed cake in amounts from 0 to 10% as a component to improve the nutritional and sensory characteristics of sourdough bread. Sourdough bread enriched with 5% flour from defatted cake from flax seed proved to be the bread with the best physio-chemical, nutritional, and sensory characteristics. By Zarzycki *et al.*, [12], pasta enriched with defatted bread flour was produced, which in terms of sensory characteristics differed significantly from traditional pasta, but was distinguished by improved nutritional characteristics (proteins, fats, and dietary fiber).

Pumpkin (fam. *Cucurbitaceae, Cucurbita pepo* L.) is valued for its pleasant taste and nutritional properties and is a source of carbohydrates, proteins, fats, vitamins, and minerals. In addition, it also has antioxidant, antimicrobial, antidiabetic, antidepressant, and hypoglycaemic effects [13, 14]. Almost all parts of the pumpkin are edible. Pumpkin seeds contain a significant amount of minerals (potassium, magnesium, selenium, zinc, copper, molybdenum, chromium), and bioactive compounds such as tocopherols and carotenoids [14, 15]. After separating the oil, the defatted cake contains a significant amount of protein (45%) and dietary fiber (15%), as well as macro- and micronutrients (carbohydrates, vitamins, and minerals). The cake also contains oleic (50.4%) and linoleic acids (29.9%), is rich in the amino acid tryptophan, and contains a certain number of phenolic compounds. The defatted cake contains more phenolic acids than the seeds, which are more readily available in free form and easier to extract. This type of waste also has high antioxidant activity (thanks to the content of bioactive components) [16, 17]. Due to its rich nutritional composition, the defatted cake is often dried and ground, resulting in flour, which can be successfully used to enrich or improve the nutritional quality of various food products.

Litvynchuk *et al.*, [17], found that replacing more than 10% of wheat flour with flour from defatted pumpkin seed cake significantly alters the nutritional composition of wheat bread. Similarly, Przybylski *et al.*, [18], used flour from defatted pumpkin seed cake in the production of gingerbread and determined that up to 25% of this type of flour can be added without compromising sensory characteristics, while also improving nutritional quality. Moreover, defatted pumpkin seed cake flour (20 and 40%) has been utilized as a substitute for wheat flour in the production of crackers, resulting in improved nutritional quality with increased protein, unsaturated fatty acid, and mineral content [19].

Confectionery products, including cookies, are food products that are used daily as a snack. They should have an attractive appearance, taste, and aroma. Each ingredient used in the production of cookies gives them specific properties. Therefore, the creation of healthier confectionery products is a challenge for manufacturers of cookies. Offering nutritionally enriched cookies with natural ingredients can meet consumer demands while providing potential health benefits [18].

The main objective of this paper is to determine the possibilities of incorporating flour from defatted cakes (obtained after oil extraction) from pumpkin and flax seeds as a substitute for wheat flour in the production of cookies and to determine the sensory quality of the produced cookies with different amounts of flour from defatted cakes.

2. Materials and Methods

2.1 Raw Materials

All the raw materials to produce the cookies were purchased from a local store in the city of Veles, Macedonia. The flour from the defatted flaxseed and pumpkin cakes was obtained by the company Super Group from Skopje.

2.2 Production of cookies

The production of the cookies was done in laboratory conditions at the Faculty of Technology in Veles, according to the AACC 10-50D method [20] with certain corrections. The recipe has been adapted for a different proportion of wheat flour and flour from defatted cake from pumpkin and flour from defatted cake from flax seed. The level of replacing part of wheat flour with flour from defatted cake from pumpkin seed and flour from defatted cake from flax seed was 30% and 60%. Using a mixer (Kitchen machine MMC 1000RLR, Gorenje, Slovenia), 260 g of granulated sugar and 128 g of margarine were homogenized for 3 minutes. Then 98 g of water was added, and mixing continued for another 2 minutes. 450 g of flour, 4.2 g of salt, and 5.0 g of baking soda (previously homogenized) were added, and homogenization continued for another 3 minutes. The resulting dough was shaped into a ball, placed in a PVC bag, and left in a refrigerator (up to 8 ^{0}C; 30 minutes). After the time has passed, the dough is rolled out with a rolling pin to a thickness of 7 mm, and the pieces of dough are formed from it using a circular shape. The pieces of dough are baked for 10 minutes at a temperature of 205 ^{0}C. The baked cookies are cooled to room temperature and packed in PVC bags.

2.3 Sensory analysis

The sensory characteristics of the produced cookies (odor, taste, color, shape, texture, and overall acceptability) were rated using a hedonic scale from 1 (extremely dislike) to 9 (extremely like) [21]. The evaluation was carried out in two cities, Veles (Macedonia), and Pristina (Kosovo). 19 evaluators/ panelists in both cities participated in the sensory evaluation. To each of the panelists before the start of the sensory evaluation, the evaluation procedure, and the way of tasting each of the samples were explained.

2.4 Statistical analysis of the obtained results

The study utilized ANOVA (analysis of variance) and Fisher's LSD (least significant differences) test at a 95% ($p < 0.05$) confidence level to determine whether there were significant differences between the sensory evaluations of tea pastries in two countries. A graphical presentation of the results was done using the XLSTAT 2019 and Microsoft Office Excel 2016 software programs.

3. Results and Discussion

In laboratory conditions, the process formulations, and parameters to produce cookies with flour from defatted cake from pumpkin and flax seed have been optimized. Five types of cookies were trial produced (Figure 1): cookies with 100% wheat flour (control; 1C), cookies with 30% flour from defatted cake from pumpkin (1CPS), cookies with 60% flour from defatted cake from pumpkin (2CPS), cookies with 30% flour from defatted cake from flax seed (1CFS), and cookies with 60% flour from defatted cake from flax seed (2CFS).

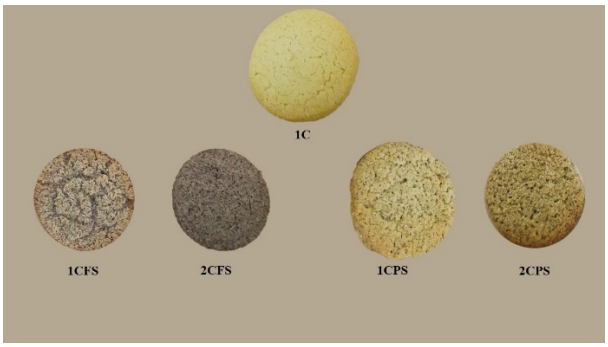
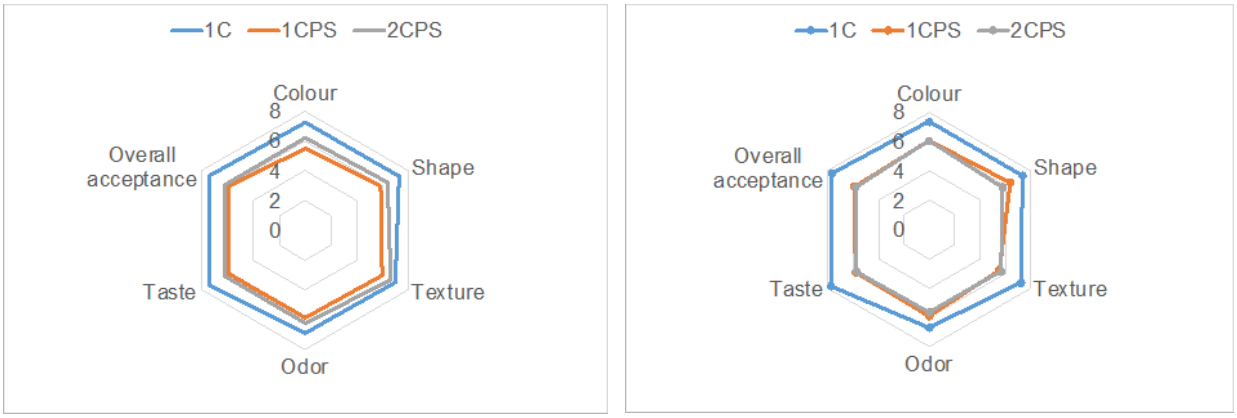


Figure 1. Produced cookies with different percentages of flour from defatted cake from pumpkin and flax seed

The color of cookies is one of the important quality factors and one of the parameters used in the control process during baking [22]. Figure 1 clearly shows the difference in the color of the produced cookies. During baking, the caramelization of sucrose and the Maillard reaction that takes place between proteins (amino acids) and reducing sugars lead to a darkening of the surface of the cookies with 100% wheat flour (1C), creating a light brown (golden-yellow) color [23]. Samples substituted with flour from defatted cake from pumpkin (1CPS and 2CPS) and flax seed (1CFS and 2CFS) have a darker brown color, indicating that the replacement of wheat flour in the recipe formulation with flours from these by-products affects the color of the new cookies. Substituting flour from defatted cake from pumpkin, which has a green color, and substituting flour from defatted cake from flax seed, which has a brown color, produced a darker brown color. The intensity of the darker color increases with increasing substitution percentage.

Sensory analysis is defined as a scientific method used to measure, analyze, and interpret responses through the senses of sight, smell, touch, and hearing, obtained during the consumption of products [24]. The results of the sensory analysis made in the two different states of Macedonia (Veles) and Kosovo (Pristina) are presented in Figure 2, Figure 3, and Figure 4.



a) b)

Figure 2. Sensory profile of cookies with different percentages of flour from defatted cake from pumpkin in a) Macedonia, and b) Kosovo

According to the results presented in Figure 2, the control cookies were rated higher than the new cookies in all parameters. However, the comparison of the ratings given by the panelists in both countries revealed that cookies containing 60% defatted cake flour from pumpkin received better ratings in all parameters from the panelists in Macedonia. The ratings were 6.21/9.00 for color, 6.42/9.00 for shape, 6.62/9.00 for texture, 6.21/9.00 for odor 6.16/9.00 for taste, and 6.16/9.00 for overall acceptability. In contrast, the panelists in Kosovo preferred cookies with 30% flour from defatted cake from pumpkin, except for the color and texture parameters. Previous studies have also investigated the use of flour from defatted cake from pumpkin in cookie production. Atuonwu and Akobundu [25], found that the best overall acceptability was obtained by replacing wheat flour with 10% flour from defatted cake from pumpkin. Jukić *et al.*, [26], tested different levels of flour from defatted cake from pumpkin and found that cookies with 40% flour had very high overall acceptability (7.57 points), and they suggested that even 60% flour could be used without a significant impact on overall acceptability. Moreover, flour from defatted cake from pumpkin (5%, 10% and15%) has been used as a substitute for wheat flour in the industrial production of bread without a significant impact on the technological process of bread production at temperatures of 210 ^{0}C and 230 ^{0}C [27].

Figure 3 presents the ratings of the panelists in Macedonia and Kosovo for cookies in which wheat flour in amounts of 30% and 60% was replaced with flour from defatted cake from flaxseed.

When comparing the sensory profile of cookies in both countries, the control cookies received the highest scores for all sensory characteristics. In both countries, the cookies containing 60% flour from defatted cake from flaxseed received higher ratings for all parameters

a) b)

Figure 3. Sensory profile of cookies with different percentages of flour from defatted cake from flax seed in a) Macedonia, and b) Kosovo

except texture, when compared to cookies containing 30% flour from defatted cake from flaxseed. Karakurt *et al.*, [28], also produced cookies using both defatted and non-defatted cake flour from flaxseed and found that the sensory properties were more significantly affected by the defatted cake flour than the non-defatted cake flour. According to Sęczyk *et al.*, [29], the addition of flour from ground flaxseed husks reflects on the sensory characteristics. In addition to color change, higher concentrations of this type of flour lead to the creation of a product with an intense aroma and worse taste. Ogunronbi *et al.*, [30], investigated the effect of the partial replacement of wheat flour with fresh flour from defatted cake from flaxseed (10% и 15%) in the preparation of brown bread. The obtained results showed that the substitution made is sufficient to improve the nutritional characteristics of the bread without having negative effects on sensory acceptability. The possibility of enriching wheat bread with ground flaxseed hulls in the amount of 1% to 5% was investigated by Sęczyk *et al.*, [29], who concluded that replacement up to 4% could ensure satisfactory overall acceptability of the produced wheat bread.

When comparing the total points for each parameter separately in the two different countries (Figure 4) and the statistical processing done, it was determined that there is no statistical difference ($p > 0.05$) between the scores of the panelists in the two states.

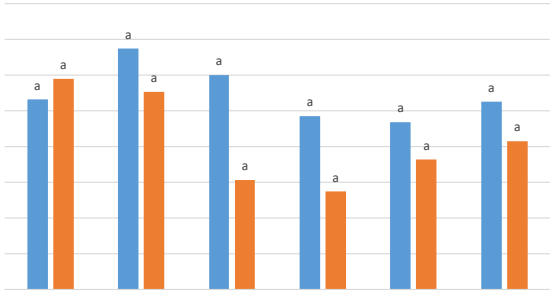


Figure 4. Mean values of sensory parameters in Macedonia and Kosovo

4. Conclusions

- From an environmental point of view, incorporating waste from the cold-pressed oil industry is an innovative and functional way of utilization. In this way, in addition to reducing environmental pollution, functional food products with better nutritional characteristics are also created. By carrying out this research, it has been established that there is a possibility of replacing wheat flour with flour from the by-products obtained during the production of cold-pressed oils (defatted cakes from pumpkin and flax seeds) in the amount of 30% and 60% in the production of cookies.
- The control cookies made with 100% wheat flour were found to have the best sensory evaluation (in terms of color, shape, texture, odor, taste, and overall acceptability). However, cookies with higher proportions of flour from by-products were generally better evaluated in terms of sensory parameters compared to those with lower proportions of wheat flour replacement.
- Further analyses and trials are necessary to determine the optimal percentage of flour from these by-products for functional and nutritionally improved products with satisfactory sensory characteristics and good overall acceptability. Therefore, future research should focus on expanding the modified basic formulation to produce cookies and identifying the appropriate ratio of wheat flour replacement with flour from defatted cake from pumpkin or flax seed.

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