Original Article
Food Science and Technology

ISSN 0101-2061 (Print)
ISSN 1678-457X (Online)

DOI: https://doi.org/10.1590/fst.99922

Development and characterization of biscuits with olive pomace

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Abstract

This work developed biscuits with the partial substitution of wheat flour with olive pomace flour (OPF). The wheat flour contents substituted by OPF in the biscuits were 0%, 10%, and 20%. The effects of the flour on the chemical composition, lipid profile, and sensory aspects of the reformulated biscuits were evaluated. The data showed that the OPF has a high concentration of dietary fiber (43.75%) and 27.70% lipids. The biscuit with 10% of the wheat flour replaced by OPF has 4.29% of total dietary fiber and 22.61% of lipids, whereas the biscuits made by substituting 20% of the wheat flour with OPF have 8.52% of total dietary fiber and 23.78% of lipids. The incorporation of OPF increased the contents of lipids, minerals, and dietary fiber. Sensorially, the sensory descriptors were not beneficial to characterize the biscuits reformulated with OPF. Also, the lightness, texture, and brittleness decreased in the biscuits with added OPF, as did the loss from baking. Hence, the BIS10 biscuit proved to have the potential to be better explored from the physicochemical and sensory viewpoint.

Keywords: olive residue; dietary fiber; sensory analysis; lipid profile; color attributes.

Practical Application: Use of a by-product that contaminates the environment due to its high biochemical demand for oxygen, and at the same time is a by-product of high nutritional value. Olive pomace flour can be used in biscuits or other food products. The use of this by-product reduces the amount discarded in the environment, in addition to providing the food with an increase in nutritional content through the addition of fatty acids, mainly oleic acid, in addition to increasing the amount of fiber, both soluble and insoluble.

1 Introduction

Growing attention is currently being given to producing healthy food such as enriched or fortified foods with bioactive compounds. Moreover, there is great interest in the recovery and recycling of byproducts of the food industry, represented by food processing waste often produced in large quantities, a potential cause of environmental pollution. On the other hand, some industrial byproducts may represent a source of valuable substances of interest with healthy compounds, such as phytochemicals and fibers (Costa et al., 2018; León et al., 2022; Prestes et al., 2022).

Olive growing is in full development in Brazil, and states such as Rio Grande do Sul, Minas Gerais, São Paulo, and Santa Catarina have presented a good potential for cultivation (Ocanha, 2018). The olives used to extract oil contain around 80% of oleic acid, besides tocopherols, phenolic compounds, various minerals, and B-complex vitamins (Mello & Pinheiro, 2012).

Olive oil extraction generates olive bagasse and olive oil in a proportion of 80:20, varying according to the extraction method used and the variety of the fruit (Medeiros et al., 2016). With the growth and development of olive growing in Brazil, the concern with the environmental problems caused by the inappropriate disposal of this waste also grows. The waste is generally used for soil fertilization (Sempiterno & Fernandes, 2010).

According to a study conducted by Júlio (2015), every 100 g of pomace contains lipids (11.5%), proteins (8.9%), ash (4%), and dietary fiber (54.5%). The high amount of fibers in the pomace stimulates some studies aiming to increase the fiber content in various foods such as pasta (Padalino et al., 2018; Cedola et al., 2020) and bread (Cedola et al., 2020). The intake of food enriched with fibers may be an alternative to increase the dietary fiber content, with the recommendation being 30 g of dietary fiber per day (Jane et al., 2019). In addition, this pomace can be containing up to 34.04 mg gallic acid/g of vegetal material of phenolic compounds and the main compounds are hydroxytyrosol, oleuropein, vanillin, apigenin, rutin and luteolin (Chanioti et al., 2021). Hence, the beneficial nutritional properties of the olive pomace polyphenols and dietary fiber render this byproduct an attractive ingredient for bakery foods. Many studies indicate that regular fiber consumption combined with a healthy diet helps both in digestion and absorption processes, as well as in the composition of the microbiota and fermentation of metabolites, improving gastrointestinal disorders (Gill et al., 2021).

Received 17 Oct., 2022
Accepted 21 Dec., 2022

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Biscuits are widely consumed globally, so they have been researched, with several studies attempting to make them "healthier" through fortification with fibers, proteins, and monounsaturated and polyunsaturated lipids (Savlak, 2020; Agrahar-Murugkar, 2020). This work aimed to produce savory biscuits rich in fiber and monounsaturated fatty acids.

2 Material and methods

2.1 Raw material

The olive pomace from the "Arbequina" cultivar was used, obtained in the city of Cachoeira do Sul, RS, Brazil (30° 00' 36.0" S, 52° 52' 02.1" W). The oil was extracted through the two-phase centrifugation method, and the olive oil waste (olive pomace) obtained was collected and stored at -18 °C.

2.2 Granulometric fractionation of the olive pomace

The olive pomace was separated using a sieve with a No. 10 mesh, and the fraction that remained on the sieve (particles < 2 mm). After, the particules was later subjected to centrifugation at 3,000 rpm for 15 min to remove the excess water; the supernatant was discarded, and the pasty part was packed in disposable cups and kept frozen for 48 h before being freeze-dried. A Terroni LS 3000 freeze dryer (TERRONI, LS Series, Brazil) was used for the freeze-drying procedure until a brittle texture was acquired (approximately 72 h), and the material was later milled in a conventional laboratory mill (MARCONI®, Brazil) until the flour was obtained, as per Speroni et al. (2019).

2.3 Preparation of savory biscuits

Three biscuits were prepared: the standard, without OPF addition (BISP), one replacing 10% of the wheat flour with 10% OPF (BIS10), and one substituting 20% of the wheat flour for 20% OPF (BIS20). The dough was obtained directly, with the ingredients mixed until a homogeneous dough was obtained. The formulation is presented in Table 1.

The dough was rolled out, and the biscuits were molded with thickness varying from 0.3 cm to 0.7. After being cut, the biscuits were arranged on a baking sheet. The biscuits were baked at 200 °C in a domestic oven (Brastemp, São Paulo, Brazil) for 17 min. After baking, the biscuits were arranged in glass refractories until they cooled, then stored in hermetically sealed packaging.

Table 1. Savory biscuit formulations with the addition of olive pomace flour.

Ingredients	Amount		
	Standard	10%	20%
Wheat flour (g)	200	180	160
Olive pomace flour (g)	0	20	40
Soybean oil (mL)	45	45	45
Water (mL)	45	45	45
Egg (g)	300	300	300
Baking powder (g)	5	5	5
Salt (g)	5	5	5
Seasoning (garlic and onion powder) (g)	5	5	5

Three repetitions of each formulation were performed, where: BISP and BIS10 yielded an average of 85 cookies and BIS20 an average of 52 cookies for each repetition. The wheat flour used was type 1.

2.4 Chemical analyses

The centesimal composition was determined for both the biscuits and the olive pomace flour, with the moisture (934.01), ash (923.03), and proteins using the Kjeldahl method (46-13), the dietary fiber through the enzymatic-gravimetric method (985.20 and 991.42) as per the Association of Official Analytical Chemists (2005), and the lipids through the method by Bligh & Dyer (1959). The carbohydrates were calculated by difference. The energy value was calculated following Mahan & Escott-Stump (2005).

2.5 Loss from baking and technological evaluation

The loss from baking was analyzed after the biscuits were cooled by mathematical Equation 1 (Philippi, 2003):

$$\text{Cooking loss} = \text{raw dough weight} - \text{biscuits final weight} \quad (1)$$

The technological characteristics were analyzed following the 10-50D method (American Association of Cereal Chemists, 2000). The weights of the biscuits were determined by weighing them before and after they went into the oven and expressed in grams.

2.6 Instrumental texture

The texture analysis was performed through a TAX-T2 Stable Micro Systems Texture Analyzer using the three-point bend rig (code HDP/3PB), determining the hardness and brittleness/crispiness of the biscuits. The parameters used in the tests were the following: a pretest speed of 2.5 mm/s, a test speed of 2.0 mm/s, a posttest speed of 10.0 mm/2, and a distance of 15 mm. The test was carried with 15 biscuits by formulation. The biscuits were selected randomly and placed horizontally on a platform for them to break in half. The evaluations were performed 24 h after baking. The brittleness corresponded to the height (mm) and hardness strength (kg).

2.7 Color

The color was evaluated using a colorimeter according to the 14-22 method of the American Association of Cereal Chemists (2000), with the color attributes a*, b*, L*, C*, and h the surface of the biscuits. The chromaticity coordinate a* indicates the color trend from red (+a*) to green (-a*), coordinate b* indicates the color trend from yellow (+b*) to blue (-b*), and L* indicates the lightness from white (L* = 100) to black (L* = 0). Moreover, the difference in chroma (ΔC*), related to the saturation (+ = more saturated, - = less saturated) and the difference in hue (ΔH*) were also determined.

2.8 Lipid profile of the biscuits

The lipids were extracted using the method described by Bligh & Dyer (1959), and the derivatization of the fatty acid methyl esters (FAME) was performed through the methodology proposed by Hartman & Lago (1986). The FAME profiles were obtained by injecting 1 μL into a gas chromatograph equipped with a flame ionization detector (GC-FID) by brand Varian, model Star 3400 CX (CA, USA), and a Varian automatic sampler model 8200 (CA, USA). The injector was kept in the split mode with a 1:20 ratio and a temperature of 250 °C. The carrier gas used was hydrogen at a constant pressure of 15 psi. The FAME were separated in a CP-Wax 52 CB capillary column (Middelburg, The Netherlands) (50 m × 0.32 mm × 0.20 μm). The initial temperature of the column was 50 °C, where it remained for 1 min, rising to 180 °C at a rate of 10 °C/min, then to 200 °C at the rate of 2 °C/min, and ultimately up to 230 °C at rate 10 °C/min, remaining in isotherm for 5 min. The detector maintained a temperature of 240 °C. The FAME identification was carried out by comparison relative to the retention times of the MIX 37 standard. The results were expressed in grams per 100 g of fatty acids.

2.9 Sensory analysis

Fifteen testers were recruited for the sensory analysis (two men and 13 women) aged 18 to 55 years accustomed to eating savory biscuits. All testers signed the free and informed consent form agreeing to participate in the research, which was approved by the UFSM ethics and research committee (CAAE 325040.2.0000.3346). The recruitment of the testers that participated in the sensory analysis was carried out in a clarified manner, informing their voluntary, free participation with no compensation. The sensory tests were carried out in individual cabins under controlled light and temperature conditions.

The testers were selected as described by Stone & Sidel (2004) through basic taste identification tests. The training of the tester panel began with the presentation of the study and clarifications about the sensory training and use of scales, among others. The study of the sensory characterization of the savory biscuits was applied for the following sensory attributes of appearance (overall, yellow and dark color), odor (characteristic of a savory biscuit and olive oil), taste (savory taste, olive oil, and bitter aftertaste), and texture (crunchiness). The definition and references used in the study were selected with the group of testers before the start of the training (Table 2). The training of the group of 15 testers was carried out for 12 h (Wang et al., 2022) and divided into four sessions. The purpose of the training was to test the evolution of the testers regarding the recognition of the descriptor terms, references, and appropriate use of the scales for each attribute. After this step, the sensory evaluation of the biscuits was carried out using an unstructured 9 cm scale anchored by ends that varied from none/low/little on the left side to high/a lot on the right side (Meilgaard et al., 1999). The biscuits were presented in covered containers encoded with three random digits and served to the testers in a monadic way in complete and balanced blocks (MacFie et al., 1989). The testers were instructed to drink water to cleanse the palate after each sample.

2.10 Statistical analysis

All analyses were performed in triplicate. The results were subjected to an analysis of variance (ANOVA) with a comparison of means through the Tukey test considering the 95% significance level ($P < 0.05$). The sensory evaluation results were analyzed through the "product characterization" option of the statistical program *XLSTAT* (version 2019.2.2). The treatments were considered a fixed effect, and the testers and sessions were submitted to the random effect model.

Table 2. Descriptor terms and references used in the training of the testers.

Descriptor Terms	References
APPEARANCE	
Overall: Global impression of the biscuit regarding the uniformity of the particle sizes, color, and thickness.	**Bad:** Biscuit with an uneven appearance (particles, cracks, etc.). **Great:** Biscuit with a uniform appearance.
Yellow color: intensity of the yellow color observed at the center of the biscuit	**Low:** Biscuit baked for 5 min at 200 °C. **High:** Yellow color of a package.
Dark color: intensity of the brown color observed at the center of the biscuit	**Low:** Biscuit (5 mm) baked for 17 min at 200 °C. **High:** Biscuit (2 mm) baked for 17 min at 200 °C
ODOR	
Characteristic biscuit odor: Odor perceived when smelling a savory biscuit	**Little:** Fresh bread odor (sandwich bread, Pullman). **A lot:** Water and salt biscuit odor (Isabela)
Olive oil odor: Odor perceived when smelling olive oil.	**Little:** Drinking water at room temperature. **A lot:** Extra virgin olive oil (Gomes da Costa).
TASTE	
Savory taste: intensity of the characteristic taste of salt.	**None:** Biscuit with no addition of NaCl. **A lot:** Biscuit with a high concentration of NaCl.
Olive oil taste: Characteristic taste of olive oil.	**None:** Soybean oil (Leve). **A lot:** Extra virgin olive oil (Gomes da Costa).
Bitter aftertaste: intensity of a bitter taste remaining in the mouth after tasting the biscuit.	**None:** Drinking water at room temperature. **High:** Biscuit (2 mm) baked for 17 min at 200 °C
TEXTURE	
Crunchiness: Intensity of the characteristic noise when biting into a biscuit.	**None:** Fresh bread (sandwich bread, Pullman, approximate size of 2.5 cm × 2.5 cm). **A lot:** Water and salt biscuit (Isabela)

3 Results and discussion

3.1 Centesimal composition

It is worth noting the great total dietary fiber potential present in olive pomace flour (Table 3), so it may thus act in preventing several pathologies such as colon cancer and cardiovascular diseases (Hassan et al., 2011). Júlio (2015) found 54.5% of total dietary fiber in olive pomace, a value close to that found in the present work. Given the results, one may state that olive pomace flour is a relevant food alternative, especially as an ingredient in bakery products, given that it reaches a diversity of consumers.

In bakery products, pomace is generally used as a functional ingredient, defined as "[...] food that affects one or more target functions of the body beneficially, besides contributing with appropriate nutritional effects in a relevant way for the improvement of the state of health and welfare and/or decrease of the risk of diseases" (Difonzo et al., 2021, p. 5). Table 3 shows that BIS20 sample replaced with 20% OPF statistically differ from the others for containing more fiber. The BIS10 sample, whereas the substitution of 10% of the wheat flour for OPF increased the fiber content relative to the standard. The soluble fiber content in the biscuits increased in proportion to the fiber content. In Brazil, Resolution No. 54 of the Brazilian Health Regulatory Agency (ANVISA) (Brasil, 2012) and establishes that a food can be considered a source of dietary fiber when in the finished product there is 3 g per 100 g of fiber product for solid foods, specifications that are met by the BISP and BIS10 samples. However, considering the same legislation, the BIS20 sample may be considered of high fiber content for having over 6 g of fiber per 100 g of product. Adding dietary fibers to food may value agricultural products and byproducts to be used as ingredients (Simonato et al., 2019).

Perez & Germani (2007) produced biscuits with the addition of eggplant flour. The biscuits containing 85% wheat flour and 15% eggplant flour resulted in 8.22% of fiber, a result similar to that found in the present work for BIS20 sample. For the biscuits with added olive pomace flour developed by Lin et al. (2017), it was also possible to notice an increase in the dietary fiber content compared to the control. Cedola et al. (2020) and Cecchi et al. (2019) assessed the chemical, sensory, and nutritional characteristics of bread with the addition of 10% olive pomace, finding a better glycemic response due to the high fiber content. According to Lin et al. (2017), the intake of biscuits with the addition of olive pomace flour increases the metabolic production of the intestinal microbiota and also elevates the levels of homovanillic acid and 3,4-dihydroxyhydrocinnamic acid, which may be related to the reduction of oxidative LDL cholesterol (low density lipoproteins).

The moisture content of all samples is in accordance with CNNPA resolution - National Commission on Food Norms and Standards No. 12/1978, which indicates a maximum of 14% (Brasil, 1978). BIS10, because as the fiber content increased, the moisture content in the cookie also increased. This is due to the greater retention of water by the fibers in the BIS20 sample during cookie cooking. This behavior was also observed in the study by Rosa et al. (2015) when replacing cocoa with carob in cakes.

Regarding the protein content, the BIS20 sample also differed statistically from the others since, as the flour content increased, the protein content decreased, given that flour is poor in protein. The protein content present in OPF is equivalent to that present in BIS20 (0.09%), but the amount present in BISP and BIS10 (0.13%).

Relative to the concentration of lipids, it was observed that the biscuits with the addition of pomace flour did not differ statistically from each other, presenting a higher lipid content; however, they differed from biscuit due to fact that pomace flour is rich in residual oil, with the predominance of monounsaturated.

In the work developed by Assis et al. (2009), where cookies of the cookie type were studied with replacement of wheat flour by oat flour or parboiled rice flour, they presented amounts of lipids similar to those found in the BIS10 sample. The authors also indicated that the oat flour used was rich in lipids.

The ash content of the prepared biscuits increased in proportion to the OPF; this increase is likely related to the addition of potassium, calcium, magnesium, iron, and sodium in the pomace (Dermeche et al., 2013). However, only the BISP is in line with CNNPA Resolution No. 12/1978 (Brasil, 1978), which allows at most 3.0%. Yet, when biscuits with high residue indices are developed, these ash contents tend to increase. On the

Table 3. Centesimal composition and caloric value of the biscuits and the olive pomace flour.

	Composition (%)			
	OPF	BISP	BIS10	BIS20
Dietary fiber	43.75 ± 1.16	3.85 ± 2.16^{b}	4.29 ± 1.16^{b}	8.52 ± 1.26^{a}
Soluble fiber	6.16 ± 2.36	$0.25 \pm 0{,}13^{c}$	$0.50 \pm 0{,}05^{b}$	$0.78 \pm 0{,}08^{a}$
Insoluble fiber	37.59 ± 2.06	3.07 ± 2.16^{c}	3.72 ± 2.66^{b}	8.24 ± 1.16^{a}
Moisture	10.07 ± 0.08	8.91 ± 0.21^{a}	8.35 ± 0.05^{b}	8.78 ± 0.13^{a}
Protein	0.09 ± 0.53	0.13 ± 0.01^{a}	0.13 ± 0.01^{a}	0.09 ± 0.01^{a}
Lipids	27.7 ± 0.64	18.79 ± 1.49^{b}	22.61 ± 0.33^{a}	23.78 ± 1.01^{a}
Ash	6.61 ± 0.08	2.79 ± 0.15^{c}	$3.15 \pm 0\ .17^{b}$	3.71 ± 0.07^{a}
Total carbohydrates	11.71±0.15	65.98 ± 0.28^{a}	61.29 ± 0.65^{b}	55.28 ± 1.39^{c}
Caloric value	297.99 kcal	433.59 kcal	450.67 kcal	435.45 kcal

OPF = Olive pomace flour; BISP = control biscuit without the addition of olive pomace flour; BIS10 = Biscuit with the addition of 10% of olive pomace flour; BIS20 = Biscuit with the addition of 20% of olive pomace flour. Mean ± standard deviation values followed by equal letters on the same row do not statistically differ according to the Tukey test at a 5% probability.

other side, the carbohydrate content decreased as OPF content increased, which was expected; however, the caloric value did not show this behavior, likely because of the residual oil content of the olive pomace flour. This carbohydrate reduction trend was also observed in other papers (Savlak, 2020; Perez & Germani, 2007).

3.2 Physical analyses

The cookies ranged from 0.3 to 0.7 cm in thickness before baking, while after baking they were 0.7 to 0.8 cm. The biscuits with the substitution of wheat flour for OPF presented lower expansion factors than the standard biscuit. With similar data having found by Lima et al. (2015) when developing gluten-free biscuits with the addition of watermelon rind flour: as the rind flour content increased, the biscuits became less thick due to the higher amount of dietary fiber in the biscuit. Thus decreasing the expansion factor (Assis et al., 2009).

According Simonato et al. (2019), adding olive pomace influences the technological properties of doughs, inducing an increase in losses from baking while shortening the baking time. The use of this byproduct may represent the alternative of extreme importance for the production of doughs because it produces functional doughs.

In Table 4, one may also observe that the more considerable the substitution of wheat flour for OPF is, the higher the values for the a* parameter were, intensifying the reddish color. Thus, it is suggested that the non-enzymatic darkening reactions are more intense in the formulations with the flour.

This fact is similar to that obtained by Zucco et al. (2011) and Moura et al. (2010). Regarding the parameter b*, the cookies added with FBO differ from the standard with greater intensity. One of the most important factors that the consumer considers is the color of the product, the luminosity "L" of BISP statistically differed from the others, presenting a lighter color. Simonato et al. (2019) developed added mass of olive pomace and as the concentration of pomace in the mass increased, lower L* value and higher b* values the product acquired.

According to Assis et al. (2009), hardness is one of the factors that determines the acceptability of the food by consumers, and, just as with brittleness, it is desirable that its values are low. When observing Table 4, both the hardness and the brittleness of the biscuits with substitutions of wheat flour for OPF differ from those of the standard biscuit, which presented higher hardness and brittleness. Results that are opposite to those found by Azevedo et al. (2015), who developed biscuits with different levels of acai flour and found that the more the amount of flour increased, the harder the biscuits got; however, in the biscuits developed in the present work, the olive pomace flour is rich in lipids, which is likely why they were not very crunchy. According to Azevedo et al. (2015), the amount of lipids and emulsifiers may influence the dough moisture.

Regarding the loss from baking, the biscuit with 20% of the wheat flour replaced with OPF differed statistically from the others, presenting lower loss from baking, similar to the work developed by Padalino et al. (2018), who observed a decrease in the loss from baking and water absorption with the addition of olive pomace flour and active transglutaminase in doughs.

3.3 Lipid profile

The fatty acid profile of olive pomace flour (Table 5) shows that the predominant saturated fatty acids palmitic. Likewise, in BIS10 and BIS20 cookies, it is the predominant saturation. Among the unsaturated fatty acids, the majority in olive pomace was oleic (omega 9). In this context, the cookies with FBO are statistically different from each other and from BISP, and as there was an increase in the content of olive pomace flour, the oleic acid content increased. FBO has little linoleic acid, consequently as the flour content in the cookies increased, the amount of linoleic acid (omega 6) decreased. The linolenic fatty acid (omega 3) is present in the flour and the biscuits in a very low amount. The fatty acid in the highest amount in the olive pomace is oleic acid (±73%), followed by palmitic acid (±12%) and linoleic acid (±10%), depending on the cultivar and type of fertilization and management used in the plantation (Silva et al., 2012).

Studies have shown a strong relationship between oleic acid (omega 9) and breast cancer prevention, suggesting that consuming olive oil may protect against breast cancer. In countries such as Italy and Spain, where olive oil is present in higher quantities in the diets, there is a lower incidence of breast cancer. Olive oil is composed of several chemopreventive agents, such as tocopherols, carotenoids, squalene, polyphenols, lignin, and

Table 4. Results of the physical analysis of color texture and loss from baking.

Analyses		Formulations		
		BISP	BIS10	BIS20
Color	L*	73.29 ± 1.01 ^{a}	36.59 ± 1.00 ^{b}	29.9 ± 0.83 ^{b}
	a*	4.35 ± 0.25 ^{c}	8.97 ± 0.15 ^{a}	8.12 ± 0.37 ^{b}
	b*	36.16 ± 1.11 ^{a}	17.69 ± 1.37 ^{b}	12.26 ± 0.36 ^{c}
	C*	36.42 ± 1.12 ^{a}	19.85 ± 1.19 ^{c}	14.71 ± 0.47 ^{b}
	h*	83.15 ± 0.31 ^{a}	62.94 ± 2.08 ^{b}	56.56 ± 0.96 ^{c}
Texture	Hardness	3.13 ± 0.87 ^{a}	2.16 ± 0.77 ^{b}	1.81 ± 0.91 ^{b}
	Brittleness	32.52 ± 1.19 ^{b}	36.32 ± 0.95 ^{a}	36.17 ± 1.12 ^{a}
% loss from baking		27.88 ± 1.20 ^{a}	26.58 ± 4.71 ^{a}	10.50 ± 1.76 ^{b}

BISP = Control biscuit without the addition of olive pomace flour; BIS10 = biscuit with the addition of 10% of olive pomace flour; BIS20 = biscuit with the addition of 20% of olive pomace flour.Mean ± standard deviation values followed by equal letters on the same row do not statistically differ according to the Tukey test at a 5% probability.

Table 5. Fatty acid profile of the biscuits and olive pomace flour.

DF (dietary fiber)	OPF	BISP	BIS10	BIS20
C4:0 (butyric)	0.63 ± 0.05	0.80 ± 0.12 ^{a}	0.62 ± 0.01 ^{ab}	0.57 ± 0.04 ^{b}
C14:0 (myristic)	0.04 ± 0.00	0.13 ± 0.01 ^{a}	0.10 ± 0.01 ^{b}	0.10 ± 0.01 ^{b}
C15:0 (pentadecanoic)	0.03 ± 0.02	0.03 ± 0.010	0.03 ± 0.00 ^{a}	0.03 ± 0.01 ^{a}
C16:0 (palmitic)	21.71 ± 0.17	17.21 ± 0.87 ^{a}	16.36 ± 0.74 ^{a}	16.30 ± 0.46 ^{a}
C16:1n9 (palmitoleic)	0.17 ± 0.01	0.12 ± 0.01 ^{a}	0.10 ± 0.00 ^{a}	0.11 ± 0.02 ^{a}
C16:1n7 (palmitoleic)	2.00 ± 0.04	0.47 ± 0.02 ^{b}	0.43 ± 0.02 ^{b}	0.58 ± 0.03 ^{a}
C17:0 (heptadecanoic)	0.11 ± 0.01	0.12 ± 0.01 ^{a}	0.12 ± 0.00 ^{a}	0.12 ± 0.01 ^{a}
C17:1 (heptadecenoic)	0.21 ± 0.01	0.07 ± 0.01 ^{a}	0.08 ± 0.01 ^{a}	0.09 ± 0.01 ^{a}
C18:0 (stearic)	2.00 ± 0.11	4.68 ± 0.14 ^{a}	4.69 ± 0.10 ^{a}	4.40 ± 0.04 ^{b}
C18:1n9c (oleic)	57.93 ± 0.63	28.35 ± 0.65 ^{c}	31.13 ± 0.28 ^{b}	34.05 ± 0.09 ^{a}
C18:1n7 (iso-oleic)	3.22 ± 0.25	1.32 ± 0.01 ^{c}	1.44 ± 0.01 ^{b}	1.61 ± 0.01 ^{a}
C18:2n6 (linoleic)	10.17 ± 0.17	40.56 ± 0.15 ^{a}	38.77 ± 0.21 ^{b}	36.53 ± 0.35 ^{c}
C20:0 (arachidonic)	0.27 ± 0.01	0.23 ± 0.02 ^{b}	0.27 ± 0.02 ^{ab}	0.30 ± 0.01 ^{a}
C18:3n6 (alpha-linolenic)	nd	0.10 ± 0.01 ^{a}	0.11 ± 0.01 ^{a}	0.08 ± 0.00 ^{b}
C18:3n3 (linolenic)	0.58 ± 0.03	4.52 ± 0.10 ^{a}	4.34 ± 0.10 ^{a}	3.96 ± 0.05 ^{b}
C20:1 (eicosanoic)	0.20 ± 0.01	0.13 ± 0.02 ^{b}	0.14 ± 0.01 ^{ab}	0.17 ± 0.01 ^{a}
C22:0 (behenic)	0.05 ± 0.00	0.15 ± 0.02 ^{a}	0.18 ± 0.02 ^{a}	0.20 ± 0.02 ^{a}
C22:1 + C20:4	nd	0.12 ± 0.04 ^{a}	0.12 ± 0.00 ^{a}	0.11 ± 0.02 ^{a}

nd: unidentified; OPF = Olive pomace flour; BISP = Control biscuit without the addition of olive pomace flour; BIS10 = biscuit with the addition of 10% of olive pomace flour; BIS20 = biscuit with the addition of 20% olive pomace flour Mean ± standard deviation values followed by equal letters on the same row do not statistically differ according to the Tukey test at a 5% probability

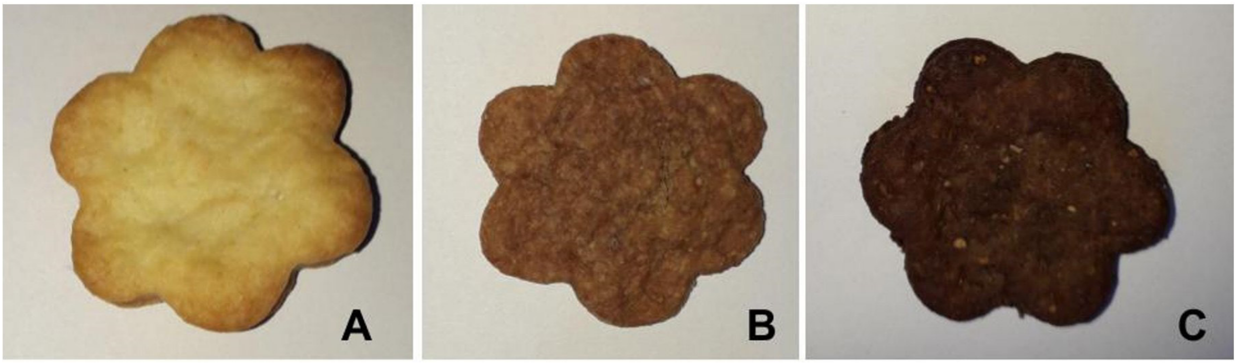

Figure 1. Biscuits after baking (A) standard; (B) 10% bagasse flour; (C) 20% bagasse flour. Source: Pamela Cristiele Oliveira Trindade (2023).

other natural chemoprotective agents, and it also helps reduce the accumulation of LDL in the blood and increase the HDL. Olive oil helps reduce diseases such as obesity and metabolic syndromes, e.g., type 2 diabetes and cardiovascular diseases (Cibeira & Guaragna, 2006).

3.4 Sensory analysis

The results of the sensorial evaluation are presented in Figure 1. The results suggest that the trained tasters identified only the sensorial attributes of homogeneity, yellow color, characteristic biscuit aroma and crunchiness as important to characterize BISP. The sensory attributes considered harmful to the quality of the cookies, such a dark color, residual bitterness and flavor of olive oil were not described for BISP. On the other hand, the cookies added with olive pomace had a different sensory profile than the control cookie. The BIS10 sample did not have any descriptor considered important to characterize the sensory quality of the cookie. Meanwhile, the descriptors homogeneity, yellow color and crispness had a negative impact on the sensory characterization of BIS10. The characterization of BIS 20 cookies were not satisfactory from a sensory point of view. These cookies were characterized only by negative descriptors, such as dark color, salty taste, olive oil flavor and bitter aftertaste. These attributes refer to characteristics that are not desirable in this type of product (Brandão & Lira, 2011). In addition, common and desired descriptors in savory biscuits, such as yellow color, characteristic biscuit aroma and crunchiness did not positively characterize BIS20 (Figure 2).

As reported by Cecchi et al. (2019), the factors that most affect the food to which olive pomace flour is added are color and bitterness. In bread, there is an increase in the internal firmness and chewability of the crumb and crust and a development of astringency. However, the addition of OPF shortens the bread fermentation time and decreases the size of the holes formed

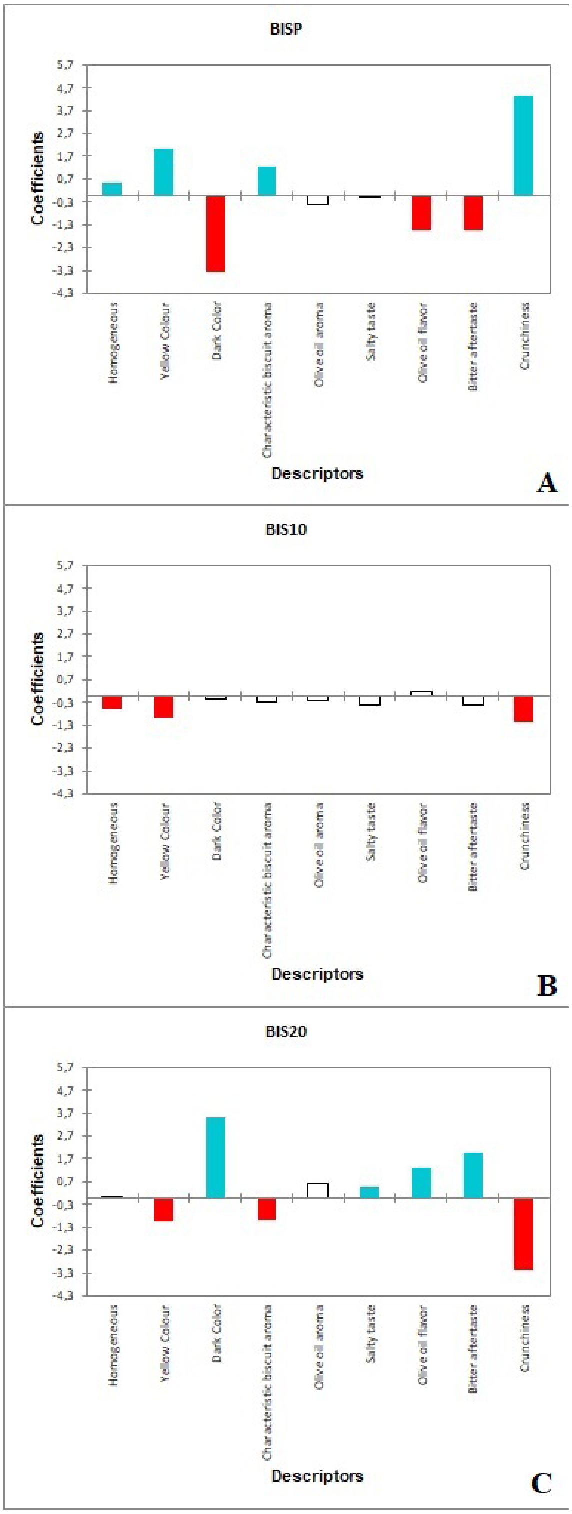

Figure 2. Chart of the descriptor terms of the biscuits (A) standard biscuit, (B) biscuit with the addition of 10% olive pomace flour, (C) biscuit with the addition of 20% of olive pomace flour.

by the gluten network. Regarding the sensory attributes of odor intensity and overall taste, there was a slight increase in the bread to which dry olive pomace was added, with "earthy" being the most discriminating attribute (Cecchi et al., 2019). In the paper developed by Ying et al. (2017) with snacks fortified with 5% dehydrated olive pomace, the attributes that differed sensorially were bitterness and color. On the other hand, Lin et al. (2017) developed sweet biscuits with added olive pomace flour and assessed their Cechi nutritional quality and sensory attributes. The cookies had high sensory acceptability, thus obtaining acceptable texture and aspects, presenting a better alternative compared to salty for the use of this type of residue.

There are also studies in which olive pomace flour was used in the production of dough as a substitute for wheat flour, with results proving satisfactory. The product presented an increase in dietary fiber content, in addition to presenting better technological parameters, with emphasis on the reduction in the available starch content and the increase in the resistant starch content. The replacement of 10% of the wheat flour with olive pomace flour was approved and considered acceptable sensory (Padalino et al., 2018; Simonato et al., 2019).

4 Conclusion

Olive pomace flour presents itself as an alternative for adding fibers, minerals, and oleic acids to food. The biscuits with added OPF to replace wheat flour showed an increase in the dietary fiber, mineral, and lipid contents, in addition to reducing total carbohydrates. It is worth stressing that the biscuits with 20% of the wheat flour replaced by olive pomace flour can be considered to have high fiber content. Cookies with FBO were darker than the control. Sensorially, the parameters that most characterized the biscuits with added olive pomace flour were the savory taste, olive oil odor, and dark color. Hence, the biscuit with 10% OPF proved to have the potential to be better explored from the physicochemical and sensory viewpoint.

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