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Desenvolvimento e avaliação de bolinhos de salmão a partir de resíduos da filetagem: impacto do amido e método de fritura

Development and evaluation of salmon cakes from filleting by-products: impact of starch and frying methods

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RESUMO

O objetivo deste artigo foi desenvolver e caracterizar bolinhos de salmão elaborados a partir de resíduos da filetagem, tratados com salga úmida. Foram avaliadas a composição centesimal (umidade, proteínas, lipídios, cinzas e carboidratos), características físicas (textura e cor) e físico-químicas (pH e atividade de água). Os bolinhos foram formulados com duas fontes de amido (batata inglesa e mandioca) e submetidos a dois métodos de fritura (óleo de soja e air fryer), além da avaliação na forma crua para comparação. O experimento foi conduzido em delineamento inteiramente casualizado (DIC), em esquema fatorial 2 x 3 (fonte de amido x método de preparo), com sete repetições. A análise estatística foi realizada por ANOVA e teste Tukey (p<0,05) no software SPEED Stat versão 2.8. Os resultados indicaram que a separação manual da carne apresentou rendimento satisfatório. A fonte de amido influenciou parâmetros como umidade, cinzas, carboidratos, pH, atividade de água, cor e textura, enquanto os métodos de fritura impactaram a umidade, proteínas, lipídios, carboidratos, pH, atividade de água, cor e textura. Assim, a fonte de amido e o método de fritura influenciam significativamente a qualidade dos bolinhos de salmão.

Palavras-chave: Aproveitamento de resíduos. Sustentabilidade. Novos produtos.

ABSTRACT

The objective of this study was to develop and characterize salmon cakes produced from filleting by-products treated with wet salting. Proximate composition (moisture, protein, lipid, ash, and carbohydrate contents), physical characteristics (texture and color), and physicochemical properties (pH and water activity) were evaluated. The cakes were formulated using two starch sources (potato and cassava) and subjected to two frying methods (soybean oil and air fryer), in addition to being assessed in their raw form for comparison. The experiment followed a completely randomized design (CRD) in a 2 × 3 factorial scheme (starch source × cooking method), with seven replicates. Statistical analysis was performed using ANOVA and Tukey's test (p<0.05) with the SPEED Stat software, version 2.8. The results indicated that manual meat separation yielded a satisfactory recovery rate. The starch source influenced parameters such as moisture, ash, carbohydrates, pH, water activity, color, and texture, while the frying methods affected moisture, protein, lipid, carbohydrate contents, pH, water activity, color, and texture. Therefore, both the starch source and frying method significantly influence the quality of salmon cakes.

Keywords: Waste utilization. Sustainability. New products.

1. INTRODUCTION

Salmon belongs to the class Teleostei, within the family Salmonidae and the order Salmoniformes (DYSIN et al., 2022). This species inhabits cold-water regions and is characterized by its migratory behavior. Due to its significant relevance in aquaculture and commercial fishing, salmon has been extensively studied. Moreover, it is recognized as a large-sized fish with high gastronomic value, appreciated worldwide. Its flesh is known for its pink coloration, distinctive flavor, tender texture, and high nutritional value, all of which drive its demand in the consumer market.

In Brazil, salmon is the most imported fish species, largely due to the growing popularity of Japanese cuisine. Its consumption has expanded beyond Japanese restaurants and is now common in steakhouses, fast food establishments, and food trucks. Fillets represent the most widely marketed form of salmon, both for home consumption and for the preparation of various dishes.

The filleting process generates between 40% and 60% of waste, which has significant potential for reuse due to its nutrient richness and high protein quality. In general, these by-products are used to produce fishmeal and oils for animal feed. However, they can also be repurposed for human consumption, particularly through the production of mechanically separated meat (MSM), which serves as an ingredient in processed products. Utilizing these by-products can add value to the industry, promote sustainability, and reduce environmental impact (MARTÍN-SÁNCHEZ et al., 2009).

As a highly perishable food, fish requires preservation technologies that ensure its quality and safety. In addition to extending shelf life, such processes can enhance product value and encourage the consumption of fish-based products. Among these techniques, salting stands out; it involves the application of salt at appropriate concentrations to delay or prevent spoilage due to autolysis and microbial activity (GEROMEL & FORSTER, 1982). This process also affects sensory attributes, altering the color, aroma, flavor, and texture of the fish.

Various factors can influence food properties during the development of new products, including the addition of starch sources. The composition and structure of starch granules vary depending on their botanical origin, resulting in different behaviors in the final product. Cassava and potato are tuberous crops widely consumed in Brazil and serve as important starch sources for the food industry (BEMILLER, 1997; GUEDES et al., 2021).

In addition to formulation, the cooking method affects both the sensory quality and nutritional value of foods. Frying is one of the most commonly used culinary techniques worldwide, providing characteristic color, flavor, and texture that enhance consumer appeal (CELLA et al., 2002). However, this method may pose health risks, as it is associated with higher fat intake, which increases the risk of conditions such as obesity and intestinal disorders. With the growing health awareness and demand for healthier alternatives, air frying has emerged as a viable option to reduce fat content without compromising sensory quality (ZAGHI et al., 2019).

Given the volume of waste generated during filleting and the need for its reuse, along with the potential for developing new products using different raw materials and cooking methods, this study aimed to develop and characterize cakes formulated from wet-salted salmon filleting by-products, using different starch sources (cassava and potato) and frying methods (oil and air fryer), in order to evaluate their effects on the chemical, physical, and physicochemical properties of the products.

2. MATERIALS AND METHODS

2.1 Raw materials and ingredients

The salmon residues were obtained as a donation from a Japanese cuisine restaurant located in the city of Lavras, Minas Gerais, Brazil. The remaining ingredients—refined salt, coarse salt, olive oil, onion, scallion, parsley, cassava, potato, egg, bread crumbs, and garlic—were purchased from local commercial establishments in Lavras, Minas Gerais.

2.2 Wet salting

The residues were salted using the wet salting method. For this process, the brine was prepared as described in Table 1. The residues were submerged in the brine and remained for 72 hours.

Table 1. Brine formulation per kilogram of residue.

Ingredient	Quantity
Salmon residue	1000 g
Refined salt	500 g
Coarse salt	250 g
Water	3 L

After 72 hours, the residues were removed from the brine and placed in separate trays at room temperature for 2 hours to allow the excess brine to drain.

2.3 Preparation of salmon cakes

The salted residues were desalted using potable water and cooked in a pressure cooker for 20 minutes. After cooking, the meat was manually separated from the bones and carcasses.

The salmon cakes were prepared using two different starch sources: potato and cassava. The remaining ingredients were added in equal proportions across all treatments, as detailed in Table 2. Additionally, the cakes were subjected to two cooking methods: frying in soybean oil and air frying (Mondial, Family IV model).

Table 2. Salmon cake formulations.

Ingredient	**Formulations (g)**	
	B1; B3 and B5	B2; B4 and B6
Desalted salmon meat	1500	1500
Olive oil	80.0	80.0
Fresh onion	450.0	450.0
Chives	49.0	49.0
Parsley	66.4	66.4
Cassava	-	2000.0
Potato	2000.0	-
Egg*	5	5
Breadcrumbs	750.0	750.0
Garlic	75.0	75.0

*Units. B1: raw salmon cake made with potato; B2: raw salmon cake made with cassava; B3: salmon cake made with potato, fried in oil; B4: salmon cake made with cassava, fried in oil; B5: salmon cake made with potato, cooked in air fryer; B6: salmon cake made with cassava, cooked in air fryer.

Initially, the separated salmon meat was sautéed in olive oil with onion and garlic. Subsequently, chives and parsley were added. The potatoes and cassava were cooked for 40 minutes and 1 hour and 25 minutes, respectively. After cooking, the sautéed salmon meat was mixed separately with the cooked potato and cassava. Once mixed with the starch source, the remaining ingredients were added.

The salmon cakes were then shaped and weighed (25 g each), packaged, and stored in a freezer (GPC-57, Gelopar, Chapa Araucária, PR, Brazil) at –18°C.

Based on preliminary tests, the use of 450 mL of soybean oil was standardized for frying ten cakes of each formulation, after which the oil was replaced before frying a new batch. For the cakes prepared in the air fryer, a standard condition of 180°C for 15 minutes was established for cooking ten cakes per formulation.

2.4 Characterization of the salmon cakes

2.4.1 Chemical characterization

Proximate composition was determined by analyzing moisture, protein, ash, and carbohydrates, following the methodologies described in the *Official Methods of Analysis of the Association of Official Analytical Chemists* (AOAC, 2012). Lipid content was determined using a protocol adapted from (FOLCH et al., 1957).

2.4.2 Physicochemical characterization

pH was measured directly on the product using a previously calibrated pH meter (model HI 99163, Hanna Instruments, Barueri, SP, Brazil) (IAL, 1985). Water activity (aw) was determined by analyzing 10 g of sample at a standardized temperature of 25 ± 1°C using an Aqualab® device (model 4 TE, Barueri, SP, Brazil).

2.4.3 Physical characterization

Instrumental color was measured using a colorimeter (model CM5, Konica Minolta Spectrophotometer), previously calibrated and configured with D65 illuminant and a 10° observation angle. The method used followed the CIELab color space standard.

Texture Profile Analysis (TPA) was performed using a texture analyzer (TA.XT2i, Stable Micro Systems Inc., United Kingdom). Each sample was compressed twice using a 12.5 cm diameter compression plate to 60% of its original height, with a 0.6-second interval between compressions. The deformation curve was obtained at a compression speed of 3.3 mm/s. Six texture attributes were evaluated: hardness (N), cohesiveness, gumminess (N), springiness, chewiness, and resilience.

2.5 Experimental Design and Statistical Analysis

The experiment was conducted using a completely randomized design (CRD) in a 2×3 factorial scheme (starch sources × preparation methods), with 7 replicates. The results were evaluated by analysis of variance (ANOVA) and means were compared using Tukey's test ($p<0.05$), performed with SPEED Stat software version 2.8.

3. RESULTS AND DISCUSSION

3.1 Chemical Characterization

Table 3 presents the results of the chemical composition analyses (moisture, protein, ash, and lipid content) of salmon cakes formulated with different starch sources and subjected to distinct preparation methods.

Table 3. Proximate composition (%) of salmon cakes prepared with different starch sources and cooking methods.

Starch source	Preparation method	Proximate composotion (%) (média ± desvio padrão)			
		Moisture	Protein	Ash	Lipids
Cassava	Raw	53.46 ± 0.78 Ba	9.72 ± 0.45 Ab	1.77 ± 0.77 Aa	7.57 ± 0.80 Ac
Cassava	Soybean oil frying	43.79 ± 0.74 Bc	11.04 ± 0.97 Aa	1.56 ± 0.04 Ba	14.71 ± 0.83 Aa
Cassava	Air fryer	47.88 ± 0.65 Bb	12.22 ± 1.07 Aa	1.89 ± 0.09 Ba	12.23 ± 0.76 Ab
Potato	Raw	60.81 ± 0.89 Aa	10.27 ± 0.95 Ab	2.10 ± 0.56 Aa	8.45 ± 0.87 Ac
Potato	Soybean oil frying	49.93 ± 0.97 Ab	11.55 ± 0.93 Aa	2.59 ± 0.91 Aa	14.38 ± 0.98 Aa
Potato	Air fryer	49.70 ± 0.84 Ab	12.33 ± 0.95 Aa	2.60 ± 0.65 Aa	12.72 ± 0.87Ab

Means followed by the same letter, uppercase for starch source and lowercase for cooking method, do not differ significantly from each other according to Tukey's test at 5% probability level.

Moisture results revealed significant variations both between the different starch sources and among the cooking methods. In general, the raw salmon cakes exhibited the highest moisture contents, which can be attributed to the fact that thermal processes tend to promote water loss. The potato-based cakes presented higher moisture levels compared to those made with cassava, indicating that the choice of starch source directly influences the water content of the food matrix. For cassava-based cakes, frying in soybean oil resulted in the greatest reduction in moisture (43.79%), followed by the air fryer (47.88%). In contrast, no significant difference in moisture was observed between frying methods for the potato-based cakes. Frying in oil induces a greater degree of dehydration, as it occurs at high temperatures and heats food more rapidly and intensely (JORGE & LUNARDI, 2005). In the air fryer, hot air is evenly distributed across the surface of the product, quickly forming a protective crust. This surface barrier limits water migration to the exterior, thus reducing moisture loss during the process.

Regarding protein content, the data showed statistically significant differences across cooking methods, with no observed differences between starch sources. The raw cakes had the lowest protein content when compared to those fried in oil or prepared in the air fryer. The absence of an effect from starch source on protein content can be attributed to the fact that neither potato nor cassava is a significant protein source, with contents around 1.02% and 0.08%, respectively, as reported in the literature (FERNANDES et al., 2013; VIRMOND et al., 2014). The lack of difference between the frying methods (soybean oil and air fryer) suggests that these thermal processes do not cause substantial protein losses. This indicates that the protein content was preserved during cooking, with no relevant degradation or leaching. The increased protein levels in the cooked cakes compared to the raw ones may be explained by the reduction in moisture content, which results in a concentration of the solid constituents of the food (FARFÁN & SAMMÁN, 2003).

Ash content results indicated statistically significant differences only between starch sources. Potato-based cakes subjected to both oil frying and air frying showed higher ash content compared to cassava-based cakes under the same cooking conditions. Potatoes and cassava have similar ash contents—approximately 0.55% and 0.61%, respectively (FERNANDES et al., 2013; VIRMOND et al., 2014)—which explains the lack of significant differences in raw cakes. However, after thermal treatments, a significant difference was observed, likely due to moisture reduction promoted by the cooking methods, which leads to the concentration of solid constituents, including minerals. Although cooking conditions were standardized, it is possible that the potato-based cakes underwent greater water loss compared to those made with cassava.

As for lipid content, no significant differences were observed between starch sources; however, cooking methods had a notable impact. Raw cakes had the lowest lipid values, which is expected, since both raw potato and cassava are predominantly composed of carbohydrates and contain minimal lipid content (0.09% and 0.06%, respectively) (FERNANDES et al., 2013; VIRMOND et al., 2014). Cakes fried in soybean oil showed the highest lipid content, as this cooking method involves immersion in hot oil, allowing significant fat absorption. Meanwhile, the air fryer method, which uses hot air circulation to cook food, resulted in intermediate lipid levels. Unlike traditional frying, the air fryer requires little to no added fat. This technology has proven effective in maintaining the sensory qualities of the product while significantly reducing fat content, with reductions of up to 80% in lipids compared to traditional oil frying (USMAN & VANHAVERBEKE, 2017).

3.2 Physicochemical Characterization

The parameters of pH and water activity (Aw) are of critical importance as they directly influence the safety and shelf life of food products. Table 4 presents the results obtained for these parameters in salmon cakes formulated with different starch sources and subjected to various cooking methods.

Table 4. pH and water activity (Aw) of salmon cakes formulated with different starch sources and preparation methods.

Starch source	Preparation method	Mean ± standard deviation	
		pH	Aw
Cassava	Raw	6.10 ± 0.09 Aa	0.97 ± 0.00 Ab
Cassava	Soybean oil frying	5.76 ± 0.13 Ab	0.84 ± 0.01 Bc

Cassava	Air fryer	5.71 ± 0.05 Ab	0.99 ± 0.00 Aa
Potato	Raw	5.91 ± 0.05 Ba	0.97 ± 0.01 Aa
Potato	Soybean oil frying	5.69 ± 0.06 Ab	0.86 ± 0.01 Ab
Potato	Air fryer	5.66 ± 0.09 Ab	0.98 ± 0.01 Aa

Means followed by the same letter, uppercase for starch source and lowercase for cooking method, do not differ significantly according to Tukey's test at a 5% probability level.

Regarding pH, a significant difference was observed between the starch sources in the raw salmon cakes, with the potato-based formulation showing a lower pH value. With respect to cooking methods, significant differences were found between raw cakes and those subjected to frying in oil and air frying, both of which exhibited lower pH values. The reduction in pH following thermal processing may have positive implications from a microbiological standpoint, as lower pH values can inhibit the growth of spoilage and pathogenic microorganisms.

For water activity (Aw), a significant difference was observed between the starch sources in the oil-fried samples, with the potato-based cakes presenting higher Aw values compared to those made with cassava (0.86 and 0.84, respectively). Significant differences were also found among the cooking methods. For cassava-based cakes, the highest Aw was observed in the air-fried samples, followed by raw and oil-fried formulations. In contrast, for the potato-based cakes, only the oil-fried samples showed a significant reduction in Aw. According to Virmond et al. (2014) and Fernandes et al. (2013), cassava and potato have intrinsic Aw values of approximately 0.98 and 0.99, respectively, indicating high levels of free water, which increases susceptibility to microbiological and chemical spoilage. Based on the results of this study, oil-fried salmon cakes exhibited the lowest Aw values; however, these values remain relatively high. Immersion frying is known to reduce water activity primarily through the intense evaporation that occurs during high-temperature oil cooking (Lima & Bruno, 2006).

3.3 Physical Characterization

Color is a key attribute directly related to sensory acceptance and consumer perception. Changes in coloration may occur depending on the type of raw material, preparation method, and chemical reactions involved in thermal processing, such as the Maillard reaction and caramelization. Table 5 presents the color parameters of the salmon cakes formulated with different starch sources and subjected to various cooking methods, enabling a comparison of the effects of thermal processing on the visual characteristics of the products.

Table 5. Color parameters of salmon cakes prepared with different starch sources and cooking methods.

Starch source	**Preparation method**	**Color (mean ± standard deviation)**		
		L*	**a***	**b***
Cassava	Raw	72.34 ± 0.88 Aa	7.13 ± 0.74 Ac	21.94 ± 0.92 Ab
Cassava	Soybean oil frying	54.87 ± 2.11 Ac	11.13 ± 2.04 Ba	23.99 ± 2.07 Bb
Cassava	Air fryer	61.73 ± 2.17 Ab	9.28 ± 0.79 Ab	26.56 ± 1.71 Aa
Potato	Raw	70.99 ± 1.87 Aa	5.32 ± 0.77 Bc	21.70 ± 0.99 Ab
Potato	Soybean oil frying	47.43 ± 2.47 Bc	13.80 ± 1.25 Aa	27.37 ± 2.03 Aa
Potato	Air fryer	57.40 ± 2.02 Bb	8.40 ± 1.32 Ab	26.75 ± 1.68 Aa

Means followed by the same letter—uppercase for starch source and lowercase for cooking method—do not differ statistically by Tukey's test at 5% probability.

For lightness (L*), no significant difference was found between cassava- and potato-based raw cakes. However, after thermal treatments, the potato-based cakes became significantly darker. Regarding the cooking methods, thermal processing led to a significant reduction in L* values for both starch sources, with deep-fried samples showing the most intense darkening. Frying is known to cause significant changes in sensory attributes such as odor, flavor, and texture, and also leads to visible browning, a characteristic directly related to consumer acceptance. Products with more intense and golden coloration tend to be more visually appealing to consumers (BOSKOU & ELMADFA, 2010). During frying, the intense evaporation of water, combined with oil absorption, promotes surface browning, which decreases light reflection and consequently reduces L* values (YU et al., 2020).

For a* (red-green axis), a significant difference was observed between starch sources: the raw potato-based cake showed less redness than the raw cassava-based one. Among fried samples, the cassava-based cake had lower a* values compared to the potato-based counterpart. In terms of cooking methods, thermal treatments significantly increased a* values for both starch types. Overall, all cakes tended to exhibit reddish hues, which can be attributed to the presence of salmon in the formulation. Salmon is well-known for its characteristic orange-pink color, which is due to the presence of astaxanthin, a carotenoid pigment. In nature, astaxanthin is synthesized by microalgae and accumulates through the food chain in crustaceans, which are consumed by wild salmon. However, in aquaculture systems, dietary supplementation of this pigment is necessary, as salmon lack the endogenous capacity to synthesize it (VALENTE, 2018). Beyond its coloring function, astaxanthin is widely recognized for its strong antioxidant potential. Studies indicate that this compound contributes to several health benefits, such as reducing inflammation in tendons and joints, strengthening the immune system, and lowering the risk of certain types of cancer (FERREIRA et al., 2014).

The b* parameter (yellow-blue axis) showed a significant difference between starch sources for oil-fried samples: the cassava-based cakes presented less yellowness than the potato-based ones. The cooking methods significantly influenced b* values as well. For cassava cakes, the air fryer method resulted in the highest b* values, followed by raw and then oil-fried samples. For potato cakes, both fried samples (in oil and air fryer) exhibited similar b* values, which were significantly higher than the raw sample. Generally, all samples displayed a predominantly yellow tone, attributed to the natural orange-pink color of salmon and the light color of the starches used. Additionally, thermal processing—particularly frying—favors the development of golden tones due to Maillard reactions and caramelization, which are enhanced at high temperatures and contribute to a more visually appealing final product.

Texture is a fundamental sensory attribute in consumer acceptance, especially for fried products. The Texture Profile Analysis (TPA) simulates the force applied by teeth during mastication, assessing how food deforms under compression (LI et al., 2007). Table 6 presents the results of TPA for the different starch sources and cooking methods used in the salmon cake formulations.

Table 6. Texture Profile Analysis (TPA) of salmon cakes prepared with different starch sources and cooking methods.

Starch source	Preparation method	Texture (mean ± standard deviation)					
		Hardness (N)	Springiness	Cohesiveness	Gumminess	Chewiness	Resilience
Cassava	Raw	618.05 ± 116.93 Ac	0.27 ± 0.02 Bb	0.26 ± 0.01 Bb	159.72 ± 38.31 Ab	42.84 ± 11.93 Ab	0.04 ± 0.00 Ac
Cassava	Soybean oil frying	1560.47 ± 136.12 Bb	0.21 ± 0.01 Bc	0.20 ± 0.01 Bc	306.10 ± 51.75 Bb	63.87 ± 13.79 Bb	0.06 ± 0.00 Bb
Cassava	Air fryer	3879.24 ± 344.32 Ba	0.39 ± 0.03 Aa	0.29 ± 0.01 Ba	1135.34 ± 99.17 Ba	445.39 ± 61.11 Ba	0.10 ± 0.00 Ba
Potato	Raw	312.99 ± 37.31 Ac	0.45 ± 0.04 Aa	0.39 ± 0.02 Aa	122.87 ± 15.74 Ac	55.34 ± 12.06 Ac	0.04 ± 0.00 Ac
Potato	Soybean oil frying	4426.25 ± 583.09 Ab	0.36 ± 0.02 Ab	0.27 ± 0.01 Ac	1177.71 ± 126.96 Ab	425.04 ± 58.84 Ab	0.07 ± 0.00 Ab
Potato	Air fryer	6563.26 ± 1052.06 Aa	0.41 ± 0.03 Aa	0.32 ± 0.01 Ab	2076.93 ± 335.98 Aa	855.82 ± 110.47 Aa	0.10 ± 0.00 Aa

Means followed by the same letter—uppercase for starch source and lowercase for cooking method—do not differ statistically by Tukey's test at 5% probability.

Hardness, defined as the force required to deform a food product (Bourne, 2002), varied significantly across cooking methods and starch sources. No significant difference was observed between the raw cassava- and potato-based cakes. However, after thermal processing, the potato-based cakes exhibited higher hardness values, indicating a firmer texture compared to cassava-based ones. Within each starch type, the preparation method significantly affected this parameter. For both starches, cakes prepared in the air fryer showed the highest hardness values, followed by deep-fried and then raw samples. This difference can be attributed to lower oil absorption and greater water loss during air frying, resulting in drier and firmer products. In contrast, deep frying incorporates oil into the product, yielding a softer texture. The increased hardness observed in potato-based cakes may also be associated with their higher amylose content, which favors starch retrogradation upon cooling, contributing to firmer structures (GOÑI et al., 1997). Additionally, cassava-based cakes fried in oil and in the air fryer were described as crispier, a characteristic that generally requires less force to fracture, thus affecting the perceived hardness.

Springiness, or the ability of a product to return to its original shape after deformation (UNE, 1994), also varied significantly among starch sources and cooking methods. Significant differences between cassava and potato were observed in the raw and oil-fried samples, with the potato-based cakes showing higher springiness in both cases. However, in the air-fried group, no significant difference was found between the two starches, suggesting that this cooking method promotes similar elasticity regardless of the starch source. When comparing cooking methods within each starch type, cassava-based cakes showed the highest springiness in the air fryer preparation, followed by raw and oil-fried samples. This indicates that air frying favors structural recovery after deformation. In contrast, for potato-based cakes, the air-fried and raw samples did not differ significantly, though both exhibited higher springiness than the deep-fried ones.

Cohesiveness, defined as the extent to which a product can be deformed before it ruptures (UNE, 1994), showed significant differences between starch types. In all cooking methods, potato-based cakes exhibited higher cohesiveness than cassava-based ones. Furthermore, cooking method significantly influenced cohesiveness within each starch source.

Gumminess, which is related to the cohesion of soft products (UNE, 1994), did not differ significantly between starch sources in the raw cakes. However, in both oil-fried and air-fried conditions, potato-based samples had higher gumminess values, consistent with their higher hardness. When analyzing the cooking methods within each starch source, both cassava and potato cakes prepared in the air fryer had the highest gumminess values, confirming the direct association between greater hardness and higher gumminess.

Chewiness, representing the amount of energy required to prepare the food for swallowing (UNE, 1994), showed no significant difference between starch sources in the raw state. However, for the oil-fried and air-fried samples, potato-based cakes were significantly more chewable than cassava-based ones. Within each starch source, the cakes prepared in the air fryer were the most chewable, supporting the influence of increased hardness on this parameter.

Resilience to deformation was also affected by both starch type and cooking method. While no significant differences were observed in raw samples, in both oil- and air-fried preparations, the potato-based cakes showed greater resistance to deformation compared to cassava-based ones. Across both starch types, air-fried cakes exhibited the highest resistance values, followed by deep-fried and then raw cakes, mirroring the trend observed in the other texture parameters.

5. CONCLUSIONS

The utilization of meat obtained from salmon filleting by-products proved to be feasible, representing a sustainable alternative for the use of raw material that would otherwise be discarded. The different starch sources and preparation methods significantly influenced the characteristics of the final product. The development of fish-based products, such as fish cakes, emerges as a promising strategy to add nutritional value, promote sustainability, and encourage fish consumption, especially given that it is a convenient food with broad consumer acceptance.

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