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Development and characterisation of fish nuggets obtained from mechanically separated meat of Nile tilapia (*Oreochromis niloticus*) with and without edible coatings

[1]Cavenaghi-Altemio, A. D., [1]Figueiredo, A. A. G., [2]Fakhouri, F. M. and [3]Fonseca, G. G.

[1]*Faculty of Engineering, Federal University of Grande Dourados, Dourados, Brazil*
[2]*Department of Materials Science and Engineering, Universitat Politecnica De Catalunya (UPC BarcelonaTech), Terrassa, Spain*
[3]*Faculty of Natural Resource Sciences, School of Health, Business and Science, University of Akureyri, Akureyri, Iceland*

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Abstract

The production of fish nuggets is an example of the valorisation of mechanically separated fish meat (MSM) with its high nutritional value. However, the consumption of breaded food is often avoided due to the large amount of fat absorbed during deep frying in oil. Therefore, the aim of the present work was to develop Nile tilapia (*Oreochromis niloticus*) MSM nuggets coated with an edible coating to reduce the fat absorption during frying, preserving the flavour. Different combinations of corn starch, gelatine, and plasticiser (glycerol or sorbitol) were evaluated for their lipid absorption, with the coating containing 5% corn starch and 20% sorbitol (Treatment 4; T4) being chosen for further studies. Subsequently, T2 (Treatment 2; control, without coating) and T4 were evaluated through chemical (proximate composition), physical (breading yield, shear force, instrumental colour), microbiological, and sensorial analyses. Proximate composition differed only due to the carbohydrates present in the coating, resulting in a breading yield of 23.80% (T4). A higher shear force (24.83 N) was observed for T4. Both T2 and T4 had acceptance indexes greater than 70%, except for the colour attribute. The instrumental colour analysis revealed that the coating and frying processes affected the colour parameters a* and b*. Despite the purchase intention had been probably limited by the acceptance rate obtained for the attribute colour, 58% of panellists certainly or probably would purchase T4.

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Introduction

Fish is highly nutritious, being rich in easily digestible protein, essential minerals such as calcium and phosphorus, and vitamins A, D, and B complex, making it a valuable dietary choice (Awuchi *et al.*, 2022). Despite its recognised nutritional benefits, meeting consumer demand for fish remains a challenge due to limited availability. Therefore, there is a need to explore new avenues for fish commercialisation. One promising approach is the use of mechanically separated meat (MSM), a by-product that can be reused in various food formulations including sausages, fish meatballs, breaded fish, and pâtés, among others (Palmeira *et al.*, 2016; Adrah and Tahergorabi, 2022; Cavenaghi-Altemio and Fonseca, 2024).

Breaded fish, an industrially processed product derived from different animal species, can be prepared using low-value commercial fish or MSM (MAPA, 2002). The convenience of preparing breaded products contributes to increased consumption of this valuable protein source (Bland *et al.*, 2021). However, the frying process, which typically involves the use of oil, can cause sensory changes in the food, affecting its quality attributes such as colour, odour, flavour, and texture (Wang *et al.*, 2021). Furthermore, oils undergo various degradation processes during frying, leading to a decline in quality and structural alterations (Ujong *et al.*, 2023).

Reducing oil uptake in fried foods is a major focus of current research. Several approaches are being explored, including advancements in frying

*Corresponding author.
Email: gustavo@unak.is

technology, modifications to frying mediums, and coating treatments. Among these methods, coating is the most widely used due to its cost-effectiveness and ease of application (Xie *et al*., 2022).

The application of edible coatings to food surfaces has received considerable attention due to their ability to enhance barrier properties, appearance, structural integrity, and mechanical handling (Matloob *et al*., 2023). They form a thin layer on the nugget's surface that forms a protective layer to oil while still allowing water vapour to escape. This effectively reduces oil absorption during frying, maintaining tenderness within, and achieves a crispy outer texture. By minimising oil absorption, these coatings prevent a greasy feel, create a lighter mouthfeel, and reduce fat content, all the while preserving the nugget's desirable crispiness (Kurek *et al*., 2017; Liberty *et al*., 2019; Jouki and Khazaei, 2022).

Common materials for these coatings include hydrocolloids (*e.g.*, starches, gums, and pectin) and proteins (*e.g.*, gelatine, soy protein, and whey protein). Each material offers unique properties, and they are often combined to enhance oil resistance. Additionally, they can incorporate antioxidants, antimicrobials, or flavourings, further enhancing food quality (Khalid *et al*., 2022).

Starch, a widely available hydrocolloid in nature, is commonly utilised as an edible coating due to its abundance and functional properties. The food industry, being the largest consumer of starch, has witnessed significant growth in its usage, both native and modified, owing to its versatile applications (Pelissari *et al*., 2019).

The present work thus aimed to develop and characterise fish nuggets made from mechanically separated meat of Nile tilapia (*Oreochromis niloticus*), with and without various types of edible starch coatings, with the goal of reducing fat absorption during the frying process.

Materials and methods

Mechanically separated meat of Nile tilapia

Nile tilapia samples were supplied by a local fishery processing plant (Itaporã, MS, Brazil). They were transported to the Laboratory of Bioengineering from the Federal University of Grande Dourados (Dourados, MS, Brazil), under refrigerated conditions, and immediately processed to produce the MSM. The MSM was produced in 3 mm particle size using a meat-bone separator (HT 250, High Tech, Brazil), operating at inlet 6°C and outlet 10°C (Cavenaghi-Altemio *et al*., 2013). The MSM was immediately subjected to microbiological analyses and nugget development. The remaining MSM was packaged in polyethylene bags, and stored frozen for further analyses.

Fish nuggets developed with MSM

The fish nuggets were obtained by homogenising the MSM of Nile tilapia (93.90%) with collagen (2.00%), sodium chloride (1.60%), spices (mixtures of garlic, coriander, cumin, nutmeg, and white pepper) (1.30%), sodium polyphosphate (0.50%), ascorbic acid (0.40%), and xanthan (0.30%), before rested for 24 h under refrigeration. Portions of 35 g were weighed, moulded, and breaded. The latter consisted of three stages: pre-dusting, addition of liquid breading (battering), and the final breading. Then, the products were stored under freezing before the application of edible coatings (Cavenaghi-Altemio and Fonseca, 2024).

Dusting and breading flours, and commercial liquid battering were supplied by Baptistella Alimentos Ltda. (Itatiba, SP, Brazil). Additives and condiments were supplied by Conatril Industrial de Alimentos Ltda. (Rio Claro, SP, Brazil).

Edible coatings (breading)

The fish nuggets were evaluated with and without the addition of edible coating. T1 and T2 were the products without the addition of coating, which were maintained raw or fried, respectively. They were considered the controls (Table 1).

The coatings were prepared with corn (*Zea mays*) starch (T3 to T6) and gelatine (T5 and T6). Glycerol (T3) or sorbitol (T4 to T6) were used as plasticising agents, and added in relation to the starch mass, which was defined in relation to 100 mL of water (Table 1). The ingredients were dissolved in 200 mL of distilled water. Then, the solution was heated in a water bath (Quimis model Q334M-28) at 120°C for approximately 10 min, stirring constantly, until the solution changed colour and texture.

The nuggets were coated using the immersion technique for 1 min in the film-forming solution. The nuggets were then kept at -20°C for 12 h. The nuggets (except T1) went through the frying process by immersion in hot soybean oil at 180°C for 9 min.

Table 1. Lipid content of nuggets obtained from mechanically separated meat of Nile tilapia with and without edible coatings.

Treatment	Coating composition (%)				Lipid content
	Corn starch	Gelatine	Glycerol	Sorbitol	
T1	-	-	-	-	19.89 ± 0.07^{b}
T2	-	-	-	-	25.12 ± 0.53^{a}
T3	7	-	20	-	20.44 ± 0.44^{b}
T4	5	-	-	20	18.80 ± 0.06^{c}
T5	5	5	-	20	19.43 ± 0.57^{bc}
T6	7	7	-	20	19.49 ± 0.33^{bc}

Means followed by similar lowercase do not differ statistically at 5% ($p > 0.05$). T1: raw nugget control (no coating); T2: fried nugget control (no coating); T3 - T6: fried nugget with different coatings.

Samples were separated for conducting the chemical and physical determinations. Other samples were packed in plastic packaging, and stored under freezing for other analyses (microbiological and sensory).

Glycerol, sorbitol, and gelatine were purchased from Vetec. Corn starch was purchased from the local commerce (Dourados, MS, Brazil).

Chemical analysis

Moisture, crude protein, and crude ash contents of the fish nuggets produced from MSM of Nile tilapia were determined in triplicate following the methods described by AOAC (2012). Moisture was determined by the oven drying method at 105°C until constant weight (method 950.46), protein by the Kjeldahl method (method 928.08) utilising a conversion factor of 6.25, ash by the muffle oven technique (method 920.153), and crude fibre by chemical digestion (method 978.10). The lipid content was obtained in triplicate by the extraction method with cold organic solvent (Bligh and Dyer, 1959). The carbohydrate content was estimated by difference.

Physical analysis

Breading yield (pick-up)

During the breading process, the fish nuggets were weighed without the cover (initial weight) and with the cover (final weight) for the calculation of the breading yield given by Eq. 1 (Cavenaghi-Altemio and Fonseca, 2024):

$$Breading\ yield = \frac{(Final\ weight - \text{Inicial weight})}{Final\ weight}\ x\ 100 \quad \text{(Eq. 1)}$$

Shear force

The texture analysis of the fish nuggets was carried out using a texture analyser Model TAXTplus (Stable Micro Systems, Surrey, England) calibrated with a standard weight of 5 kg. Fish nuggets kept at 2°C were equilibrated at room temperature (28 - 30°C) before analysis. Samples of 15 × 15 × 20 cm were cut, placed in the texture analyser, and subjected to a cutting/shearing test (speed of 1.0 mm/s, distance of 30 mm) using a Warner-Bratzler shear blade (1 mm thick) to determine the shear force (N). A minimum of ten replicates of each treatment were analysed (Kang and Chen, 2015).

Instrumental colour

The colour [CIE L* (lightness), a* (redness), and b* (yellowness)] of the fish nuggets was evaluated using a colorimeter (Chroma Meter CR 410, Konica Minolta Inc., Tokyo, Japan), with measurements standardised with respect to the white calibration plate (Alvarado and Aguilera, 2001). Five readings were made from the samples of each treatment.

Microbiological analysis

To assess the microbiological loads of the MSM of Nile tilapia and the fish nuggets, duplicate 25 g samples were aseptically transferred into a stomacher bag containing 100 mL of sterile distilled water containing 0.1% peptone (1% for *Salmonella* sp. determination). Samples were homogenised for 1 min. Ten-fold serial dilutions were prepared using sterile 0.1% peptone solution (9 mL) and spread plated (0.1 mL) in duplicate, onto broths and/or agars, for detection of typical colonies, biochemical confirmation, and identification, and plate counting for thermo-tolerant coliforms at 45°C, *Staphylococcus* positive coagulase, and *Salmonella* sp. to ensure the food safety for the panellists during the sensory analysis, following established methodology (USDA/FSIS, 1998).

Sensory analysis

Sensory analysis of the fish nuggets were conducted by 50 non-trained panellists. A nine-point hedonic scale (9 = like extremely; 1 = dislike extremely) was used for evaluation of the attributes colour, odour, taste, texture, and overall acceptance. The treatments were heated in microwave ovens for 5 s, then they were cut transversely 3 mm thick, and served in disposable containers, coded with three-digit random numbers. Purchase intention was evaluated using a 5-point scale, where 5 = certainly would purchase, 4 = probably would purchase, 3 = maybe would purchase / maybe would not purchase, 2 = probably would not purchase, and 1 = certainly would not purchase, which was expressed as the percentage of total score (Cavenaghi-Altemio *et al*., 2018). The acceptance index (AI) was calculated using Eq. 2. The sample was considered acceptable if the AI was greater than 70% (Stone and Sidel, 2004).

$$\text{AI} = \frac{\text{average of the attributed grades}}{\text{maximum attributed grade}} \times 100 \qquad \text{(Eq. 2)}$$

Statistical analysis

All data were subjected to analysis of variance (ANOVA) and the Tukey's test for comparison of means, at a level of 5% of significance, using the statistical software Statistica 7.0. The sensory attributes and purchase intention results were analysed in percentages.

Results and discussion

Composition definition of edible coating

Table 1 presents the results of lipid content for the different treatments. It shows that treatments T1 and T2 differed from each other (19.89 and 25.12%, respectively), indicating high lipid absorption when the nugget was fried without the addition of coating. T4 presented lipid content (18.80%) lower ($p < 0.05$) than the raw control (T1). T3, T5, and T6 did not differ from T1 ($p > 0.05$). Despite T4 did not differ ($p > 0.05$) from T5 and T6, this treatment was chosen for the other analysis because it was the only treatment that solely differed from T1 ($p < 0.05$) in terms of not absorbing lipids (T2 also differed but absorbed lipids).

The process of frying alone does not determine lipid retention. While frying is a primary factor in oil absorption, the coating can create a matrix with the nugget ingredients that may expel lipids from the formulation, and act as a barrier against further lipid absorption during frying (Pérez-Camino *et al*., 1991; Mellema, 2003; Bordin *et al*., 2013; Hua *et al*., 2015; Li *et al*., 2017; Khor *et al*., 2020). This could explain why T4 (fried) showed lower lipid content than T1 (raw), likely due to the presence of sorbitol (Table 1). Additionally, the increase in non-lipid mass from the coating ingredients could contribute to a decrease in total lipid content.

Regarding the plasticiser present in the film-forming solution, an increase in the flexibility and adhesion of the film-forming solution in the breading were expected, limiting the absorption of the lipids used in the frying process. The results showed that sorbitol was more effective than glycerol in limiting lipid absorption. However, the addition of gelatine to sorbitol and corn starch to obtain the coating did not improve the results. It was expected that gelatine combined with sorbitol and corn starch in the coating would contribute to the formation of a denser and more cohesive matrix, which could, to a certain degree, limit fat absorption. Gelatine plays a crucial role in food coatings as a gelling, stabilising, and binding agent. Its adhesive properties help other ingredients adhere to the food surface, enhancing the coating's texture (Lu *et al*., 2022; Luo *et al*., 2022). This is because gelatine could contribute to form a physical barrier that prevents excessive oil penetration into the coating.

When comparing sorbitol and glycerol, literature reports that sorbitol is notably more hygroscopic, meaning it retains water more effectively, and forms a denser, more cohesive gel matrix upon heating. Sorbitol is able to create more entanglement with starch chains, which results in more interactions with starch chains than glycerol (Moghaddam *et al*., 2023). These properties create a stronger barrier against oil absorption, whereas the thinner barrier formed by glycerol allows for greater oil uptake. Additionally, sorbitol's higher molecular weight and superior water-binding ability generally make it more effective at reducing oil absorption. While glycerol is beneficial in imparting flexibility and a softer texture to coatings, a desirable feature in some applications, this flexibility can slightly increase oil absorption (García *et al*., 2002; 2004; Coltelli *et al*., 2016; González-Torres *et al*., 2021). Therefore, corn starch mixed with sorbitol can be considered the best choice for reducing lipid absorption in fried foods due to its enhanced water retention, stronger barrier formation, and cohesive gel matrix.

In general, it can be stated that all coating combinations were efficient in controlling lipid absorption during frying (Table 1). The literature reports an increase in fat values for breaded croquettes made with MSM and trimmings of Nile tilapia after the pre-frying process, varying from 4.66 to 11.59% and from 1.93 to 9.17%, respectively, due to the oil absorption (Bordignon *et al*., 2010).

Chemical analysis

The proximate composition of the nuggets is shown in Table 2. The moisture content of T2 (41.11%) and T4 (39.74%) did not differ ($p > 0.05$). As discussed before, the lipid content differed ($p < 0.05$) from T2 (uncoated) and T4 (coated) nuggets, corresponding to 25.12 and 18.80%, respectively (Tables 1 and 2). There was no significant difference ($p > 0.05$) between treatments for proteins (17.24 - 17.52%). T2 and T4 also did not differ from each other ($p > 0.05$) for the ash content (2.77 - 2.81%). As expected, T4 presented higher carbohydrate content (21.17%) due to the addition of coating containing corn starch and sorbitol in its composition, compared to the control treatment (T2), without coating (Table 2).

The results obtained in the present work were very similar to the composition obtained for nuggets prepared using 86% MSM from Nile tilapia, which corresponded to 43.4% moisture, 11.6% lipids, 19.1% protein, 2.6% ash, and 23.1% carbohydrates (Bacelar *et al*., 2021). On the other hand, for breaded steaks prepared with 86.7% ground fillets of Nile tilapia, the composition consisted of 67.46% moisture, 4.08% lipids, 19.05% protein, 2.7% ash, and 6.71% carbohydrates (Cortez Netto *et al*., 2010). Legislation determines a minimum of 10% of protein for breaded products (MAPA, 2002), which was achieved in the present work. Different values can be explained by the addition of different ingredients and their respective concentrations in the formulations. Moreover, other factors including breading composition, and way and time of frying may also influence the results.

Table 2. Proximate composition, breading yield, and shear force of nuggets obtained from mechanically separated meat of Nile tilapia with and without edible coatings.

Parameter	Treatment	
	T2	**T4**
Moisture (%)	41.11 ± 0.16[a]	39.74 ± 0.65[a]
Lipid (%)	25.12 ± 0.53[a]	18.80 ± 0.06[b]
Protein (%)	17.24 ± 1.26[a]	17.52 ± 0.16[a]
Ash (%)	2.71 ± 0.15[a]	2.77 ± 0.17[a]
Carbohydrate (%)	13.82	21.17
Breading yield (%)	-	23.80
Shear force (N)	6.67 ± 0.19[b]	24.83 ± 1.32[a]

Means followed by similar lowercase in similar row do not differ statistically at 5% ($p > 0.05$). T2 and T4 are explained in Table 1.

Physical analysis

Table 2 presents the results for breading yield and shear force. Only T4 received coating. Thus, a breading yield of 23.80% was achieved in relation to T2 (uncoated). It was observed a shear force of 24.83 N for T4, which differed ($p < 0.05$) from the 6.67 N obtained for T2 (uncoated).

Regarding the instrumental colour parameters (L*, a*, and b*), it was observed that both T2 and T4 treatments presented negative values for a* (redness), but with statistical difference ($p < 0.05$) between them. Statistical difference ($p < 0.05$) was also observed between these two treatments for the parameter b* (yellowness) (Table 3). However, when comparing the corresponding raw samples for both T2 (T2 raw = T1; Table 1) and T4 (T4 raw), no significant difference ($p > 0.05$) was observed between these two treatments (Table 3). These results indicated that just the coating or the frying processes themselves did not influence the colour parameters of the nuggets. However, the frying of the nuggets coated with corn starch and sorbitol (T4) affected the colour parameters a* and b*, by decreasing redness and yellowness in comparison to the uncoated fried control (T2).

In accordance with the present results, it was reported elsewhere that the application of different commercial coatings in breaded tilapia yielded between 19.97 and 35.34% (Delfino *et al*., 2017). Changes in nuggets' texture can be influenced by the binding properties of myofibrillar proteins, and the ability of the coating to bind water, fat, and meat

Table 3. Instrumental colour (L*, a*, and b*) parameters of nuggets obtained from mechanically separated meat of Nile tilapia with and without edible coatings.

Parameter	Treatment			
	T2 (raw)	T2	T4 (raw)	T4
L*	8.56 ± 1.98[a]	10.83 ± 2.46[a]	12.76 ± 3.12[a]	12.36 ± 2.85[b]
a*	-2.00 ± 0.39[a]	-2.67 ± 0.56[a]	-1.97 ± 0.44[a]	-5.3 ± 1.06[b]
b*	7.47 ± 2.21[a]	8.43 ± 1.14[a]	9.09 ± 1.91[a]	4.44 ± 0.68[b]

Means followed by similar lowercase in similar row do not differ statistically at 5% ($p > 0.05$). T2 and T4 are explained in Table 1. Raw = before frying.

pieces during preparation and frying (Prinyawiwatkul *et al*., 1997). However, the starch utilised in the breading is probably the main factor affecting the texture. Clearly, the use of corn starch contributed to create a crisp, golden crust while locking in moisture to keep the nugget tender, thus enhancing its texture in T4 (Table 2). Accordingly, literature reports that products breaded with flour presented greater shear force (Maskat and Kerr, 2002; Adedeji and Ngadi, 2011). Regarding the instrumental colour, the differences found between a* and b* values were related to the composition of the fish species, which was reflected in fish-derived products, as in the case for breaded products (Zuanazzi *et al*., 2017), which in turn, will depend on the chemical composition, formula and structure of coatings, the different cooking oils and their properties, as well as the frying temperature and time (Xie *et al*., 2022).

Microbiological analysis

Microbiological analysis of the nuggets was carried out to ensure food safety so that sensory analysis could be performed (Table 4). The obtained results were within the limits established by the Brazilian National Health Surveillance Agency (ANVISA) for breaded products for coliforms at 45°C (maximum of 10^2 CFU/g), for *Staphylococcus* positive coagulase (maximum of 5×10^2 CFU/g), and *Salmonella* sp. (absence in 25 g) (ANVISA, 2019). Therefore, it could be concluded that the fish nuggets were prepared following the microbiological standards established for foods, thus considered safe for sensory analysis.

Sensory analysis

Table 5 shows the average scores of the attributes colour, odour, texture, taste, and overall acceptance evaluated in the acceptance test and the acceptance indexes (in parentheses), obtained from the sensory analysis.

The average scores for the attributes colour, flavour, and overall acceptance ranged from “neither liked/nor disliked” to “liked moderately” and showed no difference ($p > 0.05$) between treatments (Table 5). Therefore, the coating containing corn starch and sorbitol influenced neither the appearance nor the taste of the nuggets.

Regarding the odour and texture attributes, both showed a significant difference ($p < 0.05$) between T2 and T4, and their scores ranged from “liked slightly” to “liked moderately”. However, the panellists preferred the nuggets from the T2 for both odour and texture attributes (Table 5). This might have been due to the higher lipid content and lower shear force obtained for T2. The aroma of frying is primarily defined by the volatile aromatic compounds released during the frying process, resulting from various chemical reactions that occur during the thermal degradation of lipids, and the oxidation of fatty acids present in both the food and frying oil. As explained earlier, the texture was evaluated in terms of shear force, and the coating with corn starch and sorbitol (T4) made the product harder.

The acceptance indexes for all sensory attributes were above 70%, except for the colour. It means that the nuggets were considered accepted without statistical difference for T2 and T4, except for their colour (Stone and Sidel, 2004).

Figure 1 shows the percentage frequencies of the purchase intentions for the nuggets, with and without edible coatings. The purchase intention of “certainly would purchase” was 26% for the T2, and 32% for the T4, while that the option “probably would purchase” reached 30 and 26% for T2 and T4, respectively. The refusal rates corresponded to only 14% (T2) and 8% (T4) for the sum of frequencies of

Table 4. Microbiological analyses of nuggets obtained from mechanically separated meat of Nile tilapia with and without edible coatings.

Parameter	Treatment	
	T2	T4
Coliforms at 45°C	< 10^2 CFU/g	< 10^2 CFU/g
Staphylococcus positive coagulase	Negative	Negative
Salmonella spp.	Absent in 25 g	Absent in 25 g

CFU: colony-forming units. T2 and T4 are explained in Table 1.

Table 5. Sensory analysis of nuggets obtained from mechanically separated meat of Nile tilapia with and without edible coatings.

Attribute	Treatment	
	T2	T4
Odour	7.53 ± 1.23[a] (83.71)	6.66 ± 1.76[b] (74.00)
Texture	7.59 ± 1.11[a] (84.29)	6.72 ± 1.54[b] (76.00)
Colour	5.76 ± 1.98[a] (64.00)	5.93 ± 1.76[a] (65.89)
Taste	7.53 ± 1.09[a] (83.71)	7.28 ± 1.44[a] (80.86)
Overall acceptance	7.25 ± 1.23[a] (80.57)	7.02 ± 1.29[a] (78.00)

Means followed by similar lowercase in similar row do not differ statistically at 5% ($p > 0.05$). Values in parenthesis are acceptance index (%). T2 and T4 are explained in Table 1.

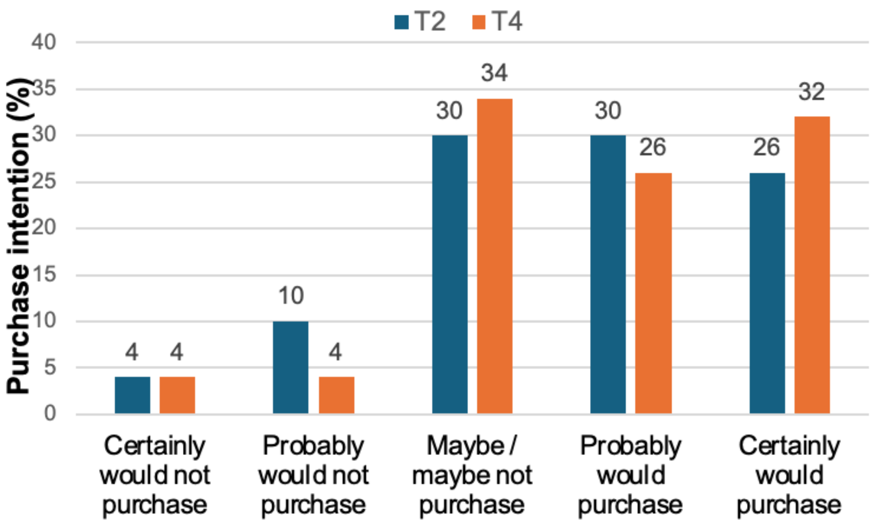

Figure 1. Purchase intention of nuggets obtained from mechanically separated meat of Nile tilapia with and without edible coatings.

"certainly and probably would not purchase". The percentage of undecided ("maybe or maybe not purchase") was 30% for T2, and 34% for T4. Comparing the results of Table 5 with those of Figure 1, it was observed that the purchase intention was limited by the acceptance rate obtained for the colour attribute, which means that the improvement of this characteristic by adjusting the formulations could be very beneficial for the commercialisation of these products in the future.

For comparison, literature reports attribute scores for the attributes appearance, aroma, taste, texture, and overall acceptance varying from 7.00 to 7.93, and purchase intention of 77% for Nile tilapia breaded steaks (Cortez Netto *et al.*, 2010), and scores above 7.0 (with an average grade of 7.4) for the parameters colour, flavour, texture, aroma, global acceptance, and purchase intention for nuggets containing 86% MSM of Nile tilapia (Bacelar *et al.*, 2021).

Conclusion

Nuggets were successfully developed from MSM of Nile tilapia, with and without the addition of an edible coating. The coating containing 5% corn starch and 20% sorbitol (T4) significantly reduced lipid absorption compared to the other treatments, thus providing a healthier product. The breading yield of 23.80% was also responsible for a higher shear force (24.83 N), which statistically affected the sensory attribute texture in T4. However, both T2 (control) and T4 treatments had all acceptance indexes greater than 70%, except for the colour attribute. Instrumental colour analysis showed that the coating and frying processes affected the colour parameters a* and b*, reducing redness and yellowness of T4 compared to T2. Despite the purchase intention had been probably limited by the acceptance rate obtained for the colour attribute, 58% of the panellists would definitely or probably buy T4.

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