Capítulo 30

Development of Clean Label Approach for Breaded Chicken Inner Fillet (Supracoracoideus)

Desenvolvimento de uma Abordagem Clean Label para o Filé Interno de Frango Empanado (Supracoracoideus)

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Abstract: This study investigated the development of breaded chicken inner fillet with a clean label formulation. The research was motivated by growing consumer demand for foods with fewer synthetic chemical additives. Seven different formulations were developed: a standard formulation (FP), containing synthetic chemical additives such as sodium tripolyphosphate and monosodium glutamate, and six experimental formulations (F1-F6), in which these additives were replaced or removed. The formulations underwent physicochemical (moisture, ash, protein, lipids, carbohydrates, pH), texture, microbiological, sensory, and cost analyses. The physicochemical and texture analyses did not reveal statistically significant differences between the formulations, indicating that the replacement or removal of synthetic additives did not compromise the product's physicochemical or textural properties. The cost analysis demonstrated the economic viability of producing clean label breaded chicken inner fillet, with some experimental formulations having lower production costs than the standard formulation. The results of the microbiological analyses demonstrated the formulations' microbiological safety. The sensory analysis did not show a statistically significant difference between the samples by the Tukey test, but did by the Dunnett test, with the sample containing sodium tripolyphosphate and yeast extract being closest to the acceptance level of the standard sample.

Keywords: natural additives; sodium tripolyphosphate; yeast extract; monosodium glutamate; chicken inner fillet.

Resumo: Este estudo investigou o desenvolvimento de filé interno de frango empanado com formulação clean label. A pesquisa foi motivada pela crescente demanda dos consumidores por alimentos com menos aditivos químicos sintéticos. Foram desenvolvidas sete formulações: uma formulação padrão (FP), contendo aditivos químicos sintéticos, como

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tripolifosfato de sódio e glutamato monossódico, e seis formulações experimentais (F1-F6), nas quais esses aditivos foram substituídos ou removidos. As formulações foram submetidas a análises físico-químicas (umidade, cinzas, proteínas, lipídios, carboidratos e pH), de textura, microbiológicas, sensoriais e de custos. As análises físico-químicas e de textura não revelaram diferenças estatisticamente significativas entre as formulações, indicando que a substituição ou remoção dos aditivos sintéticos não comprometeu as propriedades físico-químicas ou de textura do produto. A análise de custos demonstrou a viabilidade econômica da produção de filé interno de frango empanado clean label, com algumas formulações experimentais apresentando custos de produção inferiores aos da formulação padrão. Os resultados das análises microbiológicas demonstraram a segurança microbiológica das formulações. A análise sensorial não revelou diferença estatisticamente significativa entre as amostras pelo teste de Tukey, mas indicou diferença pelo teste de Dunnett, sendo a amostra contendo tripolifosfato de sódio e extrato de levedura a que mais se aproximou do nível de aceitação da amostra padrão.

Palavras-chave: aditivos naturais; tripolifosfato de sódio; extrato de levedura; glutamato monossódico; filé interno de frango.

INTRODUCTION

According to Asioli *et al.* (2017), food processing has brought benefits such as increased shelf life and reduced losses and waste. However, consumers are increasingly looking for foods that are both convenient, such as frozen foods and ready meals, for example, and healthy, with a short list of familiar and sustainable ingredients. Following this line of thought, the clean label trend has emerged.

The term clean label is old, but it still lacks specific legislation or a single definition. For most authors, it is classified as food with a short list of well-known ingredients, without artificial additives, or with natural additives. Consumer demand for clean label foods has increased in recent years, especially in more developed countries, and the industry is aiming for products to meet this growing demand (Asioli *et al.,* 2017).

In conformity with this trend, this study focused on the development of a clean label breaded chicken inner fillet with physical-chemical characteristics, texture, and cost similar to the conventional product (with artificial additives).

BRAZILIAN MEAT CONSUMPTION PROFILE AND THE CLEAN LABEL TREND

According to the 2025 annual report of the Brazilian Animal Protein Association (ABPA), per capita consumption of chicken meat in Brazil was 45.5 kg, standing out as the most consumed meat by Brazilians.

According to Venancio *et al.* (2020), chicken meat has a mild flavor and is relatively inexpensive, making it widely used in the production of processed foods. During processing, chemical additives are used to achieve specific characteristics in flavor, texture, and color, among others (Pedreira, 2022; Pinzon, 2022).

On the other hand, according to Venancio (2020) and Asioli *et al.* (2017), consumers are more attentive to the composition of the foods they consume, and trends such as clean label have been gaining ground. Although there is no single definition, the authors and Anvisa understand clean label to mean foods that contain a shorter list of ingredients, with ingredients familiar to consumers and no chemical additives, or with chemical additives replaced by natural ones. According to Sbadelotto (2021) and Silva (2021), this trend is more prevalent in industrialized countries and still underdeveloped in Brazil. In surveys conducted with consumers in Europe and Asia, there was a willingness to pay more for healthier foods, such as clean-label products (Cegielka, 2020; Hsu *et al.,* 2023).

FOOD ADDITIVES FOR MEAT PRODUCTS

According to Anvisa (Agência Nacional de Vigilância Sanitária / National Health Surveillance Agency), an additive is any substance added to food that does not serve as a nutritional component and is intended to alter physical, chemical, biological, or sensory characteristics (Brazil, 2009). Additives are used in industrialized products for various purposes, including improving texture, flavor, odor, and color, and inhibiting microbial growth and lipid oxidation, among others (Brazil, 2009), and can be artificial or natural.

One of the main synthetic additives used in meat products is sodium tripolyphosphate. It is used because of its ability to increase water retention in meat, improving the texture and yield of the finished product (Molina *et al.,* 2023; Assis, 2009). The use of sodium tripolyphosphate promotes dissociation of the actomyosin system formed in rigor mortis, thereby increasing protein solubility, water retention capacity, and gelatinization and emulsion capacity (Molina *et al.,* 2023).

Another additive widely used in foods is monosodium glutamate, a salt of glutamic acid used as a flavor enhancer. It is naturally present in some foods, such as cheese, soy sauce, and mushrooms. However, its concentration is affected by the maturation time and the production process. The longer the maturation time and the greater the water loss, the higher the glutamate concentration in the food. As industrial processes involve less water loss and shorter maturation times, monosodium glutamate is added to compensate for this loss (Kos *et al.,* 2023).

REPLACEMENT OF SYNTHETIC ADDITIVES BY NATURAL ADDITIVES IN INDUSTRIALIZED MEAT PRODUCTS

According to Delgado-Pando *et al.* (2021), replacing synthetic additives with natural ones is quite challenging for the food industry. Not all synthetic additives have natural substitutes. Natural additives are usually added in larger quantities and are more expensive. Although widely used in meat products, high consumption of inorganic phosphates, including sodium tripolyphosphate, is associated with an increased risk of cardiovascular diseases, obesity, and liver and kidney problems

(Dissanayake *et al.,* 2024), making it worthwhile to evaluate the feasibility of substituting them with natural alternatives such as fiber, starch, mushrooms, and yeast extract (Molina *et al.,* 2023; Crist *et al.,* 2019).

Even without scientific proof of its harmful effects, consumers are seeking foods with reduced or no monosodium glutamate (Kurcubic *et al.,* 2022). According to Kos *et al.* (2023) and Rocha (2017), mushrooms, yeast extract, tomato extract, and hydrolyzed soy protein are some of the natural substitutes for monosodium glutamate. In this study, the ingredient PHA 750 from the company Wenda was used as a substitute for sodium tripolyphosphate and WY12, from the same supplier, as a substitute for monosodium glutamate. PHA 750 is composed of a mixture of citrus extracts (lemon, orange, and lime) and yeast extract, which are listed as natural flavorings in the ingredient list. WY 12 is composed of yeast extract and is listed as a natural flavoring.

According to the manufacturer, citrus extracts (lemon, orange, and lime) directly affect the actin-myosin complex, allowing it to relax and hydrate. The buffering capacity and ionic strength help stabilize the complex. Maintaining the pH optimizes the product's texture, flavor, and color stability. The increase in ionic strength occurs due to the increase in meat ions. This helps in the solubilization of proteins, maintaining a high level of hydration. The yeast extract lodges in the space between the fibers created by the citrus extract, holding water inside the muscle and ensuring good product performance.

MATERIALS AND METHODS MATERIAL

This was an applied research study using a qualitative-quantitative approach, involving both objective data (physicochemical, microbiological, and cost analyses) and subjective data (sensory analysis). In terms of procedure and objective, it is a descriptive experiment. It was developed by a large company in southern Brazil. Several company-predefined breaded chicken inner fillet formulations were tested between the second semester of 2024 and the first semester of 2025. The fresh chicken inner fillets were kept refrigerated (0 to 4ºC) for up to 10 days after slaughter. The seasonings, synthetic and natural additives, and breading flours were stored at room temperature in a designated area at the company and were used according to the expiration dates provided by the suppliers. After breading and cooking, the chicken inner fillets were kept frozen at -12°C or colder.

PREPARATION OF FORMULATIONS

Six formulations were developed, removing and/or replacing sodium tripolyphosphate and monosodium glutamate, in addition to the standard formulation containing these two additives. All formulations were made using 87.57% meat and 12.43% brine. The brines were composed of water, salt, and natural seasonings, as

well as additives and/or their substitutes. The amounts of salt and natural seasonings did not vary between the formulas, as described in Table 1.

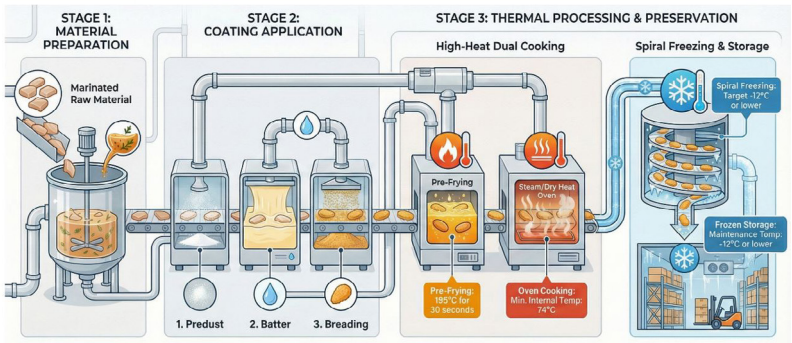
Table 1 – Composition of the different breaded formulations produced with chicken inner fillet.

	F1	F2	F3	F4	F5	F6	FP
Fillet (chicken inner fillet)	87.57	87.57	87.57	87.57	87.57	87.57	87.57
Water	9.40	10.30	10.00	10.20	10.50	9.40	10.00
Refined salt	1.10	1.10	1.10	1.10	1.10	1.10	1.10
Sodium tripolyphosphate	0.00	0.00	0.30	0.30	0.00	0.00	0.30
Natural seasonings	0.83	0.83	0.83	0.83	0.83	0.83	0.83
Monosodium glutamate	0.20	0.20	0.00	0.00	0.00	0.00	0.20
PHA 750	0.90	0.00	0.00	0.00	0.00	0.90	0.00
WY12	0.00	0.00	0.20	0.00	0.00	0.20	0.00

FP – Standard Product.
Source: The Author, 2026.

Initially, the brines were prepared by adding salt, natural seasonings, and chemical additives and/or their natural substitutes to cold, heavy drinking water, according to each formulation and the proportions described in Table 1. This mixture was homogenized and added to the previously weighed chicken inner fillets. The chicken inner fillets were marinated in a refrigerated chamber at a controlled temperature between 0 and 4ºC for 48 hours. After this period, the inner fillets were separated from the excess brine. This was weighed individually, and its value was recorded and used in the calculation of product yield and cost. The fillets were then placed on conveyor belts and automatically sent to the breading line, which consisted of applying a layer of pre-dusting flour, followed by a layer of breading liquid, and finished with breading flour. The next steps were pre-frying in a continuous fryer at 195°C for 30 seconds and cooking in a double-spiral oven using steam and dry heat until the product reached a minimum internal temperature of 74°C. This was followed by freezing in a spiral freezer until the internal temperature reached -12°C or less. After freezing, the products were packaged and stored at -12°C or lower. The production flowchart is shown in Figure 3.

Figure 3 - Production flowchart for breaded formulations.



Source: The Author, 2026 (NotebookLM, 20026).

Two weight measurements were taken for each sample (or formulation) at each process stage, up to cooking, to assess gains in breading and losses during cooking. Each measurement was taken with four fillets, using the same units for all measurements. These results were used to calculate the product's cost and yield, along with the brine absorption data.

Cost Analysis

A comparison was made between the cost of the standard product and that of the evaluated test formulas. Therefore, the amount of brine absorbed by the chicken inner fillet in each formulation was evaluated according to equation (1):

% brine absorption = (Chicken inner fillet weight after marinating – Fresh chicken inner fillet weight) / Chicken inner fillet weight after marinating *100 (1)

Gains in the pre-flouring, breading liquid application, final coating, and pre-frying stages were also evaluated, as shown in equation (2).

% gain = (stage 2 weight – stage 1 weight) / stage 2 weight *100. (2)

Next, the cooking loss was calculated using equation (3).

% loss = (weight after oven – weight before oven) / weight before oven *100 (3)

The cost of each formulation was calculated based on the amount of brine absorbed, gains in the breading stages, cooking loss, ingredient costs, and the amount of each ingredient used in each sample.

Physical-chemical analyses

The moisture content was determined by oven drying at 105°C, according to AOAC Method 925.09. To quantify ash, the samples were carbonized and then calcined in a muffle furnace at 550ºC (AOAC Method 923.03). Protein determination was performed according to the Kjeldahl method (AOAC Method 920.87). Lipids were extracted using petroleum ether in a Soxhlet apparatus, according to AOAC Method 963.15. For pH measurements, approximately 50 g of sample was weighed and homogenized in 20 mL of distilled water. The bench potentiometer was calibrated using pH 4 and 7 buffer solutions, and the pH of the prepared samples was then measured (IAL, 2008). The carbohydrate content was determined according to the Adolfo Lutz Institute (IAL, 2008), obtained by the difference between 100 and the sum of the protein, lipid, moisture, and ash contents. The texture was evaluated using maximum shear force on a TA. XTplusC texturometer.XTplusC texturometer and Warner-Bratzler blade (HDP/BS), using the compression method with a 5 kg load cell.

Microbiological Analyses

The presence of Salmonella spp., coagulase-positive staphylococci, Escherichia coli, and mesophilic aerobes was mapped, as described in Normative Instruction No. 60 of 12/23/2019 (Brazil, 2019), in the company's laboratory using

materials donated by the company. The analyses of coagulase-positive staphylococci, E. coli, and mesophilic aerobes were performed using the deep-inoculation technique, with a minimum detection limit of 10 CFU/g (colony-forming units/g). The analysis of Salmonella spp. was performed using the presence/absence technique. All analyses were performed as defined in the scope of the company's laboratory accreditation (Brazil, 2024).

Sensory Analysis

The sensory analysis was conducted at the Federal Technological University of Paraná (UTFPR). Londrina Campus. Before the tests, the project received approval from the research ethics committee of the Federal Technological University of Paraná and can be found under the following identifiers: Opinion 7.270.430, with the title "Development of clean label breaded chicken meat," and process number CAAE 82583024.5.0000.5547. A total of 100 responses were collected per test, with sessions held during the morning and afternoon at the university's sensory laboratory.

The hedonic scale was applied, a test of acceptance that expresses the evaluator's personal opinion. The assessor received the coded samples and indicated their degree of preference on a scale of 0 to 9. Where zero is I disliked it very much, and 9 is I liked it very much. (Lemes *et al.,* 2021). Each evaluator was instructed on the type of sample to be evaluated and filled out the informed consent form (ICF) and the data collection questionnaire. The samples were presented simultaneously, randomly arranged on a tray. Each sample was on a white plate coded with a random three-digit number.

Data Processing

The results were analyzed using analysis of variance and Dunnett's test at the 5% significance level in the Biostat program to detect possible significant differences between the formulations.

Results and Discussion

Percentage of Brine Absorption

After 48 hours of marinating in a cold chamber at 0 to 4°C, the chicken inner fillets were removed from the container, and the remaining liquid (not absorbed) was weighed, and the percentage of brine absorbed in each formulation was evaluated (Table 2). Sample F4, containing sodium tripolyphosphate and no monosodium glutamate, showed lower brine absorption compared to the standard sample (FP). Sample F6, with artificial additives replaced by natural ones, showed the highest brine absorption.

Table 2 – Percentage of brine absorbed in different chicken breading formulations compared to Standard Formulation (chicken inner fillet).

Formulations	% of brine absorbed
FP	n/a
F1	0.76
F2	3.35
F3	3.41
F4	-4.53
F5	4.00
F6	6.94

Source: The Author, 2026.

Percentage of breading gain and weight loss during cooking

We performed two evaluations of each formulation to determine total breading gain and weight loss during cooking, including weight gain during pre-dusting (predust), batter application, final coating (breader), pre-frying, and cooking. Each weight evaluation was performed with four chicken inner fillet units. The same chicken inner fillet units were weighed after each stage. The averages of the results of each evaluation are described in Table 3. Formulation F5, in which sodium tripolyphosphate and monosodium glutamate were removed, showed the highest weight gain in the breading stage. Meanwhile, formulation FP, which is the standard product, showed the lowest weight gain at this stage. All formulations showed cooking losses below standard, with formulation F3, containing sodium tripolyphosphate and yeast extract, showing the lowest loss. The variation in weight gain during the breading stages is directly related to the anatomy of the fillets. As it is an intact muscle, there are variations in width and thickness between the pieces, which are inherent to the animal, and these variations impact the percentage of breading aggregation. Wider pieces aggregate more coating, while narrower pieces aggregate less. In the industrial process, variations in the percentage of gain at each breading stage are acceptable.

Table 3 – Percentage weight gain in different chicken (chicken inner fillet) breading formulations determined at the breading, pre-frying, and oven stages.

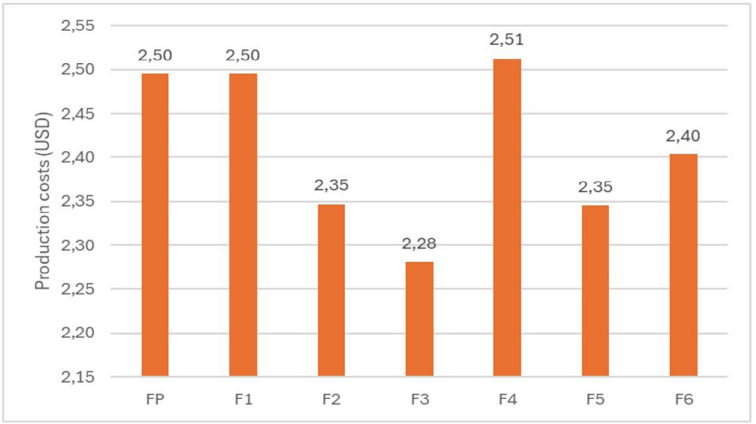
Formulações	Ganho de peso no empanamento total (%)	Diferença para o padrão (%)	Perda de peso no cozimento forno (%)	Diferença para o padrão (%)
FP	18,57		-3,16	
F1	19,82	6,73	-2,45	-22,30
F2	20,05	8,01	-1,41	-55,36
F3	19,59	5,48	-0,67	-78,91
F4	20,26	9,11	-1,82	-42,29
F5	22,32	20,19	-3,07	-2,89
F6	19,16	3,18	-1,12	-64,60

Source: The Author, 2026.

Formulation Costs

To calculate the formulation costs, weight gains in the breading and pre-frying stages, the percentage of brine absorption, and cooking loss were considered, in addition to the costs of raw materials and ingredients. The result of this calculation for each formulation is shown in Figure 4. Formulation F3, in which monosodium glutamate was replaced by yeast extract while maintaining sodium tripolyphosphate, had the lowest cost. Formulation F4, containing sodium tripolyphosphate without monosodium glutamate, had the highest cost. Formulations F5, without additives, and F6, with natural additives, had lower costs than the standard formulation, demonstrating the economic viability of their production.

Figure 4 – Costs (USD) of the different chicken breading formulations (chicken inner fillet).



Source: The Author, 2026.

Physical-chemical results: Physical-chemical analyses

Moisture, protein, lipid, ash, and carbohydrate (by difference) analyses were performed at time zero for all formulations. The results from the proximal composition are shown in Table 4. Analysis of these data indicates that there is no statistical difference between the evaluated formulations.

Table 4 – Physicochemical results at time zero quantified with the final product (contains breading flour).

	F1	F2	F3	F4	F5	F6	FP
Moisture	52.75a (±4.5)	52.02a (±5.82)	51.33a (±7.42)	51.98a (±5.81)	49.75a (±6.28)	54.85a (±4.47)	51.30a (±7.42)
Ash	3.0 a (±0.36)	3.00a (±0.36)	3.00a (±0.70)	3.02a (±0.70)	3.03a (±0.36)	3.02a (±0.70)	3.10a (±0.99)
Protein	16.51a (±0.86)	16.57a (±1.00)	16.53a (±0.86)	16.54a (±0.88)	16.53a (±0.86)	16.53a (±1.00)	16.50a (±1.00)

	F1	F2	F3	F4	F5	F6	FP
Lipids	8.22a (±0.46)	7.65a (±1.07)	7.03a (±2.21)	7.25a (±0.78)	7.58a (±1.17)	7.24a (±1.08)	7.63a (±1.07)
Carbohydrates	23.07a (±1.39)	22.37a (±0.44)	24.50a (±2.75)	23.98a (±1.39)	23.09a (±1.39)	22.38a (±0.44)	24.48a (±2.75)
pH	5.97a (±0.07)	6.02a (±0.09)	6.21a (±0.14)	6.85a (±0.04)	5.83a (±0.02)	5.61a (±0.09)	6.03a (±0.02)

** Different letters in the rows indicate statistical differences according to Tukey's test at a significance level of 5%. Identical letters indicate that the samples did not differ significantly.*

Source: The Author, 2025.

Moisture analysis was performed at time zero and after 90 days to determine whether moisture loss would occur with storage time, since the water retainers were changed in the formulations (Table 5). Formulation F6, in which artificial additives were replaced by natural additives, had a higher moisture value at time zero, while F5 (without additives) had a lower moisture at this time. This result persisted in the analysis after 90 days, with formulation F6 showing the greatest variation in moisture over storage time. However, the differences observed are not statistically significant under Tukey's test at the 5% significance level.

Table 5 – Moisture variation between time zero and after ninety days of storage.

	Moisture (time zero)	Moisture (after 90 days)
F1	52.75 (± 4.47)[a]	52.72 (± 4.47)[a]
F2	52.02 (± 5.82)[a]	51.81 (± 5.97)[a]
F3	51.33 (± 5.81)[a]	51.30 (± 7.42)[a]
F4	51.97 (± 5.81)[a]	51.62 (± 6.09)[a]
F5	49.75 (± 6.28)[a]	50.91 (± 3.45)[a]
F6	54.85 (± 4.47)[a]	52.79 (± 4.46)[a]
FP	51.3 (± 7.42)[a]	51.27 (± 7.42)[a]

** Different letters in the rows indicate statistical differences by Tukey's test at a significance level of 5%. Identical letters indicate that the samples did not show a statistical difference between them.*

Source: The Author, 2026.

Texture Analysis

The chicken inner fillets were analyzed in sextuplicate in a TA. XTplusC texturometer.XTplusC texturometer. The samples were prepared under controlled oven conditions (12 minutes, 50% humidity at 205°C) to ensure process uniformity. After baking, the breading was removed, and the units were cut into 5cm × 3cm rectangular pieces, yielding 15 evaluations per formulation. The average results are presented in Table 6.

Table 6 - Texture analysis, shear force (???)

	Texture analysis (???)
F1	5.87 (± 1.10)[a]
F2	5.32 (± 1.00)[a]
F3	5.12 (± 1.15)[a]
F4	5.53 (± 1.43)[a]
F5	4.84 (± 0.87)[a]
F6	4.81 (± 1.20)[a]
FP	5.55 (± 1.16)[a]

** Different letters in the rows indicate statistical differences according to Tukey's test at a significance level of 5%. Identical letters indicate that the samples did not show a statistical difference between them*

Source: The Author, 2026.

The results of the texture analyses showed no significant difference at 5% significance according to Tukey's test. Even with the replacement of moisture retainers, the texture was not impacted by the change in formulations.

Results of Microbiological Analyses

Microbiological analyses were performed in the company's laboratory, and the results were compared with the limits outlined in Normative Instruction IN 60 of 12/23/2019, category 5c (semi-processed meat products, seasoned or unseasoned, breaded, refrigerated, or frozen (nuggets, steaks, fingers) (Brazil, 2019). The results are described in Table 7.

Table 7 – Results of microbiological analyses of different breaded chicken strip (chicken inner fillet) formulations.

	Viable aerobic mesophilic bacteria	E. coli	Salmonella spp	Coagulase-positive Staphylococcus
FP	1.0 X 10^2 (CFU/g)	<1.0 X 10^1 (CFU/g)	Absence in 25g	<1.0 x 10^1 (CFU/g)
F1	2.0 X 10^2 (CFU/g)	<1.0 X 10^1 (CFU/g)	Absent in 25g	<1.0 x 10^1 (CFU/g)
F2	2.0 X 10^2 (CFU/g)	<1.0 X 10^1 (CFU/g)	Absent in 25g	<1.0 x 10^1 (CFU/g)
F3	1.0 X 10^2 (CFU/g)	<1.0 X 10^1 (CFU/g)	Absent in 25g	<1.0 x 10^1 (CFU/g)
F4	3.0 × 10^2 (CFU/g)	<1.0 X 10^1 (CFU/g)	Absent in 25g	<1.0 x 10^1 (CFU/g)
F5	2.5 X 10^3 (CFU/g)	<1.0 X 10^1 (CFU/g)	Absent in 25g	<1.0 x 10^1 (CFU/g)
F6	2.0 × 10^2 (CFU/g)	<1.0 × 10^1 (CFU/g)	Absent in 25g	<1.0 x 10^1 (CFU/g)

	Viable aerobic mesophilic bacteria	E. coli	Salmonella spp	Coagulase-positive Staphylococcus
Recommended on 12/23/2019	3.0 x 10^5 (CFU/g)	5 x 10^2 (CFU/g)	Absent in 25g	2 x 10^4 (CFU/g)

Source: The Author, 2025.

The microbiological results for the samples complied with the legislation, confirming that the products were prepared in accordance with good manufacturing practices and were fit for human consumption.

Sensory Analysis Results

The sensory analysis was performed at the sensory analysis laboratory of the Federal Technological University of Paraná, Londrina campus. Of the total number of participants, 54.8% were male, and 45.2% were female, with 81.5% aged between 18 and 25 years and 62.5% having incomplete higher education. A small portion of the participants had food allergies and/or intolerances, with lactose intolerance being the most prevalent. All participants were accustomed to consuming poultry, and 73% were accustomed to breaded chicken.

Although 98% of the study participants believed that breaded chicken without synthetic additives is healthier, only 16% had stopped eating it because of additives. Even so, 68% of them would be willing to pay more for breaded chicken without synthetic additives. Among the attributes that participants consider important in a chicken nugget are mainly crispiness, juiciness, and pleasant taste. Participants evaluated the overall acceptance, appearance, flavor, aroma, and texture of each sample and recorded their ratings on the hedonic scale provided on the form. The results of the average evaluations are described in Table 8.

Table 8 – Sensory evaluation using a 9-point hedonic scale for the different breaded fillet (chicken inner fillet) formulations of breaded chicken fillets (chicken inner fillet).

	FP	F1	F2	F3	F4	F5	F6
Global Acceptance	7.8^{A} (±1.0)	7.5^{B} (±1.3)	7.3^{C} (±1.5)	7.5^{B} (±1.4)	7.1^{D} (±1.7)	7.2^{E} (±1.5)	7.5^{B} (±1.5)
Appearance	7.7^{A} (±1.1)	7.5^{B} (±1.5)	7.1^{C} (±1.8)	7.7^{A} (±1.4)	7.4^{D} (±1.5)	7.6^{E} (±1.4)	7.7^{A} (±1.3)
Flavor	7.8^{A} (±1.5)	7.4^{B} (±1.7)	7.2^{a} (±1.8)	7.7^{A} (±1.5)	7.1^{D} (±1.7)	7.0^{D} (±1.9)	7.3^{C} (±1.6)
Aroma	7.3^{A} (±1.5)	7.2^{A} (±1.4)	7.0^{B} (±1.6)	7.2^{A} (±1.4)	6.9^{C} (±1.5)	7.2^{A} (±1.5)	7.1^{A} (±1.6)
Texture	7.7^{a} (±1.7)	7.3^{B} (±1.6)	7.3^{B} (±1.2)	7.7^{A} (±1.4)	7.3^{B} (±1.8)	7.2^{B} (±1.8)	7.7^{A} (±1.4)

Capital letters in the row indicate Dunnett's test
Different letters in the rows indicate statistical differences at the 5% significance level. Identical letters indicate that the samples did not show a statistical difference between them

Source: The Author, 2025.

In general, the standard formulation (FP) was preferred by the Dunnett test across all evaluated aspects. It should be noted that this test compares a standard with the other formulations (indicated in the row of Table 8), and for overall acceptance, the FP was superior to the other formulations. The appearance of the standard formulation (FP) was statistically similar to the appearance of formulations F3, with sodium tripolyphosphate and yeast extract, and F6, with natural substitutes for artificial additives. The appearance of formulation F2, with no sodium tripolyphosphate and monosodium glutamate, was the least preferred. The flavor of the standard formulation (FP) and formulation F3, with sodium tripolyphosphate and yeast extract, were the most preferred and showed no statistically significant difference. Meanwhile, the flavor of formulations F4, with sodium tripolyphosphate and no monosodium glutamate, and F5, with no additives, were the least preferred by the tasters. The aroma of the standard formulation (FP), F1, with natural substitutes for tripolyphosphate and monosodium glutamate, F3, with sodium tripolyphosphate and yeast extract, F5, without additives, and F6, with natural substitutes for artificial additives, did not differ significantly from each other. The texture of formulations F6, with no additives, and F3, with sodium tripolyphosphate and yeast extract, was not statistically different from the standard sample (FP). The texture of the other formulations was considered inferior to the texture of the standard formulation by the research participants.

The study demonstrated the technical and economic feasibility of producing clean label breaded chicken inner fillet by replacing or removing synthetic chemical additives. The experimental formulations had physicochemical and textural characteristics comparable to those of the standard formulation, as well as microbiological safety and, in some cases, lower production costs. The sensory results showed a statistical difference between the formulations, with formulation F3, containing sodium tripolyphosphate and yeast extract, being statistically similar to the standard formulation in almost all aspects evaluated, except for overall acceptance. This suggests that sodium tripolyphosphate is important for maintaining the desired sensory characteristics of breaded chicken fillets (chicken inner fillets). Replacing monosodium glutamate with yeast extract did not affect the sample's acceptance. The results of this study contribute to the development of healthier processed meat products aligned with current consumer trends.

FINAL CONSIDERATIONS

Based on the results of this study, we conclude that the best-performing formulation was F3, which used sodium tripolyphosphate and yeast extract as a substitute for monosodium glutamate. This formulation had a lower production cost than the standard formulation and showed sensory results statistically similar to those of the standard according to the Dunnett test.

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Availability of Data and Materials

Ethical approval and consent to participate

Declarations (if applicable):

a) Ethical approval and consent to participate.

Sensory analysis was only performed after approval of the project by the ethics committee, opinion number 7.270.430, CAAE 82583024.5.0000.554, and microbiological analysis was performed within the standards required by Normative Instruction No. 60 of 12/23/2019. The sensory evaluation was conducted during the morning and afternoon periods in the sensory laboratory of the Federal Technological University of Paraná, Londrina campus, with 100 untrained tasters

b) Consent for publication

Not applicable