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THE USE OF CARROT JUICE AS AN AGENT TO IMPROVE THE QUALITY ATTRIBUTES OF A PRODUCT OBTAINED FROM CHICKEN BREAST (*Musculus pectoralis*)

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Abstract

The increasing demand for the consumption of chicken meat products imposes the need for continuous and complex research in this application area. Thus, healthier alternatives are being sought by developing preparations with bioactive compounds from natural sources in their structure to improve their intrinsic properties. The current study focused on the injection of carrot juice in different percentages (5%, 10%, and 15%) in three experimental groups, using the anatomical region of the Musculus pectoralis. Experimental batches were subjected to an enzymatic wet aging process using vacuum wet aging under refrigerated conditions, followed by heat treatment. Following the analysis of the data obtained, significant results were recorded. Carrot juice can be considered as a bioactive component in optimizing the overall quality of the finished product, bringing changes in both the nutrient profile, physico-chemical indicators, and sensory properties.

Key words*: bioactive compounds, carrot juice, meat product, quality.*

INTRODUCTION

The meat industry sector is considered one of the most important players in the global industry, and innovation in this sector is driven by consumer demand and increasing competitive pressure. Chicken meat products are among the top consumer preferences because there are no religious or cultural restrictions on chicken meat (Boișteanu et al., 2025). At the same time, according to Pogurschi et al. (2018), in Romania, consumers' perceptions of food have changed rapidly in response to socio-economic dynamics over the last three decades.

According to Statista (n.d.), *Production of meat worldwide 1990-2024* (Retrieved December 3, 2024) in the year 2024, globally, poultry meat production exceeded pork production by 17.03 million metric tons, reaching a total of 138.75 million metric tons.

The poultry meat consumption market is experiencing accelerated growth. It is projected to expand by 65% from 2015 to 2035, outpacing the growth rates of pork (by 35%) and eggs (by 50%). Poultry meat consumption meets the nutritional standards of a contemporary balanced diet: high in protein, low in calories, fat, and cholesterol, and with excellent digestive bioavailability (Wołoszyn et al., 2020; Goluch et al., 2023). Since meat is an indispensable source of nutrients in the human diet (Ciobanu et al., 2005), there has been a growing concern about healthy nutrition in recent years. Thus, the food industry needs to pay more attention to optimizing the quality characteristics of meat products and converting them into functional foods, capitalizing on the benefits of products of plant origin and those of animal origin (Anchidin et al., 2024).

Although functional food is considered to be an emerging field, the concept of functional food was first defined in 1980 in Japan, and it refers to a processed food that contains ingredients that, in addition to their nutritional value, also support certain body functions (Cencic et al., 2010). In the U.S. regulatory framework, Health Canada characterized functional foods in 1995 as products "similar in appearance to conventional foods that are consumed as part of a regular diet and that have demonstrated physiological benefits and/or reduce the risk of chronic disease beyond basic nutritional functions" (DeFelice, 1995). In 1996, FUFODSE (European Commission on Functional Food Science in Europe) was initiated at the European level, actively involving many leading European nutrition and related sciences experts, and coordinated by the International Life Sciences Institute (ILSI) Europe. This commission aimed to reach a consensus on "scientific concepts of functional foods". Thus, in 1999, the functional food was defined: "a food can be considered functional if it is shown to beneficially influence one or more target functions in the body, beyond adequate nutritional effects, in a way that is relevant to improving health and well-being and/or reducing the risk of disease. A functional food must remain a food and manifest its effects in amounts normally consumed: it is not a pill or a capsule but part of the normal diet" (Diplock et al., 2000).

The development of functional foods has seen significant expansion across most food categories; however, their implementation is not evenly distributed across the whole food industry, with notable variations between different market segments (Kotilainen et al., 2006; Menrad, 2003). Thus, in the context of an accelerated development of functional foods, with varying applicability across food industry segments, the meat sector, especially poultry, shows considerable potential for functional innovation. Poultry meat is distinguished by several processing-friendly technological characteristics, such as neutral flavor, uniform texture, and light color, which facilitate the adaptation of products to market requirements. These properties make it possible to formulate products with varied sensory profiles according to the preferences of target consumer groups (e.g., products with intense flavors for adults or moderately flavored variants for children) (Barbut, 2012). As there is an increasing demand for functional and healthy foods, integrating non-animal-derived compounds is an effective measure to increase the quality of meat products (Ciobanu et al., 2025). Thus, both the involvement of various food quality enhancers (Zugravu et al., 2017) and a thorough assessment of the consequences of the use of additives or other compounds on sensory properties, which influence consumption behaviours, are necessary for modern food processing (Ciobanu et al., 2024).

The present study aimed to develop a chicken meat product by injecting the breast with carrot juice in proportions of 5%, 10%, and 15%, respectively, and to analyse the physico-chemical parameters and sensory properties.

MATERIALS AND METHODS

To achieve the objective of this study, four experimental batches were realized with chicken breast (*Musculus pectoralis*) as biological material. A control sample was injected with a saline mixture obtained from water and salt at a 1.2% concentration, and the other three experimental samples were injected with different carrot juices (5%, 10%, 15%) and salt (1.2%). The chicken breast used as raw material was purchased from a local supermarket. The carrots used for the new product were purchased at the local market and then processed into carrot juice using an electric juicer (Myria MY4013) with cold-pressing technology.

The four experimental samples are presented in Table 1, together with the ingredients used in the manufacturing process and the heat treatments applied. All experimental stages, including batch preparation and analysis, were carried out at the Ion Ionescu de la Brad University of Life Sciences in Iasi, in the specialized sections and laboratories for the processing and analysis of meat products - the Meat Processing and Processing Section and the Meat Products Control Laboratory.

Table 1. Composition of the experimental samples

Samples	**Ingredients (%)**		
	Chicken breast	**Carrot juice**	**Salt**
CS	98.8	-	1.2
L1CJ5%	93.8	5	1.2
L2CJ10%	88.8	10	1.2
L3CJ15%	83.8	15	1.2

CS - Control sample; L1CJ5% - 5% carrot juice; L2CJ10% - 10% carrot juice; L3CJ15% - 15% carrot juice.

The experimental protocol involved preparing the raw material (chicken breast) and its injection with the obtained salting solutions using a semi-automatic injection device. After injection, the samples were vacuum-packed and subjected to wet maturation for 24 h at refrigeration temperature (0-4°C). After the wet maturation step, the samples were removed from the vacuum and individually placed on stainless steel sticks, which were subjected to the heat treatment. The heat-treatment regime applied to the samples was structured in several stages, including drying, smoking, and boiling, respecting specific temperature and time parameters for each phase. Details of the process are presented in Table 2.

Table 2. The applied head treatment

Heat treatment stage	Time (min)	Cell temperature (°C)	Core temperature (°C)	Moisture (%)
Drying I	15	65	55	25
Smoking	30	65	55	25
Boiling	-	76	72	99
Drying II	20	80	72	25

After obtaining the four samples of chicken breast injected with the salting solutions, the samples were subjected to physicochemical analysis following heat treatments.

A FoodCheck analyzer (Bruins Instruments, OmegAnalyzer, Germany), a spectrophotometer using infrared light beams, was used to determine the gross chemical composition. Moreover, it quantitatively analyzes the protein, moisture, collagen, and salt content using infrared radiation to determine the organic composition of the samples analyzed (Ciobanu et al., 2023; Anchidin et al., 2023).

Physical analysis of the samples obtained included texture, colour and pH analysis. To determine textural parameters, we used the Lloyd Instruments TA1Plus (Ametek, UK) texturometer, equipped with a force sensor capable of measuring up to 500 N and a Warner-Bratzler knife. The colorimetric analyses of the studied lots were performed using the Konica Minolta Chroma Meter CR-410 (Konica Minolta, Osaka, Japan) portable colorimeter through the CIE Lab color system, which quantifies color parameters L* (black to white), a* (green to red) and b* (blue to yellow) using the standard illuminant D65. Before analysis, the colorimeter was calibrated using a standard white calibration plate. For each sample, five measurements were made, both surface and cross-sectional.

The pH analysis was performed using a Hanna Instruments portable pH meter, model HI99163, taking 5 measurements for each sample at different points of the sample, taking into account the pH variations in correlation with temperature.

Data distribution analysis was performed using SPSS Statistics, version 26.0 (IBM Corp., 2019). A comparison of mean values was performed using a one-way analysis of variance (ANOVA), followed by the Tukey post-hoc test. Differences between means were considered significant at a significance level of $p < 0.05$.

RESULTS AND DISCUSSIONS

Table 3 shows the main physico-chemical characteristics analyzed in the studied samples (fat, moisture, collagen protein, and salt).

Table 3. Arithmetic mean ± standard deviation of the physicochemical parameters determined for the analysed samples

Physicochemical parameters					
%					
Samples	**Fat**	**Moisture**	**Protein**	**Collagen**	**Salt**
CS	2.12 ± 0.044^{c}	75.78 ± 0.044^{a}	21.84 ± 0.089^{a}	20.26 ± 0.114^{a}	1.92 ± 0.044^{c}
L1CJ5%	1.68 ± 0.083^{b}	76.14 ± 0.054^{b}	22.06 ± 0.151^{b}	20.38 ± 0.044^{a}	1.9 ± 0.1^{c}
L2CJ10%	1 ± 0.070^{a}	76.74 ± 0.05^{c}	22.08 ± 0.044^{b}	20.52 ± 0.837^{ab}	0.88 ± 0.044^{a}
L3CJ15%	0.94 ± 0.054^{a}	76.76 ± 0.054^{c}	22.12 ± 0.044^{b}	20.54 ± 0.054^{b}	1.28 ± 0.044^{b}
p value	4.67E-15	2.12E-15	0.00097775	0.00011	1.70E-14

Superscript letters that differ within the same column denote statistically significant differences, as assessed by one-way ANOVA followed by Tukey's multiple comparison test ($p \leq 0.05$); CS - Control sample; L1CJ5% - 5% carrot juice; L2CJ10% - 10% carrot juice; L3CJ15% - 15% carrot juice.

The results presented in Table 3 show statistically significant differences ($p \leq 0.05$) between the analyzed samples for all physico-chemical parameters. As expected, the gradual incorporation of carrot juice visibly influenced the final composition of the product.

The fat content of the analyzed samples showed highly significant differences ($p \leq 0.001$) between the experimental groups. The progressive addition of carrot juice strongly influenced the lipid profile of the chicken breast product. The control sample had the highest fat content (2.12±0.044), followed by a significant decrease in L1CJ5% (1.68±0.08) and L2CJ10% (1±0.07), with the minimum value in L3CJ15% (0.94±0.054). This decreasing trend reflects a dilution effect caused by carrot juice's aqueous composition, which partially replaces native lipids during injection.

Moisture content increased slightly with increasing percentage of added carrot juice, from 75.78±0.044 in the control to 76.76±0.054 in the L3CJ15%. These results suggest a water-holding capacity-enhancing effect, possibly due to water and polysaccharides in the carrot juice matrix.

Protein values increased moderately with the addition of carrot juice, from 21.84±0.089 in the control to 22.12 ± 0.044 in L3CJ15%. This increase can be attributed to its rich content in bioactive compounds with functional roles, including carotenoids: α-carotenoids: α-carotene, β-carotene, lutein, zeaxanthin and lycopene (Bystrická et al., 2015), phenolic acids (chlorogenic, ferulic, p-coumaric and caffeic acids) (Ahmad et al., 2019), as well as oxyanthracocyanins including sinapoylglucosyl-galactoside, cyanidin-3-O-xylozyl-(feruloylglucosyl)-galactoside and cyanidin-3-O-xylozyl-(coumaroylglucosyl)-galactoside (Sharma et al., 2012) that participate in optimizing the nutritional value of the product. Collagen content remained relatively constant, ranging from 20.26±0.114 in the control to 20.54±0.054 in L3CJ15%. The differences, although statistically significant, are minor, suggesting that carrot juice does not significantly affect the connective protein structure of chicken breast.

The salt parameter value showed a clear decrease between the control and L3CJ15%, from 1.92±0.044 to 1.28±0.044. This decrease can be explained by the dilution effect of the added carrot juice, which positively contributes to the reformulation of low-sodium products.

According to Table 4, the addition of carrot juice in different concentrations did not cause statistically significant ($p > 0.05$) changes in color parameters on the surface of reformulated chicken breast-based products compared to color parameters in the product section, where statistically significant differences ($p \leq 0.05$) were revealed between experimental batches. This indicates that carrot juice had a more intense effect on the product section's color profile than on the product surface. In terms of colorimetry at the surface of the chicken breast injected with carrot juice, the values for lightness (L)* varied slightly, between 52.00±4.345 for L1CJ5% and 55.27±4.72 for L3CJ15%, while the control sample recorded 54.306±2.046. Although statistically insignificant, these variations can be attributed to the natural pigments in the carrot juice (mainly carotenoids), which can influence the surface reflectance without significantly altering the perceived brightness. For parameter a* (degree of red color), values remained statistically similar between groups, ranging from 15.692±1.370 to 17.818±0.673. This trend indicates that injecting the carrot juice, although rich in orange-red pigments, did not significantly emphasize the red component on the surface. Parameter b* (degree of yellow color) showed close values in all batches (between 30.778±1.620 and 34.852±3.953), suggesting a slight visually perceived yellow tint, but without statistical significance. In color analysis of chicken breast sections injected with carrot juice, the lightness (L*) values decreased significantly in the reformulated samples, from 78.428±1.299 in the control to 72.416±1.894 in L3CJ15%. This decrease may be due to the migration of carrot juice pigments, which resulted in a slight darkening of the internal tissue. A lower L* value indicates reduced brightness and more intense color.

The parameter a* (degree of red color) increased directly to the percentage of carrot juice, from 5.658±0.302 in the control sample to 11.03±2.611 in L3CJ15%. This increase confirms that carrot juice's carotenoid pigments penetrated the muscle structure, significantly emphasizing the reddish hues. According to Anchidin et al. (2023), this does not negatively influence the analyzed products, as a reddish color is specific to meat products and helps to increase their attractiveness. The b* (degree of yellow color) values followed the same trend, rising from 12.206±0.207 in the control sample to 18.482±1.129 in L3CJ15%. These data emphasize the influence of the salting mixture with carrot juice on the coloration, giving the product a more intense yellow-orange hue in the section.

Table 4. The color results obtained from the analyzed samples of the reformulated product

Samples	L*(D65)	a*(D65)	b*(D65)
Surface color of chicken breast injected with carrot juice			
CSS	54.306±2.046^{a}	16.288±1.094^{a}	31.942±2.554^{a}
L1CJ5%S	52±4.345^{a}	17.05±1.172^{a}	30.778±1.620^{a}
L2CJ10%S	53.844±1.048^{a}	17.818±0.673^{ab}	34.682±2.796^{a}
L3CJ15%S	55.27±4.72^{a}	15.692±1.370^{a}	34.852±3.953^{a}
p value	0.507157	0.040817	0.095175
Color in section of chicken breast injected with carrot juice			
CSSe	78.428±1.299^{b}	5.658±0.302^{a}	12.206±0.207^{a}
L1CJ5%Se	73.826±0.822^{a}	8.534±0.226^{b}	12.716±0.391^{a}
L2CJ10%Se	73.022±2.444^{a}	9.42±0.830^{b}	13.108±1.072^{a}
L3CJ15%Se	72.416±1.894^{a}	11.03±2.611^{b}	18.482±1.129^{b}
p value	0.000182	0.000132	3.38E-09

Superscript letters that differ within the same column denote statistically significant differences, as assessed by one-way ANOVA followed by Tukey's multiple comparison test ($p \leq 0.05$); CSS - Control sample at surface; L1CJ5%S - 5% carrot juice at surface; L2CJ10%S - 10% carrot juice at surface; L3CJ15%S - 15% carrot juice at surface; CSSe - Control sample in section; L1CJ5%Se - 5% carrot juice in section; L2CJ10%Se - 10% carrot juice in section; L3CJ15%Se - 15% carrot juice in section.

According to Table 5, the instrumental texture analysis revealed statistically significant differences ($p \leq 0.05$) between the analyzed samples for the hardness and mechanical working parameters.

Hardness values varied significantly with carrot juice concentration. The control sample recorded a value of 14.44±1.63, and the highest value was observed in L1CJ5% (16.43±3.53), suggesting that a 5% carrot juice level may contribute to strengthening the protein network. In contrast, the higher levels of carrot juice (L2CJJ10% and L3CJ15%) led to a considerable shrinkage of the product, with the hardness recording reduced values (5.77±0.74 - L2CJ10% and 7.61±2.25 - L3CJ15%). This decrease in the values of the hardness parameter can be explained by the action of enzymes or natural acids in the juice, which may interfere with the gelation process of myofibrillar proteins during heat treatment. The values for the mechanical work or energy required to cut the carrot juice-injected chicken breast followed a similar pattern, ranging from 153.29±1.83 in the control to 184.05±1.83 in L1CJ5%, then dropping sharply to 105.14±2.72 in L2CJ10% and 114.35±2.10 in L3CJ15%. These results reflect the mechanical resistance opposed during chewing or slicing. The initial increase in L1CJ5% suggests a structural hardening, possibly due to protein-carbohydrate interactions, while the decrease at higher concentrations again indicates a weakening of the matrix. In conclusion, although the moderate addition of carrot juice (5%) improved firmness and cut strength, higher amounts compromised the product's structural integrity. This behavior suggests the need to optimize juice levels to balance technological performance with nutritional benefits.

Table 5. Evaluation of the textural parameters of the analyzed samples of the reformulated product

Samples	Textural parameters	
	Hardness (N)	Work of cutting (N mm)
CS	14.4387503±1.630 ^{b}	153.28681±1.828 ^{c}
L1CJ5%	16.4252034±3.530 ^{b}	184.0468473±1.830 ^{d}
L2CJ10%	5.7693771±0.736174 ^{a}	105.14256±2.722 ^{a}
L3CJ15%	7.61318±2.25153 ^{a}	114.346±2.095 ^{b}
p value	1.10E-07	2.60E-24

Superscript letters that differ within the same column denote statistically significant differences, as assessed by one-way ANOVA followed by Tukey's multiple comparison test ($p \leq 0.05$); CS - Control sample; L1CJ5% - 5% carrot juice; L2CJ10% - 10% carrot juice; L3CJ15% - 15% carrot juice.

The pH variation at different temperatures (15.18-18.72°C) for the analyzed samples is shown in Figure 1. No statistically significant differences (p>0.05) were observed between the control and experimental samples injected with carrot juice. The control sample recorded a value of 6.28±0.008, while L1CJ5%, L2CJ10%, and L3CJ15% had values of 6.25±0.043, 6.27±0.069, 6.34±0.075, respectively. The consistency of these results indicates that injecting the carrot juice did not significantly alter the acid-base equilibrium of the chicken meat product. Even though there was a slight tendency for the pH values to increase in direct proportion to the increasing concentration of the carrot juice, the differences remained within narrow limits, reflecting the stability of the protein and enzyme systems involved in the post-processing phases.

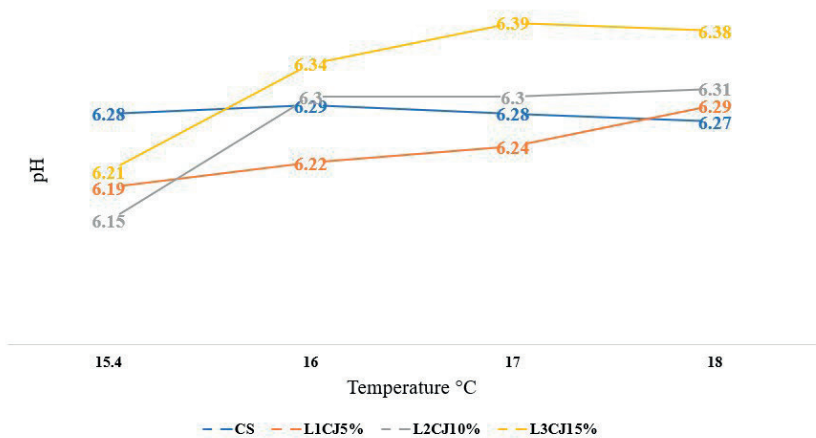

Figure 1. The pH variation at different temperatures (15.18-18.72°C) for the control samples (CS) and the experimental variants (L1CJ5%, L2CJ10%, L3CJ15%)

CONCLUSIONS

The results of this study show that including carrot juice as an injection agent in chicken breast to obtain reformulated products leads to measurable and partially significant changes in the quality attributes of the final product. From a nutritional point of view, using the salting mix with carrot juice contributed to a moderate increase in protein and moisture content while reducing the salt level, a beneficial effect in formulating healthier products.

The color analysis revealed that, although the surface parameters remained relatively unchanged, the product's cross-section underwent visible changes, with red and yellow shades intensifying due to the migration of carotenoids. These color changes may improve consumers' perception of the product's natural and fresh character.

The textural profile showed a concentration-dependent effect: at low levels (5%), carrot juice increased firmness and resistance to slicing, while higher concentrations (10%, 15%) led to a significant destabilization of the structure, possibly influenced by the enzymatic or acidic action of the compounds in the salting mixture with carrot juice.

The pH values remained constant in all experimental variants, and the inclusion of carrot juice did not disturb the matrix's acid-base balance, indicating good technological compatibility.

Overall, carrot juice can be considered a natural ingredient favorable to the development of functional chicken products, especially when used in moderate concentrations. It contributes positively to nutritional value, visual appearance, and texture modulation while supporting clean-label innovation and sustainable processing strategies.

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