

# Physical and sensory quality of chicken nuggets containing carrot flour (*Daucus carota* L.) and buckwheat flour (*Fagopyrum esculentum* Moench) at different levels

Lilik Retna Kartikasari<sup>1,2\*</sup>, Bayu Setya Hertanto<sup>1,2</sup>, Farouq Heidar Barido<sup>1,2</sup>, Winny Swastike<sup>1,2</sup>, and Adi Magna Patriadi Nuhriawangsa<sup>1,2</sup>

<sup>1</sup>Faculty of Animal Science, Universitas Sebelas Maret, Surakarta, Indonesia

<sup>2</sup>Research Group Food Technology of Animal Origin, Laboratory of Animal Product Technology, Universitas Sebelas Maret

**Abstract.** The objective of this study was to examine how substituting tapioca flour with carrot flour and buckwheat flour affected the physical properties and sensory characteristics of chicken nuggets. The treatments consisted of varying substitution levels of carrot flour (CF) and buckwheat flour (BF), specifically CF 0%+BF 0% (P0), CF 7.5%+BF 2.5% (P1), CF 5%+BF 5% (P2), CF 2.5%+BF 7.5% (P3), and CF 0%+BF 10% (P4). Each treatment included five replications for the physical quality analysis, while sensory evaluation was carried out using panelists as replications. The findings indicated that incorporating carrot flour and buckwheat flour significantly impacted ( $P < 0.05$ ) water-holding capacity (WHC), pH, cooking loss, and tenderness. In sensory evaluation, the substitution also significantly affected tenderness ( $P < 0.05$ ), whereas no significant differences were observed in aroma, color, taste, flavor, texture, or overall acceptability. The physical and sensory qualities of nuggets containing 2.5% carrot flour and 7.5% buckwheat flour were found comparable results to the control group. Therefore, the combination of 2.5% carrot flour and 7.5% buckwheat flour is considered to have suitable applicability and can help to maintain the physical and sensory quality of chicken nuggets.

## 1 Introduction

Chicken nuggets are widely consumed and are enjoyed by people across different age groups and socioeconomic backgrounds. However, certain consumers hold to have negative perceptions of this product because it contains relatively high levels of salt and fat. In response, chicken nuggets are increasingly being developed as functional foods through the incorporation of functional ingredients or bioactive compounds that provide added health benefits [1]. Their nutritional value can be enhanced by adding high-protein flours and plant-based fiber sources, thereby offering improved health attributes for consumers [2].

\* Corresponding author: [lilikretna@staff.uns.ac.id](mailto:lilikretna@staff.uns.ac.id)

Buckwheat is known to have high levels of vitamins, minerals, and starches, and offers notable advantages in its protein and fiber content compared to wheat [3]. It is regarded as a valuable protein source because it contains to have higher concentrations of essential amino acids, particularly cysteine and methionine, than rice or maize. In addition, buckwheat provides substantially more dietary fiber than common grains such as rice and maize [4]. It also is recognized to have abundant phytochemicals, including flavonoids, tocols, and rutin. Buckwheat (*Fagopyrum esculentum* Moench) flour contains various phenolic compounds that enhance its nutritional value and potential health benefits. Previous research has demonstrated the use of buckwheat flour in developing functional meat products, showing that its incorporation can influence important quality attributes of these products [5, 6]. The incorporation of buckwheat extract has been shown to significantly enhance both the quality and nutritional content of cooked sausages. Products formulated with buckwheat extract maintained their organoleptic properties for longer periods, demonstrated improved water-binding capacity, and exhibited increased biological value in cooked beef sausages [6].

Carrot flour can be utilized as an alternative filler in sausage production. It contains several essential nutrients, including 42 kcal of energy, 90.4 g of water, 28 mg of phosphorus, 9.30 g of carbohydrates, 33 mg of calcium, 6 mg of vitamin C, 1.20 g of protein, 0.66 mg of iron, 0.30 g of fat, and 0.06 mg of vitamin B1 [7]. Carrots are known to have high levels of antioxidants and provitamin A. Carrot flour is recognized to have a high fiber content and low calorie value, enabling it to enhance the nutritional quality of food products. According to Effendy et al. [8], the optimal formulation for producing fish nuggets includes the addition of 12% carrot flour, which resulted in a beta-carotene content of 24.03 ppm. This formulation also received the highest panelist scores for color, taste, aroma, and texture.

Carrot flour has not been applied extensively in processed meat products; thus, there is needed innovation by combining carrot flour with buckwheat flour as a filler in chicken nuggets. This combination is expected to offer multiple advantages, both in physicochemical properties and nutritional value. Moreover, the incorporation of buckwheat and carrot flour into meat products, such as sausages, patties, and meatballs, has the potential to enhance product quality, particularly by improving their functional nutritional value. Although both flours are used individually in nugget formulations, their combined application remains limited. Therefore, additional research is required to examine the effects of substituting tapioca flour with buckwheat and carrot flour on the physical characteristics and hedonic quality of chicken nuggets.

## 2 Materials and methods

### 2.1 Materials

The main ingredient used in the nugget formulation was broiler chicken breast meat. The additional food-grade components, including tapioca flour, eggs, skim milk, garlic, shallots, sugar, salt, ice cubes, buckwheat flour, and carrot flour, were purchased from supermarkets in the Jebres area of Surakarta. The complete formulation of the chicken nuggets is presented in Table 1.

**Table 1.** Chicken nugget formulation with the addition of buckwheat flour and carrot flour.

Treatment	P0	P1	P2	P3	P4
-----------	----	----	----	----	----

Ingredients	%				
Breast meat	70	70	70	70	70
Tapioca flour	10	0	0	0	0
Skim	3.5	3.5	3.5	3.5	3.5
Salt	1.5	1.5	1.5	1.5	1.5
Garlic	2	2	2	2	2
Pepper	0.25	0.25	0.25	0.25	0.25
Ice cube	12.75	12.75	12.75	12.75	12.75
Buckwheat flour	0	2.5	5	7.5	10
Carrot flour	0	7.5	5	2.5	0
TOTAL	100	100	100	100	100

## 2.2 Methods

In this study, the samples were prepared as steam-cooked products rather than being processed through breadcrumb frying for both the physical and hedonic evaluations. The physical quality of the nuggets was assessed by measuring pH, water-holding capacity (WHC), tenderness, and cooking loss. To determine the pH value, 5 g of the ground nugget sample were collected and analyzed. The pulverized samples were then placed in a beaker and combined with 25 milliliters of distilled water. The liquid was mixed for one minute before the pH was measured with a calibrated pH meter set to 4 or 7. Water-holding capacity was measured using the Hamm method, in which a 0.3 g sample was placed under a 35 kg load for 5 minutes. The area occupied by the nugget sample and the surrounding moisture imprint was then outlined and quantified using a planimeter, yielding the water-holding capacity value expressed in mg H<sub>2</sub>O. The mg H<sub>2</sub>O value obtained was used to determine the free water content, while water-holding capacity was calculated as the difference between total water content and free water content. Cooking loss was measured as the percentage difference in the weight of the nugget before and after cooking [9]. Nugget tenderness was evaluated using a penetrometer.

This sensory evaluation was conducted in a laboratory setting following standardized protocols and established food safety procedures. The panelists involved in the study participated only in sensory evaluations, such as assessing aroma and taste, and were included in activities that did not involve to have any clinical testing, ensuring that no health risks were posed. In addition, before the study began, all panelists completed an informed consent form that outlined the sensory evaluation procedures and confirmed their voluntary participation. The assessment was carried out with 25 semi-trained panelists. Prior to testing, the panelists filled out a questionnaire designed to gather information on their consumption habits related to chicken nuggets, including potential allergies, preference levels, and consumption frequency. The nugget samples were placed in sealed containers labeled with random three-digit codes and were kept warm in a bain-marie at 40°C until serving. Before the organoleptic evaluation, the panelists received an explanation of the sensory assessment procedures. Informed consent forms were distributed, and the panelists were asked to sign them before participating. The panelists then evaluated the nugget attributes using a 9-point hedonic scale (Figure 1), which illustrates the scoring system applied to measure consumer preference. The sensory traits assessed included aroma, color, texture, tenderness, juiciness, aftertaste, taste, and flavor. After each sample, the panelists were instructed to drink water and eat plain crackers to

help neutralize any lingering flavors. A one-minute rest interval was provided between samples to prevent sensory fatigue [9].

Data were analyzed using analysis of variance (ANOVA) to identify statistically significant differences at the  $P < 0.05$  level. When significant differences were detected among treatment means, the analysis was further continued using Tukey's test.

**Table 2.** Physical quality of chicken nuggets with the addition of buckwheat flour and carrot flour.

Parameter s	Treatments					P value
	P0	P1	P2	P3	P4	
WHC (%)	48.55±2.40 <sup>a</sup>	36.41±3.50 <sup>b</sup>	40.10±3.77 <sup>ab</sup>	40.78±6.29 <sup>ab</sup>	43.09±4.07 <sup>ab</sup>	0.013
pH	6.15±0.06 <sup>ab</sup>	6.10±0.01 <sup>b</sup>	6.10±0.01 <sup>b</sup>	6.15±0.06 <sup>ab</sup>	6.20±0.01 <sup>a</sup>	0.008
Cooking loss (%)	4.66±0.28 <sup>a</sup>	4.39±0.24 <sup>a</sup>	3.65±0.29 <sup>b</sup>	3.33±0.23 <sup>bc</sup>	3.00±0.07 <sup>c</sup>	0.001
Tenderness (mm/g/second)	7.22±0.91 <sup>a</sup>	5.81±0.35 <sup>b</sup>	6.31±0.61 <sup>ab</sup>	6.55±0.32 <sup>ab</sup>	7.18±0.55 <sup>a</sup>	0.019

Description:

Values are presented as the mean of five replicates. <sup>a-c</sup>Values with different superscripts in the same row indicate significant differences between treatments with  $P < 0.05$ .

P0 = Chicken nuggets with carrot flour : buckwheat flour = 0.0 : 0.0

P1 = Chicken nuggets with carrot flour : buckwheat flour = 7.5 : 2.5

P2 = Chicken nuggets with carrot flour : buckwheat flour = 5.0 : 5.0

P3 = Chicken nuggets with carrot flour : buckwheat flour = 2.5 : 7.5

P4 = Chicken nuggets with carrot flour : buckwheat flour = 0.0 : 10.0

### 3 Results and discussion

The findings showed that there were significant differences ( $P < 0.05$ ) in WHC, pH, cooking loss, and tenderness (Table 2). Additional analysis revealed that the combination of buckwheat flour and carrot flour, where the proportion of buckwheat flour was increased up to 10%, did not influence WHC or tenderness in a significant way. However, the treatment containing 7.5% carrot flour and 2.5% buckwheat flour resulted in a significant reduction in both WHC and tenderness. The decrease in WHC values in this treatment was most likely due to the effect of the higher addition of carrot flour compared to other treatments. Although increasing the level of buckwheat flour in this study did not produce WHC or tenderness values that differed from the control, contrasting results have been reported in nugget formulations. Yessengazyeva et al. [5] found that adding buckwheat flour at specific concentrations reduced the water-binding capacity and tenderness of semi-smoked pork sausages. In the present study, WHC values ranged from 36.4 to 48.5%. Research shows a tendency for the pH value of nuggets to increase with increasing use of buckwheat flour, which is evident at the 10% buckwheat flour level, without the use of carrot flour (P4). A similar observation was reported by Bobeică et al. [10], who found that incorporating 10% buckwheat flour increased the pH of pork sausages. Such changes in physical quality may be attributed to differences in the soluble fiber and protein content of plant-based fillers. Soluble fiber and protein can influence water-binding properties during emulsion formation in meat products, thereby affecting the ability of fat to retain water [11].

**Table 3.** Hedonic quality of chicken nuggets with the addition of buckwheat flour and carrot flour.

Parameter	Treatments					P value
	P0	P1	P2	P3	P4	
Aroma	7.36±0.95	6.80±1.19	6.44±1.39	6.64±1.11	6.92±1.08	0.07
Color	6.96±1.34	6.80±1.35	6.76±1.13	6.84±1.37	6.84±1.43	0.99
Taste	7.20±1.16	6.84±1.67	6.84±1.46	6.92±1.04	6.56±1.26	0.57
Flavor	7.32±1.21	7.16±1.57	6.84±1.46	6.92±0.99	6.68±1.22	0.44
Tenderness	7.32±0.98 <sup>a</sup>	7.40±1.32 <sup>a</sup>	6.80±1.26 <sup>b</sup>	6.68±1.07 <sup>b</sup>	6.48±1.05 <sup>b</sup>	0.01
Texture	7.16±1.10	7.04±1.37	6.96±1.27	6.80±1.23	6.48±1.01	0.32
Overall	7.36±0.81	7.20±1.26	7.16±1.18	7.08±0.95	6.76±1.01	0.36

Description:

Values are presented as the mean of five replicates. <sup>a-c</sup>Values with different superscripts in the same row indicate significant differences between treatments with P<0.05.

P0 = Chicken nuggets with carrot flour : buckwheat flour = 0.0 : 0.0

P1 = Chicken nuggets with carrot flour : buckwheat flour = 7.5 : 2.5

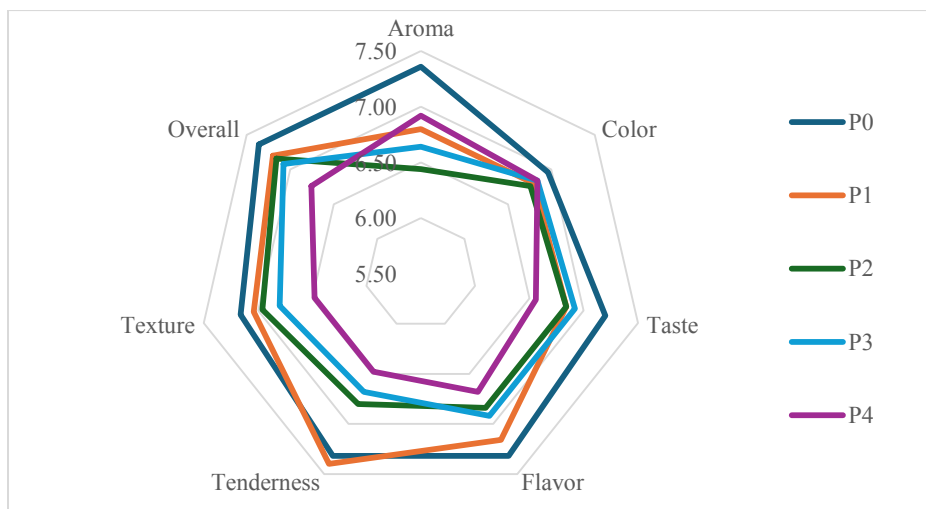
P2 = Chicken nuggets with carrot flour : buckwheat flour = 5.0 : 5.0

P3 = Chicken nuggets with carrot flour : buckwheat flour = 2.5 : 7.5

P4 = Chicken nuggets with carrot flour : buckwheat flour = 0.0 : 10.0

Table 2 shows that the use of 7.5% carrot flour combined with 2.5% buckwheat flour (P1) reduced the tenderness of chicken nuggets (5.81 mm/g/second), whereas decreasing carrot flour from 5 to 0% and increasing buckwheat flour from 5 to 10% (P2–P4; 6.31 – 7.18 mm/g/second) did not produce tenderness values that differed from the control (P0; 7.22 mm/g/second). This finding is consistent with the results of Richards et al. [12], who reported that the incorporation of carrot waste reduced the tenderness of beef patties. Variations in the hardness and elasticity of meat products are commonly associated with the fiber content of plant-derived ingredients [13]. In addition to its ability to bind water, carrot flour has gelatin-like elastic qualities when heated, which makes the final processed product more elastic [14]. The starch content of carrot flour may contribute to the observed increase in hardness. Febriyanti et al. [15] reported that carrot flour contains 26.60% amylose, which can lead to a denser texture in horse meat sausages when used at higher proportions [14]. Notably, increasing the proportion of buckwheat flour while reducing carrot flour resulted in a linear decrease in cooking loss in the nugget product, a trend that became evident when both flours were used at a 50:50 ratio (P2). The lowest cooking loss was observed in chicken nuggets formulated with the highest level of buckwheat flour (10%) and without carrot flour (P4; 3%).

The hedonic test results are presented in Table 3 and Figure 1. The statistical analysis showed that there was no significant difference in consumer preferences regarding aroma, color, taste, flavor, texture, or overall acceptability among all combinations of buckwheat flour and carrot flour. However, a significant difference (P < 0.05) was detected in the tenderness of the nuggets. The absence of differences in hedonic quality indicates that panelists generally accepted the sensory attributes of nuggets with a combination of buckwheat flour additions ranging from 2.5 to 10% and carrot flour reductions ranging from 7.5 to 0%. These findings are consistent with previous research. Sensory evaluations of beef patties containing up to 3% carrot pulp showed no meaningful differences in appearance, aroma, taste, or overall liking [12]. Likewise, for buckwheat flour, its inclusion at levels up to 6% did not influence consumer preferences related to appearance, color, aroma, consistency, taste, or juiciness in semi-smoked pork sausages [5]. The hedonic characteristics of foods formulated with buckwheat flour are shaped by the gel formed from its starch content, which can affect product elasticity and chewiness [4]. In this study, adding buckwheat flour at levels up to 10% did not modify any of the assessed sensory attributes, except for tenderness.



**Fig. 1.** The radar of hedonic quality of chicken nuggets with the addition of buckwheat flour and carrot flour. (P0 = Chicken nuggets with carrot flour : buckwheat flour = 0.0 : 0.0; P1 = Chicken nuggets with carrot flour : buckwheat flour = 7.5 : 2.5; P2 = Chicken nuggets with carrot flour : buckwheat flour = 5.0 : 5.0; P3 = Chicken nuggets with carrot flour : buckwheat flour = 2.5 : 7.5; P4 = Chicken nuggets with carrot flour : buckwheat flour = 0.0 : 10.0).

Increasing the proportion of buckwheat flour while reducing the amount of carrot flour tended to have a lowering effect on the tenderness score of the nuggets, with a notable decline observed when both flours were used at a 5:5 ratio (P2). Nevertheless, the tenderness scores did not differ significantly among treatments that contained 5–10% buckwheat flour and 0–5% carrot flour (P2–P4). These results are consistent with the findings of Kılınççeker and Karahan [3], who reported that incorporating 100% buckwheat flour as a filler in chicken meatballs reduced their texture quality. The decrease in texture scores is likely attributable to the firm structure resulting from excessive amounts of buckwheat flour. This increased firmness was also noted by the panelists in the present study.

## 4 Conclusion

The physical characteristics and consumer assessment scores of chicken nuggets prepared with 2.5% carrot flour and 7.5% buckwheat flour showed to have no noticeable differences compared to the control group. Consequently, the use of this formulation, consisting of 2.5% carrot flour and 7.5% buckwheat flour can be applied to produce nugget and can maintain the physical and sensory qualities of chicken nuggets.

## Acknowledgements

The authors would like to thank Universitas Sebelas Maret for providing research funding (non-APBN funds) under the Research Group Grant Scheme (No. 371/UN27.22/PT.01.03/2025).

## References

1. J.C. Barros, M.A. Trindade, *Brazilian Journal of Food Technology*. **26**,

- e2023032 (2023)
2. G. Gutiérrez-Silva, F. Vásquez-Lara, N.G. Heredia-Sandoval, A.R. Islas-Rubio, *Foods*. **12**, 4463 (2023)
  3. O. Kilincceker, A.M. Karahan, The Effect of Buckwheat Flour on Some Quality Properties of Chicken Meatballs as An Alternative to Wheat Flour Carpathian *Journal of Food Science And Technology*. **12**, 155-164 (2020)
  4. Y. Kwon, J. Ryu, S. Ju, Sensory attributes of buckwheat jelly (Memilmuk) with mung bean starch added to improve texture and taste. *Foods*. **10**, 11, 2860 (2021)
  5. A. Yessengaziyeva, Y. Uzakov, I. Chernukha, L. Kaimbayeva, L. Kalashinova, . Zhantleuov, The use of buckwheat flour in the technology of semi-smoked sausage. *Slovak Journal of Food Sciences/Potravinarstvo*. **1**, **17**, (2023)
  6. N. Akhundova, A. Babashli, *Eastern-European Journal of Enterprise Technologies*. **133**, 11 (2025)
  7. F. Deviurianty, Process of Making Carrot Flour (2011) [http://www.bps.gp.id/tab\\_sub/view.php?at=3&tabel=1&register=1&is\\_subyek=55&notab=65](http://www.bps.gp.id/tab_sub/view.php?at=3&tabel=1&register=1&is_subyek=55&notab=65)
  8. W.N.A. Effendy, L.M.H. Nadia, S. Rejeki, L.O. Huli, Organoleptic and Beta-carotene Analysis of Tilapia Fish Nuggets (*Oreochromis* sp.) with the Addition of Carrot (*Daucus carota* L.) flour, *Fishtech Journal*. **11**, 140-153 (2022)
  9. L.R. Kartikasari, B.S. Hertanto, A.S.D. Pamungkas, I.S. Saputri, A.M.P. Nuhriawangsa, *Sains Peternakan*. **18**, 66-72 (2020)
  10. R.G. Bobeică, B. Păsărin, G.V. Hoha, C.E. Nistor, L.M. Cârstea, The Importance of Adding Buckwheat Flour in Meat Products. *Animal & Food Sciences Journal Iasi*. 174-178 (2024)
  11. A.K. Suychinov, G.T. Zhumanova, I.V. Mironova, E.T. Akhmadullina, N.N. Kadirov, Z.A. Galiyeva, O.V. Neverova, Investigation of the chemical composition, physicochemical properties, and microstructure of meat patties with amaranth flour. *Теория и практика переработки мяса*. **8**, 3, 183-90 (2023)
  12. J. Richards, A. Lammert, J. Madden, A. Cahn, I. Kang, S. Amin, Addition of carrot pomace to enhance the physical, sensory, and functional properties of beef patties. *Foods*. **13**, 23, 3910 (2024)
  13. A. Marczak, A.C. Mendes, Dietary fibers: Shaping textural and functional properties of processed meats and plant-based meat alternatives. *Foods*. **13**, 12, 1952 (2024)
  14. Alamsyah, S.A. Kesturi, D.N.A. Paramantha, E. Basuki, Physicochemical And Organoleptic Value of Horse Meat Sausages Based on the Level of Carrot Flour Substitution. *International Journal of Research and Scientific Innovation (IJRSI)*. X X 96-106 (2023)
  15. V. Febriyanti, Y.S. Elly, H. Sri, The Effect of Substituting Carrot Paste and Tapioca Flour as Filling Materials on the Physicochemical and Sensory Properties of Mullet Fish Sausages. Thesis. Fac. of Agric. Semarang University (2013)