Physical and hedonic quality of chicken nugget with the addition of buckwheat flour (*Fagopyrum esculentum*) and red spinach (*Amaranthus tricolor*) flour

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Abstract. The purpose of this study was to determine the effect of adding buckwheat flour (*Fagopyrum esculentum*) and red spinach flour (*Amaranthus tricolor*) as a substitute for tapioca flour on physical and hedonic quality of chicken nuggets. Chicken nuggets contained tapioca flour (TF), buckwheat flour (SPF), and red spinach flour (RSF) with a ratio of P0 = 15:0:0; P1 = 0:14.5:0.5; P2 = 0:14:1; P3 = 0;13.5:1.5; and P4 = 0:13:2. Analysis of physical qualities included water holding capacity (WHC), pH, cooking loss (CL), and tenderness (TN). Hedonic quality was measured using the 9-hedonic scale test method with 25 semi-trained panelists. WHC, pH, and TN values gave highly significant differences ($P<0.01$), but CL did not differ. All hedonic quality attributes had highly significant differences ($P<0.01$). The pH and TN values decreased, but the WHC increased compared to the control. Hedonic attributes decreased in all treatments compared to control, with the exception of treatment P1, which had the same value as P0 for color, flavor, and overall. Chicken nuggets made with buckwheat flour and red spinach had lower pH and TN values, higher WHC, and maintained CL values. Hedonic attributes decreased with the addition of buckwheat flour and red spinach. However, P1 maintained color, flavor, and overall hedonic quality, making it an acceptable chicken nugget product.

1 Introduction

Chicken nuggets are minced meat products generally made from seasoned chicken and other ingredients. Chicken nuggets are a popular product among consumers of all ages and incomes. However, some consumers have negative views of this product due to its high salt and fat content. Chicken nuggets are beginning to be developed into health foods by adding

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functional nutrients that have a positive impact on health [1]. Chicken nuggets can be improved by adding high-protein flour and fiber from plant sources to increase their nutritional quality, so that it provides health benefits [2].

Buckwheat (*Fagopyrum esculentum Moench*) flour has a chemical composition of protein, fiber, and phenolic compounds, which are good for its nutritional value and potential health benefits. It is also a suitable raw material for the production of gluten-free foods [3]. Incorporating different forms of fiber into chicken nuggets not only enhances their health benefits but also increases their ability to retain water and oil [1]. The addition of buckwheat sprout flour can improve the physicochemical characteristics and sensory textural properties of mixed horse meat and chicken patties [4].

Furthermore, using red spinach can positively influence chicken nuggets. Red spinach has valuable biological properties due to its high phytochemical composition. The excellent nutritional value of spinach, its health-promoting qualities, may encourage food producers to develop functional food products [5]. The addition of amaranth flour can improve the water-holding capacity and overall sensory evaluation scores of meat patties [6]. Chicken meatballs enriched with amaranth flour, flaxseed flour, and flaxseed flour have a brighter color, lower tenderness, and acceptable flavor compared to meatballs enriched with wheat flour [7].

Furthermore, incorporating buckwheat and red spinach flour into meat products like sausages, patties, and meatballs is expected to enhance product quality, especially in terms of functional nutrients and a balanced formulation for nugget goods. Yet, the addition of buckwheat and red spinach flour to nuggets is still limited to the addition of buckwheat and red amaranth individually and has not been combined. Therefore, a study is necessary to assess the impact of a combination of buckwheat and red amaranth flour on the physical and hedonic attributes of chicken nuggets.

2 Materials and methods

2.1 Materials

The principal ingredient utilized in the production of nuggets is the breast meat from broiler chickens. Other ingredients used with food quality classification obtained from supermarkets in the Jebres area, Surakarta including eggs, tapioca flour, cornstarch, margarine, garlic, onions, sugar, salt, skim milk, ice cubes, buckwheat flour, and red spinach flour. The combination and filler quantity of chicken nuggets used are based on our prior research, incorporating adjustments to the type and amount of filler. The chicken nugget formulation is shown in Table 1.

Table 1. Chicken nugget formulation with the addition of buckwheat flour and red spinach

Treatment	**P0**	**P1**	**P2**	**P3**	**P4**
Ingredients	**%**				
Chicken Breast	56	56	56	56	56
Eggs	5	5	5	5	5
Corn Starch	2.3	2.3	2.3	2.3	2.3
Margarine	1	1	1	1	1

Treatment	**P0**	**P1**	**P2**	**P3**	**P4**
Ingredients	**%**				
Seasoning	5.7	5.7	5.7	5.7	5.7
Skimmed Milk	1	1	1	1	1
Ice Cubes	14	14	14	14	14
Tapioca Flour	15	0	0	0	0
Buckwheat Flour	0	14.5	14	13.5	13
Red Spinach Flour	0	0.5	1	1.5	2
Total	100	100	100	100	100

2.2 Methods

With certain adjustments to the cooking technique, the nugget production process was based on our previous study. Steaming was used instead of breading and frying in the physical and hedonic test. The hedonic quality test using 25 semi-trained panelists from the Faculty of Animal Husbandry, Universitas Sebelas Maret, Surakarta, who had been selected and trained on basic training and hedonic assessment. Before conducting the hedonic test, the panelists completed and signed a consent form, were given an explanation of the hedonic test process, and then conducted the hedonic test. The hedonic test used a 9-point hedonic test by marking the points corresponding to the attributes at the panelists level of acceptance. Each sample used a 3-digit number when presented in the hedonic test. The attributes assessed were color, aroma, taste, flavor, tenderness, texture, and overall appearance. Hedonic assessment with a nine-point hedonic score of 1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike somewhat, 5 = neutral (neither like nor dislike), 6 = slightly, 7 = like moderately, 8 = like very much, and 9 = dislike extremely [8].

Physical quality assessments comprised water holding capacity (WHC), pH, cooking loss (CL), and tenderness (TN), utilizing five replicate samples for each parameter. Physical quality assessments included pH using a digital pH meter, WHC using the Hamm method, tenderness using a penetrometer, and cooking loss is measured by the method of looking at the difference in weight loss after cooking in percent [8].

Data evaluation was performed using analysis of variance (ANOVA) to determine significant differences at $P<0.05$. If there was a significant difference in the treatment average, the analysis was continued with the Tukey test.

3 Results and discussion

The results of the statistical analysis of the physical quality of chicken nuggets, incorporating SPF and RSF as substitutes for TF, are presented in Table 2. There were significant differences ($P<0.01$) between the treatments in terms of WHC, pH, and TN. In contrast to the control in this study, the combination of SPF and RSF raised WHC and preserved CL, while the pH and TN dropped. Similar findings have been reported by a number of researchers regarding meat products. according to [9], water spinach leaf flour was used to beef meatballs to lower their pH and raise their WHC. In comparison to the control pig sausage, meatballs made with buckwheat flour were firmer [10]. The cooking loss of pork sausages was maintained with the addition of buckwheat flour up to 1%,

whereas firmness diminished at 2% [11]. Changes in physical quality in this study may be due to the addition of fiber-containing ingredients. Some plants that have the potential to be sources of dietary fiber are green vegetables such as spinach. In this instance, fiber can raise the WHC and lower the pH. The type of fiber used may contribute to the pH drop, and the fibers ability to absorb water is what causes the WHC to rise. In addition, fiber also affects the hardness of meat products, where increasing fiber can increase the hardness of meat products. Fiber can affect the porosity system by binding to proteins and soluble carbohydrates [12]. When fiber and protein are heated in the presence of starch and water, they generate a strong gel that can make meat products harder [2].

Table 2. Physical quality of chicken nuggets with the addition of buckwheat flour and red spinach flour

Parameters	Treatments					P value
	P0	P1	P2	P3	P4	
WHC (%)	39.35±1.42^{a}	43.69±1.96^{b}	44.12±1.09^{b}	43.29±0.99^{b}	41.35±3.60^{c}	0.008
pH	6.30±0.07^{a}	6.16±0.06^{b}	6.18±0.05^{b}	6.18±0.05^{b}	6.20±0.07^{c}	0.009
CL (%)	2.85±0.58	2.38±1.34	2.55±0.39	3.05±0.33	3.41±0.22	0.187
TN (mm/g/second)	8.09±0.85^{a}	6.33±0.36^{b}	7.17±0.61^{b}	6.31±0.55^{b}	6.74±0.59^{b}	0.001

Description:
$^{a-c}$ Different superscripts in the same column indicate a highly significant difference (P<0.01)
WHC: water holding capacity, TN: tenderness, CL: cooking loss
P0 = Chicken nuggets with tapioca flour : buckwheat flour : red spinach flour =15.0 : 0.0 : 0.0
P1 = Chicken nuggets with tapioca flour : buckwheat flour : red spinach flour = 0.0 : 14.5 : 0.5
P2 = Chicken nuggets with tapioca flour : buckwheat flour : red spinach flour = 0.0 : 14.0 : 1.0
P3 = Chicken nuggets with tapioca flour : buckwheat flour : red spinach flour = 0.0 : 13.5 : 1.5
P4 = Chicken nuggets with tapioca flour : buckwheat flour : red spinach flour = 0.0 : 13.0 : 2.0

The results of the statistical analysis of the hedonic quality of chicken nuggets with the addition of SPF and RSF as a substitute for TF are shown in Table 3 and Figure 1. Hedonic attributes resulted in a very significant difference (P<0.01) with the addition of a combination of SPF and RSF. Hedonic attributes with the combination of SPF and RSF decreased compared to the control. However, the color, flavor, and overall quality of treatment P1 still had the same quality compared to P0. Overall, with a score of 6 (slightly like), P1 and P0 qualities remained at the preferred level. Similar findings on meat products made with spinach and buckwheat have been reported by a number of researchers. When compared to the control, the texture, flavor, and odor of meatballs can be diminished by adding buckwheat flour [10]. Buckwheat flour can be added to pork sausages to lessen their color, hardness, and scent [11]. Adding spinach flour in certain amounts might reduce the flavor, juiciness, texture, and overall quality of chicken meatballs [9]. The sensory qualities of color, taste, and flavor of chicken liver nuggets are reduced when green spinach flour is added [13]. Additionally, adding red spinach flour at a certain concentration may cause fried chicken meatballs to lose some of their flavor, texture, color, and perfume [14].

Tabel 3. Hedonic quality of chicken nuggets with the addition of buckwheat flour and red spinach flour

Parameter	Treatments					P value
	P0	P1	P2	P3	P4	
Aroma	6.83±1.56[a]	6.23±1.65[b]	6.13±1.41[b]	5.33±1.65[b]	5.23±1.76[c]	0.001
Color	6.70±2.02[a]	6.3±1.47[a]	5.97±1.16[b]	4.90±1.16[c]	4.27±1.02[c]	0.001
Taste	6.23±1.72[a]	5.80±1.52[b]	4.97±1.47[b]	4.60±1.81[b]	4.10±1.69[c]	0.001
Flavor	6.27±1.74[a]	5.83±1.46[a]	5.10±1.37[b]	4.43±1.48[c]	3.97±1.65[c]	0.001
Tenderness	6.27±1.53[a]	6.10±1.56[b]	5.50±1.48[b]	4.90±1.24[c]	4.93±1.17[c]	0.001
Texture	6.47±1.43[a]	6.13±1.33[b]	5.53±1.28[b]	4.93±1.26[c]	4.87±1.25[c]	0.001
Overall	6.57±1.41[a]	6.33±1.32[a]	5.37±1.09[b]	4.90±1.32[c]	4.50±1.23[c]	0.001

Description:
[a-c] Different superscripts in the same column indicate a highly significant difference (P<0.01)
P0 = Chicken nuggets with tapioca flour : buckwheat flour : red spinach flour =15.0 : 0.0 : 0.0
P1 = Chicken nuggets with tapioca flour : buckwheat flour : red spinach flour = 0.0 : 14.5 : 0.5
P2 = Chicken nuggets with tapioca flour : buckwheat flour : red spinach flour = 0.0 : 14.0 : 1.0
P3 = Chicken nuggets with tapioca flour : buckwheat flour : red spinach flour = 0.0 : 13.5 : 1.5
P4 = Chicken nuggets with tapioca flour : buckwheat flour : red spinach flour = 0.0 : 13.0 : 2.0

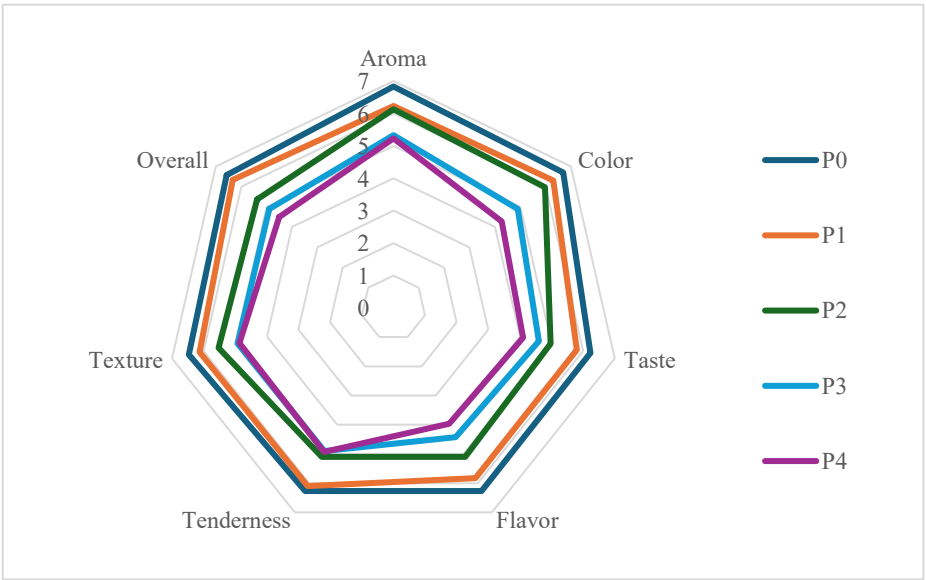

Figure 1. Spider diagram of the hedonic quality of chicken nuggets with the addition of buckwheat flour and red spinach flour. P0 = Chicken nuggets with buckwheat flour : red spinach flour = 0.0 : 0.0. P1 = Chicken nuggets with buckwheat flour : red spinach flour = 14.5 : 0.5. P2 = Chicken nuggets with buckwheat flour : red spinach flour = 14.0 : 1.0. P3 = Chicken nuggets with buckwheat flour : red spinach flour = 13.5 : 1.5. P4 = Chicken nuggets with buckwheat flour : red spinach flour = 13.0 : 2.0

Modifications to the addition of plant-based sources to meat products can cause changes in consumer sensory perception. These changes can occur due to the addition of ingredients to meat products. Added plant-based sources usually contain high fiber, which can affect consumer sensory perception. At certain doses, fiber can reduce consumer perception of

preferences, especially color, tenderness, and texture due to its water retention properties and color pigment content [15]. Fiber with a coarse structure can form a rougher matrix and absorb more water when interacting with other compounds during heating, thus affecting the sensory characteristics of meat products. Moreover, the addition of fiber can affect sensory characteristics due to the reduction of fat content, thus encouraging the formation of a denser structure and stronger inter-particle connections, thereby increasing hardness and elasticity. At certain proportions, the added fiber content can reduce sensory qualities in meat products such as texture, tenderness, juiciness, and overall. Fiber can also affect color, because fiber contains carotenoids that will affect product color. The addition of fiber can reduce color if the carotenoid color does not match the color of the product, such as the addition of okara flour can reduce the reddish color of beef patty products [12]. These factors indicate the cause of the changes in hedonic perception in this study.

The addition of plant-based dietary fiber to meat products also affects odor, taste, flavor, and texture. Several studies have indicated that in certain cases, the addition of plant-based fiber can reduce sensory quality. This is due to the type and level of the plant-based fiber source used [15]. Some plant-based sources have distinctive odors and flavors, so that at certain concentrations these odors and flavors can mask the taste and odor of the meat used. For instance, because spinach contains the enzyme lipoxygenase, adding it to meat products might lessen their flavor and odor [14]. The odor, taste, and flavor of meat products can be affected by the presence of aromatic compounds in the ingredients used. Some plant-based sources also contain certain aromatic compounds that can reduce the odor of meat products, as occurs with the addition of flaxseed flour [7]. In addition, a decrease in taste and flavor can also occur because buckwheat contains compounds that cause bitter and astringent tastes [4]. These conditions caused a decrease in sensory attributes in this study.

4 Conclusion

Chicken nuggets made with buckwheat flour and red spinach had lower pH and TN values, higher WHC, and maintained CL values. Hedonic attributes decreased with the addition of buckwheat flour and red spinach. However, P1 (chicken nuggets with tapioca flour : buckwheat flour : red spinach flour = 0.0 : 14.5 : 0.5) maintained color, flavor, and overall hedonic quality, making it an acceptable chicken nugget product.

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