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Carcass and Cooked Meat Acceptance of Broiler~~s~~ Chickens Fed the Diet Containing Fermented Moringa with the Addition Corn and Fishmeal

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ABSTRACT

The purpose of this study was to evaluate the organoleptic acceptance on the carcass and cooked meat of broilers fed the diet containing the fermented moringa leaves and yellow corn with the addition of fish meal or none.This study used 100 broiler chicks strain MB 90 and a commercial diet CP511 Bravo (CD). The substitute feed ingredients were composted of fermented domesticated *Moringa oleifera* leaf (FDMOL), yellow corn (YC), rice bran (RB), top mix (TM), and local commercial fish meal (FM). The study was performed in a Completely Randomized Design (CRD) with subsampling consisting of 5 treatments, 4 replicates, and 2 subsamples. The experimental diets were C_1= 100% CD, C_2=84.5% CD + 7.5% YC + 7.5% RB + 0.5% TM, C_3 = 84.5% CD + 5% YC + 5% RB + 5% TM + 0.5% TM, MCR= 84.5% CD + 5%FDMOL + 5% YC + 5% RB + 0.5% TM (moringa+), and MCF= 84.5% CD + 5% FDMOL + 5% YC + 5% FM + 0.5% TM (moringa++). The results indicated that carcasses from broilers fed the moringa-base diets were significantly higher ($P<0.05$) yellow coloration than those fed the control diets but the panelists' acceptances for carcass organoleptic either fresh or cooking were not significantly different ($P>0.05$). In conclusion, there were no impacts on the acceptance of fresh carcass characteristics (conformation, color, and odor) or cooked meat (color, flavor, and taste) from the broilers fed the diets containing the moringa leaves compared to the control.

Keywords: Acceptance, Broiler, Carcass, Fishmeal, Moringa

Introduction

In the last few decades, broiler industries have rapidly grown over the world. The increase in people's population causes an increase in meat demand. The main target of the common broiler producers in most countries is to highly supply meat for human needs. In the future, this goal may shift to the direct qualitative rather than quantitative. Improved people's incomes and their consciousness to eat healthier products may change their views on purchasing meat. This may ask the producers to follow the consumer's trends and this should not be imposed on them exclusively but on the feed factories as well.

The carcass and meat traits of the broilers were greatly reflected in the composition of their consumed diets. Hence, the feed formulators should reformulate their broiler diets by considering including one or more unconventional feedstuffs that have a positive impact on the birds' performances and yields. Those are commonly plant leaves, the numerous natural sources found by many researchers could support the bird's health and affect the carcass's appearance. Among others, this herbalife is the moringa leaves (*Moringa oleifera* L).

Many earlier studies have reported that moringa leaves could be used in the diet in a proper amount without detrimental effects on broiler health (Tshabalala *et al.*, 2019; Zulfan *et al.*, 2022). In fact, there were contradictive results on the performances and yields of broilers fed the diet containing the moringa. This discrepancy could be subjected to the types of moringa plants, the kinds of birds and how they were raised, the levels of the inclusions, and the balances of the dietary compositions (Zulfan *et al.*, 2021a; 2022). They also reported that using a wild type of moringa combined with yellow corn in the diet caused a decline in broiler performances and carcass weight. However, the carcass percentage was not significantly affected but the breast percentage was reduced. For this reason, in the present study, the type of moringa has been modified to the domesticated plant instead of the wild one of which both were local cultivars, and fish meal has been introduced into the moringa-corn-based diet to recover the formation of the yields.

Most recent studies reported that the inclusion of moringa leaves in the diets increased the yellow color of the broiler's carcass skin (Ayssiwede *et al.*, 2011; Zulfan *et al.*, 2022). Nevertheless, there was a lack of information reporting the people's perception of this appearance. The buyers, however, may not make the carcass's skin color the only reason why they buy meat. The majority of carcass characteristics associate with color, conformation, and odor. The tastes and tenderness are ordinarily included when the carcass was cooked.

There were contradictive results that reported the people's preferences on the carcass or cooked meat of broilers fed the moringa-based diets and this may vary from country to country. Kumar *et al.* (2018) reported increased meat flavor in the broilers fed the moringa-based diets but others reported none. Therefore, the purpose of this study was to evaluate the carcass weight and organoleptic acceptances by the consumers on the carcass and cooked meat of broilers fed the diet containing the fermented moringa and yellow corn with and without the addition of fish meal as partial substitution of the commercial diet.

Materials and Methods

The broilers were raised for 5 weeks in a broiler house of the Field Laboratory of Animal Husbandry, while broiler processing and organoleptic test were conducted at the Laboratory of Meat Processing Technology. All laboratories belong to the Animal Husbandry Department, the Faculty of Agriculture, Syiah Kuala University. The research was conducted from August 4 until September 15, 2021.

Materials and equipment

This study used 100 broiler chicks strain MB 90 marketed by PT Expravet Nasuba-Mabar Group, Medan, Indonesia, and a broiler commercial diet CP511 Bravo fabricated by PT Charoen Pokhphand, North Sumatera, Indonesia. The trial feed ingredients constituted domesticated moringa leaves (FDMOL), commercial local fish meal (CFM), yellow corn (YC), rice bran (RB), and top mix (TM). The fermentation process of moringa leaves was stuffed with effectiveness microorganism (EM4), molasses, and plastic bags. The 20 cages with the size of 1 x 1 m each completed by a heating bulb, feeder, and drinker were constructed to form experimental units. A disk mill functioned to grind the moringa leaves.The processing equipment consisted of the bleeding cones, defeathering machine, scalder, processing knives, scales, chiller, stoves, and pans.

Diets

The recent experimental diets were performed to correct the experimental diets of our former study on moringa. In the previous study, 5% moringa was a suggested level to include in the diet and the yields expectedly could be recovered by adding fish meal. Therefore, there were two moringa based-diets established based on the presence of the FDMOL in the diet: (1) the MCR diet, the replacement feeds including 5% FDMOL, 5% yellow corn, 0.5% top mix, and 5% rice bran and (2) the MCF diet, similar to the MCR diet but rice bran changed with a fish meal. Since some other feed ingredients were involved, this study presented three control based-diets: (1) the first control diet (C_1), feeding the broiler with a full commercial diet CP511 Bravo labeling no moringa, the second control diet (C_2), replacing 15.5% of the CD diet with the mixture feeds composted of none either moringa or fish meal but involved 7.5% yellow corn, 7.5% rice bran, and 0.5% top mix, and (3) the third control diet (C_3), performed to enhance the C_2 by adding 5% fish meal and removing 2.5% of yellow corn and rice bran each to gain 15.5% in substitution for the CD diet. The experimental diets were formulated to meet the dietary requirement for a broiler recommended by the NRC (1994). The nutritional contents were shown in Table 1. The experimental diets were established in the following treatments:

C_1 = CD (control 1)
C_2 = 84.5% CD + 7.5% YC + 7.5% RB + 0.5% TM (control 2)
C_3 = 84.5% CD + 5% YC + 5% RB + 5% FM + 0.5% TM (control 3)
MCR = 84.5% CD + 5% FDMOL + 5% YC + 5% RB + 0.5% TM (moringa+)
MCF = 84.5% CD + 5% FDMOL + 5% YC + 0.5% TM + 5% FM (moringa ++)

Fermentation procedures

The moringa leaves were collected from the resident gardens located in Desa Lambhuk Banda Aceh. The leaves were cleaned off the foreign materials such as stem and bark and then placed under a shading area for a week. The dried leaves were ground using a disk mill. The procedure to ferment the moringa leaves was run as follows: a bucket containing 3 liters of fresh water was added with the same amount of 3 mL of EM4 and molasses. The solution was mixed homogenize and then poured into a sprayer. As much as 6 kg of the moringa powder was sprayed gradually with this solution until finished and subsequently loaded solidly into a plastic bag to anaerobe condition. The bag then was incubated in a dark room for a week. Finally, the leaves were scattered on the clean floor and dried at room temperature.

Experimental design

Feeding broilers with the trial diets was carried out in a Completely Randomized Design (CRD) with subsampling consisting of 5 treatments, 4 replicates, and 2 subsamples. Replicates were an experimental unit living with 5 birds each. The linear model for this study was $Y_{ijk} = \mu + \tau_i + \varepsilon_{ij} + ɗ_{ijk}$ where Y_{ijk} = observation value, μ = overall mean, τ_i = effects to the experimental diets i^{th}, εij= error to the experimental diets j^{th}, and $ɗ_{ijk}$= a subsampling error (Steel and Torrie, 1991).

Research procedures

The procedures of research were conducted under a protocol of animal care. The procedures were as follows: preparation, raising the broilers, and collecting the data.

The preparation included constructing the cages and the experimental diets. The cages and equipment were washed using detergent and disinfected using a disinfectant agent. Subsequently, the cages were set up into 20 experimental units 100 x 100 cm per cage and then facilitated by incandescent light bulbs, feeder, drinker, and litter each. The diet preparation was to formulate the feed, ferment the moringa leaves, and mix the experimental diets.

Broilers were fed the experimental diets *ad libitum* for up to 5 weeks. The diets were added twice a day. The drinking water was delivered *ad libitum* and for the first fourth week added by the vitastress. The ND vaccine was given via eye drop on the 3rd day and repeated via intramuscular injection on the 21st day. The IBD vaccine was delivered via mouth on the day 10th.

At the end of the day 35th, all broilers were weighed, and then two birds from each experimental unit were chosen based on a body weight close to the average body weight of their groups. Therefore, there were 40 subsample birds slaughtered and then processed into the carcasses after they were fasted for 6 hours. The whole carcass was weighed individually to determine the carcass weight.

The 40 whole carcasses were grouped on the ceramic tables splited into 8 areas in which each area was placed 5 carcasses randomly originating from every treatment. Each carcass was coded privately and then offered to the panelists. This helped the panelists to distinguish carcass from the carcass but they were unknown which treatments those carcasses were from. The array of the carcasses from every experimental diet placed on each table was changed blindly to forget the panelists remindthe previous locations. The panelists were given a questionnaire asking about their perception of the intensity level of carcass skin yellow coloration and their acceptance of the organoleptic property of fresh carcasses. After finishing assessing all fresh carcass samples, the carcass was inserted individually into the plastic bag, wrapped, coded, and then stored overnight in the chiller. The participants were pleased going home and welcomed back tomorrow to the laboratory to explore their acceptance of cooked meat attributes.

A day after, the 40 samples of carcass bags were removed from the chiller and then allowed at approximately 28^{o}C room temperature. Afterward, the carcass was drawn out of the bag and then rinsed using clean water. The breast was cut off a whole carcass and thus sliced into 30 pieces per breast and then fried in a pan. The same pan was used for frying the meats from the same treatments but those differ in replicates, however, separated pans were used for different treatments. Every 30 pieces-cooked meat was transferred into a coded paper plate. Therefore, there were 40 plates comprising 30 pieces of meat each prepared from 5 treatments, 4 replicates, and 2 subsamples. The plates were set on the tables in the same way when determining the fresh carcass. The panelists were given another questionnaire asking about their perception of the organoleptic characteristics of cooked carcasses. Since the taste was included to assess the cooked meat, the panelists were served to drink water and biscuits to neutralize the hints. The procedures of sensory test followed Kemp *et al.* (2009) with some modifications.

Panelists

The 30 panelists of undistinguished sex either males or females were selected randomly from the community of broiler meat customers involving students, lecturers, and households. They were asked voluntarily to seek their acceptance of the carcass and meat characteristics of the broilers fed the experimental diets. This was run following the protocol of the Standard Operational Procedures of the Laboratory of Meat Processing Technology, Animal Husbandry Department, Syiah Kuala University. The whole carcass was attributed to yellowness, odor, and whole appearance, while cooked meat was categorized to meat colors, flavor, tenderness, and taste.

Parameters

This study examined the parameters as follows: weights and percentages of the whole carcass, intensity of carcass yellowness, consumer preference for fresh carcass and cooked broiler meat characteristics. The carcass weight was measured by weighing the carcass, while the carcass percentage was obtained by dividing carcass weight by live weight.

The intensity of carcass yellowness was not measured objectively but visually determined by the consumer panelists comparing those to the controls for the difference. The 5-point hedonic scales ranging from 1-5 with the criteria: 1= very less yellow, 2= less yellow, 3= moderate yellow, 4= high yellow, and 5= verymuch yellow were offered to panelists for scoring the intensity of carcass yellowness.

Frying was concerned to cook the meat according to the habits of local people in consuming broiler meat. The consumer preference for fresh carcass and cooked broiler meat were tested organoleptically by the consumer panelists exposing their acceptance of either the fresh carcasses or cooked broiler meat characteristics obtained from this study based on the consumer panels in the 7-point hedonic scales ranging from 1-7 with the criteria: 1= dislike very much, 2= dislike moderately, 3= dislike slightly, 4= neither like nor dislike, 5= like slightly, 6=like moderately, and 7= like very much.

Analysis the data

The carcass weights obtained from the treatments and the organoleptic scores obtained from the panelists were tabulated into the related observation variables and then each was analyzed by Analysis of Variance (ANOVA). The analysis was continued by Duncan's Multiple Range Test (DMRT) when the scores were detected significantly different among the treatments (Steel and Torrie, 1991; Kemp *et al.*, 2009).

Table 1. The feed ingredients and chemical compositions of the experimental diets

Item	Control based diets			Moringa based-diets	
	C_1	C_2	C_3	MCR	MCF
Ingredients			(%)		
CP511 Bravo[1]	100	84.5	84.5	84.5	84.5
FDMOL[2]	0	0	0	5.0	5.0
Yellow corn[3]	0	7.5	5.0	5.0	5.0
Rice bran[3]	0	7.5	5.0	5.0	0
Fish meal[3]	0	0	5.0	0	5.0
Top mix	0	0.5	0.5	0.5	0.5
Total	100	100	100	100	100
Chemical compositions					
Crude protein (%)	21.00–23.00	19.55–21.24	21.32–23.01	20.25–21.94	21.93–23.62
ME (kcal/kg)	2,950	2,945	2,920	2,874	2,906
Crude fat (%) (Max.)	5.00	5.56	5.75	5.56	5.54
Crude fiber (%) (Max.)	5.00	5.28	5.50	5.20	5.18
Ca (%)	0.90	0.77	0.78	0.89	0.89
P (%)	0.60	0.54	0.53	0.76	0.75
Methionine (%)	0.55	0.51	0.57	0.51	0.57
Lysine (%)	1.00	0.91	1.12	0.96	1.16

Chemical compositions refer to:

[1] The marked label of CP511 Bravo: crude protein (CP) min. 21.0–23.0%, crude fiber (CF) 5.0%, crude fat 5.0%, ME 2.900–3.000 kcal/kg, Ca min. 0.9%, P min. 0.6%, Methionine 0.55%, and Lysine 1.00%.

[2] Laboratory of Baristan, Banda Aceh 2021: CP 25.96%, CF 5.35%, crude fat 8.80%; Laboratory Nutrition and Animal Feed, Brawijaya University, Malang, 2007: ME1.380 kcal/kg= assumed 70% of the GE, Patrick and Schaible (1990), Ca 2003 mg/kg, P 204 mg/kg (Gopalakrishnan *et al.*, 2016).

[3] Sihite (2013): CP 47%, CF 2.98%, crude fat 9.54%, Ca 2.46%, and P 4.60%; Hartadi *et al.* (2005), Methionine 1.51%, and Lysine 4.62%.

[4] Hartadi *et al.* (2005).

Results and Discussion

Carcass weights and percentages

The weights and percentages of carcasses collected from all treatments were shown in Table 2. The inclusion of 5% fermented domesticated *Moringa oleifera* leaves meal (FDMOL) + 5% corn + 5% rice bran + 0.5% top (the MCR diet) in substitution to the commercial diet had no significant effect (P>0.05) on the carcass weights. This result was in contrast with the previous study reported by Zulfan *et al.* (2022), using fermented moringa mixed with yellow corn and top mix decreased significantly carcass weight due to the decreased live weight. The difference was supposed the impact of the different sources of the moringa plants (Zulfan *et al.*, 2022) of which this study used a domesticated type while the former used a wild type. Adding 5% fish meal instead of 5% rice bran to perform the MCF diet could not increase the carcass weight. Although carcass weights of the birds fed the MCF diet were relatively higher rather than those fed in the MCR diet but statistically both were not significantly different. Relatively to body weight, the percentages of carcasses of the broilers fed the MCR were not in significant difference (P>0.05) which were agree with Zulfan *et al.* (2022).

The benefit of using moringa in substitution for a partial commercial diet was to reduce feed cost without decreasing carcass percentage. It was also possible to increase meat quality (Tonga *et al*., 2016) due to its nutritional and herbal plant. However, the people acceptance of the carcass and meat of the broilers fed the diet containing moringa should be explored first since there was a possible change in appereance of the carcass of broiler fed the moringa-based diet reported by Zulfan *et al.* (2022). Therefore, the characteristics of the carcass and meat of the broilers fed the diet containing moringa should be evaluated by the consumers.

Carcass yellow color intensity

The intensity of carcass yellow coloration scored by the panelists was shown in Table 3. ANOVA indicated that the inclusion of 5% fermented domesticated *Moringa oleifera* leaves meal (FDMOL) + 5% corn + 0.5% top mix either by adding fish meal (the MCF diet) or none (the MCR diet) in substitution to the commercial diet significantly (P<0.05) increased carcass skin yellow color. Carcasses from the broilers fed the diets with the inclusion of FDMOL resulted in more yellow rather than those fed the diets without FDMOL.

Carcass-skin yellow intensity on the broilers fed the diets containing without moringa were scored in the range of 2.83–2.98 close to 3 categorized into the moderate yellow. The yellow color can also be seen by the panelists on the carcass of broilers fed the diets with no moringa (C_1,C_2,C_3) since these diets were based on yellow corn. This ingredient also contains high β-carotene i.e. 0.05–16.79 µg/g (Muzhingi *et al.*, 2008) but not as high as within a moringa i.e. 3.31 mg/g (Tahir *et al.*, 2016). The carcass-skin yellow colors on broilers fed the diets containing moringa were 3.74 and 3.79 close to 4 categorized as yellow. This result indicated that the skin yellow colors were obviously seen in the broilers fed the moringa-based diets but they were not categorized as very yellow. This was caused by the level of using moringa was not more than 5%. The skin yellow intensity was extremely supposed to score up to 5 (very yellow) if the level of moringa was applied more than 5%.

The increased carcass-skin yellow color of the broilers fed the diets containing fermented moringa strongly was affected by the increased

Table 2. Weights and percentages of whole carcasses

Parameters		Control based-diets			Moringa based-diets	
		C_1	C_2	C_3	MCR	MCF
Live weight	(g)	1,995±112	1,949±171	2,090±139	1,991±103	2,036±163
Whole carcass	(g)	1,466±72	1,395±161	1,531±102	1,432±94	1,492±125
	(%)	73.62±4.05	71.71±2.09	73.28±1.54	71.90±2.05	73.32±233
Noncarcass	(g)	529±102	554±35	559±52	559±44	544±65
	(%)	26.38±4.05	28.29±2.09	26.72±1.54	28.10±2.05	26.68±2.33

Table 3. The perception of yellow skin intensity of whole carcass appearance

Carcass color	Control diets			Moringa based-diets	
	C_1	C_2	C_3	MCR	MCF
Mean of yellow skin intensity	2.95±0.59[a]	2.83±0.36[a]	2.98±0.46[a]	3.79±0.40[b]	3.74±0.55[b]

[a,b] Mean values within a column followed by the different letters were significantly different (p<0.05).

absorption of carotene, the pigment abundantly existing within the moringa (Saini *et al.*, 2014). This result agreed with Ayssiwede *et al.* (2011) reported that the inclusion of moringa in the diet increased broiler carcass-skin coloration. The carcass-skin yellow colors among the treatments were given in Figure 1.

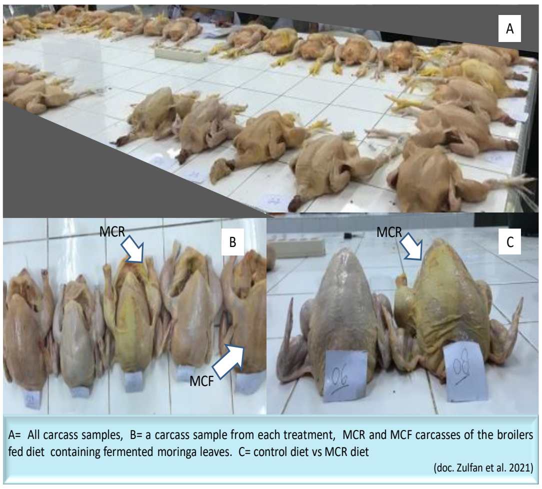

Figure 1. Carcass appearances of broilers fed the diets containing moringa *vs* non-moringa.

Consumer acceptances of broiler carcass

The preferences of broiler carcass characteristics scored by the panelists were shown in Table 4. ANOVA indicated feeding broilers on the moringa based-diets (MCR, MCF) in substitution to the commercial diet did not significantly (P>0.05) affect the acceptances of the carcass organoleptic by the panelists. Carcasses from the broilers fed the diets with the inclusion of FDMOL were similarly scored by the panelists with those fed the diets without FDMOL.

Feeding broilers on the MCR diet did not significantly decrease the conformation score. Although this score of the broilers fed the MCR diet was slightly lower than that from the C_1 diet, the average score was close to 5 categorically in like. Incorporating 5% fish meal into this diet to perform the MCF diet did not significantly improve the score of carcass conformation. Carcass conformation was highly reflected in carcass weight and percentage. Feeding broilers with moringa-based diets resulted in no significant difference (P>0.05) in the weight and percentage of the carcass (Table 2). Moringa leaves are good sources of vitamins, protein, and amino acids (Banjo, 2012). This indicated that the nutrients in moringa could be well utilized by the chickens to form carcasses. As reported by Alwaleed *et al.* (2020), although the final body weight of the broiler was reduced at the levels of more than 5% *Moringa oleifera* leave meal (MOLM), the dressing percentage was not affected by the inclusion of up to 7% of this meal. Similarly reported by Zulfan *et al.* (2022), using up to 7.5% of the moringa mixed with yellow corn reduced the weight of the whole and cut-up carcasses of broiler chickens but relative to body weight the percentages of all these parameters except for the breast did not significantly different. It was suggested to use *leubim fish waste meal* (LFWM) instead of commercial fish meal to generate a lower cost of fish meal. Hence, all parts of LFWM are nutritious as reported by Zulfan *et al.* (2021b).

Even though feeding moringa-based diets increased carcass-skin yellow intensity, the panelists' acceptance of carcass color had no significant effect (P>0.05). There was no tendency for carcass with stronger yellow was more preferable by the panelists. It means the consumers did not make the carcass-skin color the main reason to choose the carcass.This finding agreed withTazi (2014), the inclusion of 3.5 and 7% moringas in the broiler diets did not significantly affect (P>0.05) color score on thigh ranging from 5.55–5.71 *vs* 5.36 (control) and breast ranging from 6.25–6.33 vs 6.23 (control). Similarly, in a report by Imoru (2019), replacing up to 50% soybean meal with moringa leave meal increased significantly (p<0.05) skin and shank pigmentation scores but the general acceptability scores revealed no significant (p>0.05) difference. In the present study, carcasses with higher yellow intensity from the broilers fed the moringa-based diets did not affect seriously the panelists' acceptance of the carcass with the average scores did not achieve 6 (like) or 7 (very like).

Feeding a broiler with a diet containing 5% fermented moringa without a fish meal (the MCR diet) did not cause either an increase or a decrease in the carcass odor with the average score of 4.29 close to slightly like. The moringa does not have a strong aroma that can be deposited to the carcass. Adding 5% fish meal to perform the MCF diet also did not affect the odor of the carcass scoring 4.60

Table 4. The organoleptic perception of the whole carcasses

Carcass	Control based-diets			Moringa based-diets	
	C_1	C_2	C_3	MCR	MCF
Conformation	5.34±0.38	4.93±0.53	5.52±0.28	4.90±0.37	5.26±0.28
Color	4.71±0.35	4.72±0.48	4.93±0.35	4.75±0.27	4.84±0.43
Odor	4.53±0.22	4.52±0.23	4.50±0.30	4.29±0.23	4.60±0.23

categorically into like. This result agreed with Tazi (2014), the inclusion of up to 7% moringa in the diet did not significantly affect (P>0.05) the odor of the thigh scoring 5.81–5.90 *vs* 5.69 (control) or breast scoring 6.06–6.20 vs 6.11 (control). This also agreed with Ologhobo *et al.* (2014) reported that utilizing the moringa in the diet did not alter the odor.

Fish meals can be more odorous which the chicken normally well accepts for this smell but not for humans. The odor is due to the absence of trimethylamine in fish meals creates a residual fish smell in meat and eggs (Frempong *et al.*, 2019). The odor may be potentially deposited in the meat when a fish meal is used in a high concentration in the diet. The C_3 diet and the MCF diets added fish meals not more than 7.5%. The commercial diet was assumed to compose of fish meal~~,~~ not more than 10% then replaced with the mixture feeds containing up to 7.5% fish meal resulting in approximately 17.5% fish meal in the diet. There were contradictive outlooks on what the level of fish meal in the diet causes off-flavor but its presence within the diets in this study was considered still in the range of free absorbed bad odor. According to Anggorodi (1985), there is no indication the odor of fish meal is smelt by the human when it is formulated not more than 20% in the diet.

Consumer acceptances of cooked broiler meat

The panelists were asked for their perception of the fried broiler meat properties such as the taste, flavor, color, and texture. The scores were presented in Table 5. The results of ANOVA showed that there were no significant differences (P>0.05) found in the scores of all parameters of cooked broiler meat tested by the panelists.

The panelists scored the taste, color, and flavor of cooked meat for all treatments in very close choices with the range from 4.51–4.93 (taste), 4.88–5.17 (color), and 4.70–4.91 (flavor) for which all were categorized in like. Feeding the broilers with either the MCR or MCF diets did not affect the scores of these variables. The panelists could not be able to distinguish the characteristics of cooked broiler meats. High yellow colors on fresh carcasses of broilers fed the moringa-based diets were not seen by the panelists after the meats were fried. The meat color from the broilers fed the moringa-based diets revealed relatively the same as those from the broilers fed the control-based diets.

This result was not in agreement with Kumar *et al.* (2018) reporting that the inclusion of the moringa in the diet significantly (P<0.05) increased the flavor and palatability of cooked broiler meat with the scores ranging from 6.33–6.50 *vs* 5.67 (control) for the flavor and 6.13–7.03 *vs* 5.50 (control) for the palatability. This disparity might be caused by the variations in the moringa sources. They reported that increased flavor was highly supposed due to the increased natural flavor in the moringa. According to Sugiharto (2022), the effectiveness of herbal supplements on broilers was quite subject to the types of plant-derived products, the quality of raw herbs, the potency of contaminated toxic compounds, processing techniques and conditions of herbs, administration ordelivery routes, packaging, storage conditions, and the dosages of herbal supplementation.

Statistically, the score of cooked meat tenderness was not an insignificant difference (P>0.05) but the cooked meats from the birds fed the moringa-based diets were relatively scored higher by the panelists than those from the birds fed the control-based diets. Including the moringa in the diets increased the panelists' acceptance of cooked meat tenderness from slight likes to likes. It was supposed that introducing fermented moringa into the diet increased meat tenderness. This agreed with Tazi (2014), utilizing up to 7% moringa in the broiler diet significantly (P<0.05) increased the score of meat tenderness to be in the range from 6.60–6.86 *vs* 5.65 (control) on the thigh and 6.50–6.74 vs 5.01 (control) on the breast. Similarly reported by Kumar *et al.* (2018), using moringa leaves in the diet increased the score of cooked broiler meat tenderness to 5.97–6.57 *vs* 5.23 (control). Ologhobo *et al.* (2014) showed a significantly increased broiler meat tenderness score from 5.80 (control) to 7.30 (with the addition of moringa). The increased tenderness was thought not to relate to the fish meal since the score of the C_3 diet did not signal it. As reported by Jassim (2010), the panel test of cooking broiler meat declared that fish meal has no significant effects on tenderness. The meat tenderness scored by the panelists was described in Figure 2.

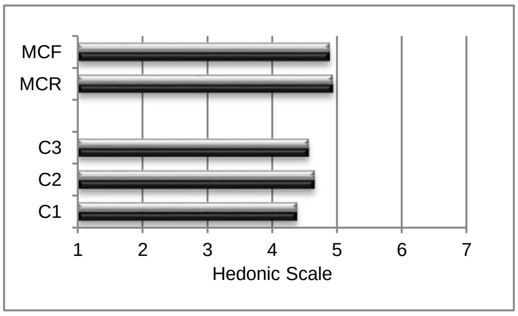

Figure 2. Scores of meat tenderness of broiler fed the diets with andcontaining moringa C1, C2, C3 = the diets without containing moringa MCR, MCF= the diets containing moringa.

Table 5. The consumer preferences for broiler meat

Cooked meat	Control diets			Moringa based-diets	
	C_1	C_2	C_3	MCR	MCF
Taste	4.51±0.25	4.53±0.24	4.67±0.33	4.59±0.43	4.91±0.33
Color	4.95±0.22	4.88±0.33	5.17±0.42	4.95±0.29	4.94±0.21
Flavor	4.74±0.25	4.68±0.25	4.81±0.25	4.70±0.36	4.91±0.25
Tenderness	4.38±0.21	4.65±0.39	4.56±0.53	4.93±0.54	4.88±0.48

The increased tenderness was presumed because of the synergistic action of numerous endogenous proteolytic enzymes. The presence and activity of endogenous enzymes within the muscle cells and the extracellular matrix was the main factor to control muscle proteins and their interactions and hence was a crucial provider to develop tenderness (Kaur *et al.*, 2021). Plant proteases such as papain, ficin, and bromelain act as a tenderizer in meat and meat products and offer the best results to tenderize the meat compared to animal and microbe proteases (Ikram *et al.*, 2021). Moringa leaves have a mixture of numerous hydrolytic enzymes such as protease (Banik *et al.*, 2018). ElKhalek*et al.* (2020) found that the protease enzymes from the moringa had the highest specific activity among all tested samples with a total protease activity, such as moringa leave= 5.058U[a], pumpkin seed= 0.790U[d], sunflower seeds= 1.142U[c], and lupine= 1.760U[b]. However, in the present study, the moringa leaves were partitioned into the diet, not within the meat. When the diet containing moringa entered the digestive tract of the broilers, the protein was degraded by the protease enzymes to be more simple proteins and the final result was free amino acids (FAAs). Subsequently, the FAAs were absorbed and transported to the tissues. The FAAs linked to moringa protein may be deposited in the carcass and then possibly play a pivotal role to tenderize the meat.

In addition, the test was very subjective since it was associated with the sensation of the panelists when their teeth penetrated the meat and this could differ among the countries depending on their habits and acceptance (Suryati *et al.*, 2018). According to Sugiharto (2022), the physical properties of broiler meats improved as a result of herbal supplementation.

Conclusions

This study concluded that incorporating the fermented moringa and yellow corn with the addition or without a fish meal as replacements for the partial commercial diet increased the yellow coloration on broiler carcass but did not affect people's acceptance. There were no impacts on the people's perception of either fresh carcass characteristics (conformation, color, and odor) or cooked meat (color, flavor, and taste) from the broilers fed the diets containing the moringa leaves compared to the control. However, the score of meat texture increased from "slightly like" to "like" on the meat from the broilers fed the diet containing the fermented moringa. The results of this study may suggest to the poultry feed industries to include moringa leaves in their broiler diet formulation when the consumers wish the broiler carcass with a higher yellow skin coloration.

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