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FULL PAPER

Thiobarbituric Reactive Substance (TBARS) and sensory evaluation of breast chicken meat from broiler fed with *Kappaphycus alvarezii* and *Sargassum polycystum* seaweeds formulated feed

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Abstract

Taste and health are significant quality considerations for both producers and consumers. Chicken provides an essential protein source for humans, in addition to other livestock supplies, and its intake can be altered to achieve a more usable food through the manipulation of broiler chicken diets. According to studies, changing feed formulations can impact sensory features as well as meat quality in broiler chickens, as indicated by lipid peroxidation. The objectives of this study were to investigate the effect of different seaweed inclusion in the nutrition of broiler chickens on the TBARS in meat and to evaluate the sensory quality of chicken breast. The experiment was performed with 480-day-old Cobb 500 chickens housed in battery cages, divided into 8 treatments, with 6 replications per treatment. Water and feed were accessible ad libitum. The chickens were fed with a negative control diet (T1), *Sargassum polycystum* (SP) 2% diet (T2), 5% SP (T3), 10% SP (T4), 2% *Kappaphycus alvarezii* (KA) (T5), 5% KA (T6), 10% KA (T7) and commercial binder (T8). Analysis of TBARS was executed by evaluating malonaldehyde (MDA) compound produced from the lipid oxidation in samples. The sensory evaluation was conducted using 40 untrained panellists at the Universiti Malaysia Pahang. The panellists evaluated the steamed breast chicken meat for colour, odour, taste and overall acceptance using a 5-point hedonic scale where the extremes of each trait were scale 1 (the worst) and 5 (the best). The results of all sensory attributes on breast meat were not significantly different among treatments (P>0.05). Meat from broiler chicken fed with 5% *K. alvarezii* diets was considered to be the most appropriate. For TBARS analysis, there was no substantial difference between the control diet and *K. alvarezii* 5% diet (P>0.05) where both showed the highest oxidation rate in the meat while the meat sample of *S. polycystum* 2% showed the lowest oxidation value (P<0.05). The results of this study indicated that the addition of seaweed to broiler chicken diets did not affect sensory acceptance of the meat and *S. polycystum* 2% had improved inhibition of lipid oxidation in meat.

1. Introduction

The livestock industry plays an important role in providing adequate raw material supply for the food industry and local consumption. The poultry industry is the largest economic contributor to the livestock sector. This industry supplies poultry meat and egg for the domestic market. However, the industry's semi-integrated poultry players will be affected by the increase in prices of raw materials for feeds like corn and soybean in the market (Lokollo *et al*., 2004). Corn and soybean meals are the main new materials for feed millers and these added to 90% of the imported ingredients. Corn and soybean constitute about 70% of the nation (Liu *et al.*, 2019). Therefore, more ingredients are needed in improving broiler production. An additional issue in the chicken sector is that animal agriculture necessitates a large volume of protein-rich feed. The production of these feedstuffs has a bigger environmental impact on the poultry farming system as a whole than the growth of the birds especially soybean meal, where are commonly

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used as a protein source in poultry feed formulations (Escobedo Del Bosque *et al*., 2020).

Over time, there has been an increase in demand for poultry products, particularly chicken. On top of that, due to increasing costs of feed ingredients and other inputs, thus increasing excessively the costs of production. Because there is a need for the product, this necessitated the development of alternate production methods which lead to investigations of potential, less expensive and readily available ingredients that can be used in formulating livestock rations, for example, palm kernel oil residue, palm kernel meal, seaweed and others (Teye *et al*., 2015; Ramiah *et al.*, 2019). Moreover, as an alternative to soybean products as poultry feed ingredients, there are regionally grown protein crops, such as beans and peas. These would help local agricultural sectors become more self-sufficient by removing the need for soy imports and their variable pricing, as well as offering environmental benefits such as biological nitrogen fixation and the ability to boost poultry production efficiency (Profeta and Hamm, 2019).

Red seaweeds such as *Kappaphycus alvarezii, Eucheuma spinosum, Gracilaria* spp. and others contain numerous amounts of bioactive compounds with rich pharmacological potential (Holdt and Kraan, 2011). Sulphated polysaccharides, such as fucoidans from brown seaweeds, agar and carrageenan (sulphated galactans) from red and green seaweeds and ulvans (sulphated glucuronoxylorhamnans) have exhibited anti-inflammatory, antioxidant, antibacterial, and immunological effects in humans (Synytsya *et al*., 2015). While phlorotannins, which are found in brown seaweed families such as Alariaceae, Fucaceae and Sargassaceae have been investigated as functional food ingredients with a variety of biological activities including antioxidant, anti-inflammatory, antidiabetic, anti-tumour, antihypertensive and antiallergic properties (Freitas *et al*., 2015).

The effect of using seaweed in animal diets in terms of animal growth performance and health had been mostly investigated nowadays. This is due to the abundance of seaweeds or macroalgae in the coastal area such as in European countries being fed to the sheep, cattle and horses either in fresh or processed form. Production of seaweed meal which is dried seaweed that has been processed into fine powder influenced the utilization of seaweed for animal consumption. Other than nutritional properties, seaweed also contributes to seaweed pigments, antioxidant properties and polysaccharide components with minerals which are important in replacing artificial colourants and preservatives. Thereby it will improve animal growth performance through natural sources of additives. Seaweed species are generally utilized for aquatic animals (oysters, scallops, clams and mussels), abalone, crustaceans, zooplankton and fish (Rajauria, 2015).

Consumers examine a variety of factors when deciding whether or not to accept meat or food products, including sensory features, nutritional value and health implications (Muchenje *et al*., 2010) Their acceptability of any food produced is influenced by flavour, which is one of the sensory evaluation components. Other than that, tenderness, juiciness and odour are also important attributes in evaluating food components. Various factors have been proven to alter meat sensory evaluations. Food availability and familiarity, for example, have an impact on sensory scores (Sveinsdóttir *et al.*, 2009). Meat sensory qualities have been proven to be influenced by the ease of access, frequency of purchase, and ethnicity. Consumers from various countries showed different acceptability of meat especially on odour attributes (Prescott *et al*., 2001). A study also showed that customers from different nations have distinct perceptions of sensory qualities. For example, low sheep meat consumption was detected in the area of Central and South-Eastern Asia and the USA, because they disliked the strong flavour and odour (Sañudo *et al*., 2007).

The most important quality factor for many food items, particularly poultry products, is appearance. Consumers frequently choose or reject products simply on the basis of their looks. The first impression typically affects other sensory aspects and appearance is equally important for final product evaluation. One of the major contributing components of appearance is colour. Colour has long been recognized as an important selection criterion for fresh poultry and meat products, as well as for customer satisfaction with the final product. For poultry meat products, the appearance of cooked poultry meat that is pink or red is often connected with undercooking and is highly undesirable. Bruises, haemorrhages, blood pooling, and a variety of other possible discolourations are all linked to other visual defects (Fletcher, 2002). The physical and chemical changes that occur in meat were the result of various processing procedures, preservation methods and technologies. Physical changes affect the sensory properties of the product, such as volume, appearance, colour, texture, scent, and taste, by altering the structure of the tissues (Gómez *et al*., 2020). In a poultry operation, it is critical to understand the elements that influence carcass features and the quality of chicken meat. Broiler meat produced from broiler chickens fed rations including additives such as rapeseed has developed an off-flavour and odour, as well as unpleasant colour development, according to previous studies (Salmon *et al.*, 1984; Moroney *et al.,* 2013; Moraes *et al.,* 2016; Trembecká *et al*., 2017). The addition of up to 10% RSHM to the diets of laying hens did not affect the eggs' flavour (Williams and Damron, 1998). Meanwhile, meat-related studies indicate that the carcass quality of livestock, especially non-ruminant livestock is directly affected by the type of feed given and the inclusion rates of the various feed ingredients (Teye *et al*., 2011). Therefore, the objectives of this study were to determine the sensory and TBARS of broiler meat produced by feeding commercial broilers fed with seaweed addition compared to no seaweed addition in the formulation.

2. Materials and methods

2.1 Seaweed powder and feed production

The dry seaweed was collected from Mini Estate, Universiti Malaysia Sabah (UMS) in Semporna and local seaweed farmers in Kunak, Sabah. The dried samples were washed to remove foreign matter such as stones, sand, dirt as well as nylon strings that are used in the cultivation process. This process is also being conducted to ensure the sea salt content in the raw materials is reduced. Salt content will affect the final gelling property of the seaweeds. Seaweeds *K. alvarezii* (KA) and *S. polycystum* (SP) (Figure 1) were dried in the oven (Memmert, Germany) at 60°C for overnight until the moisture content of the product reached less than 10% as a criterion for product stability (Normah and Nazarifah, 2003). After that, the dried seaweed was grounded coarsely and later pulverized by using a cycle tech mill to pass through a screen of 0.5 mm size and grind into fine seaweed powder.

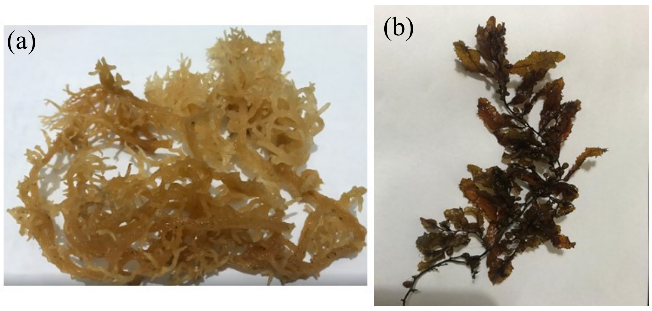

Figure 1. (a) *Kappaphycus alvarezii* and (b) *Sargassum polycystum*

Feed formulation was created by entering raw material nutrition data into the database of the Department of Veterinary Services (DVS) least-cost feed formulation programme. The experiment was carried out at a feed mill pilot plant at MARDI's Animal Science Division in Serdang, Selangor, Malaysia with a total of 200 kg of starter and grower feed per treatment produced. All solid raw materials (corn, soybean meal, wheat pollard, seaweed powder, minerals, and additives) are pulverised to minimise particle size before being mixed with palm oil followed by pelletization. The pelletizing process involves mash feed into the feeder and conditioner. Steam was injected into the mash feed and then the conditioned mash was transferred to the pelleting chamber, where the mash goes through the pellet die (3.5 mm) using a pellet mill. Fines from the process then return to the chamber to be pelletized again. Next step, the products were sieved and packed.

In this study, eight experimental treatments were formulated by incorporating 0% seaweed (control, T1), 2% (T2), 5% (T3), 10% (T4) of *S. polycystum* and 2% (T5), 5% (T6), 10% (T7) of *K. alvarezii* with the addition of commercial binder (T8) (Table 1). All of the treatments were isocaloric and isonitrogenous and the ingredients with chemical compositions used are presented in Table 2 and Table 3.

Table 1. Type of feed formulation for broiler chicken

Treatment	Feed formulation
T1	Basal ration with 0% seaweed (control)
T2	Basal ration with 2% *S. polycystum* (SP)
T3	Basal ration with 5% *S. polycystum*
T4	Basal ration with 10% *S. polycystum*
T5	Basal ration with 2% *K. alvarezii* (KA)
T6	Basal ration with 5% *K. alvarezii*
T7	Basal ration with 10% *K. alvarezii*
T8	Basal ration with commercial binder

2.2 Feeding trial

All the experimental procedures associated with the feeding trial were approved by MARDI Animal Ethics Committee (AEC). A total of 480 male day-old chicks are raised in a house fully equipped with battery cages with a feeder and water supply to each cage. The broiler chickens were provided with feed and water ad libitum during the study period. This study used a randomised full-block design with eight treatment diets and six replications per diet (20 birds per replicate). Broiler chickens were raised for 35 days, with weekly weight and feed intake measurements recorded to assess growth performance.

2.3 Thiobarbituric reactive substance

Lipid oxidation in chicken breast meat was analysed according to the TBARS method as described by Azman *et al.* (2014). One gram of each sample was weighed in a test tube and mixed with 1 mL EDTA solution. Next, the sample was mixed with 5 mL of 0.375% (w/v) of thiobarbituric acid reagent using an Ultra-Turrax (IKA, Germany) at 9600 rpm for 2 mins. During the experiment, all samples were placed in an ice bath to prevent the temperature from rising. The mixture was then incubated at 97±1°C in hot water for 10 mins and agitated during the process to form a homogeneous

Table 2. Composition of experimental starter diets fed to broiler chicken

Ingredient (%)	Diets							
	T1	T2	T3	T4	T5	T6	T7	T8
Corn	57.18	55.18	52.18	47.18	55.18	52.18	47.18	56.93
SBM meal 48%	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00
Crude palm oil	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
S. polycystum (SP)	-	2.00	5.00	10.00	-	-	-	-
K. alvarezii (KA)	-	-	-	-	2.00	5.00	10.00	-
Di-calcium phosphate	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75
Limestone powder	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
L-lysine	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Methionine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Choline chloride	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Vit. premix	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Commercial binder	-	-	-	-	-	-	-	0.25
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated Nutrient Composition								
CP (%)	20.93	21.10	21.36	21.79	21.10	21.36	21.79	20.92
Fat (%)	6.27	6.30	6.34	6.41	6.30	6.34	6.41	6.26
ME (Kcal/kg)	12.99	12.82	12.57	12.15	12.82	12.57	12.15	12.95
Calcium (%)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Sodium (%)	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Methionine (%)	0.44	0.45	0.45	0.45	0.45	0.45	0.45	0.44
Ca/P (%)	1.87	1.88	1.90	1.93	1.88	1.90	1.93	1.87

T1 (Control), T2 (2% SP Powder), T3 (5% SP Powder), T4 (10% SP Powder), T5 (2%KA Powder), T6 (5% KA Powder), T7 (10% KA Powder), T8 (commercial binder).

Table 3. Composition of experimental grower diets fed to broiler chicken

Ingredient (%)	Diets							
	T1	T2	T3	T4	T5	T6	T7	T8
Corn	58.61	58.61	56.11	54.11	58.61	56.11	54.11	58.36
SBM meal 48%	34.60	32.60	32.10	29.10	32.60	32.10	29.10	34.60
Crude palm oil	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
S. polycystum (SP)	-	2.00	5.00	10.00	-	-	-	-
K. alvarezii (KA)	-	-	-	-	2.00	5.00	10.00	-
Di-calcium phosphate	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75
Limestone powder	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
L-lysine	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Methionine	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Choline chloride	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Vit. premix	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Commercial binder	-	-	-	-	-	-	-	0.25
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated Nutrient Composition								
CP (%)	20.43	19.86	19.93	19.25	19.86	19.93	19.25	20.41
Fat (%)	6.27	6.30	6.35	6.42	6.30	6.35	642	6.26
ME (MJ/kg)	13.05	12.95	12.72	12.42	12.95	12.72	12.42	13.01
Calcium (%)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Sodium (%)	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Methionine (%)	0.46	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Ca: Available P (%)	1.87	1.88	1.89	1.92	1.88	1.88	1.88	1.88

T1 (Control), T2 (2% SP Powder), T3 (5% SP Powder), T4 (10% SP Powder), T5 (2%KA Powder), T6 (5% KA Powder), T7 (10% KA Powder), T8 (commercial binder).

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mixture and subsequently allowed to cool down. The liquid samples were collected by centrifugation. The absorbance value of each sample was measured at 532 nm using a UV-Visible spectrophotometer (Thermo Scientific, USA). The TBARS value was calculated from a malonaldehyde (MDA) standard curve with 31.9 to 133 mda (ng/mL). The results were expressed in mg malonaldehyde per kg of the sample (mg MDA/kg sample) and calculated from the standard curve of the 1,1,3,3-tetraethyoxypropane standard.

2.4 Sensory evaluation

The sensory evaluations were performed according to the method by Dutcosky (2007). The breast meat was thawed and thermally processed by steaming for 25 mins, at 80°C in a steamer, without added fat or oil. The samples were trimmed of subcutaneous fat and connective tissue, cut into uniform sizes (about 1 cm), and cooled to room temperature before being served to the panellists. Sensory profiles were determined by a 40-untrained panel. Panellists included staff and students in the Faculty of Industrial Science and Technology, Universiti Malaysia Pahang, ranging from 19 to 37 years of age. Before tasting, panellists were instructed on the assessment criteria. Panellists were asked to evaluate the samples of breast meat for attributes such as colour, odour, taste and overall acceptance on a 5-point hedonic scale (1 = dislike very much, 2 = dislike slightly, 3 = neither like nor dislike, 4 = like slightly, 5 = like very much) (Aminah, 2000). Panellists were provided with water for the neutralization of receptors before and between the samples.

2.5 Data collection and statistical analysis

All the data collected were subjected to statistical analysis with ANOVA and any difference between the treatments means was performed by Duncan Multiple Test using SAS 9.4 at P<0.05.

3. Results and discussion

3.1 Thiobarbituric reactive substance analysis in breast meat

Seaweed was known for its antioxidant properties for food supplements and applications. TBARS was conducted on the meat of broiler chicken fed with different types of treatments (from 0% of seaweed to 10% of seaweed dietary levels). This method was used to evaluate the malondialdehyde (MDA) compound produced from lipid oxidation in samples. The control sample and commercial binder sample showed no significant difference with the 5% *K. alvarezii* meat sample (P>0.05) where both samples were found to be the highest oxidation rate in broiler chicken meat (P<0.05) (Table 4). Interestingly, meat samples from chicken fed with 2% *S. polycystum* in diets showed the lowest oxidation value followed by 2% *K. alvarezii* meat samples with 0.115 and 0.127, respectively. From the results, up to 10% of *S. polycystum* inclusion in diets had improved inhibition of lipid oxidation in meat, as compared to negative control samples and *K. alvarezii* fed broiler chickens. A study reported that *S. polycystum* demonstrated higher antioxidant activity and phenolic compound compared to *K. alvarezii* (Subakir, 2021), which lower TBARS value can be attributed to the antioxidant effect compounds avoid the lipid oxidation that occurs in the meat.

Table 4. Result of TBARS analysis on breast meat of broiler chicken

Samples	TBARS (%)
Control (-ve)	0.175 ± 0.009^{a}
2% *S. polycystum*	0.115 ± 0.004^{d}
5% *S. polycystum*	0.145 ± 0.003^{b}
10% *S. polycystum*	0.133 ± 0.004^{bc}
2% *K. alvarezii*	0.127 ± 0.004^{cd}
5% *K. alvarezii*	0.177 ± 0.012^{a}
10% *K. alvarezii*	0.131 ± 0.000^{bc}
Comm. binder	0.172 ± 0.004^{a}

Values are presented as mean±SD. Values with different superscript within the same column are significantly different (P<0.05).

This result indicated that there is a possibility of active compound interaction in seaweed that had improved the inhibition of lipid oxidation in meat (Honold *et al*., 2016). Additional natural dietary supplements in the feed from antioxidant resources such as plants, soy, herbs and seaweed were reported to improve the broiler weight and reduce the fat content in the meat. These improvements were associated with bioactive compounds that exist in supplementation fed such as polysaccharides and phenolic compounds. Genchev *et al*. (2008) reported dietary supplement content of *Pleurotus ostreatus* reduced the fat content of quail breast by 2.5% which indicates that lower proportions of fat content subsequent to decreased lipid oxidation. In meat industries, synthetic additives such as preservative Butylated hydroxyanisole (BHA) and Butylated hydroxytoluene (BHT) were used to reduce this oxidative process, however, there is dubious health effect on the synthetic preservative in human health including cancer (Poljsak *et al*., 2013). Thus, potential dietary supplements such as natural antioxidants may improve the characteristics of the physicochemical, sensory and technological properties of meat.

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3.2 Sensory evaluation

Sensory evaluation was done at the Universiti Malaysia Pahang (Figure 2). The scores given by panellists for the sensory characteristics (colour, odour, taste and overall acceptance) of breast meat are presented in Table 5.

Figure 2. Sensory evaluation conducted among students at the Universiti Malaysia Pahang.

The result of sensory attributes (colour and taste) on breast meat was significantly different among treatments (P<0.05). The different levels and species of *K. alvarezii* and *S. polycystum* powder concentration were found to affect the sensory attributes, specifically in the colour and taste of meat. This study showed that colour was the highest score from the feed with commercial binder and increasing seaweed concentration from 2-10% had increased the colour score of chicken meat samples. In general, visual assessments play a role in determining the customer's preference for a product. Colour is a major indicator in meat quality evaluation (Bell and Weaver, 2002) which will influence overall consumer acceptance. The similar colour of the breast meat from this study was an indicator that seaweed did not convey abnormal colour to the meat.

However, a low TBARS value of 2% *S. polycystum* did not show a better effect on the taste score of meat samples. The taste score of breast meat samples with 2% *S. polycystum* was the lowest among treatments and the highest was from the feed with 5% red seaweed *K. alvarezii*. The less taste score of *S. polycystum* treatment was in agreement with a previous study conducted on brown algae (*Lamina japonica*) in sausages (Kim *et al*., 2010). Moreover, this indicated that as a comparison towards control treatment, either *S. polycystum* or *K. alvarezii* powder inclusion does not affect the taste of meat as tested by the panellist.

Another important sensory factor in consumer perception is odour. Salmon *et al.* (1984) demonstrated that the addition of fish meals in a broiler diet caused detrimental odour in the cooked meat. From the results, our study showed that the highest mean odour score was found from *K. alvarezii* 10% diet (3.63%) and the lowest was from broiler chicken fed without seaweeds (control diet) with 3.25%. The result also indicated that meat samples from treatment with brown seaweed (5% *S. polycystum*) showed better acceptability on odour than the control treatment.

In overall acceptance, there was no significant difference (P>0.05) detected among treatments. *K. alvarezii* 5% diet was considered the most acceptable for panellists while *S. polycystum* 2% diet has received the lowest mean score (3.38%). The data presented that the diets formulated with *S. polycystum* 2% lead to a decrease in sensory quality in breast meat, where the values were seen as the lowest in all sensory attributes, except for odour (P>0.05). However, with the addition of *K. alvarezii* 5% in the diets, the sensory quality of breast meat showed an improvement, particularly in colour and taste (P<0.05). The results of the present study are consistent with those presented before (Haščík *et al*., 2015), where propolis extract supplementation (200 $mg.kg^{-1}$ of feed mixture) led to an improvement in the sensory quality of chicken breast meat. The result also reported that the highest scores for all the sensory attributes were assigned to the meat of broiler chicken fed with *K. alvarezii* and commercial binder, while the lowest scores were from broiler chicken fed with control and *S. polycystum*. The lowest score came from the same

Table 5. Mean score for the sensorial attributes of colour, odour, taste and overall acceptance of the steam breast meat of broiler chickens fed on poultry diet containing different dietary levels of seaweed *S. polycystum* and *K. alvarezii*

Treatments	Parameters			
	Colour	Odour	Taste	Overall acceptance
Control (-ve)	$3.50{\pm}0.82^{ab}$	$3.25{\pm}0.81^{a}$	$3.75{\pm}1.01^{ab}$	$3.55{\pm}0.93^{a}$
2% *S. polycystum*	$3.20{\pm}0.99^{b}$	$3.35{\pm}0.97^{a}$	$3.28{\pm}1.04^{b}$	$3.38{\pm}0.87^{a}$
5% *S. polycystum*	$3.43{\pm}0.75^{ab}$	$3.55{\pm}1.01^{a}$	$3.58{\pm}1.01^{ab}$	$3.70{\pm}0.79^{a}$
10% *S. polycystum*	$3.47{\pm}0.96^{ab}$	$3.48{\pm}0.99^{a}$	$3.45{\pm}1.17^{ab}$	$3.58{\pm}1.13^{a}$
2% *K. alvarezii*	$3.53{\pm}0.88^{ab}$	$3.53{\pm}1.01^{a}$	$3.35{\pm}1.17^{ab}$	$3.53{\pm}0.88^{a}$
5% *K. alvarezii*	$3.60{\pm}0.71^{ab}$	$3.60{\pm}0.87^{a}$	$3.88{\pm}0.88^{a}$	$3.78{\pm}0.73^{a}$
10% *K. alvarezii*	$3.60{\pm}0.93^{ab}$	$3.63{\pm}1.03^{a}$	$3.43{\pm}1.11^{ab}$	$3.63{\pm}0.98^{a}$
Comm. binder	$3.68{\pm}0.86^{a}$	$3.58{\pm}0.96^{a}$	$3.60{\pm}0.98^{ab}$	$3.58{\pm}0.93^{a}$

Values are presented as mean ±SD (n = 40). Values with different superscript within the same column are significantly different (P<0.05).

treatment, *S. polycystum* 2% while the highest mean score on colour and taste were from the commercial binder diet and *K. alvarezii* 5%, respectively. Overall, the breast meat from dietary seaweed *K. alvarezii* and *S. polycystum* had positive effects on sensory acceptability. A similar finding was reported by a few studies where foods with seaweed had better sensory scores for overall acceptability when compared to the control (Kim *et al*., 2010; Choi *et al*., 2012) The results of this study showed that seaweed can be included up to 10% of broiler chicken diet without affecting sensory acceptance on the meat.

4. Conclusion

Overall, the chicken fed with *K. alvarezii* and *S. polycystum* had positive effects on sensory acceptability and demonstrated low lipid oxidation in the meat, which was related to higher antioxidant activity and phenolic compounds from seaweeds. Moreover, farmers can add up to 10% of seaweed in broiler feed rations to enhance the meat quality which is also able to increase the marketability of seaweeds in animal feed.

Conflict of interest

The author strongly confirms that this research was conducted with no conflict of interest.

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