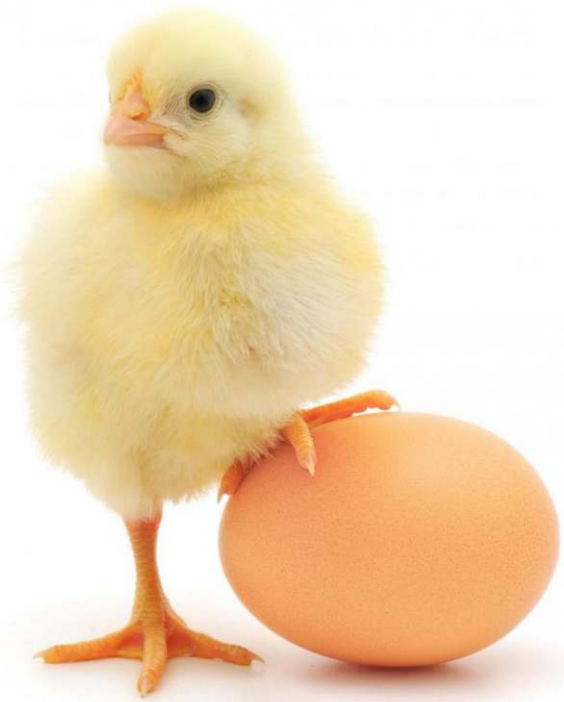
ISSN 1682-8356
ansinet.org/ijps



INTERNATIONAL JOURNAL OF POULTRY SCIENCE

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorijps@gmail.com

OPEN ACCESS International Journal of Poultry Science

ISSN 1682-8356
DOI: 10.3923/ijps.2018.221.228

Research Article
Mao Pomace on Carcass and Meat Quality of Broiler

Kanda Lokaewmanee and Panward Promdee

Faculty of Natural Resources and Agro-Industry, Kasetsart University, Chalermphrakiat Sakon Nakhon Province Campus, Bangkok, Thailand

Abstract

Objective: This study was conducted to determine the effect of mao pomace on the carcass and meat quality of broiler chickens. **Methodology:** The sample was divided into 4 groups, with 4 replicates of 25 chicks each. The chicks were provided *ad libitum* access to a diet consisting of 0% mao pomace (CON), 0.5% mao pomace (MPJ1), 1.0% mao pomace (MPJ2) or 1.5% mao pomace (MPJ3). The crude protein and metabolizable energy concentrations of these diets were adjusted to 230 g kg^{-1} CP and 13.40 MJ kg^{-1} ME for the 7-21 days-old chicks and 200 g kg^{-1} CP and 13.40 MJ kg^{-1} ME for the 22-42 days-old chicks, respectively. At 42 days, 15 chicks from each group were slaughtered and carcasses and meat quality were tested. **Results:** Carcass quality was not different among the groups, except for thigh weight with bone and total visceral organ weight, both of which decreased in the MPJ2 and MPJ3 groups. The diet supplemented with mao pomace improved the redness (a*) of the skin and the redness (a*) and yellowness (b*) of the abdominal fat, whereas it reduced the lightness (L*) of the breast meat and the redness (a*) and yellowness (b*) of the breast fillets of male broiler chickens. The shear force of the breast muscle increased in MPJ1, MPJ2 and MPJ3 groups ($p<0.05$). Cooking loss and drip loss were the highest in the MPJ3 group ($p<0.05$). The sensory scores of raw and cooked breast meat were not affected ($p>0.05$) by mao pomace supplementation. In contrast, the tenderness and taste of cooked breast meat were affected, with the highest scores ($p<0.05$) recorded from the MPJ2 group. There were no significant differences ($p>0.05$) in the meat, skin color, odor and overall acceptance of raw chicken breast samples among the CON, MPJ1, MPJ2 and MPJ3 groups. The sensory scores of cooked chicken breast meat for juiciness, flavor, mao odor and overall acceptance were not affected ($p>0.05$) by mao pomace supplementation. However, tenderness and taste were affected, with the highest scores ($p<0.05$) seen in MPJ2. **Conclusion:** Dietary supplementation of MPJ enhanced meat quality.

Key words: Carcass, meat quality, broiler chickens, mao pomace, metabolizing energy

Citation: Kanda Lokaewmanee and Panward Promdee, 2018. Mao pomace on carcass and meat quality of broiler. Int. J. Poult. Sci., 17: 221-228.

Corresponding Author: Kanda Lokaewmanee, Faculty of Natural Resources and Agro-Industry,
Kasetsart University, Chalermphrakiat Sakon Nakhon Province Campus, Bangkok, Thailand Tel: +66-42-725-036 Fax: +66-42-725-037

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

In recent years, the poultry industry has faced increasing demand for poultry meat, which is recognized for low fat and high-value protein content[1]. In the poultry industry, use of antibiotic growth promoters has been a key factor in achieving current broiler growth rates through feed and production efficiency while maintaining acceptable bird health and welfare[2]. This has led researchers to identify suitable poultry feed supplements. Moreover, phytogenic sources to replace antibiotics show promising results not only as antimicrobial agents[3] but also for stimulating antioxidant ability and growth promoter function[4]. Mao (*Antidesma* sp.) is one of many different species of medicinal plant found in Thailand. *Antidesma* sp. is known to people of Northeast Thailand as a medicinal plant[5], resulting in plentiful quantities of mao fruits being used as a raw material for making jelly jam, drinking juice, juice concentrate and even wine[6]. Recently, products such as mao juice and mao wine have become popular in Thailand. Mao pomace is a mixture of mao skins, pulp residue and seeds. Approximately 30-40% of the raw mao weight becomes waste[7]. This by-product is produced as a result of agricultural practices and represents a promising source of bioactive flavonoids, such as catechin, procyanidin B1 and procyanidin B2[6], polyphenols (97.32-130 mg g^{-1} gallic acid equivalents), proanthocyanidin[8] and organic acids such as tartaric acid, malic acid and citric acid[9]. However, wet pomace is considered an environmental problem. Feeding waste products from mao to animals could increase the efficiency of by-product utilization in the feeding system. Lokaewmanee and Sansupha[9] reported that mao pomace from the juice industry contains 2.64% crude protein, 1.44% crude fat, 1.51% ash and 111.24 kcal/100 g. Gunun *et al.*[10] found that mao seeds contain a large amount of plant secondary compounds, especially condensed tannins and also reported that supplementation with mao seed has potential to manipulate rumen fermentation by reducing protozoa. Sirilaophaisan *et al.*[11] suggested that a diet with 0.5% mao pomace could improve the growth performance of cherry valley ducks. Lokaewmanee[12] demonstrated that a diet with 0.5% mao pomace from the wine industry could reduce feed cost per dozen eggs of layer chickens due to an increased egg laying rate. Moreover, Lokaewmanee[13] found that mao pomace from the juice industry, when added to the basal diet of broilers during age 7-14 days, resulted in better viability. There are no reports on the effect of dietary mao pomace on the carcass and meat quality of broiler chickens. Thus, the aim of this study was to investigate the effects of different dietary supplements of mao pomace on the carcass and meat quality of broilers.

Table 1: Chemical composition of mao pomace from juice industry

Chemical analysis	Mao pomace from juice industry
Dry matter (%)	96.01
Crude protein (%)	7.16
Crude fiber (%)	15.95
Crude fat (%)	5.48
Crude ash (%)	3.81
Gross energy (kcal kg^{-1})	4,590.80

MATERIALS AND METHODS

Study site: The present study was performed in November, 2016 on Nakarat Farm, Nakon Panom Province, Thailand.

Preparation of mao pomace from juice industry (MPJ): Mao pomace from the juice industry was collected from the Wanawong Industry plant, Sakon Nakon Province, Thailand. The mao pomace samples were dried in a hot-air oven at 50°C for 2 days and then ground using an electronic grinder and kept at room temperature until mixed with the basal diet. The contents of dry matter, crude protein, crude fiber, crude fat and crude ash were determined according to AOAC[14] and are shown in Table 1.

Birds and experimental design: The experiment was managed in accordance with the guidelines and rules for animal experiments, Kasetsart University, Thailand. A sample of 400 Cobb male broilers with an age range of 7-42 days was used in this study. Male broilers were allocated randomly to four treatment groups containing 100 birds. Each group was distributed into five replicates with 20 birds per replicate. All birds were fed a starter diet from age 7-21 days, followed by a growing diet from 22-42 days. The basal diet was based on corn and soybean meal (Table 2) and was balanced to meet the nutrient requirements for broiler chickens according to NRC[15]. The birds were reared on concrete flooring covered with wood shavings as litter material. The dietary treatments consisted of a basal diet (CON group) and the basal diet supplemented with 0.5, 1.0 or 1.5 g kg^{-1} mao pomace from the juice industry (MPJ1, MPJ2 and MPJ3, respectively). Feeding was carried out twice daily at 07.00:08.00 am and 5.30:6.30 pm. Water was provided *ad libitum*. The light program consisted of 24 h light and birds were reared in open-sided houses with the temperature maintained at 33°C during the rainy season in northeastern Thailand.

Carcass and meat quality measurement: At age 42 days, 15 chicks from each treatment group (three birds/replicate) were slaughtered to determine the carcass and meat quality. Chicks were slaughtered by bleeding the left jugular vein

Table 2: Ingredients and nutrient composition of starter diet and grower diet

Ingredient	Starter diet (7-21 days)	Grower diet (22-42 days)
Maize	513	620
Soybean meal	328	250
Fish meal	61	34
Rice bran oil	64	63
Oyster shell	11	11
Dicalcium phosphate	9	8
Salt	4	4
DL-methionine	2	2
Concentrate mixture[a]	8	8
Nutrient composition (g kg^{-1})		
Crude protein	230	200
Crude fiber	40	40
Crude fat	40	60
Calcium	10	8
Available phosphorus	5	4
ME (MJ kg^{-1})	13.40	13.40

[a]Concentrate mixture including (per kg of diet): trans-retinyl acetate 12,000 IU, cholecalciferol 2,000 IU, DL-α-tocopheryl acetate 12 IU, menadione 1.50 mg, thiamine 1.50 mg, riboflavin 4 mg, pyridoxine 2 mg, cyanocobalamin 15 µg, biotin 0.30 mg, pantothenic acid 10 mg, folic acid 0.5 mg, nicotinic acid 60 mg, copper 6 mg, manganese 60 mg, zinc 60 mg, iron 20 mg, preservative 6.25 mg and feed supplement 25 mg

and their feathers were plucked. The head, viscera and shank were removed. The carcass was left for 1 h to remove excess water and then weighed. The breast, wings, thigh and drumsticks were removed and weighed individually. The visceral organs were carefully excised and weighed individually. The total abdominal fat content was also determined.

Color measurement: Chicken breast meat, breast fillet meat, skin and abdominal fat color were determined according to the CIE (1976) system using the L* a* b* scale, where L* is color brightness or lightness, a* is redness and b* is yellowness. Color measurements were performed at 24 h postmortem, using a CR-310 Chroma Meter (Minolta CR-310, Osaka, Japan). The instrument was calibrated on the CIE LAB color space system using a white calibration plate (Calibration Plate CR-A43, Minolta Cameras). The colorimeter used a D65 illuminant with a standard observer position of 10° and a 1 cm diameter aperture. Color measurements were taken at three locations on each sample and averaged. Averages of the meat surface, skin and abdominal fat were used for statistical analysis.

Drip loss: Fresh samples from the breast muscle at day 0 were individually weighed and recorded as initial weight (W1). The samples were then placed in sealed polyethylene plastic bags, vacuum-sealed and stored in a chiller at 4°C. After 1, 3, 5 and 7 days of storage, the samples were immediately removed from the bags, gently blotted dry and weighed (recorded as W2, the final weight). The percentage of drip loss was calculated and expressed as the percentage of the difference from the initial weight of the sample. The sample weight after 1 and 7 days of storage was divided by the initial weight of the sample using the following Equation:

$$\text{Drip loss}\,(\%) = \frac{\text{W1}-\text{W2}}{\text{W1}} \times 100$$

Cooking loss: Sample cooking and preparation were carried out using a modified method. After 1, 3, 5 and 7 days of storage at -18°C, chicken breast samples were weighed (W1) and defrosted from -18-4°C and then at room temperature (25°C) for approximately 1 h just before the cooking process. Each individual breast muscle was heated at 95°C for approximately 3-5 min resulting in a core temperature of approximately 75°C. Temperature probes were used during cooking to monitor the internal temperature of the meat. Each sample was then lightly dabbed and weighed (W2). Cooking loss was then calculated according to the formula:

$$\text{Cooking loss}\,(\%) = \frac{\text{W1}-\text{W2}}{\text{W1}} \times 100$$

Shear force: The procedure described by Malovrh *et al.*[16] was used to determine shear force measured across muscle fibers using a TA. XT Plus Texture analyzer apparatus (Stable Micro Systems, Surrey, UK) fitted with a 25 kg load cell. A TA-7 Warner-Bratzler shear type blade was used. Chicken breast meat was cut into slices 2.5 cm thick and 2.5 cm wide. The speed of the blade was 2 mm sec^{-1} and the passage of blade through an average breast width was 25 mm. Shear force data were collected and analyzed to obtain the maximum force required to shear through a sample piece.

Sensory analysis: Sensory analysis (n = 30) was conducted to evaluate the acceptability of chicken breast meat from broilers fed diets with or without mao pomace. The panelists consisted of students, staff and faculty at Kasetsart University Chalermphrakiat Sakon Nakhon Province campus, Thailand. Chicken breasts were thawed at 2-4°C for 24 h before sensory testing and were cooked to an internal temperature of 75-77°C. Cooked breasts were then cooled at room temperature for 15 min, cut into 2.5×2.5 cm cubes and kept warm (60-70°C) until panelists evaluated the samples. Random three-digit numbers were assigned to identify the samples. Sample order was randomized to address sampling order bias. Water and unsalted crackers were provided and panelists were asked to expectorate and rinse their mouths between each sample. Each panelist was asked to evaluate coded chicken breast samples from broilers that were fed diets with or without mao pomace for color, flavor, odor, taste and overall acceptability.

Statistical analysis: All data collected were subjected to one-way ANOVA according to the procedure of Steel and Torrie[17]. Significantly different means were separated according to the method of Duncan[18]. Differences between means were analyzed at a significance level of p<0.05 using Tukey's test. The results of the statistical analysis were shown as the Mean±Standard error.

RESULTS AND DISCUSSION

Carcass quality: The dressing percentage, breast, drumsticks and abdominal fat weight were not significantly different among the groups, except for the thigh and total visceral organ weight, which were significantly less in the MPJ3 group (Table 3, p<0.05). The objective of the present study was to determine whether mao pomace added to the diet of broiler chickens would improve the carcass and meat quality. In terms of phytogenic sources, the mechanism for functioning as a growth promoter has not yet been thoroughly investigated, but from previous research[19,20], the growth-promoting effect of phytogenic sources is probably due to antimicrobial activity. This mechanism in mao pomace has not been investigated. In this study, the significantly lower thigh and total visceral organ weights observed in the broilers fed MPJ3 may have had a negative effect on body weight gain. In a previous study, Lokaewmanee[13] indicated that mao pomace had an effect on broiler growth. In addition, previous research indicated that there was a positive effect on growth performance at 0.5 and 1.0% mao pomace[11]. In the present study, the effect on thigh and total visceral organ weights might have been due to the 1.5% concentration of mao pomace fed to the broilers. The study recovered a crude fiber concentration of 15.95%, which was higher than the 14.59% in the previous study[12]. These differences in thigh and total visceral organ weights may be related to the concentration of crude fiber in mao pomace and the concentration of mao pomace in the diet. It is an established fact that as the concentration of mao pomace increases, the crude fiber increases, whereas the crude protein reduces. The results obtained in this study suggest that incorporation of 1.5% mao pomace in the diet of broilers has a negative effect. At a higher level of mao pomace, the balance within the gut environment may have been distorted by nutrient imbalance and improper metabolism.

Meat quality: The color and appearance of fresh meat are presumed to be indicators of quality and freshness. Chicken muscle color is affected by a variety of factors, including age, environment and feed. The color of raw muscle is due to its light-scattering properties and normally ranges from pink to red due to muscle pigments (hemoglobin and myoglobin). One of the important factors affecting meat color is the pH of the meat. Broilers produced by organic methods have a lower pH and a lower water-holding capacity, which may be responsible for producing meat that appears more yellow and less red than broilers produced using a traditional system[21]. The color results from this study for chicken breast and breast fillets muscles are presented in Table 4. Differences in the L* of the breast muscle and a* and b* of the breast fillets muscle were significant (p<0.05) according to mao pomace supplement. The redness (a*) of the skin and abdominal fat and the yellowness (b*) of the abdominal fat were higher in the CON, MPJ2 and MPJ3 groups than in the MPJ1 group, whereas the lightness (L*) of the abdominal fat was higher in the CON group than in the MPJ2 and MPJ3 groups (p<0.05). On the other hand, the redness (a*) and yellowness (b*) of the breast muscle, the lightness (L*) of the breast fillets muscle and the lightness (L*) and yellowness of the skin were not affected (p>0.05). As noted by Hascik *et al.*[21], the chicken

Table 3: Effect of mao pomace from the juice industry on carcass quality of broilers (7-49 days of age, Mean±SE)

	Diet treatment[1]					
	CON	MPJ1	MPJ2	MPJ3	SEM	p-value
Dressing (%)	82.27±0.46	82.83±0.57	82.70±0.54	82.49±1.00	0.35	0.381
Breast weight (%BW)	22.71±1.08	23.71±0.52	23.34±0.36	23.00±0.57	0.35	0.376
Wing weight with bone (%BW)	9.71±0.26	9.52±0.15	9.52±0.16	9.33±0.11	0.08	0.528
Thigh weight with bone (%BW)	14.02±0.29[a]	13.78±0.19[ab]	13.21±0.23[bc]	13.03±0.18[c]	0.23	0.009
Drumsticks weight with bone(%BW)	12.12±0.27	12.37±0.24	12.38±0.22	11.83±0.20	0.02	0.296
Abdominal fat weight (%BW)	2.28±0.38	2.07±0.13	1.99±0.15	1.82±0.16	0.10	0.552
Total visceral organ weight (%BW)	10.76±0.24[a]	10.63±0.23[ab]	10.11±0.19[b]	9.97±0.20[bc]	0.25	0.038

[a,b,c]Means in the same row with different superscripts differ significantly (p<0.05), [1]CON group, basal diet, MPJ1, MPJ2 and MPJ3 group, basal diet containing 0.5, 1.0 and 1.5 g kg^{-1} mao pomace from the juice industry, respectively

Table 4: Effect of mao pomace from the juice industry on color value of chicken breast muscle (Mean±SE)

	Diet treatment[1]					
Parameters	CON	MPJ1	MPJ2	MPJ3	SEM	p-value
Breast						
Lightness (L*)	62.70±0.33[a]	56.39±0.51[c]	58.39±0.96[bc]	59.43±0.86[b]	1.32	0.0001
Redness (a*)	7.03±0.26	5.64±0.42	6.59±0.48	6.05±0.24	0.30	0.0581
Yellowness(b*)	18.93±1.94	21.53±0.84	21.56±0.85	20.57±1.01	0.62	0.3843
Breast fillet						
Lightness (L*)	57.68±0.30	57.93±0.80	57.52±1.22	57.67±0.86	0.08	0.9882
Redness (a*)	7.86±0.27[a]	2.94±0.38[c]	3.10±1.04[bc]	5.20±0.55[b]	1.06	0.0001
Yellowness(b*)	20.10±0.43[a]	14.92±1.38[bc]	11.72±2.12[c]	18.44±0.94[ab]	1.87	0.0006
Skin						
Lightness (L*)	73.02±0.84	71.36±0.82	71.60±0.52	73.20±0.63	0.48	0.1661
Redness (a*)	3.11±0.19[a]	0.78±0.29[b]	2.41±0.55[a]	2.91±0.46[a]	0.53	0.0009
Yellowness(b*)	18.25±0.86	20.07±1.59	20.11±1.31	20.59±1.16	0.52	0.5711
Abdominal fat						
Lightness (L*)	74.10±1.18[a]	72.80±0.72[ab]	71.96±0.49[b]	72.38±0.44[b]	0.67	0.0415
Redness (a*)	3.10±0.43[a]	-1.07±0.11[b]	2.60±0.47[a]	2.08±0.57[a]	0.94	0.0001
Yellowness(b*)	26.06±0.52[a]	3.10±0.43[b]	26.28±0.76[a]	24.00±1.12[a]	2.00	0.0001

[a-c]Means in the same row with different superscripts differ significantly (p<0.05)

Table 5: Effect of mao pomace from the juice industry on shear force value of chicken breast and thigh muscle (Mean±SE)

	Diet treatment[1]					
	CON	MPJ1	MPJ2	MPJ3	SEM	p-value
Breast	29.54±3.19[b]	48.38±6.68[a]	36.92±4.61[a]	49.37±4.08[a]	4.77	0.0172
Thigh	88.66±14.17	74.17±13.36	87.92±13.45	86.31±8.45	3.40	0.5622

[a,b] Means in the same row with different superscripts differ significantly (p<0.05)

breast muscle can be classified according to the color as: Lighter than normal (L*>53), normal (48<L*>53) and darker than normal (L*<48). However, Corzo *et al.*[22] noted that L* has been used as a measure to estimate the incidence of paleness or the pale, soft and exudative condition. Chicken breasts appearing to be normal had CIE L* values of 55 and those appearing to be pale had L* values of 60. Corzo *et al.*[22] also stated that high L* values and low ultimate pH (<5.7) were indicative of broiler breast meat that was pale in color with low water-holding capacity. Since the L* value in the mao pomace supplemented diets and in the control groups in this study exceeded the value of 56, the meat thus might be classified as lighter than normal. According to Goliomytis *et al.*[23], redness (a*) is most favored by consumers and a lower b* value (yellowness) indicates less pale meat. In addition, Hong *et al.*[24], found no differences in the breast or thigh muscle L*, a* or b* values with supplemented oregano, anise essential oils or citrus peel powder. Results of the present study were not in agreement with the findings of Jiang *et al.*[25], who reported that other plant derivatives, including isoflavone compounds, have been shown to affect the color of breast fillets of male broiler chickens. In the present study, although supplementation with mao pomace from the juice industry improved the redness (a*) of the skin and the redness (a*) and yellowness (b*) of the abdominal fat, it also reduced the lightness (L*) of the breast meat and the redness (a*) and yellowness (b*) of the breast fillets of male broiler chickens. This can be interpreted as an indication that supplementation using dietary mao pomace from the juice industry modifies the skin color by increasing the redness (a*) and may be activating mechanisms that modify the pigment distribution in the skin.

Tenderness is one of the most critical quality factors associated with ultimate consumer acceptance of a poultry meat product[26] and can be affected by several factors, including the type of chicken feed used. The impact of mao pomace on meat and carcass quality has been questioned. The Warner-Bratzler shear test results demonstrated that the tested feed additives produced a slight but significant decrease in the textures of the chicken breast and thigh meat in regards to shear force measurements (Table 5). However, none of the supplements caused a significant decrease (p>0.05) in the tenderness of the thigh muscle, whereas mao pomace supplementations increased (p<0.05) the shear force in the breast muscle compared with the control. An increase in the shear force (decreased meat tenderness) was observed in the breast muscle samples with mao pomace supplementation. In addition, the shear force results were more variable within each treatment than among treatments. Chicken meat would be indicated as very tender and would be

Table 6: Effect of mao pomace from the juice industry on cooking loss and drip loss of chicken breast meat during 7 days post-mortem storage (Mean±SE)

	Diet treatment[1]					
	CON	MPJ1	MPJ2	MPJ3	SEM	p-value
Cooking loss (%)						
0	10.05±1.90	9.90±1.07	14.10± 2.66	8.64± 0.70	1.19	0.1761
1	7.90±1.32	12.64±1.50	10.52±2.57	9.97±1.73	0.97	0.3676
3	8.15±0.61^{b}	11.56±0.42^{a}	8.15±0.61^{b}	9.63±0.67^{b}	0.81	0.0014
5	6.70±0.77	8.38±0.60	8.90±0.39	8.61±0.70	0.49	0.0984
7	5.34±0.37^{b}	6.43±0.53^{b}	4.52±0.23^{b}	16.98±2.34^{a}	2.91	0.0010
Drip loss (%)						
1	7.29±0.94	8.88±2.49	9.19±0.31	6.76±1.12	6.53	0.5810
3	9.55±1.23	10.50±1.75	8.64±1.55	7.82±0.63	2.58	0.5508
5	7.45±1.53^{b}	8.67±1.14^{ab}	5.56±0.65^{b}	11.22±1.19^{a}	1.19	0.0199
7	13.16±1.98	12.75±4.07	11.90±1.74	8.93±0.95	0.96	0.6242

[a,b] Means in the same row with different superscripts differ significantly (p<0.05)

Table 7: Effect of mao pomace from the juice industry on sensory score of chicken fed with or without mao pomace (Mean±SE)

	Diet treatment[1]					
	CON	MPJ1	MPJ2	MPJ3	SEM	p-value
Raw chicken breast						
Meat color	3.64±1.22	3.60±1.00	3.44±0.87	3.32±1.14	0.10	0.697
Skin color	3.10±0.86	2.92±1.19	2.84±0.98	2.76±1.23	0.10	0.752
Odor	3.24±0.92	3.44±0.91	3.28±1.10	3.32±0.80	0.09	0.889
Overall acceptance	3.64±0.63	3.56±0.96	3.64±0.91	3.57±0.84	0.14	0.820
Cooked chicken breast						
Tenderness	3.30±0.90^{ab}	2.88±1.12^{b}	3.88±0.92^{a}	3.32±0.85^{ab}	0.21	0.005
Juiciness	3.28±0.93	2.92±0.91	3.36±0.81	3.34±0.82	0.11	0.165
Taste	3.40±0.77^{b}	3.28±0.78^{b}	3.88±0.72^{a}	3.44±0.82^{b}	0.13	0.036
Flavor	3.56±1.04	3.60±0.96	3.84±1.01	3.60±1.02	0.06	0.767
Mao odor	4.00±1.19	3.76±1.20	3.92±1.29	3.88±1.20	0.05	0.918
Overall acceptance	3.56±0.91	3.24±1.01	3.72±0.73	3.44±0.71	0.10	0.246

[a,b]Means in the same row with different superscripts differ significantly (p<0.05) Meat color, 1: Gray, 2: Grayish-yellow, 3: Pale yellow, 4: Quite yellow, 5: Pinkish-yellow skin color, 1: Grayish-yellow with green spots, 2: Grayish-yellow, 3: Pale yellowish-pink, 4: Quite yellowish-pink, 5: Yellowish-pink Odor, 1: Off-odor, 2: Unpleasant, 3: Fair, 4: Good, 5: Pleasant overall acceptance, 1: Unacceptable, 2: Fair, 3: Good, 4: Pleasant, 5: Excellent tenderness, 1: Very tough, 2: Tough, 3: Fair, 4: Good, 5: Excellent juiciness, 1: Very dry, 2: Dry, 3: Fair, 4: Juicy, 5: Very juicy taste, 1: Unacceptable, 2: Quite unacceptable, 3: Fair, 4: Good, 5: Excellent flavor, 1: Unacceptable, 2: Quite unacceptable, 3: Fair, 4: Good, 5: Excellent mao odor, 1: Very strong, 2: Strong, 3: Fair, 4: Mild, 5: None

more acceptable to consumers if the shear force were less than 30 N[27,28]. Rababah *et al.*[29], reported a Warner-Bratzler shear force range from 16.08-22.36 N for cooked chicken breast and irradiation-cooked breast samples, respectively. These results were slightly higher than the results obtained by Malovrh *et al.*[16], who studied the Warner-Bratzler shear force for three chicken genotypes and reported an average force of 21.22 N. Interestingly, the results of the present study demonstrated that mao pomace was effective in improving the tenderness of breast meat.

There were no differences (p>0.05) in cooking loss among the broiler breast meat samples from the mao pomace and control diet treatments for days 1-5 of post-mortem storage (Table 6).The highest cooking loss was found in the MPJ3 group at day 7 post-mortem (p<0.05). Another study with broilers indicated that dietary supplementation of quercetin did not affect cooking loss[23].

There were no differences (p>0.05) in the drip loss among the broiler breast meat samples from the mao pomace and control dietary treatments at days 1, 3 and 7 post-mortem storage (Table 6). The highest drip loss was found in the MPJ3 group at day 5 post-mortem (p<0.05). Similarly, a higher drip loss value in the pectoralis muscle was found after feeding broilers a diet rich in oxidized oil[30]. The drip loss result of the present study was not in agreement with Abdullah *et al.*[31], who demonstrated that the addition of the herb *Borreria latifolia* to the diet of village chickens did not have a significant impact on the drip loss value.

No difference existed (p>0.05) among the attributes of meat and skin color, odor and overall acceptance of raw chicken breast between the CON, MPJ1, MPJ2 and MPJ3 groups (Table 7). Because all treatment samples received the same mean score, it is unlikely that consumers would be able to differentiate between raw broiler breasts and those broilers fed mao pomace. The sensory scores for juiciness, flavor, mao odor and overall acceptance of cooked chicken breast meat were not affected (p>0.05) by mao pomace supplementation. However, tenderness and taste were affected, with the highest (p<0.05) scores recovered from MPJ2. There are many criteria that the consumer uses in purchasing poultry meat, including appearance, taste, flavor, texture, color, tenderness and water-holding capacity, which are included in sensory acceptability to evaluate the meat quality because consumers prefer meat that is juicy, tender and not pale. Poultry meat quality attributes may be affected by several factors such as genotype, rearing conditions and feeding that impact muscle metabolism and chemical composition[32]. However, feeding different levels of mao pomace did not affect the overall acceptability of raw and cooked chicken breast meat. In contrast, feeding broiler chickens a diet involving dietary medicinal herb extract mix enhanced the acceptability of the meat[33]. Feeding different concentrations of the herb mixture did not affect tenderness, juiciness, aroma and palatability of the longissimus muscle of pig[34]. In the present study, adding mao pomace from the juice industry to the diet of male broiler chickens provided a preliminary platform to observe the carcass and meat quality. The current study demonstrated that MPJ increased the redness (a*) of the skin and improved the taste of the cooked chicken breast meat.

CONCLUSION

This study investigated the potential antioxidant activity of dietary supplementation with MPJ on the carcass and meat quality of male broiler chickens. Determining the effect of dietary supplementation of MPJ on the carcass quality indicated a partial, positive impact by enhancing some of the meat quality properties such as redness (a*) of the skin and taste of the cooked chicken breast meat. However, the dietary supplementation with mao pomace did not result in significantly reduced values of L* and b*or in the tenderness of the thigh. Based on the current study results, it can be presumed that dietary supplementation of MPJ plays an important role in enhancing meat quality.

SIGNIFICANCE STATEMENTS

Mao pomace, a by-product of the mao juice industry, is rich in antioxidant content and antioxidant capacity. This study determined that broiler chickens reared on a high dose of mao pomace increased meat quality. These findings will help researchers and poultry producers incorporate mao pomace correctly in their feed formulation.

REFERENCES

1. Soglia, F., J. Gao, M. Mazzoni, E. Puolanne, C. Cavani, M. Petracci and P. Ertbjerg, 2017. Superficial and deep changes of histology, texture and particle size distribution in broiler wooden breast muscle during refrigerated storage. Poult. Sci., 96: 3465-3472.
2. Emami, N.K., A. Daneshmand, S.Z. Naeini, E.N. Graystone and L.J. Broom, 2017. Effects of commercial organic acid blends on male broilers challenged with *E. coli* K88: Performance, microbiology, intestinal morphology and immune response. Poult. Sci., 96: 3254-3263.
3. Wong, S.Y., I.R. Grant, M. Friedman, C.T. Elliott and C. Situ, 2008. Antibacterial activities of naturally occurring compounds against *Mycobacterium avium* subsp. *paratuberculosis*. Applied Environ. Microbiol., 74: 5986-5990.
4. Zeng, Z., S. Zhang, H. Wang and X. Piao, 2015. Essential oil and aromatic plants as feed additives in non-ruminant nutrition: A review. J. Anim. Sci. Biotechnol., 6: 7-16.
5. Roger, B., 2004. History of fruits in the East Asia/Pacific region. Proceedings of the 17th Congress of the Indo-Pacific Prehistory Association, May 19, 2004, Cambridge, Massachusetts, USA.
6. Butkhup, L. and S. Samappito, 2008. An analysis on flavonoids contents in mao luang fruits of fifteen cultivars (*Antidesma bunius*), grown in Northeast Thailand. Pak. J. Biol. Sci., 11: 996-1002.
7. Butkhup, L. and S. Samappito, 2011. Phenolic constituents of extract from mao luang seeds and skin-pulp residue and its antiradical and antimicrobial capacities. J. Food Biochem., 35: 1671-1679.
8. Puangpronpitag, D., P. Areejitranusorn, P. Boonsiri, M. Suttajit and P. Yongvanit, 2008. Antioxidant activities of polyphenolic compounds isolated from *Antidesma thwaitesianum* Mull. Arg. seeds and marcs. J. Food Sci., 73: C648-C653.
9. Lokaewmanee, K. and S. Sansupha, 2015. Nutritive values of mao pomace (Antidesma sp.). Agric. Sci. J., 46: 569-572.
10. Gunun, P., N. Anantasook, M. Wanapat, S. Sirilaophaisan, A. Cherdthong, C. Wachirapakorn and C. Yuangklang, 2014. Effect of Mao (*Antidesma thwaitesianum* Mull. Arg.) seed supplementation on *in vitro* rumen protozoal population and digestibility using a gas production technique. Khon Kaen Agric. J., 42: 47-53.
11. Sirilaophaisan, S., P. Gunun, K. Ampaporn, P. Punyakaew and C. Hongladdaporn, 2015. Effects of mao pomace supplementation on the growth performance of Cherry valley duck. Khon Kaen Agric. J., 43: 386-391.
12. Lokaewmanee, K., 2016. Effects of mao pomace powder as a dietary supplement on the production performance and egg quality in laying hens. Int. J. Poult. Sci., 15: 139-143.
13. Lokaewmanee, K., 2017. Performance and economic evaluation of broilers fed varying dietary levels of Mao Pomace. Asian J. Anim. Vet. Adv., 12: 319-324.

14. AOAC., 1984. Official Method of Analysis. 14th Edn., Association of Official Analytical Chemist, Arlington, Verginia, USA.
15. NRC., 1994. Nutrients Requirement of Poultry. 9th Edn., National Academies Press, Washington, DC., USA.
16. Malovrh, S., K. Hribersek, D. Tercic, M. Volk, B. Zlender, T. Polak and A. Holcman, 2009. Sensory traits of capon meat in three chicken genotypes. Acta Agric. Slovenica, 94: 17-26.
17. Steel, R.R.D. and J.H. Torrie, 1980. Principles and Procedures of Statistics. 3rd Edn., McGraw-Hill International Book Co., London, Pages: 633.
18. Duncan, D.B., 1955. Multiple range and multiple F tests. Biometrics, 11: 1-42.
19. Windisch, W., K. Schedle, C. Plitzner and A. Kroismayr, 2008. Use of phytogenic products as feed additives for swine and poultry. J. Anim. Sci., 86: E140-E148.
20. Hashemi, S.R. and H. Davoodi, 2010. Phytogenics as new class of feed additive in poultry industry. J. Anim. Vet. Adv., 9: 2295-2304.
21. Hascik, P., L. Trembecka, M. Bobko, M. Kacaniova, O. Bucko, J. Tkacova and S. Kunova, 2015. Effect of different feed supplements on selected quality indicators of chicken meat. Potravinarstvo Slovak J. Food Sci., 9: 427-434.
22. Corzo, A., E.T. Moran, Jr., D. Hoehler and A. Lemmell, 2005. Dietary tryptophan need of broiler males from forty-two to fifty-six days of age. Poult. Sci., 84: 226-231.
23. Goliomytis, M., D. Tsoureki, P.E. Simitzis, M.A. Charismiadou, A.L. Hager-Theodorides and S.G. Deligeorgis, 2014. The effects of quercetin dietary supplementation on broiler growth performance, meat quality and oxidative stability. Poult. Sci., 93: 1957-1962.
24. Hong, J.C., T. Steiner, A. Aufy and T.F. Lien, 2012. Effects of supplemental essential oil on growth performance, lipid metabolites and immunity, intestinal characteristics, microbiota and carcass traits in broilers. Livestock Sci., 144: 253-262.
25. Jiang, Z.Y., S.Q. Jiang, Y.C. Lin, P.B. Xi, D.Q. Yu and T.X. Wu, 2007. Effects of soybean isoflavone on growth performance, meat quality and antioxidation in male broilers. Poult. Sci., 86: 1356-1362.
26. Fletcher, D.L., M. Qiao and D.P. Smith, 2000. The relationship of raw broiler breast meat color and pH to cooked meat color and pH. Poult. Sci., 79: 784-788.
27. Corzo, A., M.W. Schilling, R.E. Loar, V. Jackson, S. Kin and V. Radhakrishnan, 2009. The effects of feeding distillers dried grains with solubles on broiler meat quality. Poult. Sci., 88: 432-439.
28. Schilling, M.W., V. Battula, R.E. Loar II, V. Jackson, S. Kin and A. Corzo, 2010. Dietary inclusion level effects of distillers dried grains with solubles on broiler meat quality. Poultry Sci., 89: 752-760.
29. Rababah, T., N.S. Hettiarachchy, S. Eswaranandam, J.F. Meullenet and B. Davis, 2005. Sensory evaluation of irradiated and nonirradiated poultry breast meat infused with plant extracts. J. Food Sci., 70: S228-S235.
30. Zhang, W.G, S. Xiao, E.J. Lee and D.U. Ahn, 2011. Consumption of oxidized oil increases oxidative stress in broilers and affects the quality of breast meat. J. Agric. Food Chem., 59: 969-974.
31. Abdullah, A.Y., K.Z. Mahmoud, B.M. Nusairat and R.I. Qudsieh, 2010. Small intestinal histology, production parameters and meat quality as influenced by dietary supplementation of garlic (*Allium sativum*) in broiler chicks. Italian J. Anim. Sci., Vol. 9. 10.4081/ijas.2010.e80.
32. Meluzzi, A., F. Sirri, C. Castellini, A. Roncarati, P. Melotti and A. Franchini, 2009. Influence of genotype and feeding on chemical composition of organic chicken meat. Italian J. Anim. Sci., 8: 766-768.
33. Jang, A., X.D. Liu, M.H. Shin, B.D. Lee, S.K. Lee, J.H. Lee and C. Jo, 2008. Antioxidative potential of raw breast meat from broiler chicks fed a dietary medicinal herb extract mix. Poult. Sci., 87: 2382-2389.
34. Janz, J.A.M., P.C.H. Morel, B.H.P. Wilkinson and R.W. Purchas, 2007. Preliminary investigation of the effects of low-level dietary inclusion of fragrant essential oils and oleoresins on pig performance and pork quality. Meat Sci., 75: 350-355.