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Original Research Article

Effect of mao (*Antidesma* sp.) pomace supplement on growth performance and economic evaluation of broilers

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ABSTRACT

One means of exploiting the nutritive value of mao pomace is by using it as a concentrate of organic acids in broiler production. Organic acids are chelating agents of minerals to increase the absorption of minerals in the small intestine. This study examined the supplementation level effects of mao pomace (MP) on broiler growth performance and economic evaluation. In total, 288 chicks were divided into 6 treatment groups, with 4 replicates per treatment and 12 birds per replicate. Broilers were fed a basal diet, supplemented with MP at 0, 0.1, 0.2, 0.3, 0.4 or 0.5% level. Compared with the control, feeding 0.5% of MP produced greater body weight gain and productive index at 1-7 d post supplementation ($P<0.05$). Feeding 0.3% of MP decreased feed intake and feed conversion ratio at 15-21 d post supplementation ($P<0.05$). The dietary MP supplementation at level of 0.2% of MP produced greater average daily gain at 29-35 d post supplementation ($P<0.05$). Throughout the experiment, dietary MP supplementation at level of 0.4% decreased body weight gain and productive index while feed conversation ratio increased at 1-35 d post supplementation ($P<0.05$). Moreover, the dietary MP supplementation at levels of 0.4% decreased salable net return and net profits return per bird ($P<0.05$). In conclusion, the results of the present study showed that MP can be used as a good alternative, natural feed additive in broiler diet and feeding 0.5% of MP could beneficially affect the salable net return and net profits return per bird.

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INTRODUCTION

Thai broiler industry in 2017 continued to enjoy favorable export growth and profitable export prices. Thailand's chicken meat production and exports are forecast to further grow in 2018 by 5% response to anticipated growth in export and domestic demand (USDA, 2017). The increase cost of animal feeds and the ban on using antibiotic growth promoters in the poultry industry have lead researchers to focus their attention on non-controversial feedstuffs such as plants as they might contribute to a reduction in feed cost and increase the production and farmer's profitability (Abbas, 2013). Thus, herbs, spices and various plants extracts naturally used by human because of their nutritional value and medicinal effect have been studied to evaluate their contribution to poultry health and feeding (Mmereole, 2010). Mao (*Antidesma* sp.) is one of local fruits in the Northern and the Northeast of Thailand, especially on Phu Phan Mountain, Sakon Nakhon province (Vichasilp *et al.*, 2017). Recently, mao has been processed into various products such as mao juice, mao jam, and mao wine because of its unique taste and its many phytochemicals with antioxidant capacities (Jorjong *et al.*, 2015). There are more than 10 processing plants of mao products in Sakon Nakhon province. Normally, mao processing can produce about 70% of product from raw material, leaving 30% as by-products or waste (called Mao pomace, MP; primarily data from in-house pilot factory). Mao pomace contains catechin, procyanidin B1, procyanidin B2 (Butkhup and Samopiita, 2008), polyphenols (97.32-130 mg g^{-1} gallic acid equivalents), proanthocyanidin (Puangpronpitag *et al.*, 2008) tartaric acid (0.16-0.22 g $100g^{-1}$), malic acid (0.03-0.05 g $100g^{-1}$) and citric acid (0.15-0.43 g $100g^{-1}$) (Lokaewmanee and Sansupha, 2015). Lokaewmanee and Sansupha (2015) 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.*, (2014) 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. Although mao has been developed into many products, by-products such as seeds and marcs are not utilized (Vichasilp *et al.*, 2017). The current research focused on the utilization of waste from mao juice industry as an additive in broiler diets. The results can be used as a guideline for mixing mao pomace at the appropriate level.

MATERIALS AND METHODS

Study site: This study was performed in December, 2017 at Kasetsart University Chalermphrakiat Sakon Nakhon province Campus in Sakon Nakhon province, Thailand.

Preparation of Mao pomace (MP) from Mao juice industry

Mao pomace (MP) was obtained as a waste product from the mao juice industry. MP was collected at the plant of Wanawong Industry, Sakon Nakhon provice, Thailand. MP samples were dried in a hot-air oven at 60 °C for 72 h and then they were ground using an electric grinder (DY 360, Zhengzhou Dying Machine Equipment Co., Ltd., China) and kept at room temperature until mixed with the basal diet.

Birds and experimental design

The experiment was managed in accordance with the guidelines and rules for animal experiments, Kasetsart University, Thailand. A sample of 288 Cobb 500 male broilers was used with an age range of 7-42 d old. Male broilers were allocated randomly to 6 treatments and each group was distributed into 4 replicates with 12 birds per replicates. All birds were fed a starter diet from age 7-21 d and grower diet from age 22-42 d. The basal diet was based on corn and soybean meal (Table 1) and was balance to meet the nutrient requirements for broiler chicken according to NRC (1994). The birds were reared on concrete flooring covered with rice husk as litter material. The dietary treatments consisted of basal diet (control group) and basal diet supplemented with 0.1, 0.2, 0.3, 0.4 or 0.5% MP. Feeding was carried out twice daily between the hours of 07.00-08.00 A.M. and 5.00-6.00 P.M. Feed and water were provided *ad libitum*. The light program consisted of 24 h light and birds were reared in open-sided housed with the temperature maintained at 25.81 °C during the winter season in Northeastern Thailand.

Table 1. Ingredients and nutrient composition of starter diet and grower diet

Ingredients (%)	Starter diet (7-21 d)	Grower diet (22-42 d)
Maize	51.30	62.00
Soybean meal	32.80	25.00
Fish meal	6.10	3.40
Rice bran oil	6.40	6.30
Oyster shell	1.10	1.10
Dicalcium phosphate	0.90	0.90
Salt	0.40	0.40
DL-methionine	0.20	0.20
Concentrate mixture*	0.80	0.80
Nutrient composition		
Crude protein (%)	23.00	20.00
Crude fiber (%)	4.00	4.00
Crude fat (%)	4.00	6.00
Calcium (%)	1.00	0.80
Available phosphorus (%)	0.50	0.40
ME (MJ/kg)	13.40	13.40

*Concentrate mixture include (per kg od diet): Trans-retinaly 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, cyanocobalamine 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 60 mg, preservative 6.25 mg and feed supplement 25 mg

Production performance and economic return measurement

The initial weight of each birds were recorded at the start of the study and subsequently live weight measurements were recorded on a weekly basis (1-7, 8-14, 15-21, 22-28 and 29-35 d post supplementation). The feed intake was determined on a daily basis as the difference between the quantity of feed fed the previous day and the quantity left the next morning. The feed conversion ratio (FCR) was calculated as the ratio of the feed intake over the body weight gain. All pens were checked for survival rate daily. Feed cost per gain (FCG), salable net return (SBR), net profits return per bird (NPR) and return of investment were calculated and compared with the control group (ROI) according to Nopparatmaitree *et al*. (2015).

FCG (Baht/Bird) = FCR x Price of feed (Baht/kg.) x BWG (kg/bird)

SBR (Baht/Bird) = Purchase price live chicken (baht/kg) x Weight of broilers (kg/bird)

NPR (Baht/Bird) = SBR/FCG

ROI (%) = (NPR/FCG) x 100

Data analysis

All data collected were subjected to one-way ANOVA according to the procedure of Steel and Torrie (1980). Significantly different means were separated according to the method of Duncan. Differences between mean were analyzed at a significant level of 0.05 using Tukey's test. The results of the statistical analysis were shown as the mean.

RESULTS AND DISCUSSION

Particle size distribution

Broiler performance is summarized in Table 2. Compared with the control, feeding 0.5% of MP produced greater body weight gain and productive index at 1-7 d post supplementation (*P<0.05*). Feeding 0.3% of MP decreased feed intake and feed conversion ratio at 15-21 d post supplementation (*P<0.05*). The dietary MP supplementation at level of 0.2% of MP produced greater average daily gain at 29-35 d post supplementation (*P<0.05*). Throughout the experiment, dietary MP supplementation at level of 0.4% decreased body weight gain and productive index while feed conversation ratio increased at 1-35 d post supplementation (*P<0.05*). These results showed that viability was not affected by dietary treatments. The results suggested incorporation of MP significantly improved the body weight gain of broiler chickens. The results showed that supplementation with 0.5% MP in the diet for the whole experimental period increased the productive index by 0.004% compared to the basal diet. Sirilaophaisan *et al.* (2015) reported that

Table 2. Effect of mao pomace (MP) supplement on growth performance of broilers

Parameter	Diet treatment*						SEM	P-value
	Control	0.1%	0.2%	0.3%	0.4%	0.5%		
1-7 d post supplementation								
BWG (g/bird)	326.40^{bc}	330.22^{bc}	336.16^{abc}	340.67^{ab}	324.09^{c}	348.88^{a}	2.52	0.02
FI (g/bird)	417.37	430.61	423.22	434.29	423.14	433.64	11.24	0.15
ADG (g/bird/d)	49.41^{ab}	47.17^{ab}	48.02^{ab}	48.66^{ab}	46.29^{b}	49.84^{a}	0.49	0.01
FCR	1.35	1.30	1.25	1.27	1.30	1.24	0.01	0.50
Viability (%)	100.00	100.00	100.00	100.00	100.00	100.00	-	-
PI	348.56^{b}	362.35^{ab}	383.92^{ab}	381.78^{ab}	354.77^{b}	401.09^{a}	13.51	0.01
8-14 d post supplementation								
BWG (g/bird)	478.20^{ab}	461.24^{b}	471.73^{b}	469.77^{b}	490.31^{ab}	514.21^{a}	5.97	0.01
FI (g/bird)	588.38	607.66	591.99	593.78	599.30	588.38	10.43	0.18
ADG (g/bird/d)	68.31^{ab}	65.89^{b}	67.39^{b}	67.11^{b}	70.04^{ab}	73.45^{a}	0.85	0.01
FCR	1.23^{ab}	1.32^{a}	1.25^{ab}	1.26^{ab}	1.22^{ab}	1.16^{b}	0.01	0.01
Viability (%)	100.00	100.00	100.00	100.00	95.83	100.00	1.70	0.44
PI	558.86^{ab}	501.44^{b}	537.49^{b}	531.53^{b}	550.85^{ab}	635.43^{a}	35.52	0.01
15-21 d post supplementation								
BWG (g/bird)	649.14	674.31	636.03	561.33	608.26	618.46	39.91	0.47
FI (g/bird)	1039.00^{a}	1006.40^{a}	1039.00^{a}	627.15^{b}	971.77^{a}	1005.03^{a}	105.59	0.01
ADG (g/bird/d)	92.73^{ab}	96.33^{a}	88.32^{ab}	76.50^{b}	86.89^{ab}	85.60^{ab}	6.27	0.03
FCR	1.60^{a}	1.49^{ab}	1.60^{a}	1.34^{b}	1.59^{a}	1.55^{a}	0.07	0.01
Viability (%)	100.00	97.91	95.83	89.58	100.00	95.83	2.69	0.34
PI	580.28	634.53	545.13	587.94	545.45	547.24	57.18	0.12
22-28 d post supplementation								
BWG (g/bird)	550.33	460.98	550.09	680.68	566.89	581.07	70.97	0.49
FI (g/bird)	873.51	964.39	878.82	899.32	987.79	960.14	56.60	0.16
ADG (g/bird/d)	78.61	79.90	78.58	97.24	90.26	83.01	9.11	0.63
FCR	1.59	1.72	1.62	1.40	1.63	1.64	0.11	0.17
Viability (%)	97.91	91.28	100.00	95.45	90.83	100.00	3.35	0.23
PI	488.90^{ab}	357.24^{b}	499.90^{ab}	739.57^{a}	457.15^{ab}	505.98^{ab}	106.73	0.01
29-35 d post supplementation								
BWG (g/bird)	785.09^{ab}	770.49^{ab}	886.39^{a}	790.20^{a}	678.55^{b}	788.64^{a}	18.84	0.03
FI (g/bird)	1034.80^{ab}	928.69^{b}	1313.20^{a}	1050.90^{ab}	981.74^{ab}	1160.10^{ab}	6.05	0.01
ADG (g/bird/d)	97.37^{b}	110.07^{ab}	122.12^{a}	109.29^{ab}	105.87^{ab}	111.79^{ab}	2.87	0.03
FCR	1.37	1.19	1.45	1.33	1.46	1.44	0.05	0.65
Viability (%)	89.39	100.00	72.92	95.00	71.30	87.50	4.56	0.42
PI	766.21^{ab}	939.44^{a}	843.46^{ab}	865.88^{ab}	521.42^{b}	710.10^{ab}	17.55	0.01
1-35 d post supplementation								
BWG (g/bird)	2837.50^{a}	2826.2^{a}	2853.00^{a}	2853.10^{a}	2502.10^{b}	2880.30^{a}	22.17	0.01
FI (g/bird)	4071.60	4165.20	4757.50	4301.40	4346.60	4158.10	63.58	0.57
ADG (g/Bird/d)	81.07	80.74	81.51	81.43	78.58	82.29	0.63	0.75
FCR	1.43^{b}	1.47^{ab}	1.66^{ab}	1.51^{ab}	1.74^{a}	1.44^{ab}	0.04	0.01
Viability (%)	95.83	93.33	95.83	85.41	87.50	95.83	4.56	0.42
PI	460.61^{A}	483.96^{A}	475.89^{A}	447.67^{A}	252.84^{B}	461.23^{A}	18.77	0.01

^{a,b,c} Mean in the same row with different superscripts differ significantly (p<0.05),*Control group (basal diet), Basal diet supplemented with 0.1, 0.2, 0.3, 0.4, 0.5% mao pomace (MP) from the juice indystry, repectively, BWG:Body weight gain, FI:Feed intake, ADG:Average daily gain, FCR:Feed conversion ratio, PI:Production index.

Chery Valley ducks fed a diet with 0.5% MP increased body weight, body weight gain and productive index compared with 0% MP (*P<0.05*). Lokaewmanee (2017) revealed that broiler chickens fed a diet with 1.0% MP increased their feed intake and feed conversion ratio at 1-7 d post supplementation (*P<0.05*). Mao pomace contains citric acid (0.43 g 100 g^{-1}), tartaric acid (0.33 g 100 g^{-1}) and malic acid (0.05 g 100 g^{-1}) (Lokaewmanee and Sansupha, 2015). Organic acids have been used as alternatives to dietary antibiotics because they compensate for gastric acidification and inhibition of pathogenic bacteria in the gastrointestinal tract of animals (Eftekhari *et al.*, 2015). It is probable that with MP inclusion, there active components of mao pomace were able to create a harmonious gut environment suitable for the release and assimilation of digestive nutrients necessary for promoting bird health. Further studies are needed to explore the effect of MP on small intestinal histology in broilers.

The dietary MP supplementation at levels of 0, 0.1 0.2, 0.3 and 0.5% increased the salable net return while 0 and 0.5% of MP produced the highest net profits return per bird (*P<0.05*) (Table 3). However, dietary MP had no effect on the feed cost per gain (FCG) and return of investment by comparing with the control group (ROI). In contrast, Jongtamklang *et al*. (2013) reported that organic acid supplementation in broiler diet resulted in no effect on salable net return and net profits return per bird (*P>0.05*). However, FCG, salable net return (SBR), net profits return per bird (NPR) and ROI of broilers fed 0.5% MP in the present study increased by 10.80, 0.02, 0.08 and 0.28%, respectively, compared to the 0.5% MP reported by Lokeawmanee (2017). The differences in the economic evaluation of broilers fed MP could have been due to different rearing season.

Table 3. Effect of mao pomace (MP) supplement on economic evaluation of broilers

Parameter	Diet treatment*						SEM	P-value
	Control	0.1%	0.2%	0.3%	0.4%	0.5%		
FCG (baht/bird)	61.07	62.47	71.36	64.52	65.19	62.37	1.63	0.60
SBR (baht/bird)	90.79[a]	90.48[a]	91.29[a]	91.20[a]	80.06[b]	92.17[a]	0.77	0.01
NPR (baht/bird)	29.72[a]	27.96[ab]	19.93[ab]	26.68[ab]	14.86[b]	29.79[a]	2.00	0.01
ROI (%)	49.47	45.58	31.02	44.71	23.07	48.30	4.19	0.29

[a,b,c] Mean in the same row with different superscripts differ significantly (p<0.05),*Control group (basal diet),Basal diet supplemented with 0.1,0.2,0.3,0.4,0.5% mao pomace (MP) from the juice indystry, respectively, FCG:Feed cost per gain, SBR:Salable net return, NPR:Net profits return per bird, ROI:Return of investment

CONCLUSIONS

Supplementation with 0.5% MP in the diet did not have any negative effect on broilers. These results may encourage broiler farmers to include natural feed additive such as MP in broiler diets. However, further studies are needed to improve our knowledge of the effect of MP on small intestinal histology.

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