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Replacement of soybean meal by *Moringa oleifera* leaf meal in broiler diet

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Abstract

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The purpose of this study is to determine the replacement capacity of soybean meal by *Moringa oleifera* leaf meal based on soybean meal crude protein presented in the diet. The trial was conducted by using 450 Luong Phuong broilers, from 15 to 70 days of age, which were divided into 5 treatments, each treatment consisted of 10 birds with 9 replicates. The trial consisted of 5 diet formulas (NT) represented by 5 replacement levels of soybean meal by *M. oleifera* leaf; the replacement was calculated based on the crude protein level of soybean in Luong Phuong broiler diet. The crude protein content of *Moringa oleifera* leaf (P_{MO}) compares to crude protein content of soybean (P_{SB}) in the diets was NT1 (0% P_{MO}: 100% P_{SB}), NT2 (20% P_{MO}: 80% P_{SB}), NT3 (30% P_{MO}: 70% P_{SB}), NT4 (40% P_{MO}: 60% P_{SB}), NT5 (50% P_{MO}: 50% P_{SB}). Birds of 5 treatments were fed in *ad libitum* and all diets had similar metabolic energy and crude protein levels. Result showed that in the replacement rate of 20 and 30% (NT2, NT3), the parameters such as bodyweight gain, FCR, EN index were significantly beter than those of NT1; these parameters in the treatment with replacement rate of 40% (NT4) was similar to that of NT1, and those of the replacement rate of 50% (NT5) were lower than those of NT1. Birds fed with treatments NT2 to NT5 showed some improvement; however, it was not significant compared to birds fed NT1 diet in term of slaughter parameters and meat chemical composition. The carotenoids of the liver and the yellowness colour of the skin in birds of treatments NT2 – NT5 were significantly higher than those of NT1. This can be concluded that protein of soybean meal could be replaced by that of *M. oleifera* leaf meal in broiler diet up to 40%, however, the best achievement was made at the replacement rate of 20 – 30%.

Keywords: replacement; soybean meal; *M. oleifera* leaf meal; broiler chicken
Abbreviations: CF (crude fibre), CP (crude protein), DM (dry matter), EAAI (essential amino acid index), EE (ether extract), EN (economic number), FCR (feed conversion ratio), ME (metabolic energy), NFE (nitrogen free extract), LBW (live bodyweight), P_{MO} (crude protein of *Moringa oleifera* leaf meal), P_{SB} (crude protein of soybean meal)

Introduction

Moringa oleifera is a high biomass yield green fodder; in the first production year, the biomass production yield (ton/ha) can reach 90.21 to 126.1 tons, that of the fresh leaves is 34.89 to 48.77 tons, the leaf dry matter yield can reach 8.07 to 10.4 tons (Nhung et al., 2018). *M. oleifera* leaves are rich in protein and other essential nutrients; the crude protein (CP) content in leaf dry matter (DM) is 32.07 – 35.19%. The essential amino acid index (EAAI) is 87.5 – 93.11%, the total 18 amino acids in the CP from 89.62 – 92.48% (Hien, 2019). The total digestible nutrient of *M oleifera* leaf meal in broiler is remarkable, CP content is 67.97%, Ether extract (EE) is 78.15%, crude fibre (CF) is 25.48%, and Nitrogen Free Extract (NFE) is 72.84% (Hien, et al., 2017a). Metabolic energy of *M oleifera* in broiler is 10.39 MJ/kg DM, which is higher than that of other leaf meals such as *Cassava* leaf meal (9.15 MJ/kg DM), *Leucaena* leaf meal (10.11 MJ/kg DM), *Stylosanthes* grass meal (7.68 MJ/kg DM) (Hien, et al., 2017b). Moreover, *M oleifera* is rich in carotenoids content (780 mg/1kg leaf meal DM) (Hien, 2019). Carotenoids has the positive effect on broiler and layer chickens (Hoan, 2012; Trung, 2016, Hien et al., 2016; Hien et al., 2017c). *M. oleifera* has a high protein content and high EAAI, rich in carotenoids, which is the fundamental input for this study regarding replacement of soybean meal by *M. oleifera* leaf meal in broiler diet.

Materials and Methods

The experiment was carried out on Luong Phuong broiler chickens during a 56-days trial (from 15 to 70 days of age), in which a total of 450 mix male and female chickens were divided into 5 treatments, each treatment consisted of 10 birds with 9 replicates (10 x 9 = 90 birds/treatment). Luong Phuong broiler is a slow growing breed but provides the most flavour meat, which is high preferable in Vietnamese consumers.

The trial consisted of 5 diet formulas (NT) represented by 5 different replacement levels of soybean meal by *M. oleifera* leaf meal which were calculated based on the soybean meal crude protein (CP) content in the diet. The CP content of *Moringa oleifera* leaf meal (P_{MO}) compares to CP content of soybean meal (P_{SB}) in the diets was NT1 (0% P_{MO}: 100% P_{SB}), NT2 (20% P_{MO}: 80% P_{SB}), NT3 (30% P_{MO}: 70% P_{SB}), NT4 (40% P_{MO}: 60% P_{SB}), NT5 (50% P_{MO}: 50% P_{SB}). Hereinafter the formulas were referred to as NT1 (0%), NT2 (20%), NT3 (30%), NT4 (40%) and NT5 (50%).

The diet treatments were formulated from ground maize, rice bran, fish meal, soybean meal, vegetable oil, *M. oleifera* meal and other feed additives. All diet treatments have the similar CP and metabolic energy (ME) content/kg, such as 20% and 12.61 MJ during the starter period (from 15 – 42 days of age) and 18% and 12.78 MJ during finisher period. The chemical composition of all diet treatments is presented in Table 1 and Table 2.

Table 1. Chemical composition of all diet treatments (15 – 42 days)

Categories	Unit	NT1	NT2	NT3	NT4	NT5
ME	MJ/kg	12.60	12.61	12.61	12.60	12.62
CP	%	20.18	20.08	20.07	20.17	20.03
CP (1)	%	*8.11*	*6.54*	*5.75*	*4.97*	*4.14*
CP (2)	%	–	*1.64*	*2.47*	*3.31*	*4.14*
EE	%	5.24	6.03	6.25	6.45	7.04
CF	%	3.44	3.53	3.58	3.66	3.66
Lysine	%	1,19	1.17	1.17	1.17	1.17
Methionine	%	0.47	0.47	0.45	0.48	0.45
Ca	%	1.26	1.32	1.24	1.26	1.30
$P_{av.}$	%	0.46	0.45	0.45	0.46	0.46

Table 2. Chemical composition of all diet treatments (43 – 70 days)

Categories	Unit	NT1	NT2	NT3	NT4	NT5
ME	MJ/kg	12.78	12.78	12.78	12.80	12.78
CP	%	18.23	18.14	18.09	18.07	18.02
CP (1)	%	*8.11*	*6.54*	*5.75*	*4.97*	*4.14*
CP (2)	%	–	*1.64*	*2.47*	*3.31*	*4.14*
EE	%	5.78	6.65	6.97	7.37	7.59
CF	%	3.50	3.59	3.64	3.70	3.75
Lysine	%	1.03	1.00	1.00	1.00	1.00
Methionine	%	0.41	0.42	0.42	0.42	0.42
Ca	%	1.19	1.21	1.23	1.14	1.13
$P_{av.}$	%	0.39	0.40	0.40	0.37	0.37

Note: CP (1) is CP of soybean meal; CP (2) is CP of *M. oleifera* leaf meal

Soybean meal levels in the diets from NT1 to NT5 were: 18.50; 15.00; 13.20; 11.40; 9.50%

M. oleifera leaf meal levels in the diets from NT1 to NT5 were: 0; 5.30; 8.00; 10.70; 13.40%. These levels were applied for both periods (15 – 42 and 43 – 70 days of age)

Birds were accessed to feed and water *ad libitum*, other bird management program were performed similarly in all treatments.

- Monitoring parameters include liveability rate, bird performance traits, feed, slaughter criteria, meat chemical composition and EN index.
- Monitoring procedure:

Bird performance was performed after Doan et al. (2011) and EN index was calculated after Van et al. (2015).

After finished trial, 6 birds (3 males and 3 females) from each treatment were selected for dissection. The dissection was performed after Tien (1993).

Meat chemical composition was analysed after A.O.A.C. (1990). Each parameter was performed 5 times.

The skin yellowness colour was estimated by colour fan from Roche, each treatment 6 birds (3 males and 3 females).

Statistical analysis was performed after Dzung et al. (2018) using Minitab software version 18.1.

Results and Discussion

Livability rate

Birds in all 5 treatments showed well robustness and had a high livability rate, from 96.67 – 97.78%. There was no significant in liveability rate among treatments ($p > 0.05$). This proved that the replacement of soybean meal crude protein (P_{SB}) by *M. oleifera* leaf meal crude protein (P_{MO}) from 20 – 50% had no effect on livability rate. According to Foidl et al. (2001), Donkor et al. (2013), *M. oleifera* did not contain heavy metals, thus, it is safe and did not have any negative effect on poultry liveability rate.

In this experiment, birds fed with diets containing higher levels of P_{MO} showed the smoother feather, more scarlet comb, more skin yellowness colour compare to those fed with lower levels of P_{MO}. Vietnamese consumers prefer that appearance the most.

Growth and retention

Birds were weekly weight; however, Table 3 only illustrates bird weight at 1, 15, 42 and 70 days of age.

The average bodyweight of birds at 42 days of age and their bodyweight gain during 15 to 42 days were the highest in NT2 (20% P_{MO}) treatment. This can be explained that at this replacement rate, *M. oleifera* leaf meal included into diet with least amount (5.3%), this rate of leaf meal was suitable for the broiler chicken during 15 – 42 days of age (Hoan, 2012; Trung, 2016; Hien et al., 2017c). Although the NT3 (30%) treatment containing 8.0% *M. oleifera* leaf meal was not totally suitable for broiler chicken during 15 – 42 days of age, it did not inhibit birds growth, thus, bodyweight and body weight gain of birds fed NT3 (30%) were ranked at second and were similar to those in NT1 (0%). The NT4 and NT5 treatments (40 and 50% P_{MO}) containing *M. oleifera* leaf meal of 10.7 and 13.4% were believed not suitable for broilers during 15 – 42 days of age (Hoan, 2012; Trung, 2016; Hien et al., 2017c) because the higher content of leaf meal in the diets induced the unpleasant odor for the birds which resulted in reduction of feed intake, on the other hand, the higher contents of leaf meal in the diets resulted in higher fibre content which led to reduction of digestion and absoption capacities of nutrients. Therefore, bodyweight and bodyweight gain of birds in NT4 (40%) and NT5 (50%) were ranked at the fourth and the fifth position. Based on statistical analysis of average bodyweight of birds on the 42nd day and their daily bodyweight gain during 15 – 42 days, it was ranked from the highest to the lowest as follows NT2 > NT1 & NT3 > NT4 > NT5 ($p < 0.001$).

The average bodyweight on the 70th day of age and average daily bodyweight gain during 43 – 70 days of birds in all treatments changed compared to the previous phase. The above parameters of birds in NT3 (30%) which were similar to those of birds in NT1 (0%) during the previous phase but then showed higher during the second phase; those

Table 3. Body weight and bodyweight gain of experimental birds

Categories	NT1	NT2	NT3	NT4	NT5	SEM	P
Bodyweight, g/bird							
1 day	40	40	40	40	40	–	–
15 days	196	196	196	196	196	1.160	1.000
42 days	1020^{b}	1073^{a}	1027^{b}	999^{c}	973^{d}	10.689	0.000
70 days	1928^{c}	2059^{a}	2008^{b}	1913^{c}	1861^{d}	19.132	0.000
Bodyweight gain, g/bird/day							
15 – 42 days	29.43^{b}	31.32^{a}	29.68^{b}	28.68^{c}	27.75^{d}	0.346	0.000
43 – 70 days	32.43^{b}	35.21^{a}	35.04^{a}	32.64^{b}	31.71^{c}	0.311	0.000
15 – 70 days	30.93^{c}	33.27^{a}	32.36^{b}	30.66^{c}	29.73^{d}	0.323	0.000

Note: Number with different subscription letter in the same row are significant different ($p < 0.001$)

of NT4 (40%) which were lower during the first phase but then similar to those of birds in NT1 (0%) during the second phase. This can be explained as NT3 (30%) treatment with leaf meal content of 8% in the diet was not suitable during the previous phase but then became suitable during the second phase, that of NT4 (40%) which had leaf meal content of 10.3% in the diet which had resulted in the negative effect during the first phase but then did not have any negative effect during the second phase, it might be that birds had grown older so their digestion and absoption capacities were better, moreover, birds had got used to the leaf meal flavour, thus, had better feed intake. Ranking of bodyweight after statistical analysis can be made as NT2 > NT3 > NT1 & NT4 > NT5 ($p < 0.001$), for the bodyweight gain was NT2 & NT3 > NT1& NT4 > NT5 ($P < 0.001$).

Base on above analysis, the replacement rate of P_{SB} by P_{MO} in broiler diets during 15 – 42 days of age were 20 – 30% (NT2, NT3), that of 43 – 70 days of age were 20 – 40% (NT2, NT3, NT4), which would not negatively affect bird performance.

Several researchers such as Melesse et al. (2011), Alnidawi et al. (2016), Hassan et al. (2016), Ramadan et al. (2017), Voemesse et al. (2018) who also indicated that diet containing *M. oleifera* leaf meal had improved growth of broilers. Regarding the effect of *M. oleifera* leaf meal on chicken growth, it was explained by the authors that: birds fed with diet containing *M. oleifera* meal had declined pH of the gizzard from 0.2 to 1.2 units. Therefore, *M. oleifera* had decreased pH and eliminated the pathogenic microbial development in the gastro intestinal tract and improved nutrients digestion. These findings also revealed that: birds fed with diet containing *M. oleifera* meal had a high serum total protein and albumin contents, this might be due to the enhancement of contractility and contraction time of the gizzard, thus improve nutrients degradation in the diet, moreover, the liver from birds fed with diet containing *M. oleifera* meal also increased protein and albumin synthesis thus improved bodyweight gain.

Feed intake and feed conversion ratio

Feed intake and feed conversion ratio (FCR) were monitored and calculated weekly, however, Table 4 only shows the results of the 2 phases, 15 – 42 and 43 – 70 days of age.

During period of 15 – 42 days, feed intake of birds tended to decrease from NT2 (20%) to NT5 (50%). The reason for this was the replacement rates of P_{SB} by P_{MO} increased from 20% to 50%, thus, the leaf meal contents increased from 5.3% to 13.4%, the higher content of leaf meal in the diet which created pungent odor, that reduced palatability, on the other hand, this was also the begining of the trial period, bird had just aclimatized to the diet containing leaf meal. Pairwise comparision showed that feed intake of NT2 (20%), NT3 (30%) and NT4 (40%) was not significantly different from NT1 (0%) however, that of NT5 (50%) was significantly different from NT1, NT2 and NT3. Therefore, the replacement rate up to 40% P_{SB} by P_{MO} or in other words, inclusion of *M. oleifera* into diet up to 10.7% had not yet reduced feed intake significantly compare to NT1(0%) during 15 – 42 days of the trial. Results from several authors indicated that during younger age, if birds fed with diet containing reasonable leaf meal content then feed intake could be higher than those fed with diet without leaf meal, however, if the leaf meal content was too high, then feed intake would be vice versa (Hoan, 2011; Trung, 2016; Hien et al., 2017c).

The period of 43 – 70 days, feed intake of birds still tended to decrease from NT2 (20%) to NT5 (50%). However, feed intake of birds in NT2 (20%) was not significantly different from NT3 (30%) as it was during the first phase, it was only significantly different from NT4 (40%) and NT5 (50%). Especially, that of NT5 (50%) had insignificant difference compared to NT1 (0%) during this phase. This can be explained that birds had aclimatized with diets containing higher levels of leaf meal, moreover, birds had grown older, thus, they were more capable of digesting and absopting with leaf meal. Other research also reported that the leaf meal content in broiler diet during grower phase and in layer diet can be higher than that of the starter phase without giving negative effect on feed intake (Hoan, 2011; Trung, 2016; Hien et al., 2016; Hien et al., 2017c).

Table 4. Feed intake, feed utilization efficiency, EN index

Categories	NT1	NT2	NT3	NT4	NT5	SEM	P
Feed intake, g/bird/day							
15 – 42 days	65.91^{ab}	66.82^{a}	65.82^{b}	65.07^{bc}	64.36^{c}	0.676	0.000
43 – 70 days	113.26^{bc}	115.04^{a}	114.32^{ab}	113.46^{bc}	112.43^{c}	1.171	0.000
15 – 70 days	89.59^{bc}	90.93^{a}	90.07^{ab}	89.27^{bc}	88.39^{c}	0.924	0.000
FCR, kg Feed/ kg bodyweight gain							
15 – 42 days	2.24^{e}	2.13^{f}	2.22^{d}	2.27^{b}	2.32^{a}	0.012	0.000
43 – 70 days	3.49^{b}	3.27^{c}	3.26^{c}	3.48^{b}	3.55^{a}	0.018	0.000
15 – 70 days	2.90^{b}	2.73^{d}	2.78^{c}	2.91^{b}	2.97^{a}	0.014	0.000
EN index	3.43^{b}	4.06^{a}	3.78^{a}	3.34^{bc}	3.09^{c}	0.216	0.000

Note: Numbers with different subsciption letters in the same row are significant different ($p < 0.001$)

Therefore, replacing P_{SB} by P_{MO} in broiler diet of Luong Phuong breed at 40% (NT4) during 15 – 42 days and 50% (NT5) during 43 – 70 days, the daily feed intake was not significantly different from NT1 (0%) ($p > 0.05$).

During 15 to 42 days, the FCR ranked from the lowest to the highest as follows: NT2 < NT3 < NT1 < NT4 < NT5 ($p < 0.001$). This ranking showed that comparing to NT1(0%) that of NT2 and NT3 < NT1 but that of NT4 and NT5 > NT1 ($p < 0.001$). Therefore, replacement of P_{SB} by P_{MO} at the levels of 20 – 30% had a positive effect on feed utilization, however, when the replacement was made at higher levels (40 – 50%) then there would be negative effect to be seen.

During 43 – 70 days, FCR of birds fed with NT2 and NT3 was still lower than that of NT1(0%), but that of NT4 (40%) was similar to that of NT1 (note that during the previous phase NT4 > NT1), there was only NT5 (50%) higher than NT1 (0%) with statistical significance ($p < 0.001$). Therefore, during 43 – 70 days, replacement of P_{SB} by P_{MO} up to 40% had not yet negatively affected on feed utilization efficiency. Overall calculation data for both phases (15 – 70 days) was also similar to that of 43 – 70 days.

In order to assess the economical efficiency of the diet replacement of P_{SB} by P_{MO} in broiler chickens, the EN was calculated. The results showed that replacement of P_{SB} by P_{MO} at 20 – 30% achieved higher EN index compare to control (NT1, 0%), replacement level of 40% (NT4) had the EN index similar to that of NT1, but when replacement rate was at 50%, the EN index got lower than that of NT1, this difference was significant ($p < 0.001$).

The trial results were supported by several findings, that was when *M. oleifera* meal or its extracted substances added into diet with a suitable level, bird's weight and feed utilization efficiency of the tested coloured feather broilers increased (Melesse et al., 2011; Onu & Aniebo, 2011; Portugaliza & Fernandez, 2012; Voemesse et al., 2018; Shad Mahfuz & Xiang Shu Piao, 2019).

It was explained that birds fed with diet containing *M. oleifera* meal increased robustness, and feed intake, expressed in animal behaviors such as walking, eating, lying down, feather preening (Ramadan et al., 2017). The minerals, iron, calcium, magnesium contents in meat were higher in birds fed with diet containing *M. oleifera* meal, this showed the higher potential of nutrients digestibility, bio-retention and the development stage of birds (Voemesse et al., 2018). Birds fed with diet containing *M. oleifera* meal had significantly decreased uric acid, this means that leaf meal content did not decrease the kidney activity efficiency or this might be a sign to show that *M. oleifera* meal did not have any negative effect on metabolism (Voemesse et al., 2018). Other findings suggested that *M. oleifera* meal had improved digestion of other feed ingredients, which helped birds fully express the natural genetic potential (Gaia, 2005) and improve the gastro intestinal immunity and robustness of young broiler chickens (Yang et al., 2007) thus increase feed utilization efficiency. The most important thing is that *M. oleifera* meal contains rich pigments which have a number of positive effects on animals such as on liveability rate, weight gain, reducing FCR (Hien et al., 2019).

Dissection parameters

Because the average bodyweight of birds in different treatments was not similar, thus, the carcass of dissected birds were different, therefore, the pairwise comparison was performed in carcass percentage per live bodyweight and in percentage of other parameters per carcass. Totally 9 parameters have been recorded, however, only 5 parameters were presented in Table 5.

Data presented in Table 5 showed that the average carcass weight of birds in all treatments ranked from the highest to the lowest which was similar to that of live bodyweight ranking as follows: NT2 > NT3> NT1 & NT4 > NT5 ($p < 0.001$). Carcass weight per live bodyweght tended to decrease slightly from NT2 to NT5; this might due to birds accessed to diets containing higher level of leaf meals tended to develop more feather, that also similar to the development of the gastro-intestinal tract. However, the percentage of carcass per live weight of birds was not significantly different ($p > 0.05$).

The percentage of breast and thigh meat per carcass of birds in NT2 and NT3 was higher than that of birds in NT5 ($p < 0.01$), but that of birds in NT5 (50%) was not significantly different compare to that of birds in NT1 and NT4 ($p > 0.05$). This proved that replacement of P_{SB} by P_{MO} with lower levels had resulted in improvement of breast and thigh meat percentage per carcass, event if the replacement rate

Table 5. Dissection parameters of birds at the 70th day of age

Categories	Unit	NT1	TN2	TN3	TN4	TN5	SEM	P
Carcass	g/bird	1486 ^{c}	1590 ^{a}	1554 ^{b}	1473 ^{c}	1429 ^{d}	13.866	0.000
Carcass/LBW	%	76.80	77.00	77.10	76.70	76.40	0.371	0.059
Breast + thigh meat/ carcass	%	38.84 ^{ab}	39.48 ^{a}	39.46 ^{a}	38.94 ^{ab}	38.62 ^{b}	0.421	0.009
Liver/Carcass	%	2.46	2.43	2.45	2.47	2.48	0.029	0.057
Abdominal fat/ carcass	%	2.63 ^{a}	1.72 ^{b}	1.55 ^{c}	1.36 ^{d}	1.31 ^{e}	0.016	0.000

Note: LBW is live bodyweight; Numbers in the same row with different subscription letters are different significant ($p<0.01$ and $p<0.001$)

at 50% (NT5) it did not negatively affect on this parameter (which was not significantly different comparing to NT1).

The rate of liver per carcass of birds in all treatments was not significantly different ($p > 0.05$), this proved that the replacement of P_{MO} for P_{SB} at lower levels (20%) or higher level (50%) did not affect the liver, the systhezising and excreting organ. This was a good signal when a new feed material was tested at high inclusion level.

The rate of abdominal fat per carcass was decreased when replacement of P_{SB} by P_{MO}, however, this parameter was only differently significant between birds in NT1, NT2 comparing to NT4, NT5. Abdominal fat is not normally used by consumers, however, it required more energy to accumulate in chicken body. Therefore, reduction of abdominal fat is the advantage of diets with inclusion of higher level of leaf meal. Our results was supported by other previous studies such as Hoan (2011); Trung (2016); Hien et al. (2017c).

It can be concluded that, Luong Phuong broiler chickens fed with diet containing the replacement of P_{SB} by P_{MO} from 20 – 50% did not show any different regarding carcass per live weight, breast and thigh meat per carcass, liver per carcass comparing to NT1, but the abdominal fat of the birds from NT2 to NT5 was significantly lower comparing to that of NT1.

Our findings were similar to others' research results such as Zanu et al. (2012), Juniar et al. (2008) whose reports showed no effect of *M. oleifera* meal on carcass percentage and other carcass characteristics. Ayssiwede et al. (2011), Hassan et al. (2016), Ramadan et al. (2017) reported that supplement of *M. oleifera* meal into broiler diet did not have significant effect on carcass percentage, carcass characteristics (Breast meat, thigh) and the internal organs such as the heart, liver, spleen, gizzard and bursa fabracious. However, Voemesse et al. (2018) reported that the weight of these organs such as the heart, liver did not increase, but that of the gizzard and the pancreas gland increased in Isa Brown chickens fed with diet containing *M. oleifera* meal.

Meat chemical composition

The breast and thigh muscles were separately analyzed, however, the tendency regarding meat dry matter and the percentage of protein, lipid in DM were similar among the treatments, thus, the analytical data was combined and presented in Table 6.

Data in Table 6 showed that meat DM tended to decrease and protein in DM tended to increase slightly when the replacement rate of P_{SB} by P_{MO} increased in the diets. However, these differences were not significant ($p > 0.05$) Lipid content in meat decreased when replacement rate of P_{SB} by P_{MO} increased in the diets with significant difference between treatments ($p < 0.001$). The increase of meat DM, protein and the decrease of lipid in meat DM when leaf meal in the diet of broiler chickens increased had also been reported by Hoan (2011); Trung (2016); Hien et al. (2017c).

Carotenoids after being absorbed from feed are accumulated in skin, fat and the liver. Thus, the carotenoids content in the liver and the skin yellowness had the similar tendency, that was the carotenoids content in the liver and the skin yellowness in birds of NT2 to NT5 were significantly higher than that in birds of NT1 ($P < 0.001$). The carotenoids content in the liver of birds in NT4, NT5 were significantly higher than that of birds in NT2, NT3 ($p < 0.001$). The skin yellowness in birds of NT5 was significantly higher than that in birds of NT2 ($P < 0.001$). Our results were also supported by other studies such as Hoan (2011); Trung (2016); Hien et al. (2017c).

Conclusion

The replacement of protein of soybean meal (P_{SB}) by protein of *M. oleifera* (P_{MO}) in Luong Phuong broiler diet with different rates from 0%, 20%, 30%, 40% and 50% has revealed that at the replacement rates of 20 and 30% the growth, FCR, EN index of broilers were better than that of birds fed diet without replacement. Those indices of the NT4(40%) were similar to that of NT1. The other parameters such as carotenoids in the liver, the skin yellowness were also found higher in birds fed with diet replacement. It can be concluded that the protein of soybean meal can be replaced by protein from *M. oleifera* leaf meal up to 40%, but it is recommended that the most suitable replacement should be at 20 – 30%.

Table 6. Meat chemical composition of experimental birds

Category	Unit	NT1	NT2	NT3	NT4	NT5	SEM	P
a, Breast and thigh muscles								
Dry matter	%	24.38	24.27	24.21	24.15	24.04	1.108	0.996
Protein	% DM	21.40	21.43	21.48	21.54	21.56	1.701	0.999
Lipid	% DM	1.88[a]	1.72[b]	1.60[c]	1.47[d]	1.35[e]	0.040	0.000
b, Liver Carotenoids	mg %	0.51[c]	1.15[b]	1.22[b]	1.64[a]	1.78[a]	0.124	0.000
c, Skin yellowness	score	1.60[c]	3.17[b]	3.67[ab]	4.00[a]	4.33[a]	0.658	0.000

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