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Bioscience Research

Print ISSN: 1811-9506 Online ISSN: 2218-3973

Journal by Innovative Scientific Information & Services Network

RESEARCH ARTICLE BIOSCIENCE RESEARCH, 2021 18(SI-2): 272-283. **OPEN ACCESS**

Efficacy of detoxified rubber seed meal (*Hevea brasiliensis*) on growth performance, meat quality and carcass of Japanese Quail (*Coturnix japonica*)

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A 4-weeks feeding trial on 60 tails aged 2-weeks quail was conducted to evaluate the effect of supplementing soybean meal with different levels of processed rubber seed meal in quail's diet on growth performance, meat quality and carcass of quail. Rubber seed was processed into rubber seed meal (RSM) before proximate composition was done prior to diet formulation. Four dietary treatment groups consist of control (0% of RSM), treatment 1(10% of RSM), treatment 2 (20% of RSM) and treatment 3 (30% of RSM) were formulated for feeding experiment in triplicates. Daily feed intake, weekly body weight gain, average daily weight gain and feed conversion ratio were recorded and calculated. 12 quails were slaughtered at day-35 for proximate analysis, meat and liver quality analysis and carcass were conducted. Results showed that nutrient composition for crude protein (CP), crude fibre (CF), fat, nitrogen free extract (NFE), ash content and metabolizable energy (ME) of RSM were 17.62%, 8.26%, 51.01%, 17.98%, 2.09% and 2.79kcal/kg, respectively. No significant differences (p>0.05) on growth performances of quail, colour values of L* (lightness), a* (redness) and b* (yellowness**),** Shear Force, Cooking Loss and Water Holding Capacity, breast meat quail were found among all treatments and control except on carcass yield, drumstick and wing. In conclusion, soybean meal can be replaced with 10%, 20% or 30% of rubber seed meal in quail's diet as all treatments showed no negative impact on growth performance, meat quality and carcass of quail. Further detailed research on effect of supplementing soybean meal with different level processed rubber seed meal in quail's diets is fully recommended.

Keywords: Rubber seed meal, quail, growth performance, meat quality, carcass quality

INTRODUCTION

Quail production and demand for quail meat have slowly increased as quail has a good nutritional value for human consumption. The consumption of quail meat has gained popularity as protein content in quail meat is almost the same as chicken meat (Cardoso et al. 2011). Currently, there is no alternative diet for quail. Alternative protein sources to replace soybean meal are also still limited. Feed costs for quail are about 70-80% of the total cost of production due to inadequate and costly protein sources due to high importation cost. Poultry farmers face challenges in finding the cheapest source of poultry feed to maintain high poultry production. Malaysia is the fifth largest producer and exporter of natural rubber. The availability of rubber seed (*Hevea brasiliensis*) from the plantations (Khatun et al. 2015; Udo et al. 2018) could be an alternative ingredient for animal feed. Rubber seed (*Hevea brasiliensis*) is a non-conventional protein source that is a by-product of the rubber seed industry (Sharma *et al.* 2014). Rubber seed has high anti-nutritional factors and is not commonly used as feed and can be found easily scattered at rubber plantations (Deng et al. 2015). Rubber seed meal may be utilized as an alternative feedstuff for quail as this ingredient is regarded as cheap, readily available and less utilized by both man and industry. However, the use of rubber seed meal as feed is still less popular among industries due to toxic factor such as cyanogenic glucoside in seed which become obstacles in its utilization as a feedstuff (Aguihe et al. 2017). Previous studies in replacing soybean meal using rubber seed meal as rubber seed meal (RSM) shows that RSM has high amino acid contents like arginine, valine and leucine and moderate contents of phenylalanine, threonine and lysine and low content of histidine (Aguihe et al. 2017). However, there is limited information or minimal study of using detoxified RSM in quail feed. This study was done to evaluate the effect of supplementing soybean meal with different level of processed rubber seed meal on growth performance, meat quality and carcass quality of quail

MATERIALS AND METHODS

Ethical Approval

All the procedures performed in this research were approved by Universiti Sultan Zainal Abidin Animal and Plant Research Ethics Committee (UAPREC) under UAPREC/04/009. The study was conducted at Universiti Sultan Zainal Abidin (UniSZA) Tembila Campus at the Universiti livestock farm located in Besut Campus, Kuala Terengganu.

Processing of Rubber Seed into Meal

The rubber seeds were procured from RISDA, Terengganu, Malaysia and processed according to Oluodo et al (2019). All raw seeds were collected fresh and boiled for 15 minutes at 100^{o}C, and seeds were dehusked. Aging trials for rubber seed using different levels of rice husk ask (RHS) were conducted to determine crude protein in each respective levels of RHA (0%, 75%, 90%, 105% and 120%) on seed. After several trials, CP of aged seed according to RHA level were 11% (0-RHA),18.26%(75-RHA), 18.42% (90-RHA),17.77% (105-RHA) and 17.89% (120-RHA). RHA at 90% was chosen as the best method to process rubber seed into RSM as the technique produced the highest crude protein in aged rubbed seed.

Aging of seeds was done with 90% rice husk ash (RHA) for 24 hours. The seeds were washed thoroughly and boiled again for 30 mins at 100^{o}C. After boiling, the seeds were placed in the oven at 40^{o}C for 48 hours according to Fortuna et al. (2015) with minor modification. Seeds were then crushed in a milling machine to produce RSM used in this study.

Experimental design

Sixty tails two weeks old unsexed quails were obtained from a commercial hatchery. Quails were randomly assigned to four treatment groups in a controlled, isolated rearing facility for 21 days period. Quails with an average initial body weight of (98.6 g ± 0.70g) were randomly assigned into 12 groups (5 quails for each group) with three groups were assigned for each treatment. The treatments were fed with different levels of RSM % T1 (10 % RSM), T2 (20 % RSM), T3 (30 % RSM) and basal diet without RSM (control). A continuous lighting system from incandescent lamps was provided throughout the trial. Quails were provided with freshwater at *ad libitum* on a daily basis throughout the experimental period. Daily feed intake, weekly body weight gain, average daily weight gain and feed conversion ratio were recorded and calculated. After the feeding trial has reached 21 days, three quails from each treatment were selected for slaughtering according to Malaysian Protocol for the Halal Meat and Poultry Production MS 1500: 2009. After exsanguination, quails were left to bleed out between 2.5 to 3 min, before the carcasses were put into scalding tank. In the scalding tank, quails were immersed in hot water (50 to 55°C) followed by de-feathering. Internal organs were collected and weights of carcass yield were measured (g), before further analysis on meat quality and proximate analysis of breast meat and liver were conducted.

Experimental Diets

The experimental rations were formulated based on the energy, protein, vitamin and mineral supplementation to meet the nutritional requirements in which water and feed (*ad libitum*) were provided throughout the experiment.

Composition of ingredients and nutritive value of formulated diets are listed in Table 1.

Table 1: Composition of formulated diets for quail

		Treatment		
Ingredient (Kg/100kg)	C (0%)	T1 (10%)	T2 (20%)	T3 (30%)
Maize	47.00	47.00	47.00	47
Wheat pollard	5.5	5.5	5.5	5.5
Palm oil	1.5	1.5	1.5	1.5
Fish meal	4.5	4.5	4.5	4.5
Rubber seed meal	0	3.75	7.5	11.25
Soya bean meal	37.5	33.75	30	26.25
DCP	3	3	3	3
L-lysine	0.25	0.25	0.25	0.25
DL-methionine	0.25	0.25	0.25	0.25
[1]Mineral Premix	0.25	0.25	0.25	0.25
Common Salt	0.25	0.25	0.25	0.25
Total	100	100	100	100

C: diet without rubber seed meal (RSM); T1: diet with 10% RSM; T2: diet with 20% RSM and T3: diet with 30% RSM; [1]Vitamin mineral premix provided (per kg of diet): Vitamin A, 5000 I.U., Vitamin D3 1000,000 I.U., Vitamin E 15,000 mg; Vitamin K3, 100 mg; Vitamin B1, 1,200 mg; Vitamin B2, 2,400 mg Biotin, 32 mg; Vitamin B12, 10 mg; Folic acid, 400 mg; Choline chloride, 120,000 mg; Manganese, 40,000 mg; Iron, 20,000 mg; Zinc 18,000 mg; Copper, 800 mg; Iodine, 620 mg; Cobalt, 100 mg; Selenium 40 mg

Proximate analysis

The proximate composition of rubber seed meal, formulated feeds and breast meat were analysed according to AOAC (2006). The crude protein was based on Kjeldahl method and crude fat was determined by Soxhlet method. Samples were subjected to 550°C overnight for determination of ash while samples were placed at 105°C in an oven until a constant weight is achieved for moisture content. Nitrogen free extract (NFE) and Metabolizable Energy (ME) were also calculated according to the formulas:

NFE = 100 – (Moisture + CP + CF + EE + Ash) - Eq.1
ME = (NFE% x 35) + (EE% x 85) + (CP% x 35) - Eq. 2

Growth performances

Growth performance can be measured through parameter of body weight gain, average daily weight gain, feed intake and feed conversion ratio according to Dauda et al. (2014). The initial body weight of quails was taken before the experiment and the body weight of quails was taken weekly. Body weight gain and average daily weight gain (ADWG) were estimated according to the following formulae:

Body weight gain = (W2−W1) - Eq.3
Average daily weight gain = (W2−W1) / N - Eq.4
where, W2 = final weight, W1 = initial weight, N = number of days taken from initial weight to the present weight.

Feed intake was recorded daily. Feed conversion ratio refers to gain per feed intake and calculated based on formula according to Dauda et al. (2014).

Feed conversion ratio = Feed intake/average daily gain – Eq.5

Carcass Analysis and Meat Quality

The selected quails were slaughtered according to Malaysian Protocol for the Halal Meat and Poultry Production MS 1500: 2009. Quails were fasted for four hours according to Karthika et al. (2016). One quail was selected randomly from each pen of all treatments and culled before scalded in hot water at 63ºC for 3 minutes, followed by defeathering. Internal organs were collected and then weights of carcass yield were measured (g). Breast meat samples of individuals were collected for meat quality and biochemical analysis. Meat quality analysis of quail includes pH, colour, shear force, water holding capacity and cooking loss. pH values of raw breast muscle were determined at 45 min and 24 h *post-mortem* (pH45 min and pH24 h) according to Cheng et al. (2018) with slight modification using a portable waterproof meat pH meter (HI99163, HANNA instruments). Meat colour of breast muscle was assessed at 45 min and 24h by three replications using a chromameter (Konica Minolta CR-400 Chromameter) to determine colour values of L* (lightness), a* (redness) and b* (yellowness) based on CIE-LAB system.

Water holding capacity

Water holding capacity (WHC) was carried out after 24 h *post-mortem* in triplicates as described by Carvalho et al. (2017). Breast muscles of quail were cut into approximately 5 g cube, placed between Whatman No.1 two filter papers and two glass plate with a 5kg weight applied on top of glass plate for 10 mins. The estimation of WHC was determined according to formulae below.

WHC %= 100 – ((Wi –Wf / Wi) x 100) – Eq.6 Where, Wi

= initial weight of the sample (g), Wf= final weight of the sample (g)

Cooking loss

Cooking loss was determined at 24 h *post-mortem* according to Cheng et al. (2018). Approximately 10 g breast muscles were kept in plastic bags and were cooked in water bath at 75°C for 20 min, and subsequently allowed to cool at room temperature. Calculation of cooking loss based on initial muscle weight (g/kg) was according to formulae below.

Cooking loss = (W1 – W2)/W1 X 100 – Eq.7

where, W1= weight of sample before cooked

W2=weight of sample after cooked

Shear Force

Shear force analysis was performed according to Omar et al. (2018) with slight modification. Two adjacent muscle strips 1 cm (width) x 3 cm (length) in the direction of muscle fiber were cut from cooked breast muscle before sheared once. Muscle strips were placed in texture analyser by positioning fibers' directions perpendicular to Warner Bratzler blade using a 30 kg load-cell and down stroke distance of 30.0 mm for shear force determination.

Data Analysis

Results were compared and analysed by using One-way ANOVA (Minitab version 17) to evaluate the significance differences ($p<0.05$) among treatment groups in this study.

RESULTS AND DISCUSSION

Proximate composition

Proximate composition of the experimental (*Hevea brasiliensis*) RSM is shown in Table 2, while the composition of the experiment diets is shown in Table 3.

Table 2: Proximate composition of experimental processed RSM

Proximate composition	Processed RSM	Udo et al. (2018)		
		Raw	Boil	Roast
Crude protein	17.62	23.31	24.60	21.08
Crude fiber	8.26	5.88	4.47	4.95
Fat	51.01	38.47	23.13	32.57
Ash	2.09	3.77	4.68	4.57
NFE	17.98	38.58	37.40	38.73
ME (Kcal/kg)	2.79	2.88	2.32	2.58

Table 3: Nutrient Composition of Feed Samples

Composition	C	T1	T2	T3
CP	23.65	21.28	20.13	20.36
Fat	6.80	9.34	7.90	11.06
CF	2.25	2.99	3.10	3.76
Ash	6.75	6.23	6.19	5.74
Moisture	11.21	10.82	10.62	10.30
NFE	49.34	49.34	53.06	48.78
ME (Kcal/kg)	1.31	1.37	1.34	1.43

CP= crude protein (%); CF= crude fibre (%); C= control containing 0% of RSM in the diet; T1= treatment containing 10% of RSM in the diet; T2= treatment containing 20% of RSM in the diet; T3= treatment containing 30% of RSM in the diet.

Metabolizable energy (ME), crude protein (CP), crude fibre (CF), fat, nitrogen free extract (NFE) and ash contents of RSM were 2.79kcal/kg, 17.62%, 8.26%, 51.01%, 17.98% and 2.09%, respectively. CP of the processed RSM was lower in comparison with CP content in raw, boiled and toasted rubber seed as reported by Udo et al. (2018). CP of 17.62% is lower than the required amount as Retes et al (2019) recommended 26 and 22% CP for male and female quails during the growth production phases. Crude ash was also nearly twice-fold higher than in raw, boiled and toasted rubber seed by Udo et al. (2018). RHA treated RSM shows lower ash indicating lower mineral content in rubber seed treated in 90% RHA. Silica in rice husk ash composites (Udoye et al. 2021) were used to absorb antinutritional content in rubber seeds prior being processed to rubber seed meal as protein source to replace soyabean. Rice husk has an excellent prospective application in immobilization of biocatalysts (Shamsollahi and Partovinia, 2019). The low ash content in treated seed using RHA could be due to silica ability as mineralization precursor (Chen et al. 2021) that absorbed minerals in seeds during the aging process. As investigation of silica deposition in aged seeds was not done in this study, the apoplasm mechanism of RHA in seed is unknown. Metabolic energy of processed seed is similar to the three treatments by Udo et al. (2018) indicating that RHA treated rubber seeds provide similar metabolic energy as potential protein source for quail.

The nutrient composition included crude protein, ether extract, crude fibre, ash and moisture of feed samples on control and different treatments is presented in Table 3. There are no significant differences among treatments for CP. However, control shows a higher percentage value of crude protein as compared to other treatments. This is probably due to no inclusion of rubber seed in the prescribed diet. Control using soybean meal as protein source shows higher CP due to the contribution of higher protein of soybean that amounted up to 38-40% protein (Banaszkiewicz, 2011).

Diets with inclusion of rubber seed meal show higher fat content than control. Control which only has soybean meal has low fat content up to 18-20% (Banaszkiewicz, 2011) while rubber seed meal has high fat content up to 51% as shown in Table 2. Incremental rubber seed meal in diets increased crude fibre content. Crude fibre in soybean meal is much lower than rubber seed meal (Jacob, 2015) has resulted in lowered value of crude fibre in control. Results show that ash and moisture decrease with incremental rubber seed meal. Increase in rubber seed meal may supress the mineral content in diets due to small amount of anti-nutritional nutrients in aged rubber seeds. NFE ranges from 48.78 to 53.06% while no significant differences among treatments are detected.

Growth performances

Feed intake, Body Weight Gained (BWG), Average Daily Weight Gained (ADWG) and Feed Conversion Ratio (FCR) of the growing quails on different dietary treatments are presented in Table 4. Growth performance parameters like feed intake, BWG, ADWG and FCR of quails did not show any significant level ($p > 0.05$) at any level of detoxified RSM inclusion. This finding did not conform to a study by Khatun et al (2015) that shows significant differences in BWG, ADWG and FCR among treatments. Khatun et al. (2015) found that the body weight gain of broiler chicken increased when fed with rubber seed meal up to 20% while the lowest body weight gain was found when 40% of rubber seed meal was included in the diet. The physical appearance and health condition were found normal in different dietary groups during the experiment. Observation shows that quails that consumed feeds with RSM inclusion became more hyper as compared to quails that consumed feed free from RSM

. This hyper behaviorism is most probably due to higher metabolic energy in diet (T10, T20 and T30) than control. Another contributing factor to the hyper behaviorism is the effect of higher consumption of feeds by quails in order to meet their body nutritional requirement according to Ahaotu (2018). Although all growth performances parameters show no significant differences among treatments, there is a positive growth pattern of quails with inclusion of RSM that conforms to findings of Aboul-Hassan (2001) and Aboul-Seoud (2008) but differed to Oluodo et al. (2019) who suggested 20% inclusion of rubber seed meal for free range chicken

Table 4: Effects of different dietary levels of RSM on performance of growing quails in 4 weeks feeding trial

Parameter	Treatment				
	C	T1	T2	T3	P-value
BWG(g/b/d)	52.69±20.92[a]	57.69±20.64[a]	61.18±18.05[a]	66.13±25.19[a]	0.466
ADWG (g/b/d)	7.528±2.99[a]	8.157±2.95[a]	8.740±2.58[a]	9.45±3.60[a]	0.466
FI(g/b/d)	36.87±7.92[a]	35.45±7.63[a]	35.64±9.72[a]	36.54±9.93[a]	0.975
FCR	6.14±3.61[a]	5.77±4.89[a]	4.56±2.13[a]	4.62±2.70[a]	0.598

[ab] Means in the same row with different superscripts are significantly different ($p<0.05$)
BWG= Body weight gain; ADWG= average daily weight gain; FI= feed intake; FCR= feed conversion ratio

Lower FCR is preferable in animal dietary where less feed intake provides higher impact on body weight. In this study, FCR of higher inclusion of RSM show lower FCR. Feed intake of quails in this study shows that an increase in value with incremental percentages of rubber seed meal in diets of 10% RSM to 30% RSM.

Carcass Analysis

Japanese quails are not species with high slaughter yield. The carcass composition and carcass yield characteristics of 6-weeks old quail fed with different dietary treatments are shown in Table 5. Drumsticks and wings weights were markedly higher at 10% - 30% RSM inclusion. Increase of muscle weight and enlargement of the drumsticks including wings at relatively higher rubber seed meal incorporated diets, particularly at 10%-30% replacement of soybean meal may indicates the palatability of dietary RSM to quails. Amino acids like aspartic and glutamic acids in RSM that makes up of 0.20kg/kg of % protein (Oyewusi et al. 2007) may have contribute to the palatability and taste characteristics of dietary **RSB(rubber seed meal)**

. This assumption also supports higher muscular growth in higher inclusion included birds, despite heat treatment of the RS to detoxify the toxins in fresh RS. On the other hand, the higher oil contents of RS might be another factor to interfere with the mechanisms of muscle deposition and organ maintenance. This result also showed that, wing and drumstick of quails did daily physical activities as there were increased in muscle size and an increase of pectoral myopathies.

Table 5: Carcass yield of Japanese quails fed a basal diet (control) and 3 diets containing different level of RSM (T10, T20 and T30) for 4 weeks.

Carcass parts	C	T10	T20	T30
Live	345.00±5.00	361.67±17.64	346.67±7.26	348.33±26.03
Carcass	331.67±3.33	350±18.93	341.67±7.26	338.33±23.15
Eviscerated carcass	238.33±8.33	273.33±13.64	270.00±10.00	271.67±14.81
Feather	9.67±2.40	10.00±2.89	7.67±1.45	9.00±3.21
Wing	21.00±0.58[a]	26.00±1.00[b]	24.67±0.33[b]	25.67±0.88[b]
Breast	76.67±4.41	86.67±4.41	80.00±0.00	78.33±6.01
Drumstick	20.67±0.33[a]	26.00±1.00[ab]	25.33±1.33[ab]	26.33±1.76[b]
Thigh	29.00±0.58	33.00±4.58	32.33±1.20	31.33±1.33
Feet	6.67±0.33	7.00±0.00	6.67±0.33	8.33±0.88
Head	18.67±1.45	21.67±1.45	23.67±0.88	20.33±2.33
Neck	6.00±1.53	7.00±0.58	8.67±0.67	5.67±0.33
Heart	2.28±0.11	2.71±0.36	3.43±0.30	3.15±0.08
Gizzard	6.00±0.58	7.38±0.31	6.33±0.67	6.33±0.89
Empty gizzard	3.78±0.40	5.08±0.08	4.41±0.41	4.76±0.39
Proventriculus	1.80±0.12	2.00±0.12	1.78±0.15	1.97±0.15
Liver	7.00±1.00	8.33±1.45	6.67±0.33	5.67±1.20
Small Intestine	8.67±0.33	8.33±0.67	8.00±0.58	8.33±0.67
Large Intestine	1.29±0.15	1.77±0.15	1.83±0.44	1.50±0.29
Spleen	0.43±0.04	0.33±0.09	0.30±0.06	0.43±0.07

[ab] Means in the same row with different superscripts are significantly different ($p<0.05$)

Meat Quality

Meat quality of breast meat of quail like pH, colour, water holding capacity (press method), cooking loss and shar force on all treatments is presented in Table 6 below. In this study, breast meat of quail showed significant differences ($p< 0.05$) among control and all treatments in pH_{45min} and pH_{24h} value. Even though there were significant differences ($p< 0.05$) among control and all treatments in pH_{45min} and pH_{24h}, pH value of meat quail was valued as normal pH value which is above 5.5 after death. After death, pH of muscle will drop from 7 to 5.5 and it is considered normal pH (Warner, 2017). The pH value in muscle drop after death to 6 or less due to accumulation of lactic acid in the muscle. However, pH_{24h} value after 24 hrs in all treatments were slightly higher than values in $pH_{45min.}$ The increase of pH within 24 hrs postmortem could be due to quail's efficient growth ability as a fast-growing avian as compared to chicken or duck. This observation supports a study by Huo et al. (2021) that observed a higher pH_{24h} in muscles of fast-growing duck like Cherry Valley duck compared to pH_{24h} in breast of Liancheng White ducks and leg muscle of Small-sized Beijing ducks, both categorized as slow-growing ducks due to higher protein and collagen content in breast of Liancheng White ducks and the leg muscle of Small-sized Beijing ducks respectively.

A study on the relationship between meat quality characteristics and nutritional composition of Nandanam Quail-III slaughtered at different ages showed that the result of pH value for young quail at aged of 5 weeks was 6.65 (Ilavarasan et al. 2016). According to Narinc et al. (2013), the pH value of breast meat of quail after 24 hours *post-mortem* at average of 5.94. Storage conditions of quail muscles may also have contributed to differences of pH for 45min and 24hrs. Physicochemical properties like pH in quail meat may have increased due to extended storage period within 24 hours postmortem after slaughter that is in line with a study by Marcinkowska-Lesiak et al (2016) that observed positive effect of cold-storage time on pH value on chicken meat quality.

In general, broiler chicken meat with pH value after 24 hours *post-mortem* in between 5.7 and 6.1 which considered as normal pH value and did not reveal any quality problem (Zhang et al. 2005; Narinc et al. 2013)

As the results of pH value of meat quail after 24 hours *post-mortem* were in between 5.85 and 6.08, it can still be considered normal pH in meat quail. The results showed that T2 had no significant different ($p>0.05$) with control and T3 but it was significantly lowered in value than T1 in pH_{45min} and pH_{24h}.

The results of colour for breast meat of quail showed there were significant differences ($p<0.05$) in a^*_{45min}, b^*_{45min}, and a^*_{24h} value among control and all treatments but there were no significant differences ($p>0.05$) in L^*_{45min}, L^*_{24h}, and b^*_{24h} value among control and all treatments. The results showed that T2 had no significant different ($p>0.05$) with T1 and T3 but it was significantly higher in value than control in a^*_{45min} and a^*_{24h} value. b* value showed that T2 had no significant different ($p>0.05$) with control and T3 but it was significantly higher in value than T1 in b^*_{45min}

Table 6: Meat quality of quail

Parameter	Treatments				
	C	T1	T2	T3	P-value
pH_{45min}	5.83±0.15^a	6.07±0.14^b	5.76±0.06^a	5.88±0.07^{ab}	0.001
pH_{24h}	5.91±0.15^{ab}	6.08±0.11^b	5.85±0.08^a	5.89±0.06^a	0.007
L^*_{45min}	35.67±5.82^a	34.44±5.93^a	32.40±4.67^a	28.28±5.15^a	0.126
a^*_{45min}	5.73±0.71^a	6.14±1.72^{ab}	8.00±0.77^b	7.25±1.69^{ab}	0.028
b^*_{45min}	3.11±1.58^{ab}	2.65±1.30^a	4.98±0.98^b	3.89±1.76^{ab}	0.053
L^*_{24h}	32.23±6.75^a	31.29±8.03^a	30.23±6.00^a	27.11±5.12^a	0.568
a^*_{24h}	6.07±0.81^a	6.84±0.95^{ab}	8.07±0.94^b	7.01±1.68^{ab}	0.049
b^*_{24h}	4.79±1.51^a	4.38±1.63^a	5.340±1.23^a	4.69±0.95^a	0.669
WHC_p(%)	91.48±2.61^a	95.30±1.50^a	92.33±4.62^a	94.13±3.22^a	0.189
CL (%)	19.72±2.66^a	18.25±3.78^a	20.43±1.96^a	19.15±1.80^a	0.786
WB (Kg)	6.15±0.73^a	8.93±1.95^a	7.27±0.64^a	10.82±3.55^a	0.103

^{ab} Means in the same row with different superscripts are significantly different ($p<0.05$)

. According to the studies conducted on meat quality of broiler chicken, an ideal value of L* should be in between 46 and 53, and meat lower in value than 46 are called dark firm dry (DFD), which had high water holding capacity and short shelf life (Zhang & Barbut, 2005; Narinc et al. 2013). In addition, the meat quail were just like beef, duck and chicken in which it became darker and redder with increasing of aged (Boni et al. 2010). As the quails were slaughtered at aged of 35 days which showed older aged, hence the meat was getting darker when gets older as mentioned by Boni et al. (2010).

Previous study by Imik et al. (2010) on effect of dietary supplementation of some antioxidants on growth performance, carcass composition and breast meat characteristics in quails reared under heat stress was conducted. The Japanese quail was slaughtered at 21 days of age to examine some antioxidant effects, and results of color parameters on the superficialis pectoralis major muscle were 40.07, 12.20, and 3.44, and 41.45, 12.02, and 5.63 in male and female control groups, respectively. In comparison with current finding, it showed that the yellowness value was closer with Imik et al. (2010) finding but higher in lightness and redness value.

Water holding capacity is defined as ability of meat to bind water (Warner, 2017). The result of water holding capacity for breast meat of quail showed that there was no significant different (p>0.05) among control and treated quails. According to Warner (2017), the rate pH fall associated with *post-mortem* anaerobic muscle glycolysis which was major determinants of the WHC of raw meat. Furthermore, there is some loss in percentage of water holding capacity when the pH level of muscle drops from 7 to 5.5 after death. This author also mentioned that meat that known as dark firm dry had high ultimate pH (>5.8) which also had small drop in WHC. Dark firm dry meat did not undergo shrinkage in the myofibrils and muscle cells *post-mortem* and lose less fluid (Warner, 2017). Based on the result in this study and when related with statement of dark firm dry meat, it showed that meat quails had low lightness value, high water holding capacity and low drop of pH value after *post-mortem.*

Cooking loss is defined as a degree of shrinkage of meat during cooking. The result for breast meat of quail showed that there was no significant different (p>0.05) among control and treated group in cooking loss value but T2 showed high in percentage of cooking loss compared to other treatments and control. The result of Warner-Bratzler shear force in this study, described in Table 6, demonstrated that the tenderness of the meat samples were not differ statistically among control and treated quails. The result of WB shear force (kg) for breast meat of quail in this study was in between 6.15 and 10.82. Narinc et al. (2013) reported that WB shear force value in kg for breast meat of quail was 7.75kg in average. However, Le Bihan-Duval et al. (2008) found that average value of WB shear force for breast meat of broiler was 1.48kg which lowered in value compared to Narinc et al. (2013) while Warner-Bratzler shear force of sheep was 12kg (Yousefi et al. 2012; Narinc et al. 2013). Hence, Narinc et al. (2013) concluded that the toughness of quail meat was higher than broiler meat but may be closer to red meat. Table 7 shows the chemical composition of both breast meat and liver of quail.

Table 7: Proximate composition of breast meat of quail

Composition	C	T1	T2	T3	p-value
CP	22.83±0.37^{a}	21.86±0.80^{a}	22.48±0.53^{a}	22.76±0.83^{a}	0.328
Fat	15.27±0.00^{a}	5.426±0.00^{a}	4.44±3.65^{a}	8.85±5.24^{a}	0.441
Ash	1.11±0.143^{a}	0.918±0.41^{a}	1.12±0.31^{a}	1.02±0.0015^{a}	0.852
Moisture	74.019±0.71^{a}	75.005±1.22^{a}	72.26±3.01^{a}	70.54±3.04^{a}	0.155

^{ab} Means in the same row with different superscripts are significantly different (p<0.05

Table 8: Chemical composition for liver of quail

Composition	C	T1	T2	T3	p-value
CP	20.02±1.56[a]	20.61±0.31[a]	21.96±0.093[a]	18.86±2.08[a]	0.262
Fat	36.44±0.00[bc]	0.781± 0.00[a]	17.13±7.57[ab]	45.56±6.69[c]	0.003
Ash	1.670±0.21[a]	1.422±0.048[a]	1.3105±0.098[a]	1.105±0.35[a]	0.200
Moisture	69.15±2.97[a]	70.52±0.60[a]	69.498±1.71[a]	65.54±7.00[a]	0.472

[ab] Means in the same row with different superscripts are significantly different ($p<0.05$)

Proximate analysis of breast meat of quail showed that there were no significant differences ($p>0.05$) among control and all treatments in crude protein, ether extract, ash and moisture contents. In case of percentage of crude protein, the crude protein content increased with incremental of level of rubber seed meal in the treatment. The result of crude protein showed that T3 had the highest composition of crude protein for breast meat of quail.

In case of fat content or ether extract, the result showed that control which did not included any rubber seed meal in the diet had high percentage of fat compared to those treatments that had included rubber seed meal in the diet. In addition, ash content in T2 showed high in percentage compared to other treatments and control.

The result of moisture content showed that it decreased with incremental of percentage of rubber seed meal in the diet.

A previous research on comparison of meat between young quail and spent quail show that the composition of crude protein, ether extract, ash and moisture contents were 18.99%, 9.21%, 1.52% and 68.98% respectively in young quail (age 8 week ± 3 days) (Boni et al. 2010). Hence, the crude protein content of meat quail observed in this study was higher in value compared to Boni et al. (2010) on inclusion of rubber seed meal in diet. In addition, level of moisture in meat of quail was found to be higher than Boni et al. (2010) on young meat of quail. Khatun et al. (2015) reported that crude protein, ether extract and ash in meat broiler were between 24.92% and 26.21%, 7.2% and 9.88%, 4.96% and 5.23% respectively in dry matter basis when supplemented with different level of rubber seed meal in diet. Results from this study also show that crude protein, moisture and ash content of meat conformed to Ilavarasan et al. (2016) on dietary rubber seed meal although lipid content in quail meat was higher.

The chemical composition included crude protein, ether extract, crude fibre, ash and moisture of liver of quail on control and different treatments were presented in Table 8.

In Table 8, the result for chemical composition in liver of quail showed that there were no significant differences ($p>0.05$) among control and all treatments in crude protein, ash and moisture contents. However, there was a significant difference ($p<0.05$) among control and all treatments on lipid contents of quail liver. Percentage of fat also increased with incremental level of rubber seed meal from T1 to T3. The result of fat content in T1 showed had no significant different ($p>0.05$) with T2 but significantly lowered in value compared to control and T3.

Ash and moisture contents decrease with incremental percentage of rubber seed meal from T1 to T3, T3 had low percentages value of protein as compared to control and other treatments. A previous study on the basic information regarding the aspects of nutritional composition of chicken by-products showed that the result of crude protein in liver was 17.70% (Seong et al. 2015). In comparison, this study showed that crude protein were higher in liver of quails fed with rubber seed meal diet. The differences in protein contents could be attributed to type, quantity of proteins and inherent properties that constitute these by-products (Seong et al. 2015).

CONCLUSION

In conclusion, the nutritive composition value of rubber seed meal in crude protein (CP), crude fibre (CF), fat, nitrogen free extract (NFE) and ash contents of RSM were 17.62%, 8.26%, 51.01%, 17.98% and 2.09%, respectively. In addition, soybean meal can be replaced with 10%, 20% or 30% of rubber seed meal in the diet as there are no significant differences all treatments for growth performance. In addition, positive growth performances in all treatments were obtained too. Meat quality and carcass yield of quails were acceptable with the inclusion of rubber seed as a diet. The study suggests that inclusion of detoxified RSM up to 30% dietary levels can be used as growth promoter in Japanese quail diets without serious adverse effects.

CONFLICT OF INTEREST

Authors declared no conflict of interest.

ACKNOWLEGEMENT

This study was partially funded by Akuajaya Enterprise, Sabah, Malaysia. Thanks are due to all involved workers and organizations (FBIM, UniSZA, Terengganu; Ong Chuan Hin Rice Milling Sdn. Bhd, Kedah; LIGS, Sabah, RISDA Semaian Negeri, Terengganu).

AUTHOR CONTRIBUTIONS

Mokhtar NF and Rosli NA were responsible for the design and conduct of the experiment including laboratory analysis. Oluodo LA was responsible for the statistical analysis of data. Komilus CF took the responsibility of proofreading and correction of the manuscript.

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