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Growth Performance, Carcass Characteristics and Quality Responses of Broiler Fed Red Fruit (*Pandanus conoideus*) Waste

By

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Summary：The red fruit waste (RFW) contains antioxidant effect therefore the objectives of this experiment were to confirm the effects of RFW supplementation on growth performance, carcass characteristics and carcass quality of broiler chicken as an antioxidant. A completely randomized design with five treatments and four replicates was used. Two hundred day-old Ross broiler unsexed chicks were divided into five groups and placed in twenty pens (1 m × 1 m × 1 m). The chicks were fed basal diet (contained 19% crude protein and 3200 kcalME/kg) as control (T_0). T_1–T_4 were added 0.5, 1.0, 1.5 and 2.0% RFW, respectively added to T_0. Body weight and feed intake were measured on a weekly basis. At the end of feeding trial, five birds per treatment-replication were slaughtered for analysis of the contents of the carcass. The data were statistically analyzed and described. The results showed that supplementation of RFW did not affect the broiler performance and carcass characteristics. The chicks fed T_3 containing 1.5% RFW showed good tendency in the values of feed conversion, mortality and dressing carcass percentage and were significantly highest ($P<0.05$) in performance index and meat bone ratio. They also produced a total cholesterol lower than others. The protein, fat and gross energy contents in carcass from the chickens given T_4 containing 2.0% RFW were higher compared to other treatments. Addition of RFW up to 2.0% as an antioxidant could increase carotenoid, tocopherol, saturated and unsaturated fatty acid, but did not affect the carcass pH and decreased the tenderness. In sensory properties, panelists preferred the color and smell of carcass from all RFW treatments. In conclusion, RFW in broiler diet contributed positive effects to growth, characteristics and carcass quality, without affecting performance and carcass characteristics.

Key words：red fruit waste, growth, carcass characteristic, quality, broiler

Introduction

Global warming and climate change have various environmental impacts, including on animals. Broiler as an animal is sensitive to fluctuating temperature, caused by climate changes that affect their meat quality in one or two ways. There could be an effect through changing farming or abattoir practice to adapt to climate change, and there could be a direct effect of the changing weather conditions on the animals (GREGORY, 2009). It has been known that modern broiler breeds are more susceptible to heat stress than earlier genotypes. In addition, fast growing strains have lower survival during heat stress (YALCIN *et al.*, 2001). In a warm environment, cell oxidation rate increases, therefore antioxidant agents will be needed to improve broiler performance and its products. One of the antioxidant agents came from plant source, is namely Red Fruit/RF (*Pandanus conoideus*).

The RF is a common tropical fruit in Indonesia, especially in Papua Province. In 2006, the RF production was about

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1,889 tons from 4,518 ha (www.papua.go.id/potensi.php). The Papuan people have started to consume RF in their daily menus or serve as juice. The RF juice is considered a healthy drink since it contains high amounts of antioxidant, probably due to the red pigment characteristic of this fruit. In the processing of making juice the red fruits are pressed and filtered (BUDI and PAIMIN, 2005) and leave a considerable amount of waste. The RF waste (RFW) as by-product of the RF extraction process, is known to contain about 3–5% crude protein, but little is known about whether RF containts anti-nutritional factors that affect man or animals. The RFW form 50–60% of RF, therefore 0.95–1.15 ton is produced per year. Furthermore it is potentially useful in livestock rations as an additive. According to the analysis conducted by Institut Pertanian Bogor (IPB), RF contains a high degree of carotenoid (*β carotene*) and tocopherol (*α tocopherol*), about 70 mg/kg and 10 mg/kg, respectively. Also, the RFW contains other nutrients such as polyunsaturated fatty acids, calcium and iron (BUDI and PAIMIN, 2005 ; SURONO *et al.*, 2008). RFW has been fed to ruminants and non-ruminants for their energy, however little information is known about its nutritive value for poultry.

Seen from the level of compound ingredients of antioxidants as well as fatty acids within the RF, it is rationally understood that RFW utilized as supplementation for poultry diets will be beneficial to raise immunity and growth. With the banning of antibiotics use in poultry diets, it is believed that the antioxidants may be functional in improving the immune status of poultry. This study aimed to examine the effects of RFW supplementation on the growth performance, carcass percentage and carcass quality of broiler chickens.

Materials and Methods

Animal and Diets Treatment

Two hundred day-old Ross broiler unsexed chicks were divided into five groups and placed in twenty pens. Pen size was 1 m × 1 m × 1 m. Each pen was represented a replication. The chicks were fed commercial starter diet (22% CP and 3300 kcalME/kg) for 14 days, followed by respective experimental diets. Basal diet was commercial grower diet (19% CP and 3200 kcalME/kg) as a T_0. T_1 to T_4 were added 0.5%, 1.0%, 1.5% and 2.0 % RFW to T_0, respectively. The chemical analyses of the diet experiments are shown in Table 1. The variations in crude protein and energy were corrected by adding corn and soybean, to maintain similar CP and energy levels to that of the commercial diet. The chicks had *ad libitum* access to diets and water. The chicks were vaccinated against Newcastle disease at 4 and 21 days old and against IBD (gumboro) at 14 days old. The lighting regimes were 20 hours daylight and 4 hours darkness. Body weight and feed intake were recorded on a weekly basis. Index performance was counted by indicator of live weight, feed conversion ratio (FCR), mortality value and day of rearing. At the end of 35 days feeding trial, five birds per treatment-replication were slaughtered according to Moslem Methods and their carcass percentage and carcass quality were determined. The meat-bone ratio was observed after separation of meat from bone of breast, thigh and drumstick of chicks. The meat were wrapped in polyethylene bags and stored at −22℃ until further analysis.

Table 1 Chemical Analysis of the Experimental Diets

Nutrient	Groups				
	T_0	T_1	T_2	T_3	T_4
Dry Matter, %	85.59	85.83	85.93	85.27	84.75
Crude Ash,%	4.62	4.66	4.58	4.78	5.50
Crude Protein, %	19.65	19.81	19.70	19.36	19.32
Crude Fiber, %	4.65	5.14	4.62	5.03	3.51
Ether Extracts,%	5.46	6.75	6.23	6.07	7.34
NFE,%	51.21	49.47	50.80	50.03	49.08
Ca,%	0.53	0.63	0.60	0.55	0.55
P,%	0.90	0.90	0.87	0.89	0.88
EM(kcal/g)	3017	2917	3092	3070	3091

Analysis at Laboratory of Nutritional Science and Feeding, Faculty of Animal Science, Bogor Agricultural University (2009). T_0: basal diet (control), containing of 19% CP; 3200 kcalME/kg. T_1–T_4: basal diet + 0.5%–2.0% RFW , respectively.

Chemical Analysis

Chemical composition of RFW and basal diet was determined based on the method of AOAC (2005). Poly unsaturated fatty acids were analyzed by using gas chromatography (GC), the principle work of which was the same but different from using a volatile component (as gas) (ROOS and SMITH, 2006). The antioxidant and carotenoid of RFW were analyzed by using GC method (LOPEZ-BOTE *et al.*, 1997). In order to analyz carcass quality after thawing, the meat of samples was homogenized using a blender and analyzed for total content of moisture, ash, CP, crude fat and nitrogen free extract in accordance with the AOAC (2005). Gross energy was determined by bomb calorimeter. In order to determine total cholesterol contents of muscles, tissue samples were thawed and extracted with chloroform: methanol as 2 : 1 (BLIGH and DYER, 1959). The total cholesterol levels were then determined enzymatically by the method of ALLAIN *et al.* (1974). Analysis of fatty acids and antioxidant content was conducted using GC method (LOPEZ-BOTE *et al.*, 1997). Qualities of carcass such as pH, tenderness, water holding capacity (WHC), and sensory aspects were measured by pH-meter, Warner-Bratzler shear force test, WHC test (LAWRIE, 1985) and questioner of sensory panel test, respectively. Assessment of the sensory properties was conducted by scoring from 1 to 4 value (1 = not like ; 2 = somewhat like ; 3 = like ; 4 = very like) with about 40 persons, 18–22 years old, male and female. Cooking losses were determined by weighing samples before and after cooking (OBUS and DIKEMAN, 2003).

Statistical Analysis

The data collected on growth and carcass characteristics were analyzed statistically according to the General Linier Model procedure of SAS Software (2005). If there were significant effects, the means of each treatment were compared using Duncans multiple range test (STEEL and TORRIE, 1995). The data collection of carcass quality was analyzed by description.

Results and Discussion

Analysis of RFW and diets

Table 2 shows the chemical composition of RFW and basal diet. The RFW contains 3.11% CP, 0.21% crude fiber, 7.60 % crude fat, 0.91% ash and 11.30% NFE. It shows that the fat content of RFW was considerably high which was shown by the high gross energy content. It is noteworthy to point out that the NFE was similar to that of many fruit wastes, for example guava waste (EL-DEEK *et al.*, 2009) and tomato pomace (KING and ZEIDLER, 2004). These authors showed that fruit wastes of guava and tomato are capable of increasing the antioxidant contents of poultry meat. With a low crude fiber content of less than 1.0%, the RFW can be given in poultry rations at low levels without affecting the crude fiber content. As with tomato pomace (KING and ZEIDLER, 2004) RFW can be a source of pigments for poultry carcass as RFW contains carotenoid and tocopherol, giving benefits including longer shelf life and stable colour of carcasses. It also increases the antioxidant value of food. Further, it was concluded that RFW also contains overfull fatty acids, such as oleic, linoleic, linolenic and palmitoleic acid at 5163 ; 438 ; 201 and 103.3 mg/100 g, respectively.

Growth performance

RFW supplementation did not affect feed consumption, body weight, feed conversion ratio or mortality (Table 3). RFW supplementation up to 2.0% did not provide negative impact on palatability of feeds, so that feed consumption was relatively similar. Also, no anti nutrient substance was found in RFW which could influence consumption and growth of chickens. The chicks fed T_3 contained 1.5% of RFW had high body weight gain among the RFW treatment and FCR similar to T_2 (1.88). The performance index of chicks fed by T_3 was significantly highest 301.6 ($P<0.05$) compared to the other treatments, T_0 289.5, T_1 295.2, T_2 281.5, T_4 261.9, respectively. The performance index of more than 300 indicated that birds were reared in good condition environment and management (BELL and WEAVER, 2002). It was indicated that the active substances contained in RFW had a positive effect to improve feed efficiency so as to produce the best performance index. The analysis showed that RFW contained antioxidants which improve immune function and inhibit the growth of pathogenic microorganisms, especially in the digestive tract. Therefore RFW increased digestive activity, so the absorption of nutrients was better. The mortality of all RFW treatments (2.5%) showed lower than that in the control 7.5% (Table 3). This result indicated that the active substances contained in the RFW (carotenoid, tocopherol and poly unsaturated fatty acid) might increase the resistance of the body against disease.

Carcass Characteristic

Muscle growth is one of the most important factors in poultry meat production (GILLE and SALOMON, 1998). The breast, thigh and drumstick are the components yielding most of the meat and the portions that are mostly consumed (BROADBENT *et al.*, 1981 ; FEARNLEY-WHITTINGSTALL, 2007). Even though it is not a significant ($P>0.05$) effect, the birds fed by 1.5% RFW carcass dressing percentage tendency was high compared to other treatments (Table 3).

Meat bone ratio is also an important index since it predicts the amount of muscle in the whole carcass. The meat bone ratio of this experiment was significantly highest ($P<0.05$) in the group of birds fed by 1.5% RFW compared to the others, as shown in Table 3. It is indicated that even though RFW supplementation produced

Table 2 The chemical composition (% of fresh weight) and total tocopherol and carotenoid contents of RFW and basal diet

Nutrient	RFW	Basal Diet
Dry Matter, %	23.12	85.60
Crude Ash, %	0.91	4.62
Crude Protein, %	3.11	19.65
Crude Fiber, %	0.21	4.65
Crude Fat, %	7.60	5.46
NFE, %	11.3	53.21
Ca, %	0.14	0.53
Phosphorus, %	0.89	0.9
Metabolizable Energy, Kcal/kg	5816	3217
Total carotenoids, mg/kg	70.34	–
Total tocopherols, mg/kg	9.924	–
Oleic acid, mg/100g	5163	–
Linoleic acid, mg/100g	438	–
Linolenic acid, mg/100g	201	–
Palmitoleic acid, mg/100g	103.3	–

Basal diet containing 19% CP: 3200 kcalME/kg

Table 3 The growth performance, feed efficiency, mortality and carcass characteristics of broilers fed RFW

Performance Variables	Groups				
	T_0	T_1	T_2	T_3	T_4
Feed intake (g/bird)	3148.5±275.4	2987.3±117.2	2990.8±138.4	3097.4±105.5	2961.5±128.9
Weight gain (g/bird)	1639.6±200.9	1596.3±117.3	1593.8±167.9	1639.8±70.7	1507.2±95.6
Feed conversion	1.92±0.07	1.87±0.12	1.88±0.16	1.88±0.03	1.96±0.07
Performance Index	289.5±46.4^b	295.2±35.1^b	281.5±42.6^b	301.6±18.0^a	261.9±23.9^c
Mortality (%)	7.5	2.5	2.5	2.5	2.5
Dressing percent (%)	65.,4±1.8	67.5±1.9	65.7±2.3	68.6±1.1	67.5±1.5
Meat born ratio	5.4±0.7^b	5.1±0.3^b	5.3±0.5^b	6.0±0.2^a	5.8±0.2^{ab}

n=40 in the performance parameter. n=5 in the parameter of dressing percentage and meat bone ratio.
T_0: basal diet (control), containing of 19% CP;3200 kcalME/kg. T_1–T_4: basal diet + 0.5%–2.0% RFW , respectively.
^{a,b,c} significantly Difference ($P<0.05$).

similar body weight in all treatments, it has significant effect on the meat bone ratio performance. This means the RFW was beneficial in producing high muscle.

Carcass Quality

Table 4 shows the moisture, crude ash and crude fiber contents of meat in all treatments. The level of protein, fat, and gross energy of T_4 treatment tended to be higher among all treatments, while the level of NFE was in T_3 treatment (6.70%). The total cholesterol content of carcass in T_3 treatment was 41.5% lower compared to the control diet. It is indicated that RFW supplementation could decrease total cholesterol of the carcasses and the meat thus became healthy food for humans.

Fatty acids fed to poultry are absorbed unchanged and deposited in tissues either directly or after metabolic conversion (RICHARDSON and MEAD, 1999). The meat of birds fed RFW had low saturated fatty acids (SFA) compared to the control (Table 5). The lauric of T_2, T_3 dan T_4, and stearic of T_1, T_2 and T_3 were not detectable. This could be because the amount of RFW in the diet was little and value showed was minimal. The content of unsaturated fatty acid (UFA) in RFW treatments had a tendency to increase with the increase in RFW levels in the diet. The linolenic level of control diet was not detectable. The UFA consisted of antioxidant, represented by the carotenoid and tocopherol. Furthermore, the analysis of content of carotenoid and tocopherol in carcasses of control (T_0) and 2.0% RFW (T_4) showed that carcasses of 2.0% RFW treatment contained 0.0541 mg/kg carotenoid and 0.0295 mg/kg tocopherol, whereas in the control treatment there was only 0.0114 mg/kg carotenoid and 0.0137 mg/kg tocopherol compound. The meat of chicks fed 2.0% RFW had more than almost five times total carotenoid, the precursor of vitamin A, compared to the control.

The tocopherol in muscle of chicks fed diets containing 2.0% RFW was 115% more than control. Tocopherol found in RFW is also known to be in the form of natural vitamin E, and also plays an important role as an antioxidant which links with free radicals in the blood vessels, and in the long term will enhance the body immune system. Unsaturated fatty acids, especially n-3 fatty acids are important in maintaining health and are known to reduce blood pressure, reduce incidences of cancer, increase the brain cells of babies and also as antioxidants.

The characteristic of chicken meat is the light taste, because of the oxidative reaction of the microbes. The diet could effect meat flavor and stability (RICHARDSON and MEAD, 1999), and the fatty acid composition is a major determinant of flavor and shelf-life. The time between thawing and the onset of decomposition of material (chicken meat) in isothermal conditions is the oxidative-induction time (OIT). The OIT on T_0 was low (7.80 hours), whereas those on T_1, T_2, T_3, T_4 treatments were 8.39, 8.96, 9.07, 8.43 hours, respectively (Table 6). This result showed that the antioxidant strength at T_3 was high among all treatments. Generally, the content and the strength of antioxidants such as carotenoid and tocopherol increased in all carcasses of RFW treatments, but decreased the content of SFA (Table 5). Thus, this experiment showed that increasing the level of RFW could increase the oxidative-induction time of the carcasses. SURAI and SPARKS (2000) suggested that supplementation of alpha-tocopherol in broiler diets will increase the oxidation stability of carcass which indicated that antioxidants from RFW will improve the oxidation stability of meat, to allow the carcasses more safety after processing.

The physical properties of broiler carcass fed RFW as shown in Table 6, indicated that the pH of carcasses in

Table 4 The value of dry matter,ash, cp, crude fiber, ether extract, nitrogen free extract, gross energy and total cholesterol contents of broiler carcass fed RFW

Nutrient	Groups				
	T_0	T_1	T_2	T_3	T_4
Dry Matter, %	74.6	73.77	75.08	73.86	72.11
Crude Ash,%	1.26	1.56	1.62	1.13	1.64
Crude Protein, %	18.17	18.23	17.57	17.66	19.82
Crude Fiber, %	0.01	0.02	0.64	0.63	1.34
Ether Extracts,%	1.15	0.72	0.64	0.63	1.34
NFE,%	4.81	5.73	5.08	6.70	5.06
Gross Energy, kcal/kg	1660	1466	1623	1680	1896
Total Cholesterol, mg/100g	49.51	47.00	35.98	28.96	30.11

See footnote in Table 3.

Table 5 The value of saturated fatty acid (SFA) and unsaturated fatty acid (UFA) contents of broiler carcass fed RFW (mg/100 g)

	Groups (n=5)				
	T_0	T_1	T_2	T_3	T_4
Saturated fatty acids					
Lauric	192.7	140.5	0	0	0
Miristic	196.4	137.5	107.7	108.2	112.0
Palmitic	356.9	371.0	266.4	134.4	145.6
Stearic	94.0	0	0	0	47.4
Unsaturated fatty acids					
Oleic	168.9	171.8	178.9	194.1	199.1
Linoleic	187.3	189.9	211.2	230.8	274.5
Linolenic	0	67.2	75.8	80.9	100.8

See footnote in Table 3.

Table 6 The oxidative-induction time, physical and organoleptic properties of broiler carcass fed RFW

	Groups (n=5)				
	T_0	T_1	T_2	T_3	T_4
Oxidative-induction time (hour)	7.80	8.39	8.96	9.07	8.43
Physical					
pH	5.02	5.29	5.02	5.36	5.55
Tenderness	2.52	1.13	2.10	1.33	1.27
Cooking loss	34.8	28.9	39.1	29.0	32.6
WHC	56.6	51.9	61.4	50.5	64.1
Organoleptic					
Color	2.90	3.58	3.33	3.90	3.75
Smell	3.25	3.40	3.63	3.55	3.78
Texture	3.74	3.48	2.95	3.23	3.38

See footnote in Table 3.

control and RFW treatments was slightly acid (5.02 to 5.55). Rose (2001) reported that the pH of breast meat after 24 hours is 5.8. In terms of tenderness of carcass, control treatment (2.52) was high, but in T_1 treatment (1.13) was low. The tenderness is the indicator of juices of the meat, and chicken meat is white and more preferable than red meat. Cooking loss of carcass on 1.0% RFW treatment (T_2) tended to be higher than all treatment groups. This value is slightly high than Rose (2001), 23.5%. Water holding capacity (WHC) of carcass on T_4 treatment (2.0% RFW) was high in all RFW treatments. The effect of RFW on sensory properties of the carcass can be seen in Table 6. The result showed that the score of color of carcass in control was small compare to that in RFW treatments. The carcasses did not turn pale and consumers prefer to take the supplemented birds. Nevertheless, the value of smell of RFW carcass tended higher than that of control. This indicated that there were active antioxidant agents in the RFW preventing the oxidative reaction of fatty acids of carcass influencing the odor. Based on panelist assessment, the score of texture of RFW carcasses decreased compared to control, with the lowest value in T_2 treatment (1% RFW) is 2.95.

Conclusion

In conclusion, RFW had good nutritive value for use as a supplement in poultry diets. Supplementation of RFW did not affect the growth performances and carcass characteristics of broiler. The chicks fed by 1.5% RFW showed good tendency in the value of FCR, mortality and dressing carcass percentage and were significantly high ($P<0.05$) in performance index and meat bone ratio. They also produced lower total cholesterol than others. The value of protein, fat, gross energy, antioxidant content (carotenoid and tocopherol), antioxidant strength, saturated and unsaturated fatty acid content of carcass from chicks fed 2.0% RFW tended to be higher than control. In the observation of physical and sensory properties of carcasses, RFW up to 2.0% level did not affect the pH, however, the color and smell of RFW carcass were preferred by the panelists. The present finding suggested that RFW had beneficial effects to improve growth performance, carcass characteristics and carcass quality of broilers.

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ブアメラ（*Pandanus conoideus*）残さを給与したブロイラーの成長，と体性状および肉質について

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要約：本試験はブロイラー雛へのブアメラ残さ（RFW）給与がブロイラーの成長，と体性状および肉質に及ぼす影響について検討することを目的とした。ブアメラはタコノキ科の樹木で約 10 kg になる果実を年 2 回収穫できる。果肉は脂質とカロテノイドに富み，インドネシアでは蒸すか，煮て食している。本試験は 5 試験区，4 群の完全無作為法で実施した。200 羽の雌雄無鑑別ロス系ブロイラーの初生雛を 1 ケージ（1 m×1 m×1 m）に 10 羽ずつの 20 ケージに配分した。対照区（T_0）には粗タンパク質 19%，代謝エネルギー 3200 kcal/kg の基礎飼料を給与し，試験区 1～4 には基礎飼料に RFW を 0.5，1.0，1.5，2.0%添加した飼料を 35 日間給与した。体重と飼料摂取量は毎週測定した。飼育試験終了時に試験群ごとに 5 羽をと殺し，と体分析を行った。得られた成績は統計学的処理を行った。結果として RFW の添加はブロイラーの成長，と体性状に対して影響しなかった。RFW を 1.5%添加した飼料区では飼料要求率，斃死率および枝肉歩留で良好な成績を示し，成長指標の肉骨率においても他の区より有意（$P<0.05$）に高い値を示した。また，総コレステロール値は他の区よりも低かった。RFW 2.0%添加区のブロイラーのと体はタンパク質，脂肪，総エネルギー含量が他の区に比べて最も多かった。RFW を 2.0%まで高めると飼料中のカロテノイド，トコフェロール，飽和及び不飽和脂肪酸を高めることができたが，と体の pH に影響せず，柔らかさにも影響しなかった。官能試験においてパネリストは RFW 添加区の色，香りを好んだ。ブロイラー飼料への RFW の添加は成長，と体性状，肉質に対して悪影響は及ぼさず，むしろ良好な成績を誘発する可能性が示唆された。

キーワード：ブアメラ残さ，成長，と体性状，肉質，ブロイラー

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