



Influence of Cashew Apple (*Anacardium occidentale*) on the Stress Level, Productivity, Organoleptic Property and Profitability of Broiler Chickens

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Abstract

The study aims to determine how feeding dried ground cashew apple pulp (DGCAP) and fermented cashew apple juice (FCAJ) affects the stress level, productivity, organoleptic property and profitability of broiler chickens. A total of 240 day old chicks were used and data was analyzed following 2x4 factorial CRD and significant differences between treatments was analyzed using Scheffe's Test and Friedman's Test. Broilers fed with 50 grams DGCAP significantly reduced the blood cortisol, lipid profile, enhanced the organoleptic property of cooked broiler meat in terms of texture, flavor, tenderness and general acceptability, improved the ADG, weight gain and FCR, and increase net income, income per bird and ROI. Fermented cashew apple showed significant effects on the blood cortisol, blood lipid profile, enhanced all the organoleptic property of cooked meat, increase dressing percentage and reduced abdominal fat pad. Moreover, FCAJ improves the growth rate and feed efficiency, net income, income per bird and ROI. Providing DGCAP and FCAJ significantly improved the blood cortisol and blood lipid profile, ADG, abdominal fat pad, net income, income per bird and ROI. Results suggest that feeding DGCAP and 30ml FCAJ were potential CP, energy and Vitamin supplement and potential alternative and natural feedstuff to reduced feed cost and consequently maximized profit in broiler production.

Keywords: Fermented and dried ground cashew apple, cortisol, ADG, abdominal fat pad, economics

1 Introduction

Broiler is the fastest growing meat type chicken with a body weight of 1.5 – 1.8 kg in 4 weeks and more than 1.9 kg in 5 weeks. However, such growth can only be achieved when quality diet was provided fulfilled the nutrient content that can support rapid growth which is the inherent genetic potential of modern broiler.

In addition, important factor is the implemented feeding practices due to incorporation of various higher input costs of protein source feedstuff like soybean in feeds that has great impacts on animal growth and profitability. Moreover, extreme temperature brought about by climate change is known to have adverse impacts on egg and meat production and quality (6), animal metabolism and behavior, leading to lower feed intake and productivity that can be attributed to heat stress. Problems associated with heat stress could be devastating particularly to smallholders having no access to temperature-controlled housing facilities.

The severity of response of the animal to heat stress may vary depending on its breed, species, physiological and nutritional status, and genetic potential. Though poultry (i.e. chickens) undergo thermoregulatory adaptations during periods of heat stress (6), studies showed that exposure to high ambient temperature could suppress immune system of birds and may lead to death and high mortality rates if coupled with high relative humidity.

Strategy used by some broiler raisers to reduce the negative economic impacts of heat stress is by raising heat stress tolerant breeds and are well-adapted to Philippine climate and inclusion of cashew apple in the feeds that is well-known for its high CP content and other nutrients particularly high ascorbic acid (Vitamin C) of 200mg/100g and glutamic acid (28%) that can combat heat stress and had favorable immune-modulatory effect in poultry without any toxicity (3, 7, 29).

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Various attempts are continuously being carried out to improve the utilization of the existing commercial diets in the market. The most widely used additives in poultry feed are the antibiotic growth promoters (AGP), which act in the intestine of birds reducing the population of certain types of commensal bacteria, promoting better growth performance which is the standard additive in commercial broiler diets (3, 7, 11, 15, 16, 18, 19, 22-26, 29). However, the use of AGP is being banned in animal feed due to the possibility of the emergence of resistant microorganisms. Therefore, it is necessary to study *in vivo* various natural additives that have similar characteristics to the growth promoters, in order for them to be used in poultry feeding in the future (3, 7, 29). Several natural feed additives were developed and have become commercially available for efficient animal production such as probiotics, prebiotics, enzymes, nutrient supplements such as minerals, amino acids and vitamins. Other naturally occurring additives are extracts from fruits, herbs and botanical (2).

The cashew (*Anacardium occidentale* L.) is a tropical plant, scattered in almost all geographical area of MIMAROPA Region especially in Palawan and Occidental Mindoro (DA-RFU IVB). The fruit of the tree consists of an outer shell (epicarp), a tight-fitting inner shell (endocarp) and a strongly vesicant cashew nut that contains amounts of nutrients that can be utilized as probiotic and nature feed additives to enhance the performance, carcass yield, relative weight of internal organs and intestine microbiology of broiler chickens fed diets containing different inclusion levels of cashew apple (2, 3, 7, 10, 29).

Several studies had been conducted on cashew apple mixed with other feeds were used for feeding different species of animals in many parts of the world, like rabbits, pigs and layer and broiler chickens (1, 7, 12, 17, 28) resulting to improved feed intake, weight gain, and feed conversion ratio can be utilized as probiotic and nature feed additives to enhance the performance, carcass yield, relative weight of internal organs and intestine microbiology of broiler chickens. However, studies with application on how feeding cashew apple influences the stress level, productivity (growth performance, feed efficiency, dressing percentage, abdominal fat pad, weight of giblets), organoleptic property and/or meat quality (cooked and freshly dressed) and economics in raising broiler chickens are limited hence, this study was conducted. If proven effective, broiler raisers could now engage in this kind of venture. Likewise, this will also contribute to the advocacy of implementing organic farming (i.e. cashew apple as potential feed additive and/or probiotics) that is becoming popular practice in the country as stipulated in RA 10068 known as Organic Agricultural Act 2010.

The following are the objectives of the study to determine the influence of cashew apple on the productivity, stress level, organoleptic property and profitability of broiler chickens specifically as follows: determine how dried ground cashew apple (DGCA) pulp influences the productivity (final body weight, ADG and weight gain, FCR, dressing percentage, weight of giblets and AFP); stress level (blood cortisol, LDL, HDL, triglycerides and cholesterol); organoleptic property (color, texture, flavor, tenderness, juiciness and general acceptability); and profitability (net

income, income per bird and ROI) of broilers; determine how fermented cashew apple (FCA) juice influences the productivity (final body weight, ADG and weight gain, FCR, dressing percentage, weight of giblets and AFP); stress level (blood cortisol, LDL, HDL, triglycerides and cholesterol); organoleptic property (color, texture, flavor, tenderness, juiciness and general acceptability); and profitability (net income, income per bird and ROI) of broilers; and determine the influence of interaction of feeding dried ground cashew apple (DGCA) pulp and different levels of fermented cashew apple (FCA) juice on the productivity, stress level, organoleptic property and profitability of broiler chickens.

2 Materials and Methods

2.1 Materials

The following are the materials that were used in conducting of this study are as follows: broiler chicks (240 heads); fermented cashew apple juice (40 liters); dried ground cashew apple pulp (50 kg); commercial feeds (12 bags); disinfectant (creoline 1000 ml); commercial antibiotics, vitamins and minerals supplements (1 bottle); equipment and supply; experimental-brooder and grower cages (2 units); feeding trough-medium size (24 pcs); watering trough- 2 litres capacity (24 pcs); 10-watt bulbs (24 pcs); kerosene lamps (24 pcs); digital camera (1-unit); beaker-1000 ml capacity (1 pc); recording material (1 pc); newspaper (2 kgs); broom and dust pan (1 pc); syringes (24 pcs); and test tube (24 pcs).

2.2 Methods

To evaluate the influence of cashew apple on the stress level, productivity, organoleptic property and profitability of broiler chickens, the following were the methods followed by the researcher in the conduct of experiment.

2.3 Experimental design and treatment

This study is experimental in nature, specifically following the 2x4 factorial experiment of the Completely Randomized Design (CRD). A total of 240 chicks were randomly distributed to different treatments and were replicated with ten (10) birds per replication. Factor A was the addition of ground cashew apple while Factor B was the different levels of fermented cashew apple juice. The various treatment combinations are presented in Table 1.

Table 1: Treatment combinations following a 2x4 factorial CRD that was used in the study

FACTOR A (DRIED GROUND CASHEW APPLE PULP)	FACTOR B (LEVEL OF FERMENTED CASHEW APPLE JUICE)			
	B ₁ – 0 ml	B ₂ – 10 ml	B ₃ – 20 ml	B ₄ – 35 ml
A ₁ – Without	A ₁ B ₁	A ₁ B ₂	A ₁ B ₃	A ₁ B ₄
A ₂ – With	A ₂ B ₁	A ₂ B ₂	A ₂ B ₃	A ₂ B ₄

Legend: A₁B₁ – without supplementation of ground and fermented cashew apple juice; A₁B₂ – without supplementation of ground with 10ml fermented cashew apple juice; A₁B₃ – without supplementation of ground with 20ml fermented cashew apple juice; A₁B₄ – without supplementation of ground with 30ml fermented cashew apple juice; A₂B₁ – with supplementation of ground but no fermented cashew apple juice; A₂B₂ – with supplementation of ground with 10ml fermented cashew apple juice; A₂B₃ – with supplementation of

ground with 20ml fermented cashew apple juice; A₂B₄ – with supplementation of ground with 30ml fermented cashew apple juice.

2.4 Preparation and Construction of Experimental Pen

There were two experimental pens and each pen was divided into twelve cages measuring 5 feet long, 3 feet wide, 3 feet in high and the pens were elevated 3 feet from the ground. The pens were constructed using Bamboo slats that served as flooring and sliding door while good lumber for the structure of cages. The buri leaves was used as roofing materials that served as shed to provide cooler condition that is needed for growth and development of birds. Each pen was constructed a month before the actual study and was cleaned and disinfected using 3% Creoline solution. Moreover, the pens were arranged perpendicular to sunlight following east-west orientation.

2.5 Acquisition of raw materials

The fermented and dried ground cashew apple pulps were acquired from the nearest cashew farm in Bulalacao, Oriental Mindoro.

2.6 Care and Management of the Broilers

2.6.1 Procurement of stocks

Two hundred forty heads day old broiler chicks were procured from reliable poultry supplier at Roxas, Oriental Mindoro. To ensure better performance of chicks, the behavior (activity), conformation or appearance especially the eyes, feather and feet were considered.

2.6.2 Brooding Management

A total of 24 light bulb (10 watts/cage) were installed three (3) days before the arrival of the stocks. Pens were pre-heated before the arrival of the chicks. The behavior of the chicks was used as basis in determining the level of temperature inside the brooder cage. If the birds went nearer or far from the incandescent bulb adjustment was done immediately. Meanwhile, during power interruptions kerosene lamps was used to provide light and heat needed by birds. Heat in the brooder cage was conserved by providing old clean sacks and used magazines or newspapers as litter materials.

2.6.3 Feeding Management

After one week of feeding chick booster ration, the stocks were fed with commercial broiler starter followed by broiler finisher. Birds in Factor B Treatments A₂B₁, A₂B₂, A₂B₃ and A₂B₄ received 50 grams of dried ground cashew apple pulp mixed in every kilogram of commercial ration. Gradual shifting of ration was done. *Ad libitum* was the feeding system employed.

2.6.4 Lighting Management

Trial and error experiment of the temperature was done to make sure that it is above the comfort zone of chicken which was between 25-27°C using a thermometer. All cages were provided with similar light bulb in terms of watts based on the trial and error experiment prior to the conduct of the study.

2.6.4 Water Management

Pure water was given to the Control group, while water with various proportions of fermented cashew apple juice was supplied to the test birds. This was supplied twice a day, once in the morning and once in the afternoon. During the last week of the experiment, water was supplied frequently to make the birds hydrated at all times due to warm environmental condition. All watering trough were cleaned with soap and water regularly.

2.6.5 Sanitation and Waste Management

The experimental area was cleaned regularly. In order to obtain the good health of the birds, chicken dung was collected regularly once in the morning and once in the afternoon from each respective pen and was placed in old used sacks, hence the poultry house and its premises was free from house flies. These will make sure that the experimental area is free from any contamination brought by the flies. In addition, footbath was provided for strict implementation of biosecurity.

2.6.6 Blood Collection

Blood was collected after the duration of the study early in the morning using six (6) mL capacity syringe. The blood samples were collected on the jugular vein of the chicken of about five (5) mL each sample of bird. Blood samples were stored using an ice box to prevent contamination during the transportation and immediately brought to MMG Hospital, Tawiran, Calapan City, Oriental Mindoro for cortisol analysis.

2.6.7 Marketing

After 35 days of rearing, with an approximately 1.5 to 1.8 kg body weight, broilers were harvested and marketed (dressed weight).

2.7 Data Gathering

The following were carefully observed and recorded to serve as basis for the analysis and evaluation on the influence of cashew apple on the productivity, stress level, organoleptic property and profitability of broiler chickens. This was done before, during and after 35±5 days of rearing period of birds.

2.7.1 Stress level

Blood cortisol and Blood lipid profile. Blood samples were collected through jugular vein before harvesting the chicken at 35 days of rearing period. This was brought immediately at MMG Hospital, Tawiran, Calapan City, Oriental Mindoro to analyze the Blood cortisol, LDL, HDL, Triglycerides and Cholesterol.

2.7.2 Productivity

Initial weight. This was obtained by weighing the chicks on the day of arrival using the standard weighing scale and was recorded in grams.

Final live weight. This was determined by weighing the birds on the last day (35 days) of rearing period using the standard weighing scale and was recorded in grams.

Average daily gain. This was obtained by dividing the final live weight to the number of days of rearing period.

Gain in weight. This was determined by subtracting the initial weight from the final weight of the birds after 35 days of growing period.

Feed consumption. This was obtained by getting the difference of the amount of feeds given to the birds from the left over feeds.

Feed Conversion Ratio. This was determined by dividing the final gain in weight with the total amount of feeds consumed in kilograms. This was done to all treatments of the study.

Dressing Percentage. This was obtained by dividing the dressed weight of the birds by final weight x 100%.

Abdominal Fat Pad. This was measured using the Vernier calliper.

Weight of Giblets. This was obtained after dressing and heart, gizzard and liver was weighed separately using a digital weighing scale and recorded for analysis.

2.7.3 Organoleptic property

This was evaluated with 40 evaluators and obtained using five (5) hedonic scales mentioned by Cabaral *et al.*, and Rieta & Cabaral as follows (4, 21):

Color

- 5 – Very acceptable
- 4 – Slightly acceptable
- 3 – Neither acceptable nor unacceptable
- 2 – Slightly unacceptable
- 1 – Very unacceptable

Texture

- 5 – Very fine
- 4 – Fine
- 3 – Neither fine nor coarse
- 2 – Coarse
- 1 – Very coarse

Juiciness

- 5 – Very juicy
- 4 – Juicy
- 3 – Neither juicy nor dry
- 2 – Dry
- 1 – Very dry

Flavor

- 5 – Very rich meat flavor
- 4 – Rich meat flavor
- 3 – Neither rich nor bland
- 2 – Bland
- 1 – Very bland

Tenderness

- 5 – Very tender
- 4 – Tender
- 3 – Neither tender nor tough
- 2 – Tough
- 1 – Very tough

General acceptability

- 5 – Very acceptable
- 4 – Slightly acceptable
- 3 – Neither acceptable nor unacceptable
- 2 – Slightly unacceptable
- 1 – Very unacceptable

2.7.4 Profitability

Net income. This was computed by subtracting total cost from total sales.

Income/bird. This was obtained by dividing total number of birds harvested from the total sales.

Return of Investment. This was obtained by dividing the total cost from net income.

2.8 Statistical analysis

The various data gathered were analyzed and interpreted using the analysis of variance (ANOVA) following the 2x4 factorial experiment in Completely Randomized Design (CRD). This was set at 5% and 1% level of significance. Differences between and among treatments was analyzed using Scheffe's Test.

3 Results and Discussion

3.1 Stress level

Dried ground cashew apple pulp. Analysis showed significant ($p < 0.01$) differences on the blood cortisol level and blood lipid profile of broilers fed with dried ground cashew apple pulp (DGCAP) raised under induced heat stress ($AET \pm 3^\circ C$).

Broilers fed with 50 grams DGCAP in the dietary ration has significantly ($p < 0.01$) lower blood cortisol level, LDL (bad cholesterol), triglycerides, cholesterol, and higher HDL (good cholesterol) compared to the cortisol level and blood lipid profile of broilers fed without any inclusion of DGCAP in the dietary ration (Table 1).

Results in the lower cortisol level can be associated to the higher Vitamin C, niacin, riboflavin and thiamine content and essential amino acids particularly glutamic acid which enhanced performance of broilers exposed to different concurrent stressors found in the environment that significantly ($p < 0.01$) lower cortisol level, thus has the potential to combat heat stress through efficient feed utilization that consequently enhance nutrient absorption and had favorable immune-modulatory effect in poultry without any toxicity due to moderation of cortisol level in blood and urine; Okpanachi *et al.*, Bhat and Nagarala, 2008; 16) that reduce stress and anxiety (14), thus relaxes the animals which consequently reduces the incidence of stress. Furthermore, lower level of stress hormone (blood cortisol) can be correlated to the lower LDL, triglycerides, and total cholesterol which consequently enhanced the good cholesterol (8, 13, 16).

Results were in line to the findings reported by Perai, *et al.*, and Seyrek *et al.*, (2004) that Vitamin C in cashew apple significantly lowers the blood triglycerides of broiler (20). Likewise, decreased triglyceride levels, decreased low-density lipoprotein, and cholesterol levels was observed in broilers treated with Vitamin C. On the other hand, nutrient composition of cashew apple, such as Vitamin C, niacin, riboflavin and thiamine content and essential amino acids particularly glutamic acid content significantly ($p < 0.01$) reduced blood triglycerides of broilers even under heat stress due to it has favorable immune-modulatory effects to combat heat stress without any toxicity or adverse effects (Bhat and Nagarala, 2008). In contrast, Fanimo *et al.*, reported that

feeding cashew apple either fresh or dried have comparable effects ($p>0.05$) on the blood profile and cortisol level (5).

Fermented cashew apple juice. Findings on the blood cortisol and blood lipid profile of broilers raised under induced heat stress ($AET\pm 3^{\circ}C$) and fed with fermented cashew apple juice (FCAJ) regardless of level has significant ($p<0.01$) effects (Table 2).

In general, analysis revealed that providing 35ml FCAJ in broiler's ration significantly ($p<0.01$) lower blood cortisol and blood lipid profile (i.e. triglycerides and cholesterol). In addition, birds provided with 35ml FCAJ has the significantly higher LDL (good cholesterol). On the other hand, provision of FCAJ on the dietary ration of broilers did not trigger changes in blood HDL (bad cholesterol).

Findings can be associated to the fact that heat-stressed broilers supplemented with various fermented feedstuff which contains several nutrients in the drinking water and diet showed improved performance (Vierden and Kidd, 2009) due to enhance effect of lactic acid in the fermented cashew apple that improved the villi in the intestine hence improve nutrient digestibility and absorption (Murwani, *et al.*, 2011).

Table 1: Stress level in terms of blood cortisol and blood lipid profile (mg/dL) of broilers fed with or without dried ground cashew apple pulp

FACTOR A	FACTOR B (LEVEL OF FERMENTED CASHEW APPLE JUICE)			
(DRIED GROUND CASHEW APPLE PULP)	B ₁ – 0 ml	B ₂ – 10 ml	B ₃ – 20 ml	B ₄ – 35 ml
A ₁ – Without	A ₁ B ₁	A ₁ B ₂	A ₁ B ₃	A ₁ B ₄
A ₂ – With	A ₂ B ₁	A ₂ B ₂	A ₂ B ₃	A ₂ B ₄

Legend: DGCAP – dried ground cashew apple pulp; TRIG – triglycerides; CHOL – cholesterol; Means within column having different superscripts are significantly different ($p<0.01$).

In addition, providing comfort and reduced stress due to lower cortisol, bad cholesterol, triglycerides, cholesterol and moderate range of good cholesterol can be attributed to the vitamin contents and essential amino acid contents of cashew apple that might help the broilers cope with stress by reducing electrolytes excretion while improving electrolytes absorption during heat-stress condition, thus relaxes the animals which consequently reduces the incidence of stress (17). Results were supported by the finding of Oyewole *et al.*, who reported decreased in LDL fed in animals (broilers, quails) with feedstuff containing vitamin C could suppress the negative effects of heat stress that significantly ($p<0.01$) lower the LDL of broilers even under heat stress due to it has favorable immune-modulatory effects to combat heat stress without any toxicity or adverse effects (13, 16).

Table 2: Stress level in terms of blood cortisol and blood lipid profile (mg/dL) of broilers provided with different levels of fermented cashew apple juice

FACTOR B (Fermented cashew apple juice)	CORT	LDL	HDL	TRIG	CHOL
Pure Potable Water	134.750 ^a	63.190 ^b	34.550 ^a	254.835 ^a	158.835 ^a
10ml FCAJ + 990ml water	120.833 ^b	67.345 ^b	33.250 ^a	234.880 ^b	145.370 ^b
20ml FCAJ + 980ml water	117.833 ^b	65.285 ^b	32.500 ^a	219.885 ^c	143.810 ^b
35ml FCAJ + 970ml water	117.000 ^b	74.615 ^a	31.000 ^a	211.160 ^d	137.920 ^c

Legend: TRIG – triglycerides; CHOL – cholesterol; CORT – cortisol; Means within column having similar superscripts are significantly different ($p<0.01$).

3.2 Productivity

3.2.1 Growth performance and Feed Efficiency

Dried ground cashew apple pulp. The final body weight among broilers used in the experiment after 35 days of rearing raised under induced heat stress ($AET\pm 3^{\circ}C$) fed with dried ground cashew apple pulp (DGCAP) are comparable ($p>0.05$). However, analysis on the average daily gain, weight gain and feed conversion ratio (FCR) showed highly significant different ($p<0.01$).

Moreover, broilers fed with 50 grams DGCAP have significantly heavier ($p<0.01$) average daily gain with 52.083 grams per day, weight gain of 1.572 kg after 35 days and are more efficient in converting feeds into meat with an FCR of 1.338 (Table 3).

These results can be associated to the higher digestibility rate of cashew apple, high protein but low fiber content, essential minerals, appreciable quantities of vitamins A and high content of ascorbic acid and glutamic acid (9,14) that may enhance feed intake that consequently improved the growth rate and feed efficiency of animals through improve nutrient digestion and absorption (5,12,13,27).

Results were in lined to the findings reported of several researchers (1,5,7,17,28) who found out that cashew apple indeed improved growth performance (i.e. body weight, weight gain, ADG) and enhanced nutrient digestibility, that consequently enhances the feed efficiency through efficient feed utilization that consequently enhance nutrient absorption.

Table 3: Growth rate and feed efficiency fed with or without dried ground cashew apple pulp

FACTOR A (dried ground cashew apple pulp)	FWT(kg)	ADG(g/day)	WTG(kg)	FCR
Without DGCAP	1.592 ^a	49.667 ^b	1.502 ^b	1.401 ^a
With 50 grams DGCAP	1.644 ^a	52.083 ^a	1.572 ^a	1.338 ^b

Legend: FWT – final body weight; ADG – average daily gain; WTG – weight gain; FCR – feed conversion ratio;

Means within column having different superscripts are significantly different ($p < 0.01$).

On the contrary, Oddoye *et al.*, reported that feeding cashew apple in the dietary ration have comparable ($p > 0.05$) growth performance and feed efficiency but mentioned that no detrimental effects or adverse effects is observed in animals fed with cashew apple (12).

Fermented cashew apple juice. Generally, findings on the growth rate and feed efficiency of broilers raised under induced heat stress ($AET \pm 3^\circ C$) and fed with fermented cashew apple juice (FCAJ) regardless of level has significant ($p < 0.01$) effects (Table 4).

Moreover, analysis revealed that providing 35ml FCAJ in broiler's ration significantly ($p < 0.01$) enhanced the final body weight, average daily gain, weight gain and are more efficient in converting feeds into meat.

These results can be associated to the higher digestibility rate of fermented cashew apple, high protein but low fiber content, essential minerals, has appreciable quantities of vitamins A and high content of ascorbic acid (5,9,14) that may enhance feed intake that consequently improved the growth performance, nutrient digestibility and carcass characteristics.

Results can be attributed to the high crude protein content of cashew apple that are highly digestible and other nutrients like iron, probiotics (lactic acid through fermentation), lysine (essential amino acid) that enhance nutrient absorption, its high glutamic acid (28%) content that has favorable immune-modulatory effect to combat heat stress on poultry without any toxicity, hence improves the growth performance and feed efficiency of animals. In addition, it contains various essential amino acid Met, Thr, Arg, Val, Cys, Gly, Ser, Tyr, Phe, Ala, His, Pro, and Aspartic acid, Valine which content are glucogenic compound that could be converted to glucose as energy source by the animals that consequently improves feed intake and growth performance and feed efficiency (1,5,13,16,27).

In contrast, Oddoye *et al.*, reported that supplementing cashew apple in the dietary ration have comparable ($p > 0.05$) growth performance and feed efficiency but mentioned that no detrimental effects or adverse effects is observed in animals fed with cashew apple (12). Differences in results can be attributed to the variety of cashew apple, how, when, and where cashew apple is produced.

Table 4: Growth rate and feed efficiency provided with fermented cashew apple juice

FACTOR B (fermented cashew apple juice)	FWT	ADG	WTG	FCR
Pure Potable Water	1.453 ^b	46.333 ^c	1.445 ^b	1.438 ^a
10ml FCAJ + 990ml water	1.588 ^{ab}	51.333 ^b	1.528 ^{ab}	1.382 ^{ab}
20ml FCAJ + 980ml water	1.623 ^{ab}	52.000 ^b	1.563 ^{ab}	1.347 ^b
35ml FCAJ + 970ml water	1.807 ^a	53.833 ^a	1.610 ^a	1.312 ^b

Legend: FWT – final body weight; ADG – average daily gain; WTG – weight gain; FCR – feed conversion ratio; Means within column having different superscripts are significantly different ($p < 0.01$).

3.2.2 Dressing percentage, abdominal fat pad and weight of giblets

Dried ground cashew apple pulp. The broilers used in the experiment after 35 days of rearing raised under induced heat stress ($AET \pm 3^\circ C$) fed with dried ground cashew apple pulp (DGCAP) has significantly higher ($p < 0.01$) dressing percentage of 77% compared to broilers fed with pure commercial feeds with 74%. On the other hand, broilers fed with dried ground cashew apple pulp (DGCAP) has significantly lower ($p < 0.01$) abdominal fat pad (AFP) with 6.283mm compared to broilers fed with pure commercial feeds with 7.610mm AFP. In terms of weight of giblets, analysis revealed comparable ($p > 0.05$) weights of heart, liver and gizzard (Table 5).

These results can be associated to the higher digestibility rate of cashew apple, high protein but low fiber content, essential minerals like iron, calcium, magnesium, phosphorus, appreciable quantities of vitamins A and high content of ascorbic acid (9,14) that may enhances feed intake that consequently improved the growth rate and feed efficiency of animals through improve nutrient digestion and absorption (5,12,13,27), hence increases the dressing percentage while reducing the abdominal fat pad.

Table 5: Dressing percentage, abdominal fat pad and weight of giblets of broilers fed with or without dried ground cashew apple pulp

FACTOR A (dried ground cashew apple pulp)	DP	AFP(mm)	WEIGHT OF GIBLETS (grams)		
			HEART	LIVER	GIZZARD
Without DGCAP	74.186 ^b	7.610 ^a	0.013 ^a	0.558 ^a	0.519 ^a
With 50 grams DGCAP	77.090 ^a	6.283 ^b	0.010 ^a	0.575 ^a	0.537 ^a

Legend: DP– dressing percentage; AFP – abdominal fat pad Means within column having different superscripts are significantly different ($p < 0.01$).

Fermented cashew apple juice. The broilers used in the experiment after 35 days of rearing raised under induced heat stress ($AET \pm 3^\circ C$) fed with fermented cashew apple juice (FCAJ) has significantly higher ($p < 0.01$) dressing percentage of compared to broilers fed with pure potable water. On the other hand, broilers fed with fermented cashew apple juice (FCAJ) has significantly lower ($p < 0.01$) abdominal fat pad (AFP) compared to broilers fed with pure commercial feeds. Analysis on the weight of giblets revealed comparable ($p > 0.05$) weights of heart, liver and gizzard (Table 14).

Moreover, analysis revealed that providing 35ml FCAJ in broiler's ration significantly ($p < 0.01$) enhanced the dressing percentage of 77% which can be associated to the significant

($p < 0.01$) final body weight, average daily gain, weight gain and are more efficient in converting feeds into meat.

This result is attributed to the fermentation process which helps improve its enzyme content, increasing its levels and makes the food more digestible through lactic acid production which enhances the villi in the animal's intestine to absorb and digest feed more efficiently, and thus boosts the usable (amino acids) protein level and more palatable and digestible feed, which improves the overall animal performance (da Silva, 2017) in terms of higher dressing percentage and lower abdominal fat pad.

These results can be associated to the higher digestibility rate of fermented cashew apple, high protein but low fiber content, essential minerals like iron, calcium, magnesium, phosphorus, has appreciable quantities of vitamins A and high content of ascorbic acid (1, 7, 9, 14) that may enhance feed intake that consequently improved the dressing percentage and reduced abdominal fat pad of broilers fed with cashew apple.

In addition, cashew apple has higher amount of glutamic acid (28%) content that has favorable immune-modulatory effect to combat heat stress on poultry without any toxicity, hence improves the growth performance and feed efficiency of animals that consequently increases the dressing percentage and enhances the quality of the meat by reducing the abdominal fat pad.

Results implies that feeding cashew apple produces a healthy broiler chickens due to the significant increase ($p < 0.01$) in growth performance but significantly lower ($p < 0.01$) blood cortisol and blood lipid in general as well as reduced ($p < 0.01$) abdominal fat pad.

Table 6: Dressing percentage, abdominal fat pad and weight of giblets of broilers fed with different levels of fermented cashew apple juice

FACTOR B (fermented cashew apple juice)	DP	AFP	WEIGHT OF GIBLETS(grams)		
		(mm)			
			HEART	LIVER	GIZZARD
Pure Potable Water	73.865 ^b	8.065 ^a	0.010 ^a	0.456 ^a	0.533 ^a
10ml FCAJ+ 990ml water	75.202 ^a _b	7.812 ^b	0.012 ^a	0.584 ^a	0.508 ^a
20ml FCAJ + 980ml water	77.672 ^a	7.725 ^c	0.012 ^a	0.603 ^a	0.492 ^a
35ml FCAJ + 970ml water	77.817 ^a	5.585 ^d	0.012 ^a	0.623 ^a	0.578 ^a

Legend: DP– dressing percentage; AFP – abdominal fat pad
Means within column having different superscripts are significantly different ($p < 0.01$).

These findings were similar to the reported effects of cashew apple of several researchers (1, 5, 13, 17, 27) in

animal feeding and nutrition who discussed and mentioned through research results that cashew apple (either ground or fermented) has significant ($p < 0.01$) effects of the growth performance in terms of increase dressing percentage and AFP reduction. On the other hand, Tanod *et al.*, (2015) reported that feeding cashew apple has significant ($p < 0.05$) effects on the giblets weight. Differences in results can be attributed to the variety of cashew apple, how, when, and where (geographical location) cashew apple is produced.

3.2.3 Organoleptic Property

Dried ground cashew apple pulp. In general, results revealed significant ($p < 0.01$) differences on the organoleptic property of broilers fed with dried ground cashew apple pulp (DGCAP) raised under induced heat stress ($AET \pm 3^\circ C$) in terms of texture, flavor, tenderness, juiciness and general acceptability. On the other hand, findings showed that provision of DGCAP has comparable effects in cooked broiler meat color (Table 7).

Results can be attributed to the fact that heat-stressed broilers supplemented with various vitamins and nutrients needed in nutrient absorption (i.e. Vitamin C, niacin, riboflavin and thiamine, higher CP and energy) in the drinking water and diet showed improved performance. In addition, providing comfort and reduced stress and vitamin contents of cashew apple might help the broilers cope with stress by reducing electrolytes excretion while improving electrolytes absorption during heat-stress condition, thus relaxes the animals which consequently reduces the incidence of stress, thus enhanced the texture, flavor, tenderness, juiciness and general acceptability of the meat produced.

Results in the enhanced texture, flavor, tenderness, juiciness and general acceptability of broiler meat provided with cashew apple can be associated to the higher Vitamin C and glutamic acid which enhanced the overall meat quality of the cooked broiler meat (8).

In addition, glutamic acid - an essential amino acids coupled with the higher amount of Vitamin C that significantly ($p < 0.01$) lower cortisol level and blood lipid profile, thus has the potential to combat heat stress through efficient feed utilization that consequently enhance nutrient absorption (13, 16) thus relaxes the animals which consequently reduces the incidence of stress and improved the meat quality (17).

Results were in line to the findings reported by Perai, *et al.*, that high amount of Vitamin C and glutamic acid in cashew apple significantly enhances the broiler meat (20). Moreover, Fanimo *et al.*, reported that feeding cashew apple either fresh or dried have significant effects ($p < 0.05$) on the blood profile and cortisol level that consequently produced a quality, healthy and nutritious meat (5).

Fermented cashew apple juice. Findings on the organoleptic property of broilers raised under induced heat stress ($AET \pm 3^\circ C$) and fed with fermented cashew apple juice (FCAJ) regardless of level has significant ($p < 0.01$) effects (Table 8). In general, analysis on the 5-hedonic scale (4, 21) revealed that providing 35ml FCAJ in broiler's ration significantly ($p < 0.01$) enhanced the texture, flavor, tenderness and juiciness of cooked broiler meat. On the other hand, provision of fermented cashew apple in the ration did

not cause any changes in cooked meat color and general acceptability.

Table 7: Organoleptic property of broilers fed with or without dried ground cashew apple pulp

FACTOR A (dried ground cashew apple pulp)	COL	TEX	FLV	TEN	JUI	GEN. ACC
Without DGCAP	4.124 ^a	3.890 ^b	3.909 ^b	3.917 ^b	3.890 ^b	4.161 ^b
With 50 grams DGCAP	4.208 ^a	4.161 ^a	4.054 ^a	4.243 ^a	4.063 ^a	4.320 ^a

Legend: COL – color; TEX – texture; FLV – flavor; TEN – tenderness; JUI-juiciness; GEN.ACC- general acceptability; Means within column having different superscripts are significantly different ($p < 0.01$).

These results can be associated to the higher digestibility rate of fermented cashew apple, high protein but low fiber content, essential minerals like iron, calcium, magnesium, phosphorus, has appreciable quantities of vitamins A and high content of ascorbic acid (9, 14) that may enhance feed intake that consequently improved the meat quality in terms of the color, flavor, juiciness and general acceptability of broilers fed with cashew apple.

These results were in line to the findings reported by several researchers (5, 8, 13, 16, 20) who found out and reported that inclusion of cashew apple in the diet indeed enhance the organoleptic property of the meat.

Moreover, more tender and juicy meat of broilers fed with cashew apple could be attributed to the fact that heat-stressed broilers when supplemented with various vitamins and nutrients needed in nutrient absorption (i.e. Vitamin C, niacin, riboflavin and thiamine, higher CP and energy) in the drinking water and diet showed improved meat quality due to high nutrient digestion and absorption (Vierden and Kidd, 2009).

In addition, providing comfort and reduced stress and vitamin contents of cashew apple might help the broilers cope with stress by reducing electrolytes excretion while improving electrolytes absorption during heat-stress condition (Bhat and Nagarala, 2008; Seyrek *et al.*, 2004), thus relaxes the animals which consequently reduces the incidence of stress, thus enhanced the tenderness of the meat produced.

3.2.4 Profitability

Dried ground cashew apple pulp. In general, results (Table 9) revealed that raising broilers fed with 50 grams dried ground cashew apple pulp has significantly ($p < 0.01$) higher net income, income per bird and return on investment even raised under induced heat stress ($AET \pm 3^\circ C$). These results can be associated to the significantly ($p < 0.01$) higher average daily gain, weight gain, and dressing percentage that consequently improved the final body weight of broilers that was used as the basis for marketing.

Results on the higher net income, income per bird and ROI was associated to the higher dressing percentage which could be correlated to the significantly higher ($p < 0.01$) final body weight, ADG, weight gain and efficient FCR and growth performance (Tables 9 to 14) but significantly lower ($p < 0.01$) blood cortisol and blood lipid (Tables 2 to 8) of broilers provided with dried ground cashew apple pulp in the dietary ration.

Table 8: Organoleptic property of broilers of broilers provided with different levels of fermented cashew apple juice

FACTOR B (Fermented cashew apple juice)	COL	TEX	FLV	TEN	JUI	GEN. ACC
Pure Potable Water	4.027 ^a	3.848 ^b	3.722 ^b	3.875 ^b	3.793 ^b	4.098 ^a
10ml FCAJ + 990ml water	4.178 ^a	4.002 ^{ab}	3.928 ^{ab}	4.085 ^{ab}	3.890 ^{ab}	4.168 ^a
20ml FCAJ + 980ml water	4.208 ^a	4.042 ^{ab}	4.055 ^a	4.112 ^a	4.083 ^{ab}	4.335 ^a
35ml FCAJ + 970ml water	4.250 ^a	4.210 ^a	4.221 ^a	4.248 ^a	4.140 ^a	4.360 ^a

Legend: COL – color; TEX – texture; FLV – flavor; TEN – tenderness; JUI-juiciness; GEN.ACC- general acceptability; Means within column having different superscripts are significantly different ($p < 0.01$).

These results in economics and profitability of broiler raising was in line to the findings of several researchers (1,5,7,12,13,16,27) that inclusion of cashew apple indeed improved the profit due to lower production costs and higher body weight and dressing percentage owing to efficient feed conversion ratio.

Table 9: Profitability of raising broilers in terms of net income, income/bird and return of investment fed with or without dried ground cashew apple pulp

FACTOR A (dried ground cashew apple pulp)	NET INCOME	INCOME PER BIRD	RETURN ON INVESTMENT
Without DGCAP	833.39 ^b	83.338 ^b	28.084 ^b
With 50 grams DGCAP	967.28 ^a	96.728 ^a	32.591 ^a

Means within column having different superscripts are significantly different ($p < 0.01$).

Fermented cashew apple juice. The economics of raising broilers fed with different level of fermented cashew apple juice (FCAJ) has significant ($p < 0.01$) effects (Table 10) in the ration under induced heat ($AET \pm 3^\circ C$) stress was

recorded. Return on investment was also computed and analyzed to determine the economic impact of the study for the dissemination of the results to different broiler raisers.

In general, analysis revealed that broilers provided with 35ml FCAJ in the dietary ration has the highest incurred net income, income per bird and return on investment that was highly significant ($p < 0.01$) from the income of raising broilers provided with 10ml, 20ml and broilers provided with pure potable water (Table 21).

Results can be attributed to the highly significant ($p < 0.01$) final body weight of broilers provided with 35ml FCAJ in the diet even under induced heat stress ($AET \pm 3^\circ C$) that acts as an alternative protein source that enhances nutrient digestion and absorption (9, 14), hence considered a low-cost of production input, therefore decreases the total costs that consequently improves the net income and ROI.

Findings was similar to the findings reported by Huggins, 2007; Leterme *et al.*, 2009; Ly *et al.*, 2002; Malek *et al.*, 2008; Murthy *et al.*, 2013; Parashuramulu *et al.*, 2013; Vierden and Kidd, 2009; 1, 13, 17, 27, Tanod *et al.*, 2015; 5, Tanod *et al.*, 2015; 7,12) that inclusion of cashew apple indeed improved the profit due to lower production costs due to efficient feed conversion ratio and higher body weight and dressing percentage owing to increase total sales.

Table 10: Productivity of raising broilers in terms of net income, income/bird and return of investment provided with different levels of fermented cashew apple juice

FACTOR B (fermented cashew apple juice)	NET INCOME	INCOME PER BIRD	RETURN ON INVESTMENT
Pure Potable Water	488.58 ^c	48.857 ^c	16.625 ^c
10ml FCAJ + 990ml water	910.89 ^b	91.085 ^b	35.765 ^b
20ml FCAJ + 980ml water	979.70 ^b	97.972 ^b	32.988 ^b
35ml FCAJ + 970ml water	1222.20 ^a	122.218 ^a	40.972 ^a

Means within column having different superscripts are significantly different ($p < 0.01$).

4 Conclusion

The findings of the study led to the following conclusion:

1. Feeding dried ground cashew apple pulp reduced the blood cortisol and blood lipid profile, enhanced the organoleptic property of cooked broiler meat in terms of texture, flavor, tenderness and general acceptability, improved the ADG, weight gain and FCR, and increase the overall net income, income per bird and ROI.
2. Feeding FCAJ showed reduction in blood cortisol and blood lipid profile, enhanced all the organoleptic property of cooked meat as well as the meat quality in terms of improving the dressing percentage and reducing abdominal fat pad, improves the growth rate and feed efficiency, net income, income per bird and ROI.
3. Providing dried ground cashew apple pulp and fermented cashew apple juice improved the blood cortisol and blood lipid profile, ADG, abdominal fat pad, and profitability in terms of net income, income per bird and ROI.

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