

Supplementation of wonderful kola (*Buccholzia coriacea*) seed meal in diets of goats: effect on their growth hormone, performance and health status

Oluwatosin Bode Omotoso

*corresponding author: obomotoso@futa.edu.ng

Department of Animal Production and Health, Federal University of Technology, Akure, Nigeria.

ABSTRACT

Wonderful kola (*Buccholzia coriacea*) has been identified for its medicinal properties, with the potential to improve animal health and performance. Hence, *B. coriacea* seed meal was supplemented in goats' diet at 0 (control), 0.2, 0.4, 0.6, and 0.8 g/kg feed. Twenty-five West African Dwarf (WAD) goats were used for this study, which lasted 56 days. Nutrient composition, intake, digestibility, and feed conversion ratio were evaluated. Blood and serum samples were assayed for health status, while tissue samples (spleen, liver, rump, and heart) were collected to assess the insulin-like growth factor (IGF-1) gene expression in the goats. From the results, *B. coriacea* significantly ($P < 0.05$) influenced nutrient composition, nutrient intake, and apparent nutrient digestibility coefficients, whereas ADWG and FCR were not significantly ($P > 0.05$) influenced. Haematological and serum biochemical indices were within the normal range for healthy goats. Interestingly, IGF-1 gene expression in the assessed organs was upregulated and more strongly expressed in goats fed diet B (0.20 g/kg *B. coriacea*). Hence, it could be concluded that incorporation of wonderful kola (*B. coriacea*) seed meal in goats' diet would not pose detrimental effects on the animal, but rather improve their health status and stabilize performance, particularly up to 0.40 g/kg.

Keywords: *Buccholzia coriacea* seed, Insulin-like growth factor, organs, small ruminants, weight gain.

INTRODUCTION

The growing use of molecular research in ruminant studies, particularly in nutrition and physiology, has yielded a wealth of information on the cellular regulation mechanisms of important biological processes connected to growth, meat quality, marbling, and milk synthesis (Asmelash, 2018). Gene expression analysis studies are conducted in response to feed regimens. Nutrient-gene interactions (nutrigenomics) in ruminants could lead to livestock improvement and resilience in a changing climate because they will aid in the development of genotype-matched animal feed by selecting nutrients that are tailored to a specific animal and genes, considerably enhancing health and productivity (Benitez *et al.* 2017). Growth hormone serves as a key regulator of postnatal growth and metabolism in mammals, influencing growth rate, body composition, health, milk production, and modulating aging (Yakar, 2002). Growth hormone stimulates the production of Insulin-like growth factor 1 (IGF-1) in the liver as an endocrine hormone and in target tissues as a paracrine/autocrine hormone. Insulin-like growth factor-1 (IGF-1) regulates the effects of growth hormone (GH) in the body and influences growth performance (Suliman, 2014; Asmelash, 2018).

IGF-1 serves as a crucial growth factor, stimulating the growth of all cell types, including cancer cells, and inducing significant metabolic effects (Aguirre *et al.*, 2016). A notable metabolic effect of IGF-1 is its ability to signal to cells the presence of adequate nutrients for cell hypertrophy and division, thereby inhibiting cell apoptosis and enhancing cell protein production (Aguirre *et al.*, 2016; Callaway *et al.*, 2022). Conversely, IGF-1 is believed to possess some anti-aging and enhancing properties, including the maintenance and augmentation of muscle and bone mass (Callaway *et al.*, 2022). A few plants and plant products are medicinal to support tissue development (growth) and are used to improve animal health. Among such plants is Wonderful kola (*Buchholzia coriacea*). *B. coriacea* seed has been reported to contain; 13.28% CP, 1.70% EE, 3.50% CF, 4.53% Ash (Amaechi, 2012). It has antioxidant properties that help fight oxidative stress. It can act as an anti-inflammatory, helping to alleviate conditions related to inflammation (Ezike *et al.*, 2015). It aids in digestion. The bioactive components (2-methylpyrrolidine-2-carboxylic acid) help to regulate the body's homeostasis, function as a blood cleanser, strengthen hair and the nervous system, prevent premature aging, prevent and treat infertility, cure typhoid, and treat fever (Erhirhie *et al.*, 2015). Moreover, blood examination offers a valuable opportunity to clinically evaluate feed quality, disease prognosis, therapeutic monitoring, and assess feed stress. Hence, the study investigated the effects of *Buchholzia coriacea* seed meal on growth hormone (insulin-like growth factor-1) expression as it influences growth performance and health status of West African Dwarf goats.

MATERIALS AND METHODS

Experimental Site

The field trial was carried out at the Small Ruminant Unit of the Teaching and Research Farm, while laboratory analysis was conducted at the Nutritional and Microbiology Laboratories of the Department of Animal Production and Health, Federal University of Technology, Akure (FUTA), Nigeria. The University is geographically located at 7°18'01.0"N 5°08'41.3"E (GoogleMap, 2025).

Sourcing and Processing of Feed Materials

Wonderful kola seeds (Plate 1a) were sourced, washed, sliced, dried in an oven at 40 °C for 72 hours, milled into powder form (Plate 1b) using a grinding machine (blender), and kept until use. While cassava peels were sourced from the cassava processing industry, sundried to reduce moisture and cyanide contents, and to facilitate milling. Other feed ingredients were sourced from a reputable feed mill within Akure metropolis.



Plate 1a. Wonderful kola seed



Plate 1b. Wonderful kola seed meal

Diet Formulation

A basal diet was formulated using feed ingredients at fixed quantities as presented in Table 1, and divided into five equal portions. Wonderful kola (*B. coriacea*) seed meal was thoroughly mixed with each portion at 0, 0.2, 0.4, 0.6, and 0.8 g/kg, respectively and the diets were designated as A (Control), B, C, D, and E, respectively.

Table 1. Gross composition of experimental diets fed to WAD goats

Ingredients	Diets				
	Supplementation levels of <i>B. coriacea</i> seed meal				
	(g/kg)				
	A (0.00)	B (0.20)	C (0.40)	D (0.60)	E (0.80)
Cassava peel meal	50.00	50.00	50.00	50.00	50.00
Wheat offal	26.00	25.80	25.60	25.40	25.20
Palm kernel cake	20.00	20.00	20.00	20.00	20.00
Premix	1.00	1.00	1.00	1.00	1.00
Urea	1.00	1.00	1.00	1.00	1.00
Bone meal	1.00	1.00	1.00	1.00	1.00
Salt	1.00	1.00	1.00	1.00	1.00
Wonderful kola seed meal	0.00	0.20	0.40	0.60	0.60
Total	100.00	100.00	100.00	100.00	100.00

Experimental Animal Management

Twenty-five (25) West African Dwarf (WAD) goats weighing from 9.15-16.35 kg of age 6 - 12 months were used for the experiment, selected from the flock available at the farm. The animals were housed in individual pens. The goats were prophylactically treated against endo- and ecto-parasites and vaccinated against *Peste-Petit de Ruminante* (PPR/kata) while all other operations, such as feeding and management, were carried out in accordance with animal research ethical guidelines as presented by Gross and Tolba (2015). The study was approved and carried out in compliance with the Research Ethical Committee guidelines of the Department of Animal Production and Health, FUTA. A 7-day adjustment period was observed before data collection. They were randomly allocated to five (5) treatments of five (5) replicates each. The goats were fed based on their body weight (3.5 – 5%BW) throughout the feeding trial, which lasted 56 days. Water was given *ad libitum* along with the feed after the drinkers were washed.

Growth Performance and Nutrient Digestibility Trial

Feed intake was calculated by deducting the weight leftover of diets from the quantity served, while the weekly weight change was monitored using a spring balance. The goats were weighed before feeding in the morning. At the end of the feeding trial, initial weights of the goats were deducted from the final weight to determine weight gain throughout the study, while the feed conversion ratio was calculated as feed consumed divided by weight gain.

After the 56-day feeding/growth study, the goats were transferred and were housed individually in the metabolic cages, and were allowed to adapt for 7 days in cages, followed by 14 days of data collection on faecal and urine samples in the morning. Total faeces voided were collected using a net placed under the metabolic cages, and 10% of the voided faeces per goat/day were

oven dried at 105 °C for 3 hours for dry matter determination. The faecal samples from each goat were homogenously mixed, milled to pass through a 0.2mm sieve, and sealed in nylon bags. The samples were stored at room temperature until required for analysis. The volume of urine expelled from each animal was also collected in a plaque bucket placed under each cage, and 2 - 3 drops of 25% tetraoxo-sulphate (vi) acid (H₂SO₄) were added daily to trap the nitrogen in the urine according to Ahamefule *et al.* (2016). The total volume of urine expelled per goat was measured using a cylindrical bottle. Ten percent of the daily expelled urine per goat was stored in amber stopper bottles, labeled, and kept in a deep freezer until required for chemical analysis. The percentage apparent nutrient digestibility coefficient value was evaluated as shown below.

$$\text{Apparent Nutrient Digestibility (\%)} = \frac{\text{Nutrient intake} - \text{Nutrient output}}{\text{Nutrient intake}} \times \frac{100}{1}$$

Blood Collection and Serum Biochemical Assay

Prior to termination of the trial, blood samples (5 ml) were collected via the jugular vein puncture from each goat into bottles that contained anti-coagulant ethylene diamine-tetra-acetate (EDTA) bottles for haematological studies (white blood cell, red blood cell, haemoglobin, packed cell volume, lymphocytes, monocytes, neutrophils, eosinophils) and into plain bottles to harvest serum to assay serum biochemical components (total protein, albumin, globulin, liver markers – aspartate aminotransferase, total bilirubin, kidney markers – alkaline phosphatase, alanine transferase, and so on). Analyses were done using standard procedures.

Chemical Analyses of Feed, Faeces, and Urine Samples

Sub-samples of feed, faeces, and urine were bulked for chemical analysis using standard procedures. Feed and faecal samples were analysed for proximate composition (dry matter, crude protein, crude fibre, ether extract, ash), and urine samples were analysed for nitrogen, while fibre fraction components (neutral detergent fibre, acid detergent fibre, acid detergent lignin) were determined using the procedures described by AOAC (2022).

Experimental Design and Statistical Analysis

A completely randomized design with the following mathematical model: $Y_{ij} = \mu + a_i + e_{ij}$ was used. Where Y_{ij} – any of the response variables; μ – the overall mean; a_i – effect of the diets, i th treatment (i = supplementation levels of BPM - dietary treatment A, B, C, D, and E); e_{ij} – random error due to experimentation. The data generated from experimental goats and laboratory analysis of the samples were statistically analyzed using one-way analysis of

variance (ANOVA) using SPSS (2011), and differences between treatment means were separated by Duncan multiple range test of the same package, and significance level was set at 95% confidence interval.

RESULTS AND DISCUSSION

Nutrient composition of diets containing wonderful kola seed meal

Table 2 revealed that the nutritional composition of wonderful kola seed-supplemented diets fed to WAD goats was adequate to support the growth and development of growing goats.

Table 2. Nutrient composition (g/kg) of diets containing wonderful kola seed meal (WKSM)

Parameters	A (0.00)	B (0.20)	C (0.40)	D (0.60)	E (0.80)	SEM	P value
Dry matter	88.03	87.58	89.46	89.18	88.58	0.19	0.07
Crude fibre	25.80 ^c	26.13 ^b	27.82 ^{ab}	28.70 ^a	28.68 ^a	0.35	0.00
Crude protein	15.21	15.37	15.44	15.61	15.87	0.16	0.93
Ash	9.94 ^c	9.94 ^c	10.07 ^c	10.72 ^b	11.28 ^a	0.24	0.00
Ether extract	10.65 ^c	11.61 ^b	12.63 ^a	12.68 ^a	12.71 ^a	0.22	0.00
NDF	58.01 ^c	58.02 ^b	58.48 ^b	60.03 ^a	60.16 ^a	1.75	0.00
ADF	40.01 ^b	41.61 ^{ab}	42.01 ^a	42.31 ^a	42.74 ^a	1.11	0.00
ADL	10.82 ^e	13.64 ^d	15.25 ^c	15.53 ^b	15.88 ^a	0.50	0.00

^{abcd} means within the same row with different superscripts are significantly ($P < 0.05$) different. A = 0.00 g/kg WKSM, B = 0.20 g/kg WKSM, C = 0.40 g/kg WKSM, D = 0.60 g/kg WKSM, E = 0.80 g/kg WKSM. NDF = neutral detergent fiber, ADF = acid detergent fiber, ADL = acid detergent lignin. *Analyzed nutrient composition (g/kg) of WKSM is 97.31DM, 15.56CP, 3.80CF, 0.97Ash, 1.89EE.

The high dry matter indicates potential for storage over a long period of time without spoilage. The dietary crude protein contents were sufficient to support the production of enzymes necessary for the effective digestion, effective utilization of nutrients, and improve tissues and muscles, due to the production of amino acids necessary for synthesis in the organs and the overall health of the animals. The supplementation level of wonderful kola (*B. coriacea*) seed meal did not significantly ($P > 0.05$) influence the dietary crude protein (15.21 – 15.87 g/kg), but numerically and linearly increased across the dietary treatments. It is noteworthy that the diets were rich enough to support the maintenance and growth of the goats, as opined by NRC (2007) that ruminants require about 7-8% CP to enact the activities of the rumen microbes. Ash contents of the diets improved significantly with increasing level of *B. coriacea* in the diet. This implies that the diets would be rich in mineral constituents, which in turn would aid and regulate cellular function, acid-base balance, structural support, and growth. The dietary crude fibre (26.13 – 28.70 g/kg) was adequate to encourage rumination by the animals to

improve gut health. In addition, observed fibre fractions were adequate and would be beneficial for animal rumen health, increasing feed efficiency and utilization.

Nutrient intake by WAD goats fed diets containing wonderful kola seed meal

Dry matter intake is an important factor in ruminant feed utilization and an important factor in voluntary intake, digestibility, energy utilization, and performance in small ruminants (Devant *et al.*, 2000). The dry matter intake ranged from 660.71 to 705.11 g/day (Table 3).

Table 3. Nutrient intake by WAD goats fed diets containing wonderful kola seed meal

Parameters (g/d)	A (0.00)	B (0.20)	C (0.40)	D (0.60)	E (0.80)	SEM	P value
Dry matter	660.71 ^c	660.19 ^c	705.11 ^a	685.82 ^b	680.11 ^b	4.49	0.00
Crude fibre	196.13 ^c	210.36 ^b	222.02 ^a	218.86 ^a	203.34 ^{bc}	2.72	0.00
Crude protein	136.64	138.88	145.30	144.53	141.96	1.46	0.29
Ash	75.83 ^c	76.94 ^c	86.76 ^a	80.45 ^b	76.12 ^c	2.16	0.00
Ether extract	79.93 ^e	87.80 ^d	89.94 ^a	88.42 ^b	86.34 ^c	2.02	0.00
NDF	336.26 ^e	378.50 ^d	473.52 ^a	457.83 ^b	405.92 ^c	13.53	0.00
ADF	247.83 ^c	249.68 ^c	315.33 ^a	315.26 ^a	302.47 ^b	8.26	0.00
ADL	85.53 ^e	103.13 ^d	125.18 ^a	118.08 ^b	116.57 ^c	4.03	0.00

^{abcd} means within the same row with different superscripts are significantly ($P < 0.05$) different. A = 0.00 g/kg WKSM, B = 0.20 g/kg WKSM, C = 0.40 g/kg WKSM, D = 0.60 g/kg WKSM, E = 0.80 g/kg WKSM. NDF = neutral detergent fiber, ADF = acid detergent fiber, ADL = acid detergent lignin.

However, it is noteworthy that dietary protein quality and DM positively influence voluntary intake by ruminants. Further, crude fibre and its intake encourage gut motility and function, thereby enhancing rumination and nutrient absorption and digestion. Goats fed diet C (0.40 g/kg of *B. coriacea*) had the best nutrient intake. This implies that the diet was palatable and acceptable to the animals at this inclusion level, and also an indication and function of dietary crude protein and dry matter.

Nutrient digestibility and weight gain of goats fed diets containing wonderful kola seed meal

Digestibility helps to identify the best source of nutrients for the animal's diet. All the diets were well digested and utilized, as apparent nutrient digestibility coefficient values were above 50% (Table 4). Values obtained are evidence of the diets' support for healthy digestive function, satisfy their amino acid needs, support better muscle growth, prevent digestive disorders, and improve general health and nutrient utilization.

Table 4. Nutrient digestibility and weight gain of goats fed diets containing wonderful kola seed meal

Parameters	A (0.00)	B (0.20)	C (0.40)	D (0.60)	E (0.80)	SEM	P value
<u>Digestibility (%)</u>							
Dry matter	78.00 ^c	79.33 ^b	85.00 ^a	78.00 ^c	77.00 ^d	0.77	0.00
Crude fibre	82.62 ^d	87.17 ^b	88.06 ^a	85.29 ^c	84.71 ^c	0.52	0.00
Crude protein	88.33 ^a	85.28 ^b	88.73 ^a	82.36 ^c	80.69 ^c	0.87	0.00
Fat	94.80 ^b	93.54 ^c	96.67 ^a	95.75 ^{ab}	94.99 ^b	0.31	0.00
NDF	76.82 ^d	77.94 ^c	83.01 ^a	79.61 ^b	78.40 ^c	0.58	0.00
ADF	83.32 ^b	80.13 ^c	85.92 ^a	76.15 ^d	76.08 ^d	1.05	0.00
ADL	68.27 ^d	74.68 ^b	87.46 ^a	65.75 ^e	71.44 ^c	2.74	0.00
<u>Growth Performance</u>							
IW (kg)	13.73	13.77	12.50	12.77	11.88	0.71	0.93
FW (kg)	17.96	17.41	16.82	16.94	15.37	0.79	0.91
Weight Gain (kg)	4.23	3.65	4.32	4.18	3.49	0.15	0.28
ADWG (g/day)	75.48	66.12	77.20	74.58	66.26	2.66	0.28
FCR	9.28	10.35	8.75	9.18	11.28	0.39	0.28

^{abcd} means within the same row with different superscripts are significantly ($P < 0.05$) different. A = 0.00 g/kg WKSM, B = 0.20 g/kg WKSM, C = 0.40 g/kg WKSM, D = 0.60 g/kg WKSM, E = 0.80 g/kg WKSM. NDF=neutral detergent fiber, ADF= acid detergent fiber, ADL=acid detergent lignin, IW - Initial Weight, FW - Final Weight, ADWG - Average daily weight gain, FCR - Feed conversion ratio.

However, it is worth noting that goats fed diet C (0.40 g/kg WKSM) had the best feed/gain ratio (8.75) and the highest apparent nutrient digestibility coefficient values, highlighting its superior performance in promoting weight gain. This increased protein use could be attributed to a possible improvement in nitrogen availability in the rumen, which facilitates microbial growth and protein synthesis. Evaluation of growth performance is of economic importance to farmers, especially when goats are raised for meat production. Weight gain in ruminants is dependent on dry matter intake, protein intake, and the digestibility of the nutrients. The highest weight gain was obtained in goats fed diet C (Table 4) could be attributed to the afore-mentioned factors.

Haemato-biochemical indices of goats fed diets containing wonderful kola seed meal

Blood plays an intensive role in the body of the animals. It circulates in the vessels, transporting gasses such as oxygen and carbon (IV) oxide between respiratory organs, hormones, nutrients from digestive tracts to tissue and storage organs.

Haematological parameters are crucial markers in diagnosing and determining the actual physiological status of animals under any kind of physiological state (Ahmed and Egwu, 2020). Dietary treatment affected hematological parameters (Table 5). However, the obtained values were

within the limits of healthy goats. The packed cell volume (PCV) was used as a toxicity index in feed samples, and a decrease in PCV concentration indicates the presence of toxic substances (Anyu *et al.*, 2018). The PCV values obtained in this study indicate the presence of good/quality dietary protein. The hemoglobin concentration values obtained in this study were within the range of hemoglobin values recommended for healthy goats (7-15 g/dl), indicating that goats had sufficient blood pigment to properly transport oxygen to their healthy lives.

Table 5. Haemato-biochemical indices of goats fed diets containing Wonderful Kola seed meal

Parameters	A (0.00)	B (0.20)	C (0.40)	D (0.60)	E (0.80)	SEM	P value
<i>Haematological indices</i>							
PCV (%)	33.33 ^b	34.33 ^b	33.33 ^a	39.33 ^{ab}	36.33 ^b	2.35	0.04
WBC ($\times 10^3/\mu\text{l}$)	5.87 ^b	8.93 ^{ab}	10.73 ^a	9.77 ^{ab}	8.83 ^{ab}	3.48	0.01
RBC ($\times 10^6/\mu\text{l}$)	8.80 ^b	3.63 ^b	4.50 ^a	4.10 ^{ab}	3.77 ^b	0.24	0.04
Hemoglobin (g/dl)	12.53 ^b	11.43 ^b	14.53 ^a	13.57 ^{ab}	11.93 ^b	0.67	0.04
Lymphocytes (%)	37.33 ^{ab}	31.67 ^{bc}	28.00 ^c	43.33 ^a	28.33 ^c	3.22	0.01
Neutrophils (%)	58.33 ^b	64.67 ^{ab}	70.33 ^a	56.33 ^b	28.33 ^b	2.74	0.01
Monocytes (%)	4.33 ^a	1.33 ^b	1.00 ^b	1.33 ^b	0.33 ^b	0.37	0.00
Eosinophils (%)	0.00	1.33	0.00	0.00	0.00	0.02	0.13
<i>Serum biochemical indices</i>							
Total Protein (g/dl)	51.07 ^b	53.33 ^b	54.37 ^b	56.57 ^{ab}	62.93 ^a	2.49	0.01
Albumin (g/dl)	8.33 ^b	14.33 ^{ab}	18.33 ^a	20.33 ^a	20.00 ^a	1.15	0.99
Globulin (g/dl)	33.23 ^b	31.03 ^{bc}	38.93 ^a	29.33 ^c	28.40 ^c	0.54	0.00
AST (IU/L)	12.33 ^d	28.40 ^c	29.33 ^c	31.03 ^{bc}	38.93 ^a	2.98	0.72
PO3 (IU/L)	8.33 ^b	14.33 ^{ab}	18.33 ^a	20.33 ^a	20.00 ^a	2.43	0.00
ALT (IU/L)	16.67 ^{bc}	22.67 ^a	18.67 ^{ab}	17.67 ^{bc}	12.67 ^c	2.08	0.02
Total Bilirubin (mg/dl)	10.33	9.67	9.33	12.00	11.33	0.93	0.30

^{abcd} means within the same row with different superscripts are significantly ($P < 0.05$) different. A = 0.00 g/kg WKSM, B = 0.20 g/kg WKSM, C = 0.40 g/kg WKSM, D = 0.60 g/kg WKSM, E = 0.80 g/kg WKSM. AST – Aspartate aminotransferase, PO3 – Alkaline phosphatase, ALT – Alanine transferase.

White blood cells (WBC) and their derivatives fight foreign bodies/infections by protecting the body through a process called phagocytosis. High value of WBC above normal values could be due to the effects of toxicity of diets or poor detoxification process which lead to increased production of white blood cell to fight foreign substances in the body, but a low value suggest susceptibility to infection. The level of lymphocytes observed in the goats in the study showed that the experimental goats were well protected against infections. The values of neutrophils, basophils, and monocytes observed in this study were within the range of

values recommended for healthy goats, an indication that the dietary treatment did not cause an allergic reaction. Serum total protein observed is a reflection of sufficient dietary crude protein, translating into the bloodstream when nutrients are absorbed. Cellular protein synthesis was improved in goats fed diet C (0.4 g/kg *B. coriacea*). An increased activity of globulin in the serum is a well-known diagnostic indicator of liver injury.

The globulin concentration observed in this study indicates that wonderful kola seed meal has the potential to improve immunity in goats due to the therapeutic potential of the seed (Ijarotimi *et al.*, 2015). It noteworthy that the higher the concentration of globulin, the greater the ability to fight infection because globulin is known to fight infection. However, low level of globulin could lead to high mortality. AST and ALT are enzymes that are present in large amounts in the liver and are often used to detect liver damage (Pratt, 2010). However, the values observed in this study were within the normal range for ruminants by Ileyemi (2017). Total bilirubin is an orange-yellow pigment created when the body breaks down old red blood cells. It serves as an antioxidant that protects cells from damage and serving as an essential diagnostic biomarker for liver, gallbladder and blood health. Throughout the study, no mortality was recorded, and thus suggestive of a well-developed immune system in the goats.

Expression of insulin-like growth hormone (IGF-1) genes in WAD goats fed wonderful kola-supplemented diets

Gene expression analysis studies are performed in response to diet, as biochemical parameters depend on specific gene transcripts (Asmelash, 2018). Diet can act as bioactive molecules that cause changes in molecular mechanisms depending on the physiological state of the animal (Benitez *et al.*, 2017). Figures 1-4 show the expression of insulin-like growth hormone (IGF-1) genes in WAD goats fed wonderful kola-supplemented diets. IGF-1 is mainly expressed in the liver.

In this study, the expression of IGF-1 in the liver was down-regulated because its production is triggered mostly by consumption of animal protein (Yakar, 2002; Berton *et al.*, 2018). However, the expression level could be influenced by the age of the animals used. In the spleen, rump, heart, and liver, IGF-1 was relatively expressed or up-regulated in all the goats fed diets supplemented with WKSM, particularly in diets B and C, confirming that the animals had sufficient growth hormones to support good performance in their tissues.

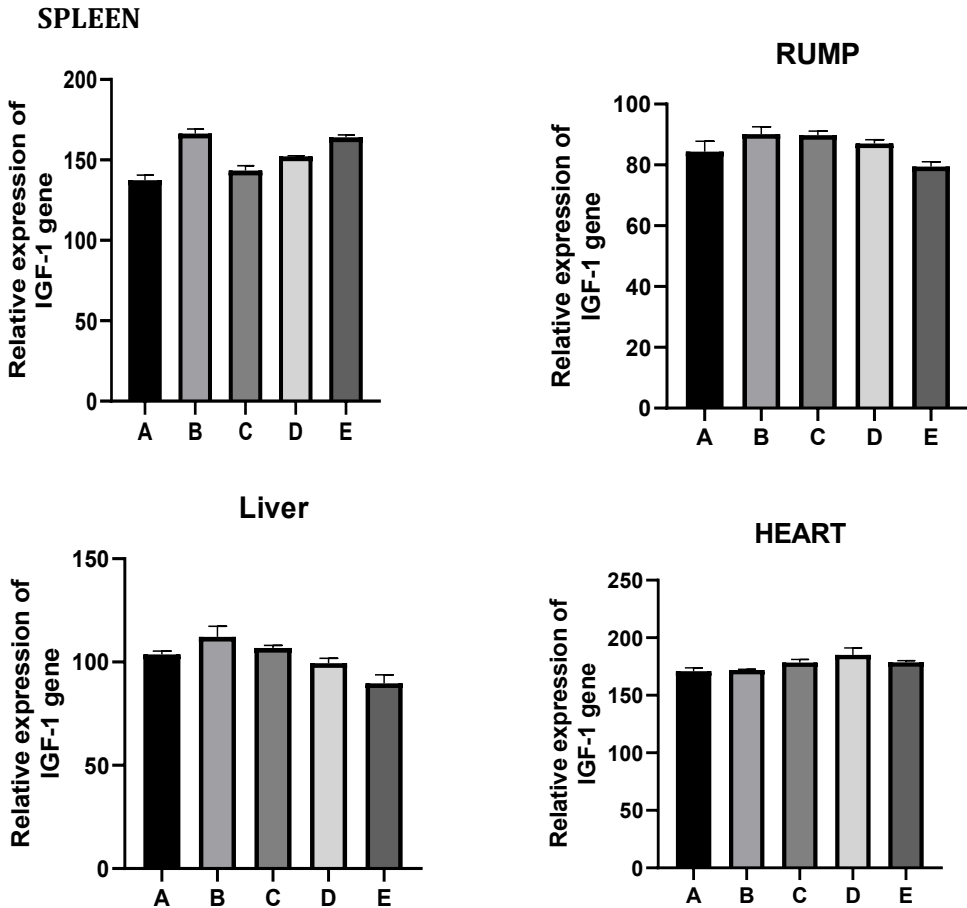


Figure 1-4. The Insulin-like Growth Factor (IGF-1) growth hormone expressed in the spleen, liver, rump and heart of the WAD goats fed *B. coriacea* supplemented diets. A = 0.00 g/kg WKSM, B = 0.20 g/kg WKSM, C = 0.40 g/kg WKSM, D = 0.60 g/kg WKSM, E = 0.80 g/kg WKSM.

Dietary protein intake serves as the primary determinant of IGF-1 level (Suliman, 2014), and higher proportions of daily calorie intake from protein, especially animal protein, correlate with elevated IGF-1 levels (Aguirre *et al.*, 2016).

CONCLUSION

Based on the foregoing, wonderful kola (*Buchholzia coriacea*) seed meal in WAD goats' diet influenced growth hormone expression, weight gain, and

health status of the animals. Supplementation of wonderful kola (*Bucchozia coriacea*) seed meal in goat's diets at 0.4 g/kg had higher nutrient content and nutrient digestibility, without any detrimental health implications on the animals, and it is thus recommended to ruminant farmers for improved and sustained ruminant production. Further research could be conducted on the anthelmintic potency of *B. coriacea* seed, and also reproductive performance (particularly, milk production and quality) of dairy-type ruminants could be explored.

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