International Journal of Innovation Scientific Research and Review
Vol. 06, Issue, 11, pp.7331-7337, November 2024
Available online at http://www.journalijisr.com
SJIF Impact Factor 2023: 6.599

Research Article

ISSN: 2582-6131

EFFECTS OF GRADED LEVEL OF CASSAVA LEAF MEAL FED TO GROWER RABBIT ON MEAT QUALITY

*** Iyiola, V.O, Yaikyur, N.S, Omotoso, O.B**

Department of Animal Production and Health, Federal University Wukari, Nigeria.

Received 2nd September 2024; Accepted 3rd October 2024; Published online 30th November 2024

ABSTRACT

The effects of graded level of cassava leaf meal fed to grower rabbit on meat quality were evaluated. A total of Eighteen (18) 4-5 weeks old female rabbits of mixed breeds were used in an 8 weeks feeding trial. The animals were randomly selected and assigned to three treatments each with six rabbits and had three replicates of two rabbits per replicate using Completely Randomized Design (CRD). The proximate composition of cassava leaf meal and rabbit meats including the sensory quality, amino acids, vitamins and mineral contents of the meats were analyzed. Data collected were statistically analyzed using one way analysis of variance. The significantly different means were separated using Least Significant Difference (LSD).The results of feeding cassava leaf meal to grower rabbits showed no significant difference ($p>0.05$) in the proximate composition, sensory quality and mineral content of the meat across treatments. However, significant differences ($p<0.05$) were observed in the content of certain amino acids in the meat of grower rabbits fed cassava leaf meal, specifically excluding valine, histidine, lysine, serine, aspartic acid, glutamic acid, and proline. Furthermore, regarding the effect of cassava leaf meal on vitamin content in grower rabbit meat, a significant difference ($p<0.05$) was observed only in vitamin A whereas vitamins B1, B2, B3, and E showed no significant differences across treatments. Therefore, cassava leaf meal can be used partially in the diet of grower rabbits to reduce costs while maintaining good nutritional and sensory meat quality.

Keywords: Rabbit; Meat; Cassava leaf meal; Proximate; Sensory quality.

INTRODUCTION

Meat a muscle tissue of slaughter animals (Lawrie & Ledward, 2006) is the most common and valued food of animal origin all over the world due to its outstanding sensory and varied culinary properties. Meat is a rich source of highly valued proteins, variety of fats, minerals and vitamins (Ijarotimi & Keshinro, 2020). Cattle, sheep and goats and recently poultry, pig and rabbits are the main livestock of commercial importance used for meat production in Nigeria (Ogbeide, 2015). Demand for meat is ever increasing with increase in the population and awareness about its nutritional value (Al Sayed, *et al*., 2019). A consumer demand driven increase in the production and consumption of meat and meat products had been predicted to occur in the developing countries between 2010 and 2050 (FAO, 2011). Due to increase in population and demand for meat, a livestock that is fast growing and has short gestation period should be reared in other to meet the demand of the consumers. Among other animals rabbit (*Oryctolagu scuniculus*) is a monogastric animal that is fast growing and has short gestation length, with the ability to rebreed shortly after parturition (Lebas *et al*., 1996). They are highly prolific, have the ability to efficiently convert non-competitive feed sources to meat (Suttle, 2010) and can utilize up to 30% crude fiber (Egbo *et al*., 2001). Rabbit meat has high biological value protein (DalleZotte 2000) notable amount of polyunsaturated fatty acids (PUFA) which decrease low density lipoprotein cholesterol levels thereby decrease cardiovascular risk (Whitney & Rolfes, 2002), It also contains variety of minerals and vitamins (DalleZotte & Szendro, 2011). A gap exists between the demand and supply of conventional feed resources for feeding livestock in the country due to unavailability and high cost of the feedstuffs. This has affected the meat industry which is faced with a number of challenges in producing high quality meat products in a cost effective manner with regards to expensive and unavailability of feed ingredients in raising the animals. In order to manage this problem, it is essential to exploit the use of non-conventional feed resources that is cheap, readily and locally available in order to replace expensive and scarce feedstuffs for livestock production (Ben Salem *et al*., 2004). One of the non-conventional feed resources is dry cassava (*Manihote sculenta*) leaf meal. Cassava leaf are highly nutritious; they have high protein content ranging from 16.6% to 39.9% (Khieu, 2005). Fasuyi (2005) also reported that cassava leaf are a significant source of potential alternative protein resource for both humans and animals. The leaf depending on the varieties also contain mineral levels, as well as being a valuable source of vitamin B_1, B_2, C and carotenes (Adewusi & Bradbury, 1993). Several authors reported the use of cassava leaf meal as a source of protein (Adegbola & Okonkwo, 2002), minerals and vitamins (Adewusi and Bradbury 1993) in rabbit's diets and can, partly, replace soybean meal in rabbit diets (Phuc, 2001). However, significant level of Hydrocyanic acid (HCN) found in fresh cassava leaf can limits their use in livestock feed (Ngiki *et al*., 2014). Drying or ensiling of cassava leaf has been reported to markedly reduce the HCN content to 80% of the original concentrations found in the leaf (Borin *et al*., 2005). Therefore partly incorporation of cassava leaf meal in the diet of rabbits will help to relieve the scarce and high cost of feedstuffs and more so produce a cheaper quality rabbit meat that will meet the nutritional and better sensory qualities demand of the public thereby affecting the consumers, meat industry, meat processors and animal feed producers positively through profit optimization. This study evaluated the effects of graded level of cassava leaf meal fed to grower rabbit on meat quality.

MATERIALS AND METHODS

Fresh cassava leaf were harvested from the farm, washed and dried under shade for seven days to a constant weight. The dried cassava leaf were milled and put into an airtight container. Sample of the

***Corresponding Author: Iyiola, V.O,**
Department of Animal Production and Health, Federal University Wukari, Nigeria.

milled cassava leaf were taken for proximate analysis. Three diets were formulated using Cassava Leaf Meal (CLM) in replacement for full fat soybean as shown in the Table 1; Diet 1 (control with 0% CLM) while diet 2 and 3 contained CLM at 10 and 20% inclusion levels respectively. A total of eighteen (18) 4-5 weeks old female rabbits of mixed breeds were used in an 8 weeks feeding trial. The animals were randomly selected and assigned to treatments using Completely Randomized Design (CRD) on the basis of equal mean live weight to three treatment groups each with six rabbits. Each treatment had three replicates of two rabbits per replicate. The experimental rabbits were housed in a wood-wire hutches equipped with feeders and drinkers. The experimental diets, fresh forages (*Trida xprocumbens*) and water were provided adlibitum. The rabbits were allowed to acclimatize to their various hutches for one week during which they were dewormed. At the end of the 8 weeks feeding trial, three rabbits per treatments (0ne per replicate) were slaughtered and the loin part of the rabbits from each of the treatments were removed and stored at 12°C under very hygienic condition until needed for proximate, sensory, vitamins, minerals and amino acids analysis,

Table1: Percent age composition of the experimental diets of grower rabbits

Diet Ingredients	T1 (Control)	T2 (10% CLM)	T3 (20% CLM)
Maize	36.40	36.40	36.40
Full fat soybean	31.60	28.44	25.28
Cassava leaf meal	-	3.16	6.32
Maize offal	27.70	27.70	27.70
Bone meal	3.00	3.00	3.00
Premix	0.50	0.50	0.50
L-methionine	0.25	0.25	0.25
L-Lysine	0.25	0.25	0.25
Salt	0.30	0.30	0.30
Total	100	100	100
Calculated Chemical Composition			
Metabolizable energy	3009.06	2914.59	2814.74
Crude protein (CP)	20.17	18.66	17.15
Crude fibre (CF)	4.79	5.09	5.25
Feed cost per kg/diet (₦)	139.62	126.05	112.47

Proximate analysis

The proximate compositions of the cassava leaf meal and rabbit meat were determined by the method described by AOAC (2006). This includes the moisture content, ash, crude protein, fat content and nitrogen free extract. Moisture content was determined by drying 5g of cassava leaf meal and meat samples in an oven at temperature of 105±5°C to a constant weight. Crude protein of the cassava leaf meal and meat samples were determined by Kjeldahl methods while ether extract/ fat content was obtained by soxhlet extraction method using petroleum ether. Ash content of cassava leaf meal and meat samples were obtained by igniting 1g of meat and cassava leaf meal samples in a Muffle furnace at 500°C for 5 - 6 hours until ashes were produced

Sensory evaluation

The sensory quality of the rabbit meat was evaluated by the method described by Nasiru *et al*., (2011). Weighed samples of the loin part of the grower rabbits from each of the treatments were cut into pieces, washed and dip into salt solution and cooked for 45 minutes after which they were removed and randomly assigned for sensory evaluation. The meat samples were served to 18 trained panelists drawn from 500 level students of Animal Production and Health, Faculty of Agriculture and Life Sciences of Federal University Wukari. Each panelist evaluated at most two treatments and each of the samples was given one at a time and evaluated using the sensory questionnaires. The samples were evaluated for tenderness, juiciness, flavor, connective tissue and off flavor characteristics using a 8 points hedonic scale where 8 = extremely desirable, extremely juicy, intense in rabbit flavor, extremely tender whereas 1 = extremely undesirable, extremely dry, devoid of rabbit flavor and extremely tough.

Determination of amino acids profile in rabbit meat

Amino acids were determined according to procedures described by ISO (2005). Five (5) grams of rabbit meat were hydrolyzed in 10mL of 6N hydrochloric acid at 110 ° C for 24 hours. The hydrolysates were diluted in 20 ml of 0.2 N sodium citrate, pH 2.3. After evaporation of acid, the sample was recovered in 10 mL of 70% ethanol, filtered on a millipore filter paper and 2 mL of each sample were injected in high performance liquid chromatography chain. Elution was done in gradient mode with a flow rate of 1 mL / min. Detection was carried out using a Waters spectrofluorometer 2475Excitation and emission were carried out respectively at 340 nm and 450 nm.

Analysis of vitamin content in the rabbit meat

The vitamin content in the rabbit meat was analyzed by the procedure described by European pharmacopoeia book (2014).The vitamin content of the samples was determined by high performance liquid chromatography technique

Determination of the mineral content in the rabbit meat

Using atomic absorption spectrophotometer (AAS), 1g of a blended rabbit meat sample was weighed into a porcelain crucible. It was preashed at 300ºC and brought to 600ºC for2 hours in a furnace and allowed to cool. 25 ml of 3 M HCl was added to it and filtered into a 100 ml volumentric flask and diluted to volume with deionized water. The sample was vortex for proper mixing and transferred to centrifuge tubes and centrifuged at 3000 rpm for 10 mins. The supernatant was decanted into clean vials for macro element determination using AAS. The concentrations of the various mineral were determined in mg/100g of sample.

Statistical analysis

The data generated were statistically analyzed using one–way analysis of variance (ANOVA) and significantly different means were separated using Lower significant difference (LSD). SPSS 20 version was used

RESULTS AND DISCUSSION

Table 2: Proximate composition of cassava leaf meal

Composition	g/kg-1/Dm
Moisture	8.90
Dry matter	91.10
Crude protein	32.10
Crude fibre	11.20
Ash	6.70
Ether extract	7.02
Nitrogen free extract	34.08

The proximate composition of cassava leaf meal (CLM) as shown in Table 2 showed that cassava leaf meal used in this study had the moisture content of 8.9%, crude protein (32.10%), crude fiber (11.20%), ash content (6.70%), ether extract value (7.02%) and nitrogen free extract (33.90) respectively. The moisture content of cassava leaf meal in this study is lower than 9.55 ± 0.1(g 100 g−1) reported by (Oresegun *et al*., 2016) but higher than 5.00% reported by (Idris *et al*., 2013). The lower level of moisture content observed in this study is enough to discourage microbial growth and undesirable enzymatic activities. Crude protein content of cassava leaf meal (32.10 g/kg-1/Dm) of this study was higher than 24.2% reported by (Adegbola & Okonkwo, 2002), 23.87% reported by (Idris *et al*., 2021) but within the range of 17.7–38.1% dry basis reported by (Latif and Müller, 2015). This is an indication that cassava leaf meal found in this study contains good amount of protein as reported by (Khieu, 2005) and can be an alternative source of protein as reported by (Fasuyi, 2005; Adegbola & Okonkwo, 2002). The level of crude fiber found in this study was lower than 14.8% reported by (Adegbola & Okonkwo, 2002) while the ash content of the cassava leaf meal was higher than 5.56 ± 0.03 reported by (Oresegun *et al*., 2016) and 6.53% reported by (Idris *et al*., 2021). This is an indication that the cassava leaf meal has high mineral content (Adewusi and Bradbury 1993) which is of benefit to the functionality of the body system of rabbits. In addition the ether extract value found in this study was higher than 6.00% reported by (Idris, *et al*., 2021). The use of the cassava leaf meal (CLM) may supply a positive balance for the nutritional quality because they present higher contents of proteins, vitamins, minerals and fibre (Corrêa, 2004; Ngudi*, et al*., 2003). The variability in proximate composition observed in this study with the results from other researchers could be attributed to the variety of the cassava, age of the plant, the proportional size of the leaf, soil type, climatic condition as well as processing condition (Idris *et al*., 2021; Ngudi *et al*., 2023; Gil and Buitrago 2002).

Effects of graded level of cassava leaf meal fed to grower rabbit on proximate composition of meat

Table 3: Effects of graded level of cassava leaf meal fed to grower rabbit on proximate composition of meat

Parameters	T_1 (Control) (%)	T_2 (10%CLM) (%)	T_3(20%CLM) (%)	SEM
Moisture	72.75	71.72	71.91	0.96
Ash	1.11	1.60	1.64	0.20
Crude protein	21.79	21.74	21.76	0.34
Fat	1.35	1.64	1.34	0.15
Nitrogen free extract	3.00	3.30	3,35	0.32

[a]CLM: Cassava leaf meal; [b]SEM=Standard Error of Mean.

The proximate composition of foods which includes moisture, ash, fat, protein and nitrogen free extract contents are food components which are of interest in the food industry for product development, quality control or regulatory purposes. The results of the effect of graded level of cassava leaf meal fed to grower rabbit on proximate composition of meat shown in Table 3 indicated no significant difference (p>0.05) across the treatments. However, little variations that were not significantly difference (p>0.05) were observed in the parameters across the treatments. The moisture content of the grower rabbit meat was high across the treatments but bit higher in the control (72.75%) than other treatments. The range of the moisture content (71.72 – 72.75%) in this study was higher than 69.7% reported by (Hernandez and Zotte, 2010; DalleZotte & Szendro, 2011) but within the range of 66.2 - 75.3% reported by (DalleZotte, 2002), but lower than the range of 74.07 - 75.97% reported by (PoganySimonová *et al*., 2010). The high moisture content of the meat recorded across the treatments is an indication that the meats would have better sensory qualities of colour and juiciness because amount of moisture on a meat surface will affect the amount of light that is reflected and the brightness and/or lightness that an observer perceives (Faustman & Suman, 2017). However the higher moisture content could cause microbial spoilage of the meat if not properly preserved because high moisture content encourages growth of wide range of organism. According to Jay *et al*., (2005), water activity and availability of specific nutrients are required for the growth of bacteria, yeasts, and molds.

Meat from rabbit fed diet that contained 20% cassava leaf meal (CLM) (T_3) had the highest ash content (1.64%) while control (T_1: Diet without CLM) had the lowest ash content (1.11%) across the treatments. The ash contents of the rabbit meat increased across the treatments as a result of increase in inclusion level of cassava leaf meal in the diet of grower rabbit. This shows that addition of the cassava leaf meal in the diet enhanced the mineral content of the rabbit meat. This agrees with Fasuyi, (2005) who reported that cassava leaf meal is a good source of minerals in animal feeds. The range of ash content (1.11-1.64%) of the study was lower than 3.63±0.13, 3.33±0.08, 3.30±0.02, 3.66±0.08 and 3.31±0.11g/100g of meat of rabbit fed diet partially replaced with 50% of *Solanummelongena, Abelmoschusesculentus, Corchorusolitorius, Ipomoea batatas and Vignaunguiculata*leaf respectively (Wognin *et al*., 2018), 1.8% reported by (Hernandez and DalleZotte, 2010; DalleZotte & Szendro, 2011). But higher than 1.2 and 1.3% found in young and older rabbits respectively as reported by (Malík, 2002), 1.04 =1.06% as reported by (Dal Bosco*et al*., 2001) and 1.00- 1.07% reported by (PoganySimonová *et al.,* 2010). The variations of the ash content of the rabbit meat found in this study and from several researchers could be attributed to the chemical composition of various diets, age of the rabbit, sex and breed of the rabbits

The crude protein content of rabbit meat was similar (p>0.05) across the treatments and ranged from 21.74-21.78%. The similarity in the crude protein content across the treatments is an indication that cassava leaf meal can be used to achieve the similar result as of the control when fed to the rabbit. This is in agreement that rabbit has the ability to efficiently convert non-competitive feed sources to meat (Suttle, 2010) and can utilize up to 30% crude fiber (Egbo *et al*., 2001). More so the protein content of the cassava leaf meal in the diet has the potential to enhance the protein quality of the meat (Fasuyi, 2005). In addition the result also showed that rabbit meat has high biological value protein (DalleZotte 2000). The crude protein content in this study is higher than 19.07±1.50%, 19.16±0.86% and 20.56±0.65% crude protein of meat from rabbit fed 50% of *Solanummelongnia*, *Abelmoschusesculentus* and *Corchorusolitorius* leaf respectively (Wognin *et al*., 2018), 19.60 - 20.8% reported by Marounek *et al*., (2007) and 21.5 g.100 g-1 reported by (Malík, 2002). But lower than the range of 21.37 - 21.80% reported by (PoganySimonová *et al*., 2010) and 22.89 - 22.97% reported by (Dal Bosco *et al*., 2001). However it was within the range of18.10 - 23.70% reported by (DalleZotte, 2002). Crude protein content of the rabbit meat in this study is higher than 0.83g/kg/day which was recommended as nutritional intake of protein for human (AFSSA, 2007). This is an indication that rabbit meat produced in this study can be used as protein source in human diets (Whitney & Rolfes, 2002).

Fat is mainly used to determine the energy value of food products by food processors. No significant difference (p>0.05) found on the fat contents of the rabbit meat across the treatments is also an

indication that CLM can be used to obtain similar result as of the control. The fat content (1.34%) of meat from rabbit fed diet that contained 20% CLM was expected to increase as a result of increase in inclusion level of CLM but however unexpected reduction was observed. This showed that to achieve lower fat content of rabbit meat, inclusion level of cassava leaf meal in the diet of grower rabbit should be increased. The fat content in this study is lower than 6.73±0.25, 6.03±, 6.64±0.017, 7.79±0.28 and 7.11±0.09 g/100g of meat of rabbit fed diet partially replaced with *Solanummelongena, Abelmoschusesculentus, Corchorusolitorius, Ipomoea batatas and Vignaunguiculata* leaf respectively (Wognin *et al*., 2018) and range of 2.3 - 4.5 g.100 g-1 reported by (Malík, 2002). But higher than the range of 0.6 - 14.4% reported by (Zotte & Dalle, 2002) and 1.81-1.85% reported by (Dal Bosco *et al*., 2001). However, it was within the range of 1.33 - 1.44 g.100 reported by (Pavelková *et al*., 2017), 1.40% reported by (PoganySimonová *et al*., 2010) and 1.39 - 1.41% reported by (Capra *et al*., 2013). The low fat content in this study is in agreement with Hernanded & Gondret (2006) who reported low fat content and less saturated fatty acid in rabbit meat. Hernanded & DalleZotte (2010) also reported that rabbit meat is a lean meat and the leanest portion is the loin with average of 1.8g $100g^{-1}$. This implies that rabbit meat is good for consumption especially people with health related issue to animal fat consumption. The higher fat content (1.64%) of the meat from rabbits that were fed diets that contained 10% inclusion level of cassava leaf meal (CLM) would have better sensory quality (flavour and juiciness) compare to other treatment. Winger & Hagyard (1994) reported that juiciness is related to the fat content of the meat. Fat was also found to be the most important precursors of cooked meat flavor (Resconi *et al*., 2013).

Effects of graded level of cassava leaf meal fed to grower rabbit on meat sensory quality

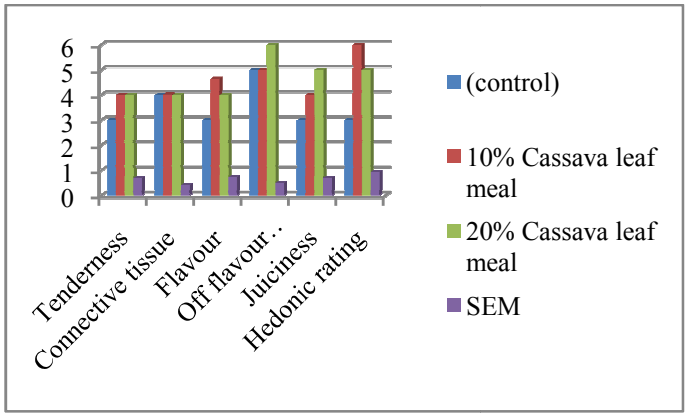

Figure 1: Effects of graded level of cassava leaf meal fed to grower rabbit on meat sensory quality

The effects of graded level of cassava leaf meal fed to grower rabbit on meat sensory quality presented in Table 4 showed no significant differences (p>0.05) in all the sensory parameters evaluated across the treatments. This is an indication that partial use of cassava leaf meal in the diet of grower rabbits can achieve similar sensory qualities as that of the control H o w e v e r , increase in inclusion level of cassava leaf meal (CLM) in the diet of the grower rabbit led to an increase in the tenderness of the meat samples across the treatments. Meat from the rabbit fed the diet that contained10% cassava leaf meal (T_2) was more preferable by the panelists and had the highest sensory score than other treatments although not significantly difference. This could be attributed to its amino acids content (Table 4). This agrees to several authors report on amino acids as essential substances for the specific flavor of the meat (Chen & Liu 2004; Khan *et al*., 2015). Meat from rabbit fed diet that contained 10% CLM had lower amino acids content compare to other treatments (Table 4) and it influenced the flavour of the meat. This agrees with Khan *et al*., (2015) who reported that peptides and amino acids degradation in meat improve its sensory quality. In addition the flavour and tenderness of the meat could also be influenced by its high fat content (Table 3). This agrees with the report of Winger & Hagyard (1994) that fat influences the flavour and juiciness of a product. The score on juiciness (5.00) and tenderness (4.00) obtained from the meat of the rabbit fed diet that contained 20% of CLM in this study is lower than 6.08 and 6.00 of juiciness and tenderness obtained from meat from pigs fed CLM respectively while the score of flavour (6.00) in this study is higher than 5.80 obtained from meat from pigs fed CLM (Ekpo *et al*., 2022). Sensory evaluation can be used for product development, quality control, shelf-life testing, market research, and consumer education (Mihafu, *et al*., 2020). It is very important in determining consumer acceptability of meat.

Effects of graded level of cassava leaf meal fed to grower rabbit on amino acid profile of meat

Table 4: Effects of graded level of cassava leaf meal fed on grower rabbit on amino acid profile in meat

Parameters	T_1 (Control) g/100g	T_2 (10%CLM) g/100g	T_3 (20%CLM) g/100g	SEM
Threonine	3.83	3.52	3.62	0.029
Valine	3.71	3.56	3.43	0.001
Methionine	2.85^{a}	2.73^{b}	2.83^{a}	0.260
Isoleusine	5.48^{ab}	5.66^{a}	5.24^{b}	0.100
Leusine	8.45^{b}	8.65^{a}	8.14^{c}	0.028
Phenylalanine	3.77^{ab}	3.69^{b}	3.92^{a}	0.042
Histidine	4.02	4.00	4.02	0.034
Lysine	10.63	9.97	10.07	0.289
Arginine	5.63^{a}	5.23^{b}	5.53^{a}	0.072
Serine	4.86	4.59	4.77	0.133
Tyrosine	4.82^{a}	4.67^{a}	4.22^{b}	0.116
Alanine	5.73^{a}	5.02^{c}	5.55^{b}	0.023
Aspartic	9.33	9.32	9.15	0.083
Glutamic	15.59	15.47	15.86	0.143
Glycine	5.06^{b}	4.96^{b}	5.35^{a}	0.045
Proline	0.56	0.44	0.65	0.075

[c]SEM: Standard Error of Mean, [d]abc Means in the same row with different superscripts are significantly different (p<0.05).

Effects of graded level of cassava leaf meal fed to grower rabbit on amino acid profile of the meat presented in Table 4 showed significant differences (p<0.05) on some of the amino acids except on valine, histidine, lysine, serine, aspartic, glutamic and proline were no significant differences (p>0.05) were observed across the treatments. Meat from rabbit fed control diet (T_1: diet without cassava leaf meal) was significantly higher in threonine (3.83 g/100g) and alanine (5.73 g/100g) content across the treatments. However, its methionine, isoleusine, phenylalanine and arginine content were not significantly difference (p>0.05) from the meat of rabbit fed diet that contained 20% CLM (T_3). Meat from rabbit fed diet that contained 10% cassava leaf meal (T_2) was significantly (p>0.05) higher in leusine (8.65 g/100g) content across the treatments. Phenylalanine (3.92 g/100g and glycine (5,3g/100g) content in meat from rabbit fed diet that contained 20% cassava leaf meal (T_3) were found to increase as a result of increase in cassava leaf meal in the diet of the rabbit. Observation of no significant differences (p>0.05) in valine, histidine, lysine, serine, aspartic, glutamic and proline is an indication that addition of cassava leaf meal (CLM) in the diet of grower rabbit can be

used to achieve similar result on the meat as of the control especially its content of essential amino acids that must be present in the protein of the feed. This shows that cassava leaf could be a potential protein or amino acids source for monogastric animals especially rabbit. This agrees with the report of Fasuyi (2005) that cassava leaf are a significant source of potential alternative protein resource. Gil and Buitrago (2002) also reported that cassava leaf meal is rich in amino acids compared to other leafy legumes. The values of phenylalanine, leucine, threonine, valine, lysine, methionine and tyrosine found in this study are higher than that reported on meat from rabbit fed leafy vegetables (*Solanummelongena, Abelmoschusesculentus, Corchorusolitorius, Ipomoea batatas and Vignaunguiculata*leaf) (Wognin *et al*., 2018). Similarly, the values of lysine, threonine, leucine and phenylalanine content of rabbit meat in this study are also higher than 2.12, 2.01, 1.73 and 1.04g100g^{-1} of lysine, threonine, leucine and phenylalanine of rabbit meat reported by (Hernadez and DalleZotte, 2010) respectively, According to Chen & Liu (2004) the content and composition of amino acids in meat is an essential index for the assessment of the nutritional value and also affects the meat quality. Therefore the increased amino acids found in this study give rabbit meat proteins a high biological value.

Effects of graded level of cassava leaf meal fed to grower rabbit on vitamin content in meat

Table 5: Effects of graded level of cassava leaf meal fed to grower rabbit on vitamin content in the meat

Parameters	T_1 (Control) µg/100g	T_2 (10%CLM) µg/100g	T_3 (20%CLM) µg/100g	SEM
Vitamin A	507.45^{ab}	494.71^{b}	512.04^{a}	3.79
Vitamin B_1 (Thiamine)	0.09	0.10	0.09	0.00
Vitamin B_2	0.08	0.09	0.09	0.00
Vitamin B_3 (Nicotinamide)	12.79	13.24	12.88	0.29
Vitamin E	10.56	11.74	12.29	1.09

[e]CLM: Cassava leaf meal; [f]SEM: Standard Error of Mean,

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

The effects of graded level of cassava leaf meal fed to grower rabbit on vitamins content in the meat presented in Table 5 showed significant difference (p<0.05) only in vitamin A whereas no significant difference (p>0.05) were found in vitamin B_1(Thiamine), B_2 (Riboflavin), B_3 (Nicotinamide) and E, Meat from the rabbit fed diet that contained 20% cassava leaf meal (CLM) had the highest content of Vitamin A(512.04 µg/100g) while the lowest vitamin A content (494.71 µg/100g). was found on the meat from the rabbit fed diet that contained10% CLM. All the Vitamin in this study especially Vitamin A and E content of the rabbit meat increased due to increment of the inclusion level of CLM in the diet of the grower rabbit. The result of the study showed that cassava leaf meal is a good source of vitamins in the diet of rabbit and has the capacity of enhancing the nutritional quality of the meat. This is in agreement with Apata and Babalola (2012) who reported that cassava leaf are rich in vitamins like A, B2, C and E. Hernandez and DalleZotte (2010) reported that the Vitamin E content of the rabbit meat depends on the rabbit diet and can be increased by > 50% with dietary supplements (Castellini *et al*., 2000). The range value of Vitamins A (494.71- 512.04 µg/100g) and Vitamin E (10.56 – 11.74 µg/100g) differs from the values obtained by Wognin *et al*., (2018) on the study of the effect of partial substitution of concentrate diet to leafy vegetables on the vitamins contents of meat rabbit which could be attributed to the differences in the composition of the diet. The result of the study agrees the report that rabbit have the ability to efficiently convert non-competitive feed sources to meat (Egbo *et al*., 2001).

Effects of graded level of cassava leaf meal fed on grower rabbit on mineral content in the meat

Table 6: Effects of graded level of cassava leaf meal fed to grower rabbit to mineral content in the meat

Parameters	T_1 (Control) Mg/100g	T_2 (10%CLM) Mg/100g	T_3 (20%CLM) Mg/100g	SEM
Calcium	21.15	21.86	21.14	0.39
Phosphorus	318.55	334.42	321.34	6.85
Potassium	360.64	363.44	363.04	6.16
Magnesium	21.47	21.43	21.72	0.34
Sodium	42.24	42.70	43.67	0.53

Table 6 showed no significant differences (p>0.05) in the effects of graded level of cassava leaf meal fed to grower rabbit on mineral content in the meat. However, variations that were not significantly difference were observed. Meat from the rabbit fed diet that contained 10% cassava leaf meal (CLM) had the highest value in calcium (21.86 mg/100g), phosphorus (334.42 mg/100g) and potassium (363.44 mg/100g) while meat from the rabbit fed diet that contained 20% CLM had the highest magnesium (21.72 mg/100g) and sodium (43.67 mg/100g) content across the treatments. The control diet (diet without CLM) had the lowest value of all the minerals evaluated in this study. This is an indication that incorporation of cassava leaf meal in the diet of rabbit can enhanced the mineral contents of the meat. This agrees with the report of Wobeto *et al*. (2006) that cassava leaf are rich in iron, zinc, manganese, magnesium, and calcium. Adewusi & Bradbury (1993) also reported that cassava leaf contain varieties of mineral. The value of sodium in this study is higher than 37 mg 100g^{-1} of the loin part of the rabbit meat (Hernandez and DalleZotte. 2010), the range of 33.49±1.45 and 21.11± 0.65 mg/100g of meat from the rabbit fed 50% of *Abelmoschusesculentus* and *Corchorusolitorius* leaf in the rabbit diet respectively (Wognin *et al*., 2018) but lower than 49.5 mg 100g^{-1} of the hind leg reported by (Hernandez and DalleZotte. 2010), 53.28±3.28 and 57.23± 2.5 mg 100g^{-1} of meat from the rabbit fed 50% of *Solanummelongena* and Vignaunguiculata leaf in the rabbit diet respectively (Wognin *et al*., 2018). The low value of sodium in this study makes the meat suitable for those suffering hypertension and other health related issue. The phosphorus content found in this study is higher than 222 and 234 mg 100g^{-1} for the loins and hind legs (Dave Zotte, 2002), 308.98± 4.60 and 280.66±6.32 mg 100g^{-1} of meat from the rabbit fed 50% of *Ipomoea batatas* and *Vignaunguiculata* leaf in the rabbit diet respectively (Wognin *et al*., 2018). But lower than 336.99±10.39 mg 100g^{-1} of meat fed 50% of *Solanummelongena in the diet of rabbit* (Wognin *et al*., 2018). In addition the value of calcium found in this study is higher than the values reported by (Wognin *et al*., 2018) on the effect of partial substitution of concentrate diet to leafy vegetables on minerals contents in rabbit meat. Furthermore, it is also higher than 200, 174 and 147 - 194 mg 100g^{-1} of phosphorus contents of poultry, pork and mutton respectively (Williams, 2007). This shows that inclusion of cassava leaf meal in the diet of grower rabbit can aid in the production of a nutritious rabbit meat compare to other meat types. Minerals are essential in the functionality of the body system of rabbits.

CONCLUSION

The results of feeding graded level of cassava leaf meal to grower rabbits showed no significant difference (p>0.05) in the proximate composition, sensory quality and mineral content of the meat across treatments.However significant differences (p<0.05) were observed in the content of certain amino acids in the meat of grower rabbits fed cassava leaf meal, specifically excluding valine, histidine, lysine,

serine, aspartic acid, glutamic acid, and proline. Furthermore regarding the effects of graded level of cassava leaf meal on vitamin content in grower rabbit meat, significant difference ($p<0.05$) was found only in vitamin A across the treatments where as vitamin B 1,2,3 and E showed no significant difference ($p>0.05$). Meat from rabbit fed diet that contained 20% CLM had the highest value of vitamin A (512.04 µg/100g) while the lowest value (494.71µg/100g) was found on meat from rabbit fed diet that contained 10% CLM across the treatments. Therefore, cassava leaf meal can be used partially in the diet of grower rabbits to reduce costs while maintaining good nutritional and sensory meat quality.

ACKNOWLEDGEMENT

We sincerely appreciate the staff and students of the Department of Animal Production and Health, Faculty of Agriculture and Life Sciences, Federal University Wukari for their assistance in ensuring the success of this research.

REFERENCES

Adegbola,T.A.,& Okonkwo,J.C.(2002).Nutrientintake,digestibilityandg rowthofrabbitsfed varying levels of cassava leaf meal. Nigerian Journal of Animal Production, 29, 21-26. Adewuse,S.R.A., & Brabury,J.H.(1993).Caratenoidsincassava :Comparisonofopen-columnand HPLC methods of analysis. Journal of Science of Food and Agriculture, 62, 375-383.

AFSSA (2007). French Agency for Food Safety. Protein intake: consumption, quality requirements and recommendations. p. 461

Al Sayed, M. A. U., Susmita, D., Farjana, A., & Nusrat, A. (2019).An investigation on price elasticity of demand for protein consumption in Sylhet City, Bangladesh.

AOAC.2006.Association of Official Analytical Chemists.Official Mehtods of Analysis. In: Horwitz,W. (Ed.), 18th Ed. AOAC Press, Arlington,(pp.1-48) VA,USA.

Apata1, D. F., & Babalola, T. O. (2012). The use of cassava, sweet potato and cocoyam, and their by-products by non – ruminants. International Journal of Food Science and Nutrition Engineering, 2(4), 54-62. DOI: 10.5923/j.food.20120204.02

Borin, K., Lindberg, J. E., & Ogle, R. B. (2005). Effect of variety and preservation method of cassava leaf on diet digestibility by indigenous and improved pigs. Animal Science, 80(3): 319-324.

Capra, G., Martínez, R., Fradiletti, F., Cozzano, S., Repiso, L., Márquez, R., & Ibáñez, F. 2013. Meat quality of rabbits reared with two different feeding strategies: with or without fresh alfalfa ad libitum. World Rabbit Science, 21(13), 23-32. https://doi.org/10.4995/wrs.2013.1197.

Castellini, C., Dal Bosco, A., & Bernardini, M. (2000).Improvement of lipid stability of rabbit meat by vitamin E and C administration. Journal of the Science and Food agricultural, 81, 46-53

Chen, G.H., & Liu, M,Z (2004) Analysis of muscle nutrition characteristics of wild pig hybrids. Pig breeding 1:24–27

Corrêa, A. D. (2004). Remoção de polifenóis da farinha de folhas de mandioca. Ciência e Tecnologia de Alimentos, 24, 159–164.

DalleZotte, A. (2002). Perception of rabbit meat quality and major factors influencing the rabbit carcass and meat quality A. Livestock Production Science, 75(1), 11-32. https://doi.org/10.1016/S0301-6226(01)00308-6.

DalleZotte A. (2000). Main factors influencing the rabbit carcass and meat quality. In: Proceedings of the 7th World Rabbit Congress (Valencia, Spain), pp. 1–32.

DalleZotte, A., & Szendro, Z.(2011). The role of rabbit meat as a functional food. Meat Science, 163, 319-331

Dal Bosco, A., Castellini, C., & Bernardini, M. (2001). Nutritional quality of rabbit meat as affected by cooking procedure and dietary Vitamin E. Journal of Food Science, 66(7), 1047-1051. https://doi.org/10.1111/j.1365-2621.2001.tb08233.x

Egbo, M.L., Doma, U.D. and Lacdaks, A.B.(2001). Characteristics of small scale rabbit production and management in Bauchi metropolis. Proceedings of the 26th Annual Conference of Nigerian Society for Animal Production (NSAP), 160-162. ABU, Zaira.

Ekpo, J., Idorenyin, M. S., Metiabasi, U., & Grace Idiong, C. (2022). Meat quality and sensory evaluation of pork from pig fed pro-vitamin A cassava leaf meal, pumpkin stem and moringa leaf meal as dietary supplements. Journal of Agriculture and Food Science, 6, 10-23.

FAO(2011) World Live stock 2011. Live stock in food security. FAO publications

Fasuyi, A. O. (2005). Nutrient composition and processing effects on cassava leaf (Manihotesculenta, Crantz) antinutrients. Pakistan Journal of nutrition, 4(1), 37-42.

Faustman. 1. and Suman, S.P. (2017). The eating quality of meat: I—Color., Wood head Publishing Series in Food Science, Technology and Nutrition Pages 329-356

Gil, J.L., & Buitrago, A.J.A. (2002). La yuca en la alimentacion animal. In: Ospina B, Ceballos H, (ED.). La yuca en el tercermilenio: sistemasmodernos de producci´on, procesamiento, utilizaci ´on y comercializaci ´on. Cali, Colombia: Centro Internacional de Agricultura Tropical. p 527–69. http://www.clayuca.org/PDF/libro_yuca/capitulo28.pdf.

Hernández , P., & Gondret,F.(2006). Rabbitmeat quality. In:Maertens L.,& Coudert P.(Eds.). Recent Advances in Rabbit Sciences (pg 269-290). ILVO, Merelbeke, Belgium.

Hernández , P., & DalleZotte, A (2010). Inflence of diet on rabbit meat quality. In: de Blas, C., & Wiseman, J, (Eds.), Nutrition of the rabbit (2nd edition), Pg.163-178. CPI Antony Rowe Ltd UK.

Idris, S. B., Shamsudin, R., Nor, M. Z. M., Mokhtar, M. N., & AbdGhani, S. S. (2021). Proximate composition of different parts of white cassava (ManihotesculentaCrantz) plant as a ruminant feed. Advances in Agricultural and Food Research Journal, 2(1).

Ijarotimi, O. S., & Keshinro, O. O. (2020).Nutritional composition of selected meat sources and their benefits to human health. Food Science & Nutrition, 8(5), 2381-2393.

ISO (2005).International Organization for Standardization. Animal feeding stuffs - Determination of amino acids content, Ed 1. 17 p.

Jay, J.M., Loessner, M.J., & Golden, D.A. (2005).Modern food microbiology. (7th edn), New York: Spring Science.

Khan, M.I., Jo, C., & Tariq, M.R. (2015) Meat flavor precursors and factors influencing flavor precursors: a systematic review. Meat Science, 110, 278–284

Khieu.B. (2005).Cassava foliage for monogastric animals. Doctoral diss. Dept. of Animal Nutrition and Management, SLU. Acta Universitat is agriculturaeSueciae, vol. 2005, pp 82. http://diss-epsilon.slu.se/archive/00000903/.

Lebas, F., Coudert, P., De Rochambeau, H., & Thé bault, R.G. (1996). The rabbit: breeding and pathology. p.143. FAO Animal Production and Health Collection No19, Rome.

Latif, S., & Müller, J. (2015). Potential of cassava leaf in human nutrition: A review. Trends in Food Science and Technolog, 44, 147-158.

Lawrie, R.A., & Ledward, D. A. (2006). Lawrie's meat science (7th ed.). Cambridge: Wood head Publishing. ISBN 978-1-84569-159-2.

Malík, V. (2002.) Poultry and rabbits (Hydina a králiky). Bratislava : PRÍRODA, p. 88-104. ISBN 80-07-00963-9.

Marounek, M., Skrivanova, V., Dokoupilova, A., Czauderna, M., & Berladyn, A (2007). Meat quality and tissue fatty acid profiles in rabbits fed diets supplemented with conjugated linoleic acid. Veterinarni Medicina, 52(12), 552-561

Mihafu, F. D., Issa, J. Y., & Kamiyango, M. W. (2020).Implication of sensory evaluation and quality assessment in food product development: A review. Current Research in Nutrition and Food Science Journal, 8(3): 690-702.

Nasiru, A., Muhammad, B.F., & Abdullahi, Z. (2011).Effect of cooking time and potash concentration on organoleptic properties of red and white meat. Journal of food technology, 9(4), 119 – 123.

Ngudi, D.D., Kuo. Y.H., & Lamben, F. (2003) Cassava cyanogens and free amino acids in raw and cooked leaf. Food and Chemical Toxicology, 41(8), 1193-7 DOI:10.1016/S0278-6915(03)00111-X

Ngiki, Y,U., Igwebuike, J.U., & Moruppa, S.M. (2014). Utilisation of cassava products for poultry feeding: a review. International Journal of Science and Technology, 2(6), 48 - 59.

Ogbeide, O.N. (2015). Meat industry development in Nigeria: Implications of the consumers' perspective. Mayfair Journal of Agribusiness Management, 1(1), 59-75.

Oresegun, A., Fagbenro, O. A., Ilona, P. & Bernard, E. (2016).Nutritional and anti-nutritional composition of cassava leaf protein concentrate from six cassava varieties for use in aqua feed. Cogent Food & Agriculture, 2(1),1147323.

Pavelková, A., Tkáčová, J., Červienková, K. & Bučko, O. (2017).The rabbit meat quality after different feeding. PotravinarstvoSlovak Journal of Food Sciences, 11(1), 634-640. doi: https://dx.doi.org/10.5219/811

PogánySimonová, M., Lauková, A., Chrastinová, Ľ., Szabóová, R., & Strompfová, V. (2012). Microbial status and quality of rabbit meat after rabbits Feed supplementation with phyto-additives. Potravinarstvo, 6(4), 41-44. https://doi.org/10.5219/213

Phuc, B. H. N. & Lindberg, J. E. (2001). Ileal apparent digestibility of amino acids in growing pigs given a cassava root meal diet with inclusion of cassava leaf, leucaena leaf and groundnut foliage. Animal Sciences, 72: 511–517.

Resconi,V.C., Escudero, A., & Campo, M.M.(2013). The development of aromas in ruminant meat. Molecules, 18(6), 6748-6781.

Suttle N.F. (2010). Mineral Nutrition of Livestock. 4th ed. CAB International, Oxfordshire, UK

Whitney, E.N., & Rolfes S.R. (2002). Understanding nutrition (9th ed.), Thomson Learning.

Williams, P. (2007). Nutritional composition of meat. Nutrition and Dietetics, 64, 115-119,

Winger, R.J. & Hagyard, C.J. (1994).Juiciness, its importance and some contributing factors. In: Pearson, A.M., Dutson, T.R. (Eds.), Advances in meat research, quality attributes and their measurement in meat, poultry and fish products, vol. 9. Chapman and Hall, New York.

Wobeto, C., Corrˆea, A.D., de Abreu, C.M.P., dos Santos, C.D., & de Abreu, J.R. (2006). Nutrients in the cassava (Manihotesculenta, Crantz) leaf meal at three ages of the plant. CiencTechnol Aliment, 26, 865–9.

Wognin, M.F., Otchoumou, K.A., Yao, K.F., & Niamke, S. (2018). Improving the nutritive value and sensory quality of rabbit meat by using leafy vegetables as feedstuffs. Journal of Animal and Plant Sciences,36,5812-5824. http://www.m.elewa.org/JAPS;

Wood,J.D.,Enser,M.,Fisher,A.V.,Nute,G.R.,Sheard,P.R.,Richardson, R.I.,Hughes,S.I., & Whittington, F.M. (2008). Fat deposition, fatty acid composition and meat quality: A review. Meat Science, 78(4), 343 – 358.

****