European Journal of Biotechnology and Bioscience
ISSN: 2321-9122
Impact Factor: RJIF 5.44
Received: 08-11-2018; Accepted: 09-12-2018
www.biosciencejournals.com
Volume 6; Issue 6; November 2018; Page No. 30-36

Effect of mixing two leafy vegetables on the quality of rabbit meat

Wognin Légbé Marie Flavienne Raïssa[1], Otchoumou Kraidy Athanase[2*], Yao Konan Franck[3], Niamke Sébastien[4]
[1-4] Biotechnology Laboratory, Biosciences Faculty, Felix Houphouët Boigny University, 22 BP 582 Abidjan, Côte d'Ivoire

Abstract
Leafy vegetables play an important role in food security. Many research have been conducted in order to promote their nutritional assets. One of the areas of emphasis was to study impact of their contribution as green forage on nutritive value and sensory properties of meat. 105 rabbits (400 - 450 g) weaned at 35 day old were used to evaluate the effect of forage during 63 days. The experiment was a completely randomized design involving seven treatments. Each treatment was replicated three times with five rabbits per replicate. Results showed that leafy vegetables affected significantly (P>0.05) nutritional composition of meat. Ash contents ranged 2.74 g/100g (control diet) to 4.63 g/100 g (group V). Protein contents ranged 16.87 g/100 g (control group) to 19.52 g/100 g (group IV). Minerals content were higher for group V with levels estimate to 17.7 mg/100 g for calcium, phosphorus (443.40 mg/100g), potassium (593.30 mg/100 g) and zinc (8.88 mg/100 g). The amino acids concentration were similar. The inclusion leafy vegetables in the diets did not significantly (P<0.05) influenced the appearance, juiciness, tenderness and overall acceptability. The study revealed that mixtures *Ipomea batatas* and *Solanum melongena* mixture on the hand or *Corchorus olitorius* and *Vigna unguiculata* on the other hand can be used to enhance the nutritive value and organoleptic properties of meat rabbit.

Keywords: leafy vegetables, rabbit meat, nutritive value, organoleptic properties

Introduction

Plant biodiversity represents the primary source for food and many other products means that make life on Earth possible and enjoyable (WCMC, 1992) [33]. This is includes vegetables that can be defined as the fresh part of plant consumed raw or cooked. These edibles parts are leaves, stems, roots, flowers, seed, fruits, bulbs, tubers and fungi (Uzo, 1989; Uwaegbute, 1989) [32]. Plant resources of tropical Africa (PROTA) reported 280 out of 397 vegetables consumed in sub-Saharan Africa are leafy vegetables (PROTA, 2004) [28]. Therefore, increasing attention to leafy vegetables as a component of diets is important. According to Chweya and Eyzaguirre (1999) [8], these are essential ingredients in traditional sauces or soups that accompany foods rich in carbohydrate such as cassava, cocoyam, maize, millet, rice and plantain. Studies have repeatedly shown that African leafy vegetables are an important place among appreciable sources of micronutrients and health promoting phytochemicals for humans (Dougnon *et al*., 2012; Kamga *et al.*, 2013; Inyang, 2016) [12, 20, 18]. In addition, most of them are used for therapeutic purposes (Mulungulungu *et al*., 2015) [23]. An investigation conducted by Fondio *et al.* (2013) [15] revealed that in Côte d'Ivoire, 26 vegetable plants are cultivated for the leaves that are widely consumed by populations. Studies on biochemical composition of these leaves have shown that, they contained appreciable amount of minerals as calcium, potassium and other nutrients as proteins, vitamins (Acho *et al.,* 2014, Oulai *et al.,* 2014) [2, 26]. Leafy vegetables are therefore a good source of essential nutrients for basic body functions such as heart rate, muscle contraction, movement, growth and regulation processes. However, their high-water content makes them very perishable foods, resulting in huge losses after harvest. Conservation methods using solar drying or shade, low or high temperature storage have been put to keep leafy vegetables in good condition. Their use in animal feed may also be considered to resolve these losses. The animal chosen in this study is rabbit. Rabbit occupies little space in that it is a mini livestock that is easy to manage, highly prolific and has a short generation interval (Adeyemo *et al.*, 2013; Coulibaly, 2013) [4, 10]. Being pseudoruminants, rabbits can convert plant into animal protein for human consumption. Thus, studies have been carried out to valorize plants, particularly leafy vegetables in their diet. Abonyi *et al.* (2012) [1] have shown that sweet potato leaves can replace 50% of the concentrated feed in a ration and reduced considerably cost of production. In addition, Yao *et al*., (2016) [36] have shown that other leafy vegetables could be used to feed rabbits without significant difference of growth between rabbits feeding only to concentrate and those whose leaves are part of the feed. Wognin *et al.* (2018) [34] reported relationships between nutritional value of feed and carcass characteristics, nutritive value and sensory quality meat. Indeed, according to these authors, the *Solanum melongena* leaves with concentrate mixture allowed to obtain a rabbit meat characterized by the increasing content of crude protein, minerals and essential amino acids. The aim of this study was the assessment the impact of combination of two leafy vegetables on nutritional and sensory quality of the meat.

Materials and Methods

Animals and Management

The experiment was held out in traditional rabbitary farm of Bingerville municipality, located on latitudes 5° 21'708 "North and longitudes 3° 54'639" west in Côte d'Ivoire. One hundred and five (105) rabbits weaned at 35 day old, clinically healthy with an average initial weight 400-450 g were used. The rabbits were progenies obtained from mating between New Zealand White X California. They were housed individually and fed in wire-netting (70 × 40 × 50 cm) equipped with aluminum feeders and drinkers. The cages, feeders and drinkers were thoroughly washed and disinfected before rabbits were allocated into them.

Experimental diets and design

Four leafy vegetables (*Solanum melongena*, *Vigna unguiculata*, *Corchorus olitorius* and *Ipomea batatas*) were used. The fresh leaves of these plants were obtained everyday from markets in Abidjan, Côte d'Ivoire. Leafy vegetables were cleaned according to the procedure reported by Kimsé *et al*., (2013) [21]. Seven (7) experimental diets were worked out by adding to the concentrate diet (C) a mixture of two leafy vegetables (LV) in proportions of 50% C / 25%LV1 / 25% LV2. Diets formulated were summarized in Tables 1, 2 and 3.

Table 1: Proximate composition of concentrate diet and forages (g/100 g dry matter)

	Dry matter	Crude protein	Fat	Ash
Concentrate diet	89.39 ± 0.00 c	14.63 ± 0.18 b	3.68 ± 0.02 a	8.38 ± 0.10 a
Solanum melongena	24.75 ± 0.11 b	12.55 ± 0.24 a	3.67 ± 0.12 a	14.05 ± 0.09 c
Corchorus olitorius	24.28 ± 0.19 b	18.31 ± 0.29 d	4.76 ± 0.05 b	8.10 ± 0.23 a
Ipomea batatas	21.03 ± 0.20 a	15.83 ± 0.41 c	3.75 ± 0.14 a	14.24 ± 0.24 c
Vigna unguiculata	20.76 ± 0.21 a	19.15 ± 0.32 d	5.29 ± 0.02 c	9.93 ± 0.28 b

Values in the same column with different superscripts were significantly different (P<0.05).

Table 2: Mineral contents of concentrate diet and forages (mg/100 g dry matter)

Minerals	Concentrate diet	Solanum melongena	Corchorus olitorius	Ipomea batatas	Vigna unguiculata
Calcium	980.30±14.88 a	3312.7± 60.93 d	1019.72±44.64 a	1938.54±30.05 c	1512.96±71.05 b
Iron	97.84±1.48 d	115.54± 5.09 e	35.44±2.87 b	17.66±0.29 a	52.22±4.87 c
Potassium	3919.26±59.48 d	3095.7± 69.20 c	1328.9±85.43 a	5103.48±51.99 e	1986.94±72.91 b
Magnesium	188.77±2.86 b	244.65±10.50 c	106.29±7.26 a	387.73±6.01 d	196.41±11.54 b
Phosphorus	693.08±10.52 b	1257.22±24.95 c	501.62±19.63 a	1804.32±27.93 d	633.7±31.40 b
Sodium	81.23±1.23 c	88.93±4.01 c	51.26±3.80 a	50.66± 0.80 a	61.78± 4.45 b
Zinc	5.27±0.08 b	8.47±0.34 c	0.43±0.10 a	28.13±0.43 d	0.21±0.08 a
Copper	41.73±0.63 c	82.07±3.18 d	20.01±0.96 b	127.41±9.55 e	5.39±1.69 a

Values in the same row with different superscripts differ at 5 % (P < 0.05)

Table 3: Amino acids (g/100 g) of concentrate diet and forages

Parameters	concentrate diet	Solanum melongena	Corchorus olitorius	Ipomea batatas	Vigna unguiculata
Phenylalanine	2.85	4.56	2.84	3.51	3.65
leucine	9.25	9.41	8.91	4.16	9.16
Threonine	4.02	1.83	4.51	3.24	4.36
Valine	4.04	6.17	3.98	4.07	4.1
Lysine	4.65	8.72	4.69	2.56	5.03
Methionine	1.37	0.97	1.42	1.37	1.4
Tyrosine	4.66	3.24	4.70	2.34	4.88

The rabbits were randomly allotted to seven (7) dietary treatments with five (5) rabbits per treatment in a completely randomized design. The animals were acclimated to the experimental conditions and diets for seven (7) days (Pérez *et al.,* 1995). During this period, the animals received prophylactic antibiotic treatment. Thus Cocciliumforte ® (Amprolium hydrochloride 20% and 0.2% vitamin K3) was used in the drinking water at a dose of 15 g per 15 liters of water for three (3) days to prevent coccidiosis (Kpodékon *et al*., 2009). After the acclimatization period, the rabbits were fed to satiation with different diets twice daily (9 am and 5 pm) until the age of 98 days. Feed intake was determined as the difference between the feed supplied and left over for each replicate per day. Feed and water were provided to appetite. The feeding trial lasted for 63 days (9 weeks) during which information was collected on the concentrate diet and forage intake. Feed intake was determined by difference between feed offered and leftovers uneaten feed. This experiment was repeated 3 times with a batch of 35 rabbits each time. At the end of the experiment, all the rabbits were slaughtered to determinate nutritional value and organoleptics parameters of meat.

Data collection

The rabbits were slaughtered on days 63 of the experiment by severing the jugular vein and carotid artery at the level of the atlas vertebra. The carcasses were prepared as reported by Blasco and Ouhayoun (1996) [11] by removing the skin, the distal part of the limbs, genital organs, the bladder and the gastrointestinal tract. Total dissectible fat was eliminated manually. The longissimus lumborum muscle between the 1st and the 7th lumbar vertebra, including the muscles of abdominal wall and hind legs, were removed from carcasses as samples for further analyses. Samples were divided into two subsamples, the first were deboned and homogenized in a blender together, packed into polyethylene bags, frozen and stored at -18 °C for determination of protein, ash, fat, minerals and vitamins content, as well as for the analysis of amino acids composition. The second subsample essentially comprising hind legs muscle was used for sensory test.

Proximate analysis of rabbit meat: Samples of meat, leafy vegetables and concentrate were chemically analyzed for the determination of each of dry matter, protein, fat and ash contents according to the method of AOAC (1990). All analyses were carried out in triplicate

Minerals analysis: The mineral elements comprising sodium, calcium, potassium, magnesium, iron, zinc and phosphorus were estimated by dry ashing 10 g of sample in a muffle furnace (Pyrolabo, France). The ash was dissolved in an acid mix of HCl/HNO3 and analysed using the atomic absorption spectrophotometer (AAS model, SP9).

Essential amino acids composition: It was determined to ISO (2005) methods.

Sensory evaluation of meat: It was performed on the hind leg muscle. This was refined at 4 °C for 24 hours and cooked on charcoal for 20 to 25 minutes without added salt or spice. Sensory analysis included assessment of appearance, taste, juiciness, texture and overall acceptability of meat on a 3-point scale (Akinnusif *et al*., 2007) [5]. The evaluation was performed by a panel of 15 assessors with previous sensory evaluation experience.

Statistical analysis

All the data taken from this study were subjected to the analysis of variance (ANOVA) using SPSS 17 software. The variations in means were separated using the Duncan Multiple Range Test (Duncan, 1955) [14]. Hierarchical ascendant classification (HAC) was carried out on XLSTAT version 2015 to separate diets according their impact on quality of rabbit meat.

Results

Results of feed and nutrients intake (Table 4) showed a significant (P<0.05) differences between different groups. *Ipomea batatas* and *Solanum melongena* were highest consumed in all diets where they were included. Rabbits of group II and group V have been consumed more concentrate and forage than the other groups who fed with the leafy vegetables. The variations noted for feed intake were reflected in daily nutrients intake (Table 4). The group fed with *Solanum melongena* and *Corchorus olitorius* mixture had significantly (P<0.05) higher dry matter intake than all the other groups. The similar results were obtained for protein and fat intake with 18.86 ± 0.14 g and 4.52 ± 0.02 g respectively. Mineral (ash) intake was significantly higher for 5th group likely because *Ipomea batatas* and *Solanum melongena* were higher in ash (Table 4) than the other forages used. It was the same for amoung of crude protein (19.30 ± 1.13 g) and fat (4.50 ± 0.20g) intake by rabbit which received the diet of group III. Except diet *Solanum melongena* + *Vigna unguiculata* + concentrate, the other forages have increased daily nutrient intakes while those fed only concentrate were lowest.

Table 4: Proportions of leafy vegetables, concentrate diets and nutrients intake (g/rabbit/day)

Group diets	Diets intake			nutrients intake			
	Leafy vegetable 1	Leafy vegetable 2	Concentrate diet	Dry matter	Protein	Ash	Fat
group I	108.07± 3.39 c	100.87± 5.49 abc	73.04± 7.64 abc	108.95± 7.95 ab	16.59± 1.13 b	13.14± 0.71cd	4.02±0.31ab
group II	112.88± 0.94 c	108.19± 2.10 bc	81.11± 0.35 c	128.87± 0.72 c	18.86± 0.14 c	14.15± 0.09 d	4.52± 0.02 b
group III	101.99± 9.23 bc	96.16± 13.36 abc	79.79± 0.20 bc	118.09± 5.25 bc	19.30± 1.13 c	10.46± 0.52 b	4.50± 0.20 b
group IV	91.93± 7.62 ab	86.90± 13.15 a	67.33± 5.61a	100.98± 2.88 a	14.58± 0.32 ab	11.66± 0.20bc	3.73± 0.12 a
group V	107.75± 3.33 c	111.78± 4.57 bc	79.50± 3.76 bc	122.72± 6.33 bc	16.35± 0.87 b	17.20± 0.95 e	4.15± 0.21 ab
group VI	98.88±5.30 abc	100.76± 13.43 abc	69.03± 8.58 ab	108.98± 14.35 ab	16.50± 2.21 b	13.16±1.74cd	3.78± 0.49 a
Control group	–	–	114.70± 10.31 d	102.53±9.22 a	13.30± 1.20 a	8.55± 0.77 a	3.99± 0.36ab

The values represent the mean ± the standard deviation of the triplicate trials tested. Values in the same column with different superscripts were significantly different (P<0.05).

Protein, ash and fat contents of rabbit meat from the seven experimental diets were presented in Figure 1. They were significant (P<0.05) differences between proteins and ash levels of rabbit meat fed to pelleted diet only and those fed to pelleted and forages mixture. Protein and ash contents in rabbit meat were lowest with pelleted diet but that of fat remained high. No statistical differences were observed to fat and ash contents of group V and IV while level of proteins was higher for the second group.

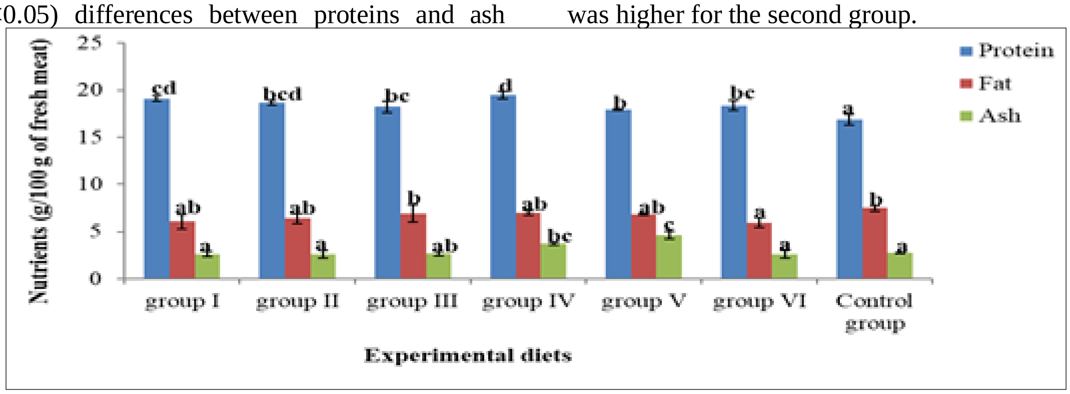

Fig 1: Effect of leafy vegetables mixture on proximate composition of rabbit meat

Table 5 showed effect of leafy vegetables on minerals composition of rabbit meat. Data indicated that group V had higher mineral contents than other groups especially for calcium (17.7 ± 3.01 mg.100^{-1}g) and potassium (593.30 ± 100.76 mg.100^{-1}g). Highest levels of zinc in meat were obtained with association of *Solanum melongena* leaf to *Ipomea batatas* leaf (8.88 ± 1.50 mg/100 g) or *Corchorus olitorius* leaf (7.16 ± 1.70 mg/100 g). Like ash contents, mineral concentrations were also lowest with the pelleted diet. They were no significant differences on levels of sodium for all diet used in this study.

Table 5: Effect of leafy vegetables mixture on minerals composition of rabbit meat

Group diets	Minerals (mg/100 g)						
	Calcium	Magnesium	Phosphorus	Sodium	Potassium	Zinc	Copper

Group I	4.80±1.22 a	16.70±0.76 ab	287.74±13.12 b	48.80±2.22 a	229.40±10.47 a	2.67±0.12 ab	_
Group II	8.10±1.92 ab	18.60±4.41 abc	370.28±87.90 bc	51.80±12.30 a	254.40±60.40 a	7.16±1.70 c	0.01±0.00 a
Group III	10.9±1.28 bc	30.20±3.54 de	358.49±42.08 bc	42.80±5.02 a	465.60±54.64 c	0.60±0.07 a	0.04±0.00 b
Group IV	12.8±0.28 c	26.0±4.47 cd	120.28±2.62 a	50.00±1.09 a	379.40±8.26 bc	4.05±0.09 b	_
Group V	17.7±3.01 d	34.30±0.75 e	443.40±75.30 c	40.30±6.84 a	593.30±100.76 d	8.88±1.50 c	_
Group VI	8.20±0.72 ab	24.30±2.13 bcd	372.64±32.60 bc	50.80±4.44 a	276.70±24.20 ab	3.97±0.35 b	0.05±0.00 b
Control group	5.48±0.53 a	13.78±1.34 a	147.33±14.30 a	51.93±5.04 a	170.44±16.53 a	1.20±0.12 a	0.71±0.07 c

The values represent the mean ± the standard deviation of the triplicate trials tested.Values in the same row with different superscripts differ at 5 % (P < 0.05)

Comparison of the proportions of amino acids of the different meat revealed that each group was characterized by one of amino acid (Table 6). Percentage of lysine (2.54±0.05 %) and tyrosine (4.23±0.09 %) were highest when rabbit were fed to *Solanum melongena* and *Vigna unguiculata*. Control group was characterized by high content of leucine (1.44±0.05 %) while methionine (10.11±0.44 %) and valine (0.17±0.00 %) were amino acids which would separated group II and group V from the others. The contents of phenylalanine, leucine, threonine and valine in meat provided by *Corchorus olitorius* and *Vigna unguiculata* mixture were less than what were recorded for the others diets. Lysine and tyrosine contents present in rabbit meat were significantly (P<0.05) lower with all feed that where *Ipomea batatas* used as forage.

Table 6: Effect of leafy vegetables mixture on essential amino acids of rabbit meat

Group diets	**Amino acids (g/100 g)**						
	Phenylalanine	**Leucine**	**Threonine**	**Valine**	**Lysine**	**Methionine**	**Tyrosine**
group I	0.22±0.02a	0.65±0.01b	0.10±0.00b	0.09±0.02cd	0.54±0.01a	4.49±0.09b	0.32±0.03a
group II	-	0.84±0.01c	0.23±0.00c	0.06±0.01b	-	10.11±0.44d	-
group III	0.23±0.01a	0.50±0.06a	0.03±0.00a	0.01±0.00a	2.00±0.07d	4.20±0.14b	0.63±0.02b
group IV	0.55±0.01c	0.86±0.03cd	0.10±0.00b	0.06±0.00b	2.54±0.05e	1.81±0.15a	4.23±0.09d
group V	-	0.79±0.03c	0.10±0.00b	0.17±0.00e	-	1.53±0.08a	-
group VI	1.07±0.03d	0.68±0.02b	0.30±0.01d	0.06±0.00b	0.78±0.02b	7.07±0.20c	0.34±0.01a
Control group	0.31±0.01b	1.44±0.05e	0.10±0.00b	0.08±0.00c	0.98±0.03c	1.84±0.20a	0.95±0.03c

The values represent the mean ± the standard deviation of the triplicate trials tested.Values in the same column with different superscripts were significantly different (P<0.05).

Results obtained during sensory test (Table 7) indicated that tenderness of various meats not differed significantly with treatments (P<0.05). According to panel, the rabbit meat from group IV had very lean and presented salty taste much utter. Juiciness was highest for meat of control group and group III for which the overall acceptability was highest.

Table 7: Sensory evaluation of rabbit meat fed to leafy vegetables mixture

Group diets	Appareance	Taste	Tenderness	Juiciness	Overall acceptability
group I	2.67±0.49 bc	2.42±0.67 b	2.30±0.48 a	1.75±0.62 ab	2.18±0.64 ab
group II	2.46±0.52 abc	1.57±0.51 a	2.46±0.52 a	1.62±0.51 a	1.94±0.83 ab
group III	2.38±0.42 abc	1.33±0.49 a	2.08±0.28 a	2.00±0.38 b	2.24±0.56 b
group IV	2.77±0.26 c	2.33±0.49 b	2.08±0.51 a	1.93±0.47 ab	2.12±0.07 ab
group V	2.23±0.44 ab	2.53±0.52 b	2.29±0.47 a	1.85±0.38 ab	1.71±0.69 a
group VI	2.00±0.00 a	2.36±0.50 b	2.31±0.48a	1.85±0.38 ab	1.94±0.43 ab
Control group	2.21±0.43 ab	2.25±0.62 b	2.27±0.46 a	2.00±0.38 b	2.29±0.47 b

The values represent the mean ± the standard deviation of the triplicate trials tested. Values in the same column with different superscripts were significantly different (P<0.05).

The first cluster was composed by group I and group VI when the second contained group II and group IV. The third cluster was represented by group III, group V and control group (Figure 2). The characteristics of each cluster appeared in Table 8. The cluster C1 recorded the highest levels of phenylalanine (0.64 g/100g), threonine (0.20 g/100g) and lowest fat content (6.04 g/100g). The second cluster registered the highest concentrations of zinc (5.60 mg/100g), lysine (1.27 g/100g), methionine (5.96 g/100g) and tyrosine (2.11 g/100g). Cluster C3 had the most important amount of ash (3.61 g/100g). It was also characterized by high calcium (11.36 mg/100g), potassium (409.78 mg/100g) and magnesium (26.09 mg/100g).

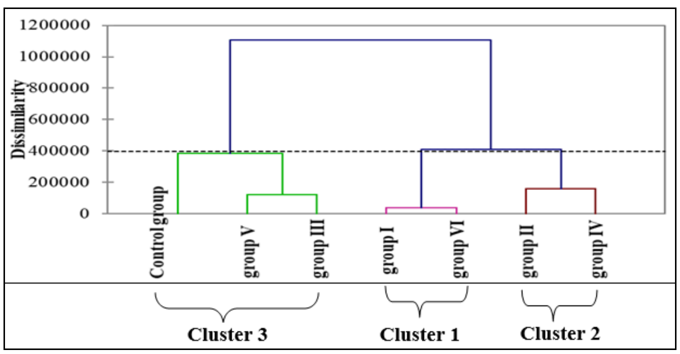

Fig 2: Dendogram of experimental diets dissimilarity

Table 8: Average characteristics of rabbit meat produced with the experimental diets

Clusters characteristics of rabbit meat	C1	C2	C3
Fat	6.0400	6.7250	7.0833
Ash	2.6300	3.2050	3.6167
Calcium	6.5000	10.4500	11.3600
Potassium	253.0500	316.9000	409.7800
Magnesium	20.5000	22.4500	26.0933
Zinc	3.3200	5.6050	3.5600
Phenylalanine	0.6450	0.2750	0.1800
Threonine	0.2000	0.1650	0.0767
Valine	0.0750	0.0600	0.0867
Lysine	0.6600	1.2700	0.9933
Methionine	5.7800	5.9600	2.5233
Tyrosine	0.3300	2.1150	0.5267

C1: group I and group VI; C2: group II and group IV; C3: group III, group V and control group

Discussion

Each leaf vegetable used as fodder has exceptional nutritional characteristics. An association between them in a diet could improve the nutritional value of the feed and help better meet the needs of the growing rabbit.

Differences in forage intake indicated that rabbits had a higher preference for *Ipomea batatas* and *Solanum melongena* leaves. The presence of anti-nutritional factors such as tannins in leafy vegetables is a possible factor that could contribute to this result. This finding was also recorded by Yao *et al*. (2016) [36] during a palatability study on thirteen leafy vegetables. A large amount of roughage justified the high level of nutrient intake. Indeed, many studies including those of Gidenne *et al*. (2000) [16] and Kimsé *et al*. (2013) [21] showed that the presence of roughage improved digestive transit and was therefore responsible for better digestibility of nutrients.

High protein and ash level of rabbit meat obtained with groups I, II, III, IV, V and VI diets may result from high intake of nutrients resulting from the inclusion of leafy vegetables as forage. The protein contents of rabbit meat recorded in this study agrees with the values reported by Nguyen and Nguyen (2008) [25].

Rabbit meat of control group was characterized by its high fat content while lipids intake was lower. This result could be explained by the presence of starch carbohydrates mainly in the concentrate diet which would be responsible for the increase of the level of feed energy. According to Dalle Zotte *et al*. (1996) [11] and Xiccato (1999) [35], this feed could increase fat content of meat. Low levels of fat in all meats produced in this work confirm that rabbit meat is lean, which can be of benefit to people suffering from obesity.

Minerals concentration of rabbits meat were correlated to minerals composition of diet used to feed them. Indeed, the high mineral contents of *Ipomea batatas* and *Solanum melongena* had a beneficial effect on the quality of the meat that came out of it. This is possible thanks to the ability of the rabbit to convert efficiently roughages into meat of good nutritional quality for human consumption. This ability has also been used by Kowalska and Bielański (2009) [22] and Doukoupilová *et al*. (2007) to improve vitamin E and selenium levels in rabbit muscle by supplementation of feeding. Results of present research revealed that rabbit meat could provide appreciable levels of minerals elements to consumers which according Grosvernor and Smolin (2002) [17] were required for diverse metabolic functions. In addition, the high potassium and low sodium concentration may make rabbit meat particularly recommended for hypertension diets.

In contrast to minerals composition, it is hard to made relationship between amino acids content of meat and those were recorded in diets even if many researchers argued that amino acid contents of feed influence composition of aminoacids of meat rabbit. That would be the result of the combination of leafy vegetables by two in the diet while they contain almost identical amino acid levels. The obtained values were in agreement with the investigations of Adel *et al*. (2017) [3] who reported that soybean can be replace by *Spirulina platensis* without harm meat nutritional properties. But they were twice as low as those recorded by Simonová *et al*. (2010) [29]. In general, meat contained reasonable concentrations of essential amino acids that the body cannot directly synthesize and are needed for the maintenance and repair in the body.

Regarding sensory evaluation, it was not significantly affected tenderness when leafy vegetables mixture replaced 50 % of commercial feed. The same scores obtained for tenderness showed that the parameters (temperature and time) of the cooking used have not vary during the samples preparation even if it was a traditional method in which it is not easy to keep them. Combes *et al.* (2001) [9] demonstrated that the couple (temperature and time) trained the denaturation of collagen that influenced the mechanical tenderness of rabbit meat. The differences related to the juiciness were not easy to explain because no significant difference in chemical and biochemical parameters of muscles were found. Sensory analysis results were consistent with a study that emphasized the importance for consumers of meat juiciness and tenderness (Talukder, 2013) [30].

XLstat software allowed to gather feeds used in this study to three clusters according to nutritional and organoleptic settings of meat produced. This classification was possible thanks to the nutritional composition of meats, especially through fourteen parameters whose squared cosines were the highest. This makes these nutritional components discriminating factors. Moreover, analysis of the average nutrient content of cluster 3 (C3) revealed that group III, group V and the control group would be responsible for meat containing more essential nutrients. It therefore appears that mixtures of *Ipomea batatas* and *Solanum melongena* on the one hand, *Corchorus olitorius* and *Vigna unguiculata* on the other hand were better for use as a dietary supplement in the production of rabbits.

Conclusion

The abundance of essential nutrients in leafy vegetables is an asset for their use in rabbit feeding. In this work, it showed that an association between them increases the nutritive value of the feed when they were added as roughage. Increase of nutrients in rabbit feed could also affect the composition of the meat. Relationship between nutritional composition of feed and the meat produced was highlighted through minerals content. *Ipomea batatas* and *Solanum melongena* mixture as well as that of *Corchorus olitorius* and *Vigna unguiculata* had a beneficial effect on the meat while retaining its organoleptic properties. These two diets can be recommended in breeding during feed shortage.

References

1. Abonyi FO, Iyi EO, Machebe NS. Effects of feeding sweet potato (*Ipomoea batatas*) leaves on growth performance and nutrient digestibility of rabbits. African Journal of Biotechnology. 2012; 11(15):3709-3712.
2. Acho CF, Zoué LT, Akpa EE, Yapo VG, Niamké SL. Leafy vegetables consumed in Southern Côte d'Ivoire: a source of high value nutrients. Journal of Animal and Plant Sciences. 2014; 20(3):3159-3170.
3. Adel EM, Mohamed MN, Aziz MH, Yousef YS, Diaa AM. Effect of Substitution Soybean by Blue Green Alga *Spirulina platensis* on Performance and Meat Quality of Growing Rabbits. American Journal of Food Technology. 2017; 12(1):51-59.
4. Adeyemo AA, Adeyemi OA, Ekunseitan DA, Taiwo OS. Effect of concentrate to forage ratio on the performance and haematological parameters of growing rabbits. Gbobal Journal of Biology, Agriculture & Health Sciences. 2013; 2(2):114-118.
5. Akinnusif AO, Bamgbosea M, Odunaroo E, Aladea A. Carcass characteristics and sensory evaluation of meat from rabbits fed cashew-nut residue based diets. ASSET An International Journal. 2007; 7(1):19-25.
6. AOAC. Official methods of analysis. Association of Official Analytical Chemists Ed., Washington DC, 1990, 684.
7. Blasco A, Ouhayoun J. Harmonization of criteria and terminology in rabbit meat research. World Rabbit Science. 1996; 4(2):93-99.
8. Chweya JA, Eyzaguirre PB. The Biodiversity of Traditional Leafy Vegetables. International Plant Genetic Resources Institute (IPGRI), Rome, Italy, 1999, 182.
9. Combes S, Lepetit J, Darche B, Lebas F. Influence of temperature and cooking time on mechanical tenderness and collagen content of rabbit meat, 9th Journ. Rech. Rabbit, Paris, France, 2001.
10. Coulibaly D. Breeding development policy in Côte d'Ivoire. 9th Conference of African Ministers in charge of Resources Animal. Ministry of Animal Resources and Fisheries, Planning and Programs direction, 2013, 13.
11. Dalle Zotte A, Ouhayoun J, Parigi Bini R, Xiccato G. Effect of age, diet and sex on muscle energy metabolism and on related physicochemical traits in the rabbit. Meat Science. 1996; 43:15-24.
12. Dougnon TV, Bankolé HS, Johnson RC, Klotoé JR, Dougnon G, Fernand G, *et al*. Phytochemical Screening, Nutritional and Toxicological Analyses of Leaves and, Fruits of *Solanum macrocarpon* Linn (Solanaceae) in Cotonou (Benin). Food and Nutrition Sciences. 2013; 3:1595-1603.
13. Dokoupilová A, Marounek M, Skřivanová V, Březina P. Selenium content in tissues and meat quality in rabbits fed selenium yeast. Czech Journal of Animal Sciences. 2007; 52(6):165-169.
14. Duncan BD. Multiple Range and Multiple F Tests *in* Biometrics Vol. 11, No. 1 International Biometric Society. 1955; 11(1):1-42.
15. Fondio L, Agbo AE, Mahyao A, N'zi JC, Gbesso MFDP, Djidji, Kouame C. What contributions of traditional leafy vegetables to food security and poverty alleviation of urban populations in Côte d'Ivoire? Yamoussoukro, Côte d'Ivoire. 2013; 3-7:13.

16. Gidenne T, Pinheiro V, Falcao Cunha L. A comprehensive approach of the rabbit digestion: consequences of a reduction in dietary fibre supply. Livestock Production Science. 2000; 64:225-237.
17. Grosvernor MB, Smolin LA. Nutrition: From Science to Life. Harcourt College Publishers, New York, USA, 2002, 288-371.
18. Inyang UE. Nutrient Content of Four Lesser – Known Green Leafy Vegetables Consumed by Efik and Ibibio People in Nigeria Nigerian Journal of Basic and Applied Science, 2016, 1-5.
19. ISO. International Organization for Standardization. Animal feeding stuffs - Determination of amino acids content, Ed. 2005; 1:17.
20. Kamga RT, Kouamé C, Atangana AR, Chagomoka T, Ndango R. Nutritional evaluation of five african indigenous vegetables. Journal of Horticultural Research. 2013; 21(1):99-106.
21. Kimsé M, Soro D, Bléyéré MN, Yapi JN, Fantodji A. Contribution of tropical green forage, Centrosema pubescens, in addition to pellets: effect on the growth and health performance of the rabbit *Oryctolagus cuniculus.* International Journal of Biological and Chemical Sciences. 2013; 7:1234-1242.
22. Kowalska D, Bielański P. Meat quality of rabbits fed a diet supplemented with fish oil and antioxidant, Animal Science Papers and Reports. 2009; 27(2):139-148.
23. Mulungulungu ND, Mpiana TP, Mbayo KM, Tshisand TP, Badibanga ML, 2015.
24. Survey of antidrepanocytary activity and thermos degradation of aqueous, methanolic and ethanolic crude extracts extracted from Ipomea batatas, an edible plant with therapeutic vertues. International Journal of Innovation and Applied Studies, 11, 684-690.
25. Nguyen Van T, Nguyen Thi KD. Effect of water spinach and sweet potato vine associated with 2 other natural plants, on growth performance, carcass values and economic return of growing crossbred rabbits in the Mekong Delta of Vietnam. 9th World Rabbit Congress. 2008; Verona – Italy –6.
26. Oulai P, Zoué L, Mégnanou RM, Doué G, Niamké S. Proximate composition and nutritive value of leafy vegetables consumed in northern Côte d’Ivoire. European. Scientific Journal/ 2014; 10(6):212-227.
27. Perez JM, Lebas F, Gidenne T, Maertens L, Xiccato G, Parigi-Bini R, *et al*. European reference method for in vivo determination of diet digestibility in rabbits. World Rabbit Sci. 1995; 3:41-43.
28. PROTA. Plant Resources of Tropical Africa. Vegetables. Grubben GDH, Denton OA (Eds) PROTA Foundation, Wageningen, Netherlands/Backhuys Publishers Leiden, 2004.
29. Simonová MP, Chrastinová L, Mojto J, Lauková A, Szabóová R, Rafay J. Quality of rabbit meat and phyto-additives. Czech Journal of Food Sciences. 2010; 28:161-167.
30. Talukder S. Effect of dietary fiber on properties and acceptance of meat products: A review, Critical Reviews in Food Science and Nutrition. 2013; 55:1005-1011.
31. Uwaegbule AC. Vegetables: Nutrition and utilization. In: Food crops production. Dotan publishers Ltd. Ibadan, 1989, 39-44.
32. Uzo JO. Tropical vegetable production. In: Food crops productions. Dotan publisher Ltd. Ibadan, 1989, 45-49.
33. WCMC. World Conservation Monitoring Center. Global Biodiversity: Status of the Earth’ Living Resources – Chapman & Hall, London, 1992, 584.
34. Wognin LRMF, Otchoumou KA, Yao KF, Niamké S. Improving the nutritive value and sensory quality of rabbit meat by using leafy vegetables as feedstuffs ; Journal of Animal & Plant Sciences. 2018; 36(1):5812-5824.
35. Xiccato G. Feeding and meat quality in rabbits: a review. World Rabbit Science. 1999; 7:75-86.
36. Yao KF, Otchoumou KA, Wognin LRMF, Konan KA, Niamké S. Growth Parameters, Protein Digestibility and Health Status of Rabbit *Oryctolagus Cuniculus* Fed with Palatable Leafy Vegetables. European Scientific Journal. 2016; 12:17.