Improving the nutritive value and sensory quality of rabbit meat by using leafy vegetables as feedstuffs

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1 SUMMARY

The study examined the effect of feeding leafy vegetables on nutritional and sensory qualities of rabbit meat. For this, thirty weaned rabbits of 6 weeks of age (535.24-537.83 g) were allotted to six treatments in a completely randomized design with five replicates. The control diet was a concentrate while treatment diets were a mixture of leafy vegetables and concentrate (50:50; w/w). The rabbits were housed, fed in individual cages and the experiment was conducted for 9 weeks with 7 days of adaptation. This study revealed that 50 % *Abelmoschus esculentus* and 50% *Vigna unguiculata* leaves combined with 50 % of concentrate diet allowed the highest carcass yield. The meat bone ratio of the rabbits fed with the diets *Abelmoschus esculentus* and *Vigna unguiculata* were the highest with (5.56±0.15) and (5.40±0.10) respectively. The rabbits fed *Vigna unguiculata* with concentrate diet presented the highest protein content (20.92 %). The meat produced by feeding *Solanum melongena* with concentrate recorded the highest levels of potassium (546.56mg/100 g) and phosphorus (336.99 mg/100 g). The lysine content of rabbit meat obtained with *Solanum melongena* diet was higher than other groups. Leafy vegetables supplementation had no significant effect (P>0.05) on the appearance, juiciness and tenderness of rabbit meat. This study showed that *Solanum melongena* with concentrate mixture allowed the best nutritive value of meat as well as its sensory quality.

2 INTRODUCTION

Proteins are indispensable constituents for the growth, maintenance and renewal of tissues and for the synthesis of hormones, enzymes and other molecules essential to the human body (Petsko and Ringe, 2008). The absence of proteins in the diet leads to nutritional deficiencies, which may be severe in the case of animal proteins because of its high biological value. One of the solutions to address the issue of protein deficiency is the breeding of animals that have a short production cycle such as rabbits. The rabbit (*Oryctolagus cuniculus*) is a monogastric animal with a high reproductive potential (Lebas *et al.*, 1996). Rabbits convert up to 20% of the protein consumed into meat, more than pigs (15-18%) and cattle (9-12%) (Suttle, 2010). In comparison to meat of other animal species, rabbit meat is appreciated for its nutritional and dietetic properties, as it is lean, and rich in protein of high biological value (Dalle Zotte, 2000). In addition, rabbits are herbivores, which efficiently convert forages to food. According to Adeyemo *et al.*, (2013), Yao *et al.*, (2016) rabbit perform better when fed with mixture of forage and concentrate. Abonyi *et al*., (2012) and Garza *et al*., (2012) recommended the use of 50 % of sweet potato leaves to 50 % of commercial pellet in the diets of rabbit weaned for a best growth and decreased a production cost. So, these forages can be provided as supplementary diet to the basic concentrate in order to meet the fiber, vitamins and minerals requirements. In Côte d'Ivoire, a research conducted by several authors (Zoro *et al.,* 2013; Acho *et al*., 2014; Oulaï *et al*., 2014) indicated that the leafy vegetables had relatively high protein and minerals contents. Kimsé *et al.,* (2014) found that tropical forages added to industrial pellet diet have good impact on rabbit health by reduced sanitary risk index. Recently Yao *et al.* (2016) reported that theses leafy vegetables could be use in feeding of rabbit as forage to improved health status and growth parameters. However, these studies have not focused on the nutritive value and sensory quality of the rabbit meat. Thus, the present study was undertaken to assess the nutritional quality and sensory characteristics of meat of rabbits fed with leafy vegetables associated with concentrate diet.

3 MATERIALS AND METHODS

3.1 Site of experiment: The experiment was conducted in a traditional rabbit farm in Bingerville municipality (Côte d'Ivoire). The study area is located between 5° 21'708 "North latitude and 3° 54'639" West longitude.

3.2 Experimental diets : Experimental diets consisted of pellets of a balanced concentrate and *Vigna unguiculata, Abelmoschus esculentus*, *Ipomoea batatas*, *Solanum melongena* and *Corchorus olitorius* leaves**.** The pellets used in this study were obtained from Ivograin® Company. Leaves distributed to animals were purchased daily at 7 a.m from markets of Abidjan district. Leafy vegetables were rinsedwith10 L of water containing 2 mL of sodium hypochlorite (12°) for a few minutes to be disinfected (Kimsé *et al*., 2013).

3.3 Experimental design: Thirty rabbits (535±40 g) from crosses (New Zealand x Californian) (Martignon *et al*., 2010), weaned at 35 days of age were housed individually in wire-netting (70 × 40 × 50 cm) raised from 80 cm to ground. The cages were subjected to natural ventilation and daylight. The average temperature recorded during the experimental period was 29±2°C. Water was provided *ad libitum*. The rabbits were randomly allotted to six (6) dietary treatments with five (5) rabbits per treatment in a completely randomized design. The treatment groups were made up of the following:

Cd: 100 % concentrate diet;
SMCd: 50 % of *Solanum melongena* leaves with 50 % of concentrate diet;
AECd: 50 % of *Abelmoschus esculentus* leaves supplemented with 50 % of concentrate diet;
COCd: 50 % of *Corchorus olitorius* leaves supplemented with 50 % of concentrate diet;
VUCd: 50 % of *Vigna unguiculata* leaves supplemented with 50 % of concentrate diet;
IBCd: mixture 50 % of *Ipomoea batatas* leaves with 50 % of concentrate diet. 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.

3.4 Slaughtering and sampling: At the age of 98 days, all rabbits were weighted to determine their final live weight and slaughtered for evaluating meat quality and sensorial characteristics. The carcass of each animal was weighed before the abdominal fat was removed and weighed. Abdominal fat was expressed as percentage of the carcass weight, while carcass yield was obtained by calculating the ratio between the carcass weight and final live weight. The carcass without head was divided according to the method described by Blasco and Ouhayoun (1996). The carcass was cut between the last thoracic and the first lumbar vertebrae and between the 6th and 7th lumbar vertebrae. One of hind limb from each carcass was dissected for the estimation of the meat to bone ratio. The other hind leg was stored at 4 ºC for 24 h for sensory evaluation. After the carcass measurements evaluation, all the meat pieces were separated from the bone, minced, well mixed and vacuum-packed and frozen at -18 °C until the chemical analysis.

3.5 Determination of chemical composition of meat: Meat chemical composition was determined according to the procedures of AOAC (1990). Moisture content of meat samples (2 g) was determined by oven drying at 105°C for 24 hours until a constant weight. The ash content was obtained by mineralization of 10 g of meat samples in a muffle furnace set at 550°C for 12 h. Crude protein was calculated as nitrogen amount (Kjeldhal method) multiplied by 0.625 per 100 g of meat. Fat from meat samples was determined with Soxhlet extraction method using petroleum ether as solvent.

3.6 Minerals analysis: Ten (10) g of the processed samples were subjected to dry ashing in a well-cleaned porcelain crucible at 550 °C in a muffle furnace (Pyrolabo, France). The resultant ash was dissolved in 5mL acid mix of HCl/HNO_3. The mineral composition was determined using atomic absorption spectrophotometer (AAS model, SP9).

3.6.1 Determination of essential amino acids: Amino acids were determined by the procedures of ISO (2005). Five (5) grams of rabbit meat were hydrolyzed in 10 mL 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. This chain included a Waters Alliance unit, model e2695 equipped with two Lichrocart 125-4 Lichrospher 100 RP-18 columns in series. Each column was 12.5 cm long and 5 µm in diameter. Elution was done in gradient mode with a flow rate of 1 mL / min. Detection was carried out using a Waters spectrofluorometer 2475. Excitation and emission were carried out respectively at 340 nm and 450 nm.

3.6.2 Determination of vitamins: The vitamin content of the samples was determined by high performance liquid chromatography technique using the method described by European pharmacopoeia book (2014).

3.6.3 Determination of vitamins A and E: Alpha-tocopherol and retinol were analyzed by an HPLC system (SHIMADZU SPD 20A) with DAD detector, a high-pressure pump and a C18 column ODS, 250x4.60 mm (Cluzeau, France). The mobile phase consisted of acetonitrile and methanol, and a flow rate of 1.5 mL/min was used. Alpha-tocopherol and retinol were identified by using UV detector and comparing the samples' retention time with the pure standards. The quantification was carried out using by comparing the area sample peak with that of the reference standards, which are retinol acetate and alpha-tocopherol. Before injection into the HPLC system, 5 g of samples were crushed in 25mL of methanolic solution. The filtrate collected was used to evaluate the levels of vitamins.

3.6.4 Determination of water soluble vitamins: Two (2) grams of sample were placed in 25 mL of acid sulphuric (0.1 N) solution. Then, the contents were adjusted to pH 4.5 with 2.5 M sodium acetate. The preparation was stored at 35°C overnight. The mixture was then filtered through a Whatman paper and the filtrate was diluted with 50 mL of pure water and filtered again through a micropore filter (0.45 µm). Twenty microliters (20 µl) of the filtrate were injected into the HPLC system. Quantification of vitamins B5, B6, B9 and B12 content was accomplished by comparison to standards. Chromatographic separation was achieved on a reversed phase (RP) HPLC column through the isocratic delivery mobile phase at a flow rate of 1.5 mL/min. Ultraviolet (UV) absorbance was recorded at 270 nm at room temperature.

3.7 Sensory evaluation: The hind limb from each treatment group was used for sensory evaluation after cooking without salt or spice on charcoal for 20 to 25 minutes. The meat samples were cut into pieces and served to15 people randomly chosen to avoid location effects. These people were trained to evaluate the meat sensory quality by using 5 descriptors (appearance, taste, juiciness, texture, acceptability) according to a ranking test of intensity level (1= lesser; 3=greater) of each descriptor. Descriptors were made up of the following (Akinnusif *et al*., 2007)

Appearance: fatty, lean
Juiciness: juicy, dry
Taste: salty, bland
Texture: tender, tough

3.8 Statistical analysis: Data were analyzed by using the SPSS17software. Differences between means were separated using Duncan Multiple Range Test (Duncan, 1955).

4 RESULTS AND DISCUSSION

The results indicated variations in crude protein, crude lipid, ash and minerals among the five vegetables species and industrial diet (Table 1). *Corchorus olitorius* and *Vigna unguiculata* leaves recorded the highest crude protein ($P<0.05$) respectively 18.31 ±0.29 g/100 g and 19.15 ±0.32 g/100 g. These protein levels respect the 16 % of proteins recommended by Lebas (1989). *Corchorus olitorius* and *Vigna unguiculata* leaves have more than adequate levels of the nutrients to meet crude protein requirements of rabbit growth. These leafy vegetables can be protein source for feed formulation for growing rabbit. The crude lipid ranged from 3.67 g/100 g to 5.29 g/100 g for leafy vegetables and industrial diets. These values were within the range reported by Lebas (1989) which recommended 3-5 g/100 g of fat for young rabbit's diets to cover energy needs. Ash content was higher ($P<0.05$) in *Ipomoea batatas* (14.24 %), *Solanum melongena* (14.05 %) followed by *Abelmoschus esculentus* leaves (10.69 %). The same trend was observed to minerals analysis in which *Ipomoea batatas* and *Solanum melongena* had the highest levels of minerals. Table 1 showed that calcium (3312.70 ± 60.93 mg/100 g) and iron (115.54 ± 5.09 mg/100 g) in *Solanum melongena* were significantly ($p<0.05$) higher. Except iron and sodium which values were lower, the leaves of *Ipomoea batatas* indicated averages twice than those obtained for *Abelmoschus esculentus*, *Corchorus olitorius*, *Vigna unguiculata* and concentrate diet. High amounts of minerals especially for calcium and phosphorus could increase growth performance of rabbits because there plays a key role in organic processes, such as heart function, muscle contraction and involved in energy metabolism. In addition, the recorded levels related to the calcium to phosphorus ratio of 1.5:1 to 2:1 recommended by de Blas and Wiseman (2003) for a best growth.

Table 1: Nutrients contents of leafy vegetables and concentrate diet (% Dry matter)

	Leafy vegetables and Concentrate diet					
Nutrients	***Solanum melongena***	***Abelmoschus esculentus***	***Corchorus olitorius***	***Ipomoea batatas***	***Vigna unguiculata***	**Concentrate diet**
Dry matter (g/100 g)	24.75 ± 0.11 c	19.66 ± 0.17 a	24.28 ± 0.19 c	21.03 ± 0.20 b	20.76 ± 0.21b	89.39 ± 0.00 d
Crude protein (g/100 g)	12.55 ± 0.24 b	10.58 ± 0.64a	18.31 ± 0.29e	15.83 ± 0.41d	19.15 ± 0.32e	14.63 ± 0.18c
Lipids (g/100 g)	3.67 ± 0.12 a	4.42 ± 0.20b	4.76 ± 0.05c	3.75 ± 0.14a	5.29 ± 0.02d	3.68 ± 0.02a
Ash (g/100 g)	14.05 ± 0.09d	10.69 ± 0.18c	8.10 ± 0.23a	14.24 ± 0.24d	9.93 ± 0.28b	8.38 ± 0.10b
Calcium (mg/100 g)	3312.7 ± 60.93e	1325.14 ±64.87b	1019.72 ±44.64a	1938.54 ±30.05d	1512.96 ±71.05c	980.30 ±14.88a
Iron (mg/100 g)	115.54 ± 5.09e	93.80 ±5.64d	35.44 ±2.87b	17.66 ±0.29a	52.22 ±4.87c	97.84 ±1.48d
Potassium (mg/100 g)	3095.7 ± 69.20d	401.88 ±39.95a	1328.9 ±85.43b	5103.48 ±51.99f	1986.94 ±72.91c	3919.26 ±59.48e
Magnesium (mg/100 g)	244.65 ±10.50c	233.81 ±12.03c	106.29 ±7.26a	387.73 ±6.01d	196.41 ±11.54b	188.77 ±2.86b
Phosphorus (mg/100 g)	1257.22 ±24.95d	384.04 ±62.64a	501.62 ±19.63b	1804.32 ±27.93e	633.7 ±31.40 c	693.08 ±10.52c
Sodium (mg/100 g)	88.93 ±4.01c	62.65 ±5.22b	51.26 ±3.80a	50.66 ± 0.80a	61.78 ± 4.45b	81.23 ±1.23c
Zinc (mg/100 g)	8.47 ±0.34d	1.99 ±0.12b	0.43 ±0.10a	28.13 ±0.43e	0.21 ±0.08a	5.27 ±0.08c
Copper (mg/100 g)	82.07 ±3.18d	7.45 ±1.38a	20.01 ±0.96b	127.41 ±9.55e	5.39 ±1.69a	41.73 ±0.63c

[a,b]values in the same row with different superscripts differ at 5 % ($P < 0.05$)

The essential amino acids and vitamins contents of experimental diets are presented in Table 2. The most abundant amino acid in diets was leucine, which ranged from 8.91 to 9.41 g/100g protein for *Corchorus olitorius* and *Solanum melongena*, respectively. Proportion of threonine in *Solanum melongena* leaf (1.83 g/100 g) is lower than those of other, while *Ipomoea batatas* had the lowest content of lysine (2.56 g/100 g protein) and tyrosine (2.34g / 100 g protein). *Corchorus olitorius* leaf recorded amino acid concentrations almost similar to those obtained in concentrate diet. Despite the differences noted, amino acid concentrations in leaves and concentrate diet were higher than the proportions required for a growing young rabbit. According to Lebas (1989), young rabbit needs 0.70 g / 100 g of lysine, 1.05 of leucine, 0.7 g/100 g of valine and 0.55 g / 100 g of threonine for growth. The evaluation of vitamin contents in leaves and concentrate revealed that *Abelmoschus esculentus* contained highest levels of provitamin A (197.99µg /100 g) and B6 (155.69 µ/100 g). The lowest percentage of provitamin A was obtained with *Vigna unguiculata*, whose leaves were characterized by high concentrations of vitamin B5 (94.99 µg /100 g) and B12 (31.37 µg / 100 g). For *Solanum melongena* leaf the vitamin B9 was estimated to 275.2 µg / 100 g and was higher than the proportions of other leafy vegetables and commercial pellets. In this study, the vitamin levels recorded were low compared to the values required to meet the animal's needs. Also, the amounts of proteins, vitamins in some leaves being low and the absence of vitamin E in all leafy vegetables, compared to the values recommended for best growth performances may retard growth if the animal does not feed to satiety.

Table 2: Essential amino acids and vitamins contents of leafy vegetables and concentrate diet (% Dry matter)

Nutrients	Leafy vegetables and Concentrate diet					
	Solanum melongena	***Abelmoschus esculentus***	***Corchorus olitorius***	***Ipomoea batatas***	***Vigna unguiculata***	**Concentrate diet**
Amino acids(g/100g)						
Phenylalanine	4.56	3.86	2.84	3.51	3.65	2.85
Leucine	9.41	9.33	8.91	4.16	9.16	9.25
Threonine	1.83	4.40	4.51	3.24	4.36	4.02
Valine	6.17	5.21	3.98	4.07	4.1	4.04
Lysine	8.72	7.70	4.69	2.56	5.03	4.65
Methionine	0.97	0.72	1.42	1.37	1.4	1.37
Tyrosine	3.24	4.88	4.70	2.34	4.88	4.66
Vitamins (µg/100 g)						
Vitamin A	104.86	197.99	144.54	143.15	28.5	115.74
Vitamin E	Nd	Nd	Nd	Nd	Nd	Nd
Vitamin B5	42.94	20.4	35.86	24.7	94.99	27.27
Vitamin B6	15.19	155.69	69.09	18.4	41.7	36.99
Vitamin B9	275.2	122.75	92.68	101.1	202.58	124.32
Vitamin B12	5.99	17.79	21.04	9.1	31.37	21.56

Nd : Non detected

Table 3: Average feed and nutrient intakes (g/day/rabbit) of rabbits fed with concentrate diet and leafy vegetables

	Treatments					
Parameters	**SMCd**	**AECd**	**COCd**	**IBCd**	**VUCd**	**Cd**
Forages intake	198.04 ±15.38c	179.71 ±10.66b	191.25 ±8.60bc	232.29 ±3.77d	192.08 ±9.14bc	0.00 ±0.00a
Pellet intake	67.98 ±1.14a	73.99 ±1.48b	70.66 ±1.00a	68.33 ±0.63a	70.53 ±2.39a	107.9 ±3.93c
Total feed intake	266.02 ±15.95b	253.70 ±11.90b	261.91 ±8.17b	300.62 ±4.37c	262.61 ±10.58b	107.9 ±3.93a
protein intake	15.04 ±0.13 c	13.41 ±0.29 a	18.44 ± 0.37 e	16.67 ±0.20 d	17.10 ±0.60 d	14.11 ±0.51 b
Lipids intake	4.04 ±0.04 b	4.00 ±0.90 b	4.72 ±0.10 d	4.08 ±0.05 b	4.43 ±0.16 c	3.55 ±0.13 a
Ash intake	12.07 ±0.11 c	9.32 ±0.21 b	9.36 ±0.16 b	11.98 ±0.16 c	9.24 ±0.32 b	8.08 ±0.29 a

[a,b]values in the same row with different superscripts differ at 5 % ($P < 0.05$)

Table 3 and Table 4 showed the daily nutrient intake, final weight and carcass characteristics respectively. The final weight and carcass characteristics were affected by nutrients intake. The highest weight gains were obtained with the groups fed to SMCd (1371.98± 39.75 g) and

IBCd (1415.83 ±51.57 g) which rabbit intake more amounts of protein and minerals. The increase of weight gain with these two diets could be due to proteins and calcium, which contributed in construction of rabbit body and represent major components of the skeletal system, are cofactors of several enzymatic reactions, involved in nerve transmissions and acid-base regulation of blood and other body fluids. The same result was reported by Abonyi *et al.*, (2012) who observed that rabbits fed with concentrate supplemented with sweet potato leaves had a growth rate similar to rabbits feeding only concentrate diet. These leaves can be recommended to breeders to promote good growth of rabbits. Low minerals intake associated with high proteins and lipids intake have allowed to final weight also high with COCd diet. These results could be explained by good balance between the components of diet because Ouhayoun and Delmas (1983) and Trocino *et al.*, (2000) showed that protein / energy ratio and energy level are important factors that may increase weight gain. These factors could help to understand the high weight gains observed with the control diet. Although beneficial to the animal, the presence of some constituents in leaves could also reduce the bioavailability of nutrients, which would have a negative influence on growing rabbit and quality of the meat. It noted data recorded for carcass characteristics (carcass weight and abdominal fat) are not in agreement with the results by Renouf and offner (2007), Fernandez, and Fraga (1996) which demonstrated that low and moderate increase carcass yield and the amount of dissectible fat. Despite the presence of diets with lower weight gains, all experimental diets had given at the end of the experiment, carcasses with characteristics similar to those described by Ouhayoun et *al.,* (1986). According these authors, the commercial carcass should weigh 1285 Kg with a carcass yield of 57%.

Table 4: Effect of leafy vegetables on the carcass characteristics of rabbit fed with leafy vegetables and concentrate diet

	Treatments					
Parameters	**SMCd**	**AECd**	**COCd**	**IBCd**	**VUCd**	**Cd**
Initial weight (g)	535.24 ±40.82a	534.54 ±40.55a	532.09 ±40.83a	535.46 ±39.35a	533.91 ±40.68a	537.83 ±39.83a
Final weight (g)	1910.76 ±52.79bc	1794.84 ±60.51a	1927.76 ±65.21c	1948.91 ±93.47c	1817.11 ±50.61ab	1907.45 ±72.60bc
Weight gain (g)	1371.98 ±39.75b	1257.82 ±31.87a	1402.41 ±20.60b	1415.83 ±51.57b	1287.72 ±51.27a	1369.82 ±71.20b
Carcass weight (g)	1228.89 ±25.21ab	1192.59 ±24.93a	1255.42 ±21.73ab	1239.48 ±61.95ab	1185.00 ±30.16a	1302.90 ±27.60ab
Carcass yield (%)	64.25 ±0.75bc	64.52 ±0.17c	63.72 ±0.99abc	62.35 ±0.43ab	64.66 ±0.18c	61.92 ±1.31a
Meat/ bone ratio	4.48 ±0.15b	5.56 ±0.15d	4.77 ±0.09bc	3.98 ±0.09a	5.40 ±0.10d	4.87 ±0.17c
Abdominal fat (%)	1.64 ±0.19a	1.53 ±0.48a	1.78 ±0.41a	2.62 ±0.19b	2.84 ±0.12b	2.78 ±0.46b

[a,b]values in the same row with different superscripts differ at 5 % (P < 0.05)

Effects of experimental diets nutritional quality of rabbit's meat were summarized in table 5 and 6. The dry matter, protein, ash, lipids and minerals were significantly affected (P<0.05) by treatments. Crude protein was significantly higher (P<0.05) for diets that include leaves of *Corchorus olitorius* (20.56±0.65 g/100 g), *Ipomoea batatas* (19.83 ±1.48) and *Vigna unguiculata* (20.92±0.32 g/100 g). The higher proportion of proteins in rabbit meat could be explained by the presence of significant levels of proteins in forages use to fed animals. Indeed, ability of the rabbit to convert 20% of the proteins ingested to meat, which is an asset that makes it possible to optimize the use of leafy vegetables in breeding. This is in agreement with the values reported by Nguyen and Nguyen (2008) after using sweet potato leaves as forage in rabbit feed. In addition, the ingestion of 100 g of rabbit meat obtained from experimental diets would contribute significantly to the recommended nutritional intakes of protein, which are estimated at 0.83 g / kg / day for human according to AFSSA (2007). The diets including respectively *Solanum melongena* leaves (3.63±0.13 g/100 g) and *Ipomoea batatas* (3.66±0.08 g/100 g) recorded the highest ash content. The same trend was observed for mineral contents in rabbit meat obtained with the mixture of *Solanum melongena* or *Ipomoea batatas* and concentrate diet. Results indicated that meat contained higher calcium, potassium, phosphorus, magnesium and copper while theses minerals were lower for rabbit meat fed with control diet. Similar effect was obtained by Doukoupilová *et al*., (2007), which showed that hind leg meat of rabbits fed the selenium-supplemented diet contained four times more selenium than meat of control rabbits. Crude lipid levels estimated to be less than 10% in the muscles are similar to percentage recorded by many authors. This low-fat content allows some authors as Gigaud and Combes (2007) to describe rabbit meat as dietetic food.

Except phenylalanine (0.71± 0.05 g/100 g) and tyrosine (1.42 ±0.11 g/100 g) values, the other amino acids were significantly ($p<0.05$) low for mixture of *Ipomoea batatas* leaf with concentrate diet. Essential amino acid averages revealed that valine, lysine and methionine contents of rabbit meat fed to *Solamun melongena* and concentrate were significant ($p<0.05$) higher than meat obtained with other diets. The combination of *Solanum melongena* leaves with concentrate diet was characterized by the highest proportion of fat-soluble vitamins. Data provided in table 6 indicated that vitamin A content decreased significantly ($P<0.05$) when the leaves of *Vigna unguiculata* were used in rabbit's diet. Except for vitamin B12, proportions of vitamins B5 (1425.63 µg/100 g), B6 (355.00 µg/100 g) and B9 (11.46 µg/100 g) obtained from the control diet were higher than those of experimental diets. These results confirm the capacity of rabbit to convert efficiently feed consommed. It was demonstrated by several studies, including Simonová *et al*., (2010) which reported that oregano (*Origanum vulgare*) and sage (*Salvia officinalis*) extracts as well as *Eleutherococcus senticosus* could be involved in rabbit's diet to in improve amino acid composition of rabbit meat. The lower concentration of amino acids observed for meat derived to IBCd diet could be attributed to low contents of amino acids in *Ipomoea batatas* leaves. These results matched with Adel *et al*., (2017) paper where it is shows those amino acid contents of feed influence composition of amino acids of meat rabbit. Amino acid and vitamin concentrations of rabbit meat obtained from experimental diets could cover at least 50% of the recommended human nutritional intake according to the data provided by AFSSA (2007). All data revealed that vegetables are good source of nutrients and could be used for manufacture of pellet feed.

Table 5: Effect of partial substitution of concentrate diet to leafy vegetables on macronutrients and minerals contents of meat rabbit

Parameters	Treatments					
	SMCd	AECd	COCd	IBCd	VUCd	Te
Macronutrients (g/100 g)						
Dry matter	29.58±0.62d	25.80±0.59a	26.72±0.64ab	26.06±0.51a	28.56±0.54cd	27.83±1.00bc
Crude protein	19.07±1.50ab	19.16±0.86ab	20.56±0.65b	19.83±1.48b	20.92±0.32b	16.54±0.32a
Crude lipid	6.73±0.25b	6.03±0.17a	6.64±0.17b	7.79±0.28c	7.11±0.09b	8.33±0.31c
Ash	3.63±0.13c	3.33±0.08b	3.30±0.02b	3.66±0.08c	3.31±0.11b	2.94±0.04a
Minerals (mg/100 g)						
Calcium	9.91±0.31c	8.90±0.19 b	9.89±0.15c	10.12±0.15c	8.29±0.19b	5.88±0.09a
Potassium	546.56±16.85 d	373.82±8.11b	490.93±7.56c	495.26±7.37c	497.13±11.20c	182.91±2.78a
Magnesium	25.63±0.79e	20.91±0.45b	22.37±0.34c	23.24±0.35cd	23.76±0.54d	14.79±0.22a
Phosphorus	336.99±10.39 d	290.86±6.31b	332.85±5.12d	308.98±4.60c	280.66±6.32b	158.11±2.40a
Sodium	53.28±3.28d	33.49±1.45b	21.11±0.65a	31.75±0.94b	57.23±2.58e	44.99±1.37c
Zinc	7.23±0.22 d	0.71±0.02a	4.38±0.07c	4.47±0.07c	11.92±0.27e	1.29±0.02b
Copper	1.12±0.03 e	Nd	0.13±0.00a	0.88±0.01c	0.97±0.02d	0.76±0.01b

a,b values in the same row with different superscripts differ at 5 % ($P < 0.05$)

Table 6: Effect of partial substitution of concentrate diet to leafy vegetables on essential amino acids and vitamins contents of meat rabbit

Parameters	Treatments					
	SMCd	AECd	COCd	IBCd	VUCd	Cd
Essential amino acids (g/ 100 g)						
Phenylalanine	0.77±0.03 b	0.71±0.02 b	0.27±0.02 a	0.71± 0.05 b	0.89 ±0.01 c	0.31±0.02 a
Leucine	0.81±0.04 a	1.52±0.12 b	1.44±0.04 b	0.81± 0.06 a	1.46±0.02 b	1.44±0.08 b
Threonine	1.34±0.06 b	1.50± 0.12 b	1.79±0.06 c	0.89 ±0.07 a	1.73 ± 0.03 c	1.52 ±0.09 b
Valine	0.14±0.01 d	0.07± 0.00 b	0.07±0.00 b	0.04±0.00 a	0.09 ± 0.00 c	0.08±0.01bc
Lysine	3.71±0.17 c	0.94± 0.07 b	1.00±0.03 b	0.70± 0.05 a	0.97± 0.02 b	0.98±0.06 b
Methionine	2.00±0.09 c	0.99± 0.08 a	0.93±0.03 a	1.42 ±0.11 b	0.95±0.01 a	0.84±0.05 a
Tyrosine	0.89±0.07 d	0.50± 0.02 b	0.97±0.03 d	0.15 ±0.01 a	0.65±0.01 c	0.95±0.05 d
Vitamins (µg/100 g)						
Vitamin A	0.19	0.11	0.14	0.14	0.01	0.31
Vitamin E	280.67	147.47	153.91	146.81	151.97	273.59
Vitamin B5	223.55	741.19	368.41	370.07	624.01	1425.63
Vitamin B6	164.92	191.12	69.36	52.68	57.64	355.00
Vitamin B9	5.50	0.72	6.15	6.16	4.15	11.46
Vitamin B12	11.86	14.12	6.27	10.89	13.80	13.18

a,b values in the same row with different superscripts differ at 5 % ($P < 0.05$)

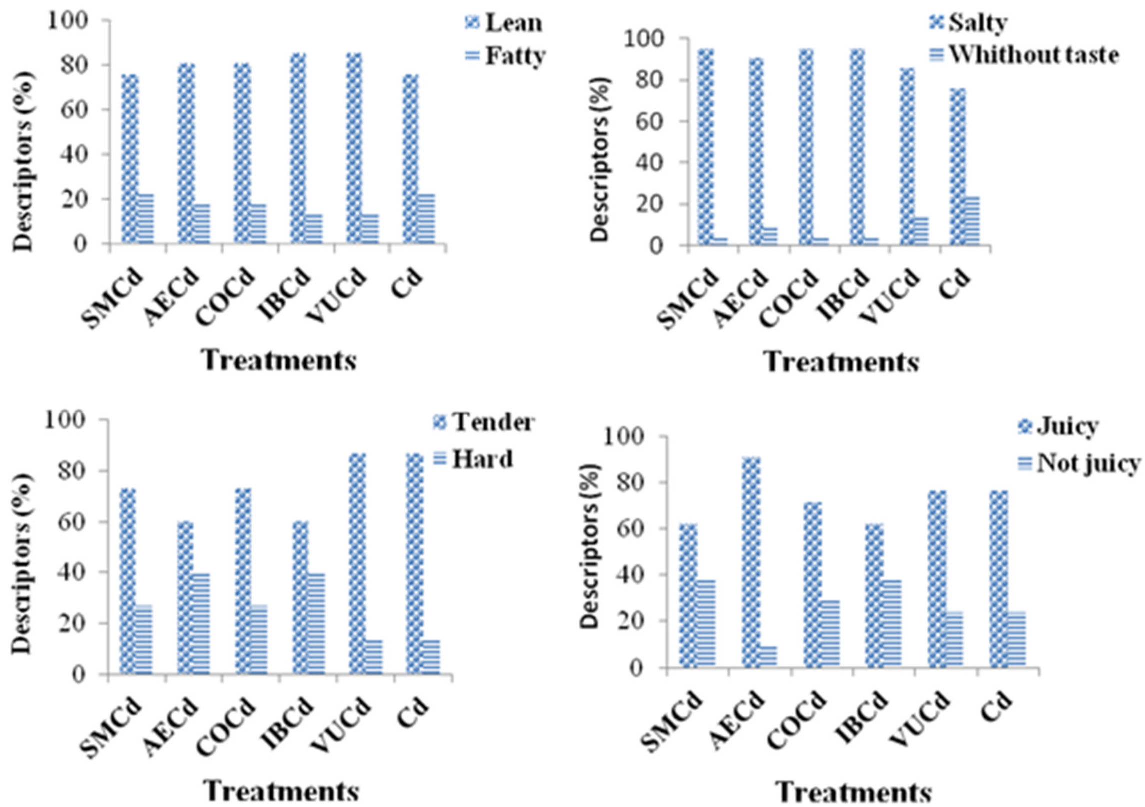

Figure 1: Distribution the rabbit meat quality descriptors

Table 7: Average of sensory attributes of meat from rabbits fed with diets

Treatments						
Descriptors	**SMCd**	**AECd**	**COCd**	**IBCd**	**VUCd**	**Cd**
Appearance	2.13±0.35 a	2.28±0.46 a	2.24±0.44 a	2.18±0.39 a	2.13±0.35 a	2.21±0.42 a
Taste	2.50±0.51 ab	2.24±0.44 a	2.21±0.42 a	2.72±0.46 b	2.47±0.51 ab	2.55±0.51 ab
Tenderness	1.94±0.44 a	2.07±0.46 ab	2.00±0.68 ab	2.30±0.47 ab	2.05±0.40 ab	1.94±0.24 ab
Juiciness	1.53±0.51 a	1.68±0.48 a	1.59±0.62 a	1.60±0.50 a	1.74±0.45 a	1.76±0.56 a
Overall acceptability	2.00±0.00 abc	1.83±0.38 a	2.33±0.49 c	2.22±0.43 bc	2.11±0.32 abc	1.94±0.42 ab

[a,b]values in the same row with different superscripts differ at 5 % ($P < 0.05$)

The Figure 1 indicated the distribution the rabbit meat quality descriptors obtained after feeding the rabbits. The data showed that the meat was lean, tender and juicy with a salty taste. The rabbit meat from AECd diet and COCd diet presented the lowest averages for the taste descriptors with respectively values of 2.24±0.44 and 2.21±0.42 and those fed with *Ipomoea batatas* and concentrate was characterized by highest value (2.72±0.46). Differences between meats tastes observed may be due to high sodium and potassium content in meat. These high concentrations of potassium and of sodium in meat would be responsible for the salt taste described by the panel. In addition, meat produced from AECd and COCd could be recommended to the persons with hypertension. Overall acceptability was higher for meat rabbit fed with industrial diet combined to *Corchorus olitorius* (2.33±0.49) (table 7) whereas those produced by the AECd diet were no accepted by the panel. Lipid content in meat might explain this preference because the juiciness of meat that is important for consumer choice is connected to fat content. It is important to mention that the meat produced from different diets differ for taste and fibrousness. The difficulty to separate the meat samples according to tenderness and juiciness was reported in the investigations of Omojola (2007) and Kowalska, (2008).

CONCLUSION

The results of this study indicated relationships between nutritional value of feed and carcass characteristics, nutritive value and sensory quality of meat. The richness of nutrients in leafy vegetables is an important asset for increasing these nutrients in meat. The SMCd diet had produced rabbit meat characterized by increase of averages of crude protein, minerals and essential amino acids contents. Except for AECd diet, all meat from experimental diets was accepted by the tasters. In addition, the association of *Solanum melongena* leaves and industrial diet could be recommended to the breeders because this system provides a better quality of the meat with sensorial characteristics that were very appreciated by the consumers. Additional work would be required to assess the impact of combination of two of these 5 leafy vegetables on nutritional and sensory quality of the meat.

REFERENCES

Abonyi F. O., Iyi E. O. and Machebe N. S. (2012). Effects of feeding sweet potato (Ipomoea batatas) leaves on growth performance and nutrient digestibility of rabbits. *African Journal of Biotechnology* Vol. 11(15), pp. 3709-3712.

Acho C.F., Zoué L.T., Akpa E.E., Yapo V.G. and Niamké S.L. (2014). Leafy vegetables consumed in Southern Côte d'Ivoire: a source of high value nutrients. *J. Anim. Plant Sci.*, 20(3): 3159-3170.

Adel E. M., Mohamed M. N, Aziz M. H., Yousef Y. S. and Diaa A. M. (2017) Effect of Substitution Soybean by Blue Green Alga *Spirulina platensis* on Performance and Meat Quality of Growing Rabbits.*American Journal of Food Technology,* 12 (1): 51-59

Adeyemo A.A., Adeyemi O.A., Ekunseitan D.A. and Taiwo O.S (2013). Effect of concentrate to forage ratio on the performance and haematological parameters of growing rabbits. *Gbobal Journal of Biology, Agriculture* & *Health Sciences* Vol.2 (2):114-118

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

Akinnusif A. O., Bamgbosea M., Odunaroo E. and Aladea. A. (2007). Carcass characteristics and sensory evaluation of meat from rabbits fed cashew-nut residue based diets. *ASSET An International Journal* Vol. 7 (1): 19-25

AOAC (1990). Official methods of analysis. Association of Official Analytical Chemists Ed., Washington DC, 684 p.

Blasco A. and Ouhayoun J. (1996). Harmonization of criteria and terminology in rabbit meat research. *World Rabbit Science*, 4 (2), 93-99.

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

Dalle Zotte A. and Szendrő Z. (2011). The role of rabbit meat as functional food: a review. *Meat Science*, 88, 319-331.

De Blas C. and Wiseman J. (2003). The Nutrition of the Rabbit. CABI Publishing, Oxon, UK.

Dokoupilová A., Marounek M., Skřivanová V. and Březina P. (2007). Selenium content in tissues and meat quality in rabbits fed selenium yeast. *Czech J. Anim. Sci.*, 52 (6): 165–169.

Duncan B. D. (1955). Multiple Range and Multiple F Tests *in* Biometrics Vol. 11, No. 1 *International Biometric Society*. pp. 1-42.

Fernandez C. and Fraga M. J. (1996). The effect of dietary fat inclusion on growth, carcass characteristics. *J. Anim. Sci.*, 74, pp 2088-2094.

Garza M.T., Lukefahr S.D., Schuster G.L. and McCuistion K.C. (2012). Developing sustainable diets for rabbits: effect of sweet potato forage on growth and feeding traits. World Rabbit Science Association, Proceedings 10 th World Rabbit Congress, Egypt, 781-785.

Gigaud V. and Combes S. (2007). Nutritional advantages of rabbit meat: comparison with other meat products. 12th Cuniculture Research Days, Mans, France, pp.187-190.

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

Iyeghe-Erakpotobor G.T. and Muhammad I.R. (2008). Intake of tropical grass, legume and legume-grass mixtures by rabbits. Trop. Grasslands, 42: 112-119.

Kimsé M., Soro D., Bléyéré M. N., Yapi J.N. and Fantodji A. (2013). Contribution of tropical green forage, Centrosema pubescens, in addition to pellets: effect on the growth and health performance of the rabbit *Oryctolagus cuniculus*. *Int. J. Biol. Chem. Sci.*, 7: 1234-1242.

Kimsé M., Gnanda B.I., Beugré G.A.M., Bodji N'guessan C. and Fantodji A. (2014). Effect of associated using of commercial feed supplementation and green forage on rabbit (*Oryctolagus cuniculus*) growth and health. *Scientia Agriculturae* 6 (3): 114-119

Kowalska D. (2008). Effect of dietary supplementation with rapeseed and fish oil mixture and antioxidant on rabbit meat quality. *Meat Quality and Safety*, 9th World Rabbit Congress – June 10-13, – Verona – Italy, 1372-1376.

Kpodékon M., Youssao A. K. I., Koutinhouin G. B., Baba I. L., Dessou J. M. and Djago Y. (2009). Effect of granulation on growth performance, feed efficiency and viability of young rabbits under tropical conditions. Revue Elev. Méd. Vét. Pays Trop., 62: 75-80.

Lebas F. (1989). Nutritional requirements of rabbits: bibliography and perspectives. *Cuni-Sci.*, 5 : 1-28.

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

Martignon M.H., Combes S. and Gidenne T. (2010). Digestive physiology and hindgut bacterial community of the young rabbit *Oryctolagus cuniculus*: Effects of age and short-term intake limitation. Comparative Biochemistry and Physiology-Part A. Mol. Integr. *Physiol.*, 156: 156- 162.

Nguyen Van T. and Nguyen Thi K.D. (2008). 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 – June 10-13 – Verona – Italy –6 p.

Omojola A.B. (2007). Effect of Delayed Bleeding on Carcass and Eating Qualities of Rabbit *Meat Pakistan Journal of Nutrition,* 6 (5): 438-442,

Ouhayoun J., Poujardieu B., and Delmas D. (1986). Study of the growth and body composition of rabbits after 11 weeks of age. *J. Rech. cunic.*, 24 p.

Ouhayoun J. and Delmas D. (1983). Comparative valorization of different levels of feed by rabbits selected for growth and traditional rabbits. II/ Study of nitrogen composition and energetic metabolism of Longissimus dorsi and

Biceps femoris muscles. *Ann. Zoo- tech*., 32, 277-286.

Ouhayoun J., Poujardieu B., and Delmas D. (1986). Study of the growth and body composition of rabbits after 11 weeks of age. *J. Rech. cunic*., 24 p.

Oulai P., Zoué L., Mégnanou, R.M. Doué, G., and Niamké S. (2014). Proximate composition and nutritive value of leafy vegetables consumed in northern Côte d'Ivoire. *Eur. Sci. J.,* 10 (6): 212-227.

Perez J.M., Lebas F., Gidenne T., Maertens L., Xiccato G., Parigi-Bini R., Dalle Zotte A., Cossu M.E., Carazzolo A., Villamide J., Carabano R., Fraga M., Ramos M.A., Cervera C., DeBlas E., Fernandez J., Falcao E., Cunha L. and Bengala F. J. (1995). European reference method for in vivo determination of diet digestibility in rabbits. *World Rabbit Sci*., 3: 41-43.

Petsko G. A. and Ringe D. (2008). *Structure and function of proteins*, Bruxelles, De Boeck

Université, First ed., 212 p.

Ph. Eur. (2014). European pharmacopoeia, 8th Edition, tome 1, p: 96-97

Renouf B. and Offner A. (2007). Effect of the energy level and distribution period of the feed on rabbit growth, mortality and yield at slaughter.2th Cuniculture Research Days, 27-28 November, Le Mans, France. 4p

Simonová M. P., Chrastinová L., Mojto J., Lauková A., Szabóová R. and Rafay J. (2010). Quality of rabbit meat and phyto-additives. *Czech J. Food Sci*., 28: 161–167.

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

Trocino A., Xiccato G., Queaque P.I. and Sartori A, (2000). Feeding plans at different protein levels: effects on growth performance, meat quality and nitrogen excretion in rabbits.

Journal of the World Rabbit Science Association, Volume 8, pp 467-473

Yao K. F. Otchoumou K. A. Wognin L.R.M.F., Konan K.A. and Niamké S. (2016). Growth Parameters, Protein Digestibility and Health Status of Rabbit *Oryctolagus Cuniculus* Fed with Palatable Leafy Vegetables. *European Scientific Journal* vol.12, 17 p

Zoro, A. F., Zoué, L. T., Kra, S. A. K, Yépié, A. E and Niamké, S. L., (2013). An Overview of Nutritive Potential of Leafy Vegetables Consumed in Western Côte d'Ivoire. *Pak. J. Nutr.* 12 (10): 949-956.