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Research Article

Voluntary Feed Intakes, Feed Preferences and Growth Performance of Growing and Fattening Rabbits Under Tropical Coastal Climate of Benin

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Abstract

Good knowledge of tropical animal species requirements is required to improve their productivity. The paper describes voluntary dry matter intakes in growing and fattening rabbits as affected by tropical climate. This study aims at determining the levels of concentrate feed consumed alone or in association with fodder. Thus, two commercial concentrate feed (pellet and mash) and two fodder (*Elaeis guineensis* or *Panicum maximum*) currently used in Benin were tested. A total of 192 young rabbits were used (96 young rabbits, 35 ± 2 days old at the growth stage and 96 young rabbits, 70 ± 2 days old at the fattening stage). The amounts of single feed intake and of the association feed concentrate-fodder were recorded daily on dry matter basis. The daily quantity of feed ingested by growing rabbit was 106g of pellet alone; 81.3g of pellet + 6.7g *Panicum maximum*; 84.6g of pellet + 8.1g of *Elaeis guineensis*; 63.6g of mash alone; 42.5g of mash + 7.4g of *Panicum maximum*; 41.1g of mash + 12.9g of *Elaeis guineensis*. The fattening rabbits ingested 129.9g of single pellet; 112.8g of pellet + 15.2g of *Panicum maximum*; 98.6g of pellet + 14.3g of *Elaeis guineensis*; 78.6g of single mash; 72.9g of mash + 20.1g of *Panicum maximum*; 66.7g of mash + 26.0g of *Elaeis guineensis*. The pellet diet was better appreciated and the better growth and Daily Weight Gain (DWG) was obtained with the pellet diets than mash and the addition of fodder mostly improved the ingestion of the mash diet in fattening rabbits.

Keywords: *Benin; Feed Preferences; Rabbits; Voluntary Feed Intake*

Introduction

Over the last years, rabbit production has gained popularity in many tropical countries especially in Africa and West Africa particularly [1]. For nearly a decade, in Benin, rabbit production has emerged. Rabbit is a short-cycle, prolific and fast-growing animal. Breeding is easy and accessibility to landless farmers while meat is of exceptional quality [2-4]. However, the rabbit rearing is facing difficulties such as feed cost due to the price of imported raw materials and diets do not meeting the standards for rabbits feed requirement. Forages are interesting alternative feed sources for rabbits owing to their greater availability and the ability of rabbits to convert forage into meat [1]. Despite the ability of rabbit to exploit a large number of feedstuffs and its limited maintenance requirements in amino acids and vitamins thanks to caecotrophy, rabbit feeding is a great challenge in intensive rearing systems, for both economical and sanitary reasons [5]. Asso-

ciation of concentrated feed with fodder is common practice in rabbit breeders in Benin. This feeding technique associating concentrated feeds with fodder presents economic and physiological advantages, which are certain for rural small-scale breeders, since it makes it possible to reduce the cost of the rabbit feeds. Aboh., *et al.* [6] have also reported the physiological advantage of this association, showing that addition of green forage to the basic diet increases the total feed intake per day. It is therefore necessary to develop a diet based on a better feed association (fodder + concentrate feed) adapted to the digestive physiology, nutrient needs and feed preferences of rabbits to optimize their growing performance. For several years, rabbit nutritionists are looking for developing feeding strategies able to increase feed efficiency so lowering feeding and total production costs [5]. Alternative solutions must therefore be found in order to make this breeding sustainable, efficient and profitable. This study focuses on two fodders *Panicum maximum* and *Elaeis guineensis* commonly used in Benin by breeders to feed rabbits. They have been classified by Adéhan., *et al.* [6] as one of the fodder that present the best palatability for rabbits. In Benin, concentrate feeds are usually either in mash or pelleted form.

Aim of the Study

This work aims at measuring the effect of the association of concentrate feeds (mash or pellet) with fodder on the voluntary dry mater intake and animal performance of growing and fattening rabbits.

Materials and Methods

Site of study, animals housing and experimental procedure

The experiment was conducted at the University of Abomey-Calavi experimental farm in Benin The climate is sub-equatorial characterized by two rainy seasons (from April to July and from September to November) and two dry seasons. The average annual rainfall is 1200 mm. The ambient temperature varies between 23 and 32°C.

In all, 192 rabbits (*Oryctolagus cuniculus*) from local breed were used. The experiments were carried out in two periods: growing period using 96 weaned rabbits, 35 - 70 days old, 426g to 598g live weight and fattening period (70 days old) using 96 rabbits, 70 days old, 1016g to 1043g live weight. Feed intakes and growth data were collected for 25 and 21 days respectively. At the onset of each experimental period, a and 5-days adaptation period was observed respectively to allow rabbits to get used to the new feed. The animals were individually caged in a three-tier system. A completely randomized design was used to allocate rabbits to six treatments so as to get similar mean live weights within bloc, each bloc corresponding to a diet and each rabbit being considered as a repetition. Animals were kept in wire mesh cage for single rabbit (75 cm X 46 cm X 30 cm). Each cage for single rabbit was numbered to facilitate data recording and equipped with feeders and drinkers.

Animal feeding and data collection

Accordingly, to breeder practices in Benin, compound feeds were distributed to rabbit alone or mixed with fodder. Thus, the dry matter intakes were measured for two fodders (*Panicum maximum* and *Elaeis guineensis)* and two compounds feed (Pelleted feed and Mash) distributed to animals alone or mixed (Mash *+ Panicum maximum*, Mash *+ Elaeis guineensis*, Pelleted feed *+ Panicum maximum*, Pelleted feed + *Elaeis guineensis*). Fodders tested are the most commonly used by farmers to feed rabbits and were collected from grazing lands. The compound feed tested was purchased from the local market. Feed (forage or/and concentrate) and water were supplied daily *ad libitum.* Animals were fed the morning at 8.00 and the refusal was recorded next day before offering the fresh feed. Feed intakes were recorded daily and calculated as difference between feed offered and refusals. The amounts of feed offered to animals were gradually increased and adjusted weekly according to rabbit requirements. KERN scale was used to weighed animals and diets. All animals had been treated against internal parasites with Pipérazine® (Laprovet, France, 5 ml/10 kg LW) and Trisulmix®: 1 g/l of water during three days prior to the experiment.

Chemical analysis

Experimental diets were analyzed according to AOAC [7] procedures for Dry Matter (DM) (method no. 934.01), organic matter (OM, method no. 942.05), ether extract (EE, method no. 920.39), crude fibre (CF, method no. 978.10) and ash (method no. 942.05). Crude Pro-

tein (CP) was determined by the Kjeldahl method, as nitrogen (N) x 6.25. Nitrogen Non-extract (NNE) was calculated as: (1,000 - CP - NDF - ash - ether extract, fractions being expressed as g/kg) [8].

Data analysis

Average feed intakes, mean weights, DWG and the feed conversion ratio (FCR) were compared using the Proc Means procedure of SAS [9]. The data were analyzed according to General Linear Model procedure (GLM) of SAS [9]. The F test was used to determine the significance of the diets or physiological stage effects then, the least squares means were estimated and compared within variables by the Student test. The fixed effects which are taken into account in the model are the diets (Mash, Pellet, Mash+PM, Mash+EG, Pellet+PM, Pellet+EG) and the physiological state (Growth and fattening).

Results

Composition of forage and concentrate diets fed to growing and fattening rabbit diets

The nutrients values of compound feeds and fodder ingested by rabbits are given in table 1. However, the proximate composition showed that the forages are sources of protein, fibre, fat and minerals. Comparing the two concentrate feeds, the protein content of mash (208 g/kg DM) was higher than that of the pelleted feed (177 g/kg DM) as mash content in digestible energy (2937 versus 2478 kcal/kg DM). However, the digestible protein values of the two feeds were similar (99.8g/kg DM for the pelleted feed and 99.9 g/kg DM for the mash feed). As a result, the mash presented a ratio DP/DE (34.0 g) lower than the pelleted feed (40.3g). With regard to the fiber contents, the mash contains lower crude fiber values (84 g/kg DM versus 182 g/kg DM), NDF (552 g/kg DM versus 711 g/kg DM) and in hemicellulose (134 g/kg DM versus 369 g/kg DM) than the pelleted feed. However, the mash contains more ADF (418 g/kg DM) than the pelleted feed (342 g/kg DM).

Chemical composition	Elaeis guineensis	Panicum maximum	Pellet	Mash
DM (g/kg)	973	969	889	879
Organic matter (g/kg DM)	928	876	882	899
Total ash (g/kg DM)	72	124	118	101
Crude protein (g/kg DM)	127	154	177	208
Fat (g/kg DM)	31	24	47	64
Crude Fibre (g/kg DM)	248	286	182	84
Neutral-detergent fibre (g/kg DM)	499	764	711	552
Acide-detergent fibre (g/kg DM)	385	325	342	418
Hemicellulose (g/kg DM)	114	439	369	134
Nitrogen free extract (g/kg DM)	522	412	476	543
Digestible energy kcal/Kg	2169	1991	2478	2937
Digestible protein (g/Kg)	656	897	998	999
DP/DE (g/kcal)	30.2	45.0	40.3	34.0

Table 1: *Composition of forage and concentrate diets fed to growing and fattening rabbit diets.*

Considering the two forages, the *Panicum maximum* content in protein (154 g/kg DM) was higher than that of the leaves of *Elaeis guineensis* (127 g/kg DM), likewise its crude fiber contents (286 g/kg DM versus 248 g/kg DM), NDF (764 g/kg DM versus 499 g/kg DM) and hemicellulose were also higher than in *Panicum maximum*. However, the ADF values of *Panicum maximum* was lower (325 g/kg DM versus 385 g/kg DM) in *Elaeis guineensis*. The energy value of *Elaeis guineensis* (2169.4 kcal/Kg DM) is slightly higher than that of *Panicum maximum* (1991.5 kcal/Kg DM) and the reverse was obtained from the digestible protein and the energy to protein ratio.

While comparing concentrate feed with fodder, the chemical analyses show that the concentrate feed content in protein (177 g/kg DM to 20.8 g/kg DM), digestible protein (99.79 to 99, 90 g/kg DM), fat (47 to 64 g/kg DM) and digestible energy (2478.2 to 2936.9 Kcal/kg DM) was higher than that of fodder. However, fodders content in crude fiber was higher than compound feeds. *Panicum maximum* has a better digestible protein/digestible energy ratio than the other feeds and higher digestible protein, total ash and crude fiber contents.

Concentrate and forage intake of growing rabbits

Feed intakes varied significantly (P < 0.001) depending on the feed characteristics and the types of combination compound - fodders (Table 2). The compound feeds distributed alone were significantly (P < 0.001) more ingested than compound feeds mixed with fodders. Thus, the single pelleted feed intake (106.1g) was significantly higher (P < 0.001) than when combined with *Elaeis guineensis* (84.6g) or *Panicum maximum* (81.3g). The same is true for the single mash diet intake (63.6 g), which is significantly higher (P < 0.001) than when combined with *Elaeis guineensis* (41.1g) or *Panicum maximum* (42.5g). In general, pelleted feeds (106.1g) were more ingested than mash diet (63.6g) and feed intake levels decreased significantly (p < 0.001) when combined with forage. In the presence of compound feed, fodder intakes were low and varied between 6.7g and 12.9g DM. *Elaeis guineensis* intakes were significantly higher (p < 0.001), especially when served in the presence of mash diet. Total DM intakes was significantly higher (p < 0.001) in compound feeds distributed alone. In compound feed mixed with fodders, total DM intake was higher in rabbits fed on *Elaeis guineensis* leaves. During the growth period, a young rabbit fed simultaneously with fodder and compound feeds consumed on average a total amount of dry matter 1.8 kg, i.e. 88% of concentrate feed and 12% of forage. When concentrate feeds were presented with forage, young rabbits preferred concentrate feeds to forage.

Feed intakes	Mixed feed				Single feed		P < F
	Mash + Eg	Mash + Pm	Pellet + Eg	Pellet + Pm	Pellet	Mash	
Concentrate (g)	41.1a	42.5a	84.6b	81.3c	106.1d	63.6e	***
SE	0.83	1.05	1.49	1.38	1.29	0.81	
Forage (g)	12.9a	7.4b	8.1b	6.7b	-	-	***
SE	0.39	0.16	0.24	0.14	-	-	
Total DM (g)	53.9a	49.9a	92.7b	88.0c	106.1d	63.6e	***
SE	1.05	1.12	1.62	1.42	1.29	0.81	

Table 2: *Effect of concentrate and forage type on feed intake of growing rabbits.*
Averages followed by different letters differ significantly at the 5% level;
**** (P< 0.001); SE: Standard Error; Eg: Elaeis guineensis; Pm: Panicum maximum.*

Concentrate and forage intake of fattening rabbits

Dry matter total intake was significantly higher in compound feeds distributed alone. In compound feed mixed with forages, the total intake of DM was higher in rabbits fed pelleted feed (Table 3). During the fattening period, the total quantity of dry matter ingested is estimated at 2.25 kg which represents 82% of compound feed and 18% of fodder.

Feed intakes	Mixed feed				Single feed		P < F
	Mash + Eg	Mash + Pm	Pellet + Eg	Pellet + Pm	Pellet	Mash	
Concentrate (g)	66.7a	72.9b	98.6c	112.9d	129.9e	78.6f	***
SE	0.71	1.14	1.27	1.19	1.53	1.06	
Forage (g)	26.0a	20.7b	14.3c	15.2c	-	-	***
SE	0.43	0.38	0.39	0.30	-	-	
Total DM (g)	92.7a	93.6a	112.9b	128.1c	129.9c	78.6d	***
SE	0.87	1.25	1.45	1.27	1.53	1.06	

Table 3: *Effect of concentrate and forage type on feed intake of fattening rabbits.*
Averages followed by different letters differ significantly at the 5% level;
**** (P< 0.001); SE: Standard Error; Eg: Elaeis guineensis; Pm: Panicum maximum.*

In the case of compound feed, feeds distributed alone were significantly (P < 0.001) more ingested than compound feeds mixed with fodder. Thus, ingestion of the pelleted feed alone (130g) was significantly higher (P < 0.001) than when combined with *Elaeis guineensis* (98.6g) or *Panicum maximum* (113g). The same is true for the mash intake distributed alone (78.6g), which was significantly higher (P <0.001) than when combined with *Elaeis guineensis* (66.7g) or *Panicum maximum* (72.9g). In general, pelleted feeds were better ingested (129.9g) than mash feeds (78.6g) and compound feed intake levels decreased significantly (p < 0.001) when combined with forage. When fodder were distributed simultaneously with compound feeds, their ingestions were low and varied between 14.3g and 26g DM. Ingestions of the two fodders *Elaeis guineensis* (26g DM) and *Panicum maximum* (20.7g) were significantly higher (p < 0.001) when they were served in the presence of the mash.

Performance of growing and fattening rabbits fed on concentrate and forage

Final live weights recorded during the growing period with rabbit fed on pellet were higher (from 1256.8g to 1662.8) than those on mash (from 825.0 to 1137.0g). The same trend was observed during fattening period.

During the growing period, the young rabbits fed on pellet alone had the highest DWG (35.4 g/d). The lowest values were recorded in rabbits fed on the mash diet (19.5 g/d), the mixtures Mash + *Elaeis guineensis* (18.8 g/d) and Mash + *Panicum maximum* (15.8 g/d). Intermediate values were recorded with the combinations pellet + *Elaeis guineensis* (30.0 g/d) and pellet + *Panicum maximum* (29.1 g/d) which showed similar values (P > 0.05) (Table 4). During fattening, the best DWG were obtained with the pellet + *Panicum maximum* combination (29.1 g/d) and the pelleted feed alone (27.46 g/d); while the lowest DWG was recorded for the young rabbits fed on the mash alone (15.31 g/d). Intermediate values were recorded for pelleted feed + *Elaeis guineensis* (24.60g), mash + *Panicum maximum* (20.64g) and mash - *Elaeis guineensis* (19.41g) which are similar (P > 0.05) (Table 5).

The feed conversion ratios obtained were not significantly different (P > 0.05) for the growing young rabbits on the one hand, and the fattening rabbits on the other hand. However, The feed conversion ratio recorded in fattening rabbits were relatively higher than those of the growing stage. These ratios ranged from 2.88 to 3.26 during the growth stage and from 4.40 to 5.15 during the fattening stage (Table 4 and 5).

Feed	ILW (g)		FLW (g)		DWG (g/d)		FCR	
	Means	SE	Means	SE	Means	SE	Means	SE
Mash + Eg	429.2a	14.45	885.3c	26.14	18.7a	1.33	3.0a	0.12
Mash + Pm	428.8a	7.55	825.0c	16.70	15.8a	1.91	3.4a	0.23
Mash	432.0a	8.12	1137.0b	28.36	19.5a	1.36	3.4a	0.20
Pellet + Eg	509.3a	11.12	1256.8b	18.31	29.9b	1.84	3.1a	0.08
Pellet + Pm	509.1a	11.60	1237.5b	26.97	29.1b	1.31	3.0a	0.10
Pellet	508.4a	5.49	1662.8a	17.17	35.4c	1.20	3.1a	0.09
P<F	NS		***		***		NS	

Table 4: *Effect of concentrate and forage type on performance of growing rabbits.*
Eg: Elaeis guineensis; Pm: Panicum maximum; ILW: Initial Live Weight; FLW: Final Live Weight.

Feed	ILW (g)		FLW (g)		DWG (g/d)		FCR	
	Means	SE	Means	SE	Means	SE	Means	SE
Mash + Eg	1213.7a	24.31	1633.3ab	32.43	19.4ab	1.40	4.8a	0.24
Mash + Pm	1169.3a	33.85	1620.8ab	32.34	20.6ab	1.46	4.5a	0.25
Mash	1116.8a	11.75	1444.3b	18.80	15.3b	1.41	5.6a	0.54
Pellet + Eg	1253.5a	23.05	1700.0a	42.61	24.6ba	2.16	4.9a	0.29
Pellet + Pm	1288.2a	13.54	1845.8a	28.57	29.1a	2.25	4.6a	0.31
Pellet	1141.1a	21.24	1695.0a	26.40	27.5a	1.16	4.8a	0.18
P<F	NS		***		***		NS	

Table 5: *Effect of concentrate and forage type on performance of fattening rabbits.*
Eg: Elaeis guineensis; Pm: Panicum maximum; ILW: Initial Live Weight; FLW: Final Live Weight.

Economic of growing and fattening rabbits fed on concentrate and forage

The economic calculations were made taking into account the production costs (feeds, veterinary treatments and manpower) and the selling prices of the animals (Table 6). The kg of mash costs 175 FCFA and that of the pellet is 200 FCFA. The selling price per kilogram of alive rabbit considered for the calculation is 1500 FCFA/kg. Health expenditure per animal was estimated at 49.35 FCFA, the cost of labor force was 67 CFA per young rabbit for animals fed a compound-forage combination and 50 FCFA for those fed compound diets alone. All feeds combined, feeds expenses represent on average more than 74% of the main operating expenses (Table 6). Whatever the physiological stage, feed expenditure is higher with pelleted feeds (79.27% to 86.00% of production costs) than with mash (67.20% to 76.30%). The economic calculation shows that during the growth stage, the animals having consumed the mash + *Elaeis guineensis* diets obtained the best profit ratios (118.48%). In the case of animals fed only on compound feed, the pelleted feed yielded the best profit ratios compared to the mash (96.47% vs 87.86%). In contrast to the growth stage, in fattening stage, the highest beneficiary ratio was the one of the pelleted feed distributed alone (73.34%). Mash distributed alone or in combination with forage had better benefit ratios compared to pellet - fodder combinations.

Parametres	Growth						Fattening					
	Pellet + Pm	Pellet + Eg	Pellet	Mash+ Pm	Mash + Eg	Mash	Pellet + Pm	Pellet + Eg	Pellet	Mash + Pm	Mash + Eg	Mash
ATFI (kg)	2.3	2.4	3.0	1.2	1.2	1.8	2.7	2.3	1.9	1.7	1.6	1.2
CFI (FCFA)	457	475	610	211	205	319	533	465	380	304	279	203
TWG (g)	728	747	884	396	469	487	558	446	554	452	420	327
F C T L W G (FCFA)	1092	1121	1488	594	702	687	836	669	830	677	629	491
CL (FCFA)	67	67	50	67	67	50	67	67	50	67	67	50
CVC (FCFA)	49	49	49	49	49	49	49	49	49	49	49	49
CP (FCFA)	573	592	710	328	321	419	649	582	479	421	395	302
AP (FCFA)	519	529	777	266	381	267	186	87	351	256	234	188
TPR (%)	90	89	109	81	118	64	29	15	73	61	59	62

***Table 6**: Effect of concentrate and forage type on economic of growing and fattening rabbits. ATFI: Average total feed intake; CFI: Cost of Feed Intake; TWG: Total Weight Gain; FCTLWG: Feed Cost for Total Live Weight Gain; CVC: Cost of Veterinary Care; CL: Cost of Labour; CP: Cost of Production; AP: Apparent Profit; TPR: Total Profit Ratio (TPR).*

Discussion

Effect of feed composition and forage type on feed intakes in growing and fattening rabbits

Mean DMI varied with the animals age and live weight, feed chemical composition feed presentation form. From weaning the daily feed intake of the domestic rabbit increases correlatively to the metabolic live-weight [10]. Then, similarly to this study, between the weaning (4 - 5 weeks) and 8 weeks of age, the weight gain reached its highest level while the feed conversion is optimal. Then, the feed intake increases less quickly as well the growth speed, and the intake levelled up at around 12 weeks of age for domestic rabbit [10].

Referring to the recommendations of Lebas [11] on the nutrient requirements of rabbits (protein: 160 g/kg DM, digestible energy: 2400 Kcal/kg DM, crude fiber: 150 g/kg DM), the chemical compositions of concentrate diets allow covering rabbits requirements. However, a deficit in crude fiber content and an excess in protein content and digestible energy was obtained with the mash diet. On the other hand, forages nutrients values are for the most part below the requirements recommended by the same authors except for the need for

cellulose that is covered. Forages alone could not meet the rabbits need. Then, the contribution of green forage could be considered as mainly a complement of crude fibers, although their protein and digestible energy levels are interesting. The chemical composition of the forages is consistent with the contents found by Kpodekon., *et al.* [12] and Lebas [13]. Rabbits would have oriented their choice on the feed likely to be suitable for their nutrient requirements. When energetic diet poor in fiber (concentrate feed) is distributed at choice with a fibrous feed (forage), rabbits prefer the former [14], which explains the observed high intake of compound diets to the detriment of forage. These is in accordance with findings of Iyeghe-Erakpotobor., *et al.* [15] who evaluated concentrate, grass and legume combinations on performance of growing rabbits under tropical conditions. Rabbits dry matter intakes were 130 g/d for total feed intake, 86.0g for concentrate and 44.07g for grass intake. In the similar experiment, Iyeghe-Erakpotobor [1] recorded the concentrate intake was 45.4g, grass intake was 23.2g, forage intake was 33.9g and the total feed intake was 102.6g. Indeed, palatability [16] and energy content [14] of a feed can influence its choice. One of the main dietary components implicated in feed intake regulation, after weaning, is the digestible energy concentration [10]. The poor consumption of the mash by the animals would be in accordance with its presentation form and its chemical composition. Its energy density is above the standard recommended by Lebas [11] and as rabbits regulate their ingestions according to the energy level of feed [13]. This high energy content would in part have contributed to the poor ingestion of the mash. The quantity of feed consumed by the rabbit often depends on the chemical composition of the feeds and more particularly on the digestible energy and protein content. In growing rabbit, the digestible energy concentration of the diet explains a great part of the variability of feed intake (R^2 = 0.74). Increasing 1 MJ DE/Kg diet decreases feed intake by 12 g/day and feed conversion ratio by 0.29 point [17]. On the other hand, Verdlhan [18] showed a decrease in consumption of 4 g/d/rabbit per 100 Kcal of energy concentration increase between 2200 and 2800 Kcal/kg.

In addition, when concentrated feeds and fodder are distributed simultaneously to animals, they reduce the consumption of concentrates in favor of fodder. In this case, the consumption of fodder is not a matter of chance or a simple pleasure for animals, but they are in search of certain elements the fodder would contain. This desired element in fodder would certainly be fiber, since according to the observation of Lebas [11], the young rabbits in fattening have a greater need for fiber. So, it should be remembered that a low rate of incorporation of fiber into the feed affects the health of young growing rabbits [10,19]. Indeed, the function of crude fiber as ballast, a regulating factor of digestive transit has been proven by several authors [10,19]. The fiber deficiency incidence on rabbit health has also been reported by several authors [10,14,20]. Results of Gidenne and Lebas [21] show clearly that a minimum dietary fibre supply is essential to prevent digestive troubles in the growing rabbit. They reported mainly digestive disorders such as nonspecific enteritis which, according to Koehl [22], can cause up to 12% of fattening mortalities. In addition, a minimum fiber intake is favorable for good digestive function [23]. This decrease of concentrate feed intakes would be due to a higher fiber requirement of rabbit. However, according to De Blas., *et al*. [5], both excess and deficit of fiber in the diet lead to a decrease in performance of rabbits. It is therefore necessary to incorporate an optimum level of fiber in rabbit diet.

The amounts of pelleted feed (84.57g and 98.59g respectively in growing and fattening) and mash (41.07g and 66.73g respectively in growing and fattening) ingested are in agreement with the levels of ingestion reported by Kpodékon., *et al.* [24] on the same types of feed, i.e. concentrated feeds mixed with palm leaves. They found 65.6g and 87.6g for the mash respectively during the first four weeks and the last four weeks of fattening, compared to 77.5g and 96.9g for the pellet respectively during the same periods. In diets containing different forages, Owoleke., *et al.* [25] found similar daily feed intakes with values that ranged from 80g in rabbits on *Amaranthus hybridus* to 90g in rabbits on *Lactuca sativa* based diets respectively. Feed intakes of weaner rabbits fed cassava peel as replacement for maize varied from 76.39 to 86.21 g/day [26].

The results showed that both leaves were better ingested when distributed with the mash. It should be noted that the mash contains less fiber, which would explain an increase in the amount of forage to fill this fiber deficit. However, the combination of forage and concentrate feed has not improved the total dry matter intake, contrary to the result obtained by Aboh., *et al.* [6] when they supplemented a mash-based diet with forage.

Effect of concentrate presentation form and forage type on feed intakes in growing and fattening rabbits

Among the compound feeds (pellet or mash), the pellet is much better ingested than the mash. The diet presentation is an important factor modulating the feeding behaviour in the rabbit [21]. Studies by Harris., *et al.* [27] also confirmed this result. They showed that in a

free choice situation, the rabbit prefers to 97% a pelleted feed rather than a mash. With respect to its presentation, this observed feeding behavior is in agreement with the results of Kpodékon., *et al.* [28] and Kpodékon., *et al.* [29] in Benin, who reported that rabbits show a clear preference for pellet. The low ingestions of the mash in the case of this study would also be attributable not only to its presentation form [24] but also to its poor fiber content [10,19] as evocated previously.

In this study, concentrate feeds have been better consumed than fodder, regardless of the age of the rabbits and the type of combination of the feed (alone or mixed). Gidenne., *et al.* [10] confirmed this feeding behavior in situation of free choice for domestic caged rabbit. He reported that, when a concentrate (low fiber diet compound diet) and a fibrous material are proposed as free choice to rabbits, they prefer the concentrate. Accordingly, to this study, they observed that, the fibrous material is consumed in only small quantities. This is the consequence of the specific search of rabbit for energetic sources (scarce in the wild), the dominant regulation system of feed intake in rabbits [10]. In addition, in free choice situation a simple variation of humidity of one component may change the equilibrium in the rabbit's choice [10]. For example, when dehydrated lucerne and normally dried maize grains (11% moisture) are offered *ad libitum* to rabbit the result of the choice is 65% lucerne/35% maize. But if the water content of the maize grains is increased up to 14 - 15%, the proportion of maize becomes 45 - 50% [10]. In this case, the choice reason of rabbits seems motivated more by the immediate palatability of the feeds than by their nutritive value [10]. However, it could be concluded that, the regulation of intake in free choice situation is delicate to predict [10].

First of all the feed resources available for wild rabbits are most generally constituted by a great range of plant material. Rabbit clearly prefer graminaceous plants and graze only few dicotyledons if sufficient grasses are available [10]. Accordingly, to previous study by Gidenne., *et al.* [10], the forage palatability test alone showed that *Panicum maximum* leaves were preferred to palm leaves. The studies of Adéhan., *et al.* [6] on the palatability of 23 plants also confirmed this preference for *Panicum maximum* by rabbits.

Effect of concentrate and forage type on performance and economic of growing and fattening rabbits

The characteristics of feeds and their chemical compositions induced differences in feed intakes and consequently in animal growth. In fact, the better ingestion of the pellet has allowed higher growing rates to be obtained both during the growing and fattening stages. This result is in agreement with the one found by Kpodekon., *et al.* [24] when comparing the growth and viability performance of young rabbits fed on a pelleted feed and a mash. They recorded a DWG of 28.3 g/d for the pelleted feed versus 24.6 g/d for the mash while our results are 32.3 g/d and 17.4 g/d respectively for pellet and mash. In addition, Rahman., *et al.* [30] also evaluated the effect of pellet and mash feeding on the performance of growing rabbit and found that DWG values were 12.5 g/day for rabbits fed with green grass + mash feed, 17.9 g/day for green grass + pellet feed and 14.7 g/day for green grass + 50% mash feed + 50% pellet feed. The DWG of the growing rabbits (15.8 to 29.9 g/day) and of the fattening one (15.3 to 29.1) were closed to values obtained by Houndonougbo., *et al.* [31] in Benin (19.6 to 23.1g) however these values were higher than 16.7g found in Benin with similar rabbit breed [32]. In Benin, when Koura., *et al*. [33] evaluated the effect of incorporation of cowpea and soybean pods in diets on weight gain performances of rabbits they obtained a DWG of 22.1 g/d for rabbits fed on cowpea and 12.1 g/d for soybean pod. Despite the differences in DWG and weight gain due to the effect of diet, the feed conversion ratio were similar at all animal groups. This result is related to the poor genetic performance of local breeds of rabbits raised in Benin. Thus, despite a high ingestion of rich feed, the growth of animals is impaired by their genetic potential. The values of feed conversion ratio (FCR) during the growth period varied between 2.9 and 3.7 and between 4.8 and 5.4 for the fattening stage [24]. These different values of the FCR are close to those obtained in this study. Higher values of FCR were obtained in Nigeria (ranged from 5.79 to 7.93) in rabbits fed with forages based diets [25] and in rabbits fed with cassava peel (4.39 to 6.64) [26]. The average FCR among the diets were, 5.21 for rabbits fed with green grass + mash feed, 4.22 for green grass + pellet feed and 5.32 for green grass + 50% mash feed + 50% pellet feed and the results did not differ significantly ($p > 0.05$) within the groups, but highest performance was found in the pelleted group [30]. When Kpodékon., *et al.* [29] determine the feeding level effect of the cotton seed cake on the growth performances of fattened rabbits, at the end of the fattening, the young rabbits weights varied between 887g and 1704g. The final live body weights of rabbit (1718 to 1805g) obtained in Benin by Houndonougbo., *et al.* [31] in rabbit fed with Rabbits fed Palm-Press fibres-based diets are close to final weights in this study and those reached in Nigeria, when Owoleke., *et al.* [25] fed rabbits with diets containing different forages (from 1432 to 1750g). Values found by Bovera., *et al.* [34] range of 1638.9 to 1862.5g. Final body weights obtained by Rahman., *et al.*

[30] were 1366.0g for rabbits fed with green grass + mash feed, 1650.0g for green grass + pellet feed and 1504.0g for green grass + 50% mash feed + 50% pellet feed.

This practice of feeding rabbit with forage in addition to concentrate feed aims to reduce the cost of rabbit production by reducing feed expenditure. There is no economic benefit to combining forage with concentrated feed, as forage did not reduce the rabbit production cost despite the availability of low-cost forage. However, when Iyeghe-Erakpotobor., *et al.* [1] evaluated the concentrate, grass and legume combinations on performance of grower rabbits under tropical conditions, they found the combination of concentrate, grass and legume shows promise in the reduction in the cost of production of grower rabbits. Abdu., *et al.* [35] also reported that the total cost of feed consumed during the entire experimental period was decreases with increasing level of carrot leaf meal inclusion in experimental diets up to 15%. Analysis of economic performances by Koura., *et al.* [33] showed that feed cost as well as economic efficiency of the control and experimental feed were similar. Although, the cost of diets with soybean pods [33] and *Moringa oleifera* leaves meal [36] were better than that of the conventional diet. Then grass, legumes leaves and pod shells and over unconventional feedstuffs experimented by many authors in rabbit diets allow to reduce the feed cost. Thus, including legumes or grass in rabbit diet is a good issue for empowerment of rabbit farms [33]. When comparing the two concentrated feed (granulated and mash), the use of granulated feed for rabbit production has a more interesting economic advantage because its apparent profit is better than that of mash diet. Then, despite the high feed expenditure for rabbits on pellet, the economic calculation shows that the best total profit ratio is obtained for growing and fattening rabbit on single pellet.

Conclusion

This study on the voluntary DMI, feed preferences and growth performance is of scientific interest for rabbit production in the tropics as it complements data on rabbit production standards. It accurately measured feed quantities for growing and fattening rabbits, for mash and pellet feed, or when mixed with forage. The present work has also confirmed that pellet remains the best palatable feed for the rabbit. The combination of forages with concentrate diets did not significantly improve total DMI, animal growth rate and economic profitability of rabbit fattening production. For all the concentrate and forage mixed diet, feed cost was lower than single concentrate and though feed cost Kg^{-1} gain was slightly higher for rabbit on pellet and forage. Apparent profit was better for growing rabbits on pellet than those on mash diets while total profit ratio was higher for rabbit on mash diets. This study has therefore shown that the practice in Benin that consist to provide green fodder to rabbits does not present economic and animal growth advantages. The use of fodder by rabbit producers increases the labor time of the workforce and could contribute to the destruction of the environment and promote the contamination of animals by pathologies especially in case of epidemics diseases. Rabbits farmer would be trained and strengthened through training to develop good practices in animals feeding for improved rabbit productivity. Furthermore, locally available feed resources used for feeding rabbits must be identify and their nutritive value must be determined so as to provide better recommendations to farmers on their efficient use. Effect of inclusion levels of dried forages in concentrate diets must be achieve.

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