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Effect of soybean meal substitution with okara in growing rabbits in fattening phase in northern Benin

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Abstract

The food of rabbits constitutes one of the major constraints in rabbit breeding. To mitigate this constraint, the valorization of the by-products locally available can be considered. This trial aims at determining the effect of soybean meal substitution by okara, in fattening rabbit feed, to reduce feeding costs. 144 locals rabbits aged 41 ± 2 days weighing on average 524 ± 1.1 g were used for an experiment during 8 weeks. They were divided into three equal and homogeneous batches (48 rabbits /group). Group 1 had received the experimental feed: R1 basic diet (2457 ED / kg, 16.4% crude protein and 14.3% crude fiber); Group 2, diet R2 (2455 ED / kg, 16.4% crude protein and 13.7% crude fiber) and group 3 received the R3 diet (2455 ED / kg, 16.4% protein crude and 14.0% crude fiber). The data were subjected to one-way analysis of variance using R 3.14. No significant difference ($p>0.05$) was observed in the growth rate of young rabbits in the three batches. Nevertheless, the weight gain was higher ($p>0.05$) in group 3 (16.7 vs. 14.7 vs. 14.5 g/d) in the respective lots 1 and 2. Similarly, there is no significant difference ($p>0.05$) between the consumption indices of the young rabbits of the three groups. The best carcass yield was obtained with the rabbits of group 3. The highest net profit is 729 FCFA for the food of group 3. The food R3 can therefore be recommended for the fattening of rabbits.

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Introduction

The proteins of soybean meal are of excellent nutritional value and well balanced in essential amino acids which makes it an essential product for the feeding of animals in intensive breeding (Cetiom 2008). But soybean meal remains expensive in a context of steady increases in raw material costs.

The research for food autonomy is therefore more relevant than ever in animal nutrition and in particular the search for alternative sources of protein to soy. The use of locally available by-products in a substitution alternative of raw materials in rabbit breeding would be an asset to consider. In addition, soybean meal appears to be the only by-product of soybean processing. Indeed, okara is the residue left by soy after extraction of the extractable fraction of the water used to produce soy milk (Toole 1999).

It has a high quality feed protein Ma *et al* (1996). In addition, Abd-Elsamee *et al.* (2005) reported that the use of okara as a substitute for soy meal in broiler diets up to 60% did not affect the food conversion and improved economic efficiency. Despite the presence and availability of this by-product in Benin, no study has been devoted to its recovery in rabbit production. Incorporation and recovery of this tofu residue in the diet of rabbits could be an interesting alternative to improve the growth performance of rabbits and reduce the cost of food production. The aim of this test is to investigate the possibility of total replacement of soybean meal by okara in rabbits feeding during the fattening phase.

Material and methods

Framework and study area

The experiment took place from December 2, 2015 to January 27, 2016 at the application farm of the Faculty of Agronomy (FA) located in University of Parakou. This farm is located at the north-east exit of the city of Parakou. Regional capital of the north of the country, the city of Parakou, is between l9° 21 'north latitude and 2° 36' east longitude.

The commune of Parakou is characterized by a Sudano-Guinean climate with two seasons: a rainy season which extends from April to October, and a dry season from mid-October to mid-April with a harmattan regime from December to February and scorching heat from March to April. The water level recorded annually varies between 1000 mm and 1500 mm for 75 to 140 effective days of rain.

Animals

The animal material used consisted of 144young rabbits aged 41 ± 2 days with an average live weight (LW) of 524 ± 1.1 g. These common breeds are characterized by a small size, a dress ranging from white to black or from black to spotted or gray white. These 144 rabbits were divided into three groups of 48 rabbits each.

The distribution was as homogeneous as possible and took into account mainly the weights of the rabbits. There were four rabbits per cage. The sex of the rabbits was not taken into account because, until the age of 12 weeks, it influences neither the growth nor the quantities ingested.

They were fattened in metal cages of dimensions 75 cm x 45 cm x 30 cm arranged in a naturally ventilated building lit by daylight. A manger and a concrete trough were placed in each cage. Rabbits were identified by ear tagging. Foods were distributed at will to rabbits.

The animals were fed with the flour food (feed) and a supplementation by *Tridax procumbens* and *Elaeis guineenssis*. One week before the start of the experiment, a dietary transition was made to promote a gradual adaptation of the rabbits to the diets to be tested. Group 1 had received the experimental feed: the basic diet R1 at 10% soybean meal (24567 ED / kg, 16.4% crude protein and 14.3% crude fiber); group 2 had received diet R2 at 5% okara and 5% soybean meal (2455 ED / kg, 16.4% crude protein and 13.7% crude fiber) and group 3 had received the R3 at 10% okara (2455 ED / kg, 16.4% and 14.0% crude fiber). The percentage composition of foods R1, R2, R3 is given in Table 1.

Process of obtaining okara

This residue comes from the manufacture of tofu (a consistent paste made from coagulated soy milk).

The method of obtaining or manufacturing is closely linked to tofu's one. Thus, the first operation is to rid the soybeans of all impurities (pebbles, rotten seeds and others) and then wash it. Then the soy is soaked in fresh water for about 12 hours: this is the maceration of soy grain. It allows to obtain a flavored product. The macerated element is boiled for about 30 minutes. The cooked seeds are removed from the cooking water, sent to the mill and then finely crushed (Fig. 1). This produces a paste (Fig. 2) which is actually a mixture of soy milk and its residue.

The following phase is to it filter through a cloth to separate the two constituents. To do this, a filter device consists of a large pot on which a basket containing a cloth inside (Fig. 3).

The pasty mixture is poured into the basket that holds the residue while the milk fluid drips and goes down to the pot. The liquid collected in the pot will be cooked for a few minutes after mixing with acidified water. This causes the formation of a solid that will lead to cheese making. On the other hand, the wet rejection will be squeezed, drained of water and then dried (Figs 4 and 5) in order to obtain a product that can be used as raw material for animal feed.

Chemical analysis and nutritional value of foods

A sample of each feed diet was taken to determine dry matter (DM), total ash (TA), crude fiber (CF), fat (F), and total nitrogen content (MAT). Following official methods approved by AOAC (2005).

Health and medical prophylaxis

Two weeks prior to the transfer of the rabbits in the site, the building, cages, drinking troughs and feeders were thoroughly cleaned and disinfected with 150 mL of bleach in 5L of water and dried in the sun. Trisulmycin Forte (sulfadiazine 66.7 g and trimethoprim 13.3 g) was used for preventive control against coccidiosis at a dose of 2 mg / kg body weight. All the rabbits used were vaccinated against the Viral Hemorrhagic Disease (HDV).

Collection of data

After an individual weighing of the animals on D0 using a TANITA brand scale with a range of 3kg, with an accuracy of ± 5g, the animals were weighed weekly on a fixed day during the eight weeks of fattening.

The quantities of food served, consumed and discarded were recorded daily on a monitoring sheet which also included the weekly live weight of the rabbits, the amount of food distributed, wasted and remaining in the manger as well as mortalities. During the test, the dead animals were registered and removed from the cages. Also a system of recovery of the wasted food which consisted in attaching cloths using wire under the cages, was installed. The wasted food mixed with the poop. Every two days sieving was done to recover the wasted food. The rabbits were divided according to their weight into three batches of 16 animals each, at the rate of 4 rabbits per cage.

Data analysis

The weekly weights were recorded and the various daily average earnings, beef yields and economic profitability were calculated. The consumption index was calculated based on the number of rabbit-days. The statistical analyzes were performed by the software R 3.1.3 at a factor represented by the rate of incorporation of okara into the food. No significant difference was observed between the three replicates and therefore the repetition effect was not taken into account in the analysis model. The analysis of the variance was obtained by the procedure of the generalized linear models (GLM). The averages were calculated and compared by the t-test. The bilateral Z test was used to compare mortality rates between the three groups. The mean was done using the 5% Tukey test when averages are significantly different.

Results

Nutritional values of okara and diets

The chemical components of okara, its nutritional value and those of the diets formulated for the rabbits are presented in the following table 2.

Table 1. Ingredients composition of the experimental diets of growing rabbits.

Ingredients	Diet 1	Diet 2	Diet 3
Maize, kg	7	11	14
Soybean, kg	10	5	0
Okara, kg	0	5	10
Cottonseed meal, kg	4	6	7
Wheatbran, kg	34,5	33	25
Oyster shell, kg	2,50	2,5	2,5
Salt, kg	0,5	0,5	0,5
Palm kernelcake, kg	21	18	23
Ricebran, kg	20,5	19	18
Total, kg	100	100	100

Feed intake

The average weekly amounts of food ingested per day and per rabbit are shown in table 3. During the first three weeks, the daily amounts of food consumed gradually increased in each batch (Table 3). During this period, the average daily consumptions are similar for the three batches and do not show any significant differences (P> 0.05). From the fourth to the eighth week, food consumption in all the three groups increased and decreased.

Table 2. Chemical composition of okara and experimental diets.

Chemical composition	Okara	D1	D2	D3
Fat (F) %	11.3	3.10	3.59	3.92
Crude Fiber (CF) %	15	14.3	13.8	14.1
Crude Protein (CP) %	34.5	16.4	16.4	16.4
Dry matter (DM) %	93.8	86.2	86.4	86.8
Total Ash (TA) (%)	3.9	5.89	5.61	5.25
Digestible Energy (Kcal/kg)	2364	2456	2454	2455

This consumption was not significantly different between the three groups (P> 0.05). The average daily feed intake per batch is 61.87 ± 3.02 g for batch 1; 60.15 ± 2.55 g for group 2 and 62.59 ± 3.38 g for group 3. These three values are not significantly different (P> 0.05). As a result, the most consumed food is the food R 3 followed by the food R 1 and the food R 2.

Table 3. Average weekly feed intake of rabbit per day.

Weeks	Diet 1	Diet 2	Diet 3	SEM	P
1	43.8	41.2	39.2	2.20	0.37
2	61.2	59.3	56.4	3.65	0.64
3	72.2	64.1	68.5	2.28	0.08
4	66.6	59.7	62.2	3.25	0.30
5	60.9	58.9	68.4	3.28	0.14
6	64.2	60.1	70.7	3.17	0.39
7	61.3	59.3	66.5	3.44	0.30
8	64.7	68.7	68.8	2.59	0.44
Average	61.9	60.2	62.6	2.26	0.01

The results are expressed as a function of the mean ± standard error of mean (SEM).

Table 4. Feed rejected according to the diet.

Weeks	Diet 1	Diet 2	Diet 3	SEM	P
1	317 [a]	270 [a]	295 [a]	37.1	0.69
2	465 [a]	421 [a]	387 [a]	40.3	0.43
3	554 [a]	425.4 [b]	310 [b]	32.5	0.01
4	259 [a]	195.2 [ab]	211 [b]	16.5	0.02
5	246 [a]	242.1 [a]	168 [b]	16.2	0.01
6	131.8 [a]	93.9[ab]	54.6 [b]	10.7	0.01
7	173 [a]	161.6 [a]	129 [a]	11.7	0.08
8	82.9 [a]	94.57[a]	79.5 [a]	4.35	0.06
Means	285 [a]	238 [a]	204 [a]	21.2	0.39

Means along the same row with different superscript letters are significantly different (P <0.05).

Waste of food

No significant difference was observed for the rejected food throughout the duration of the experiment. The average quantities of feeds discarded individually per day are shown in Table 5.

Over the entire experimental period, there was a significant difference between the weekly averages of feed rejected in the three batches (P <0.05) (Table 4). However, for the first two and the last two weeks, no significant difference was observed between these weekly quantities of feed rejected in the three batches (P> 0.05). But from the 3rd to the 6th week, a significant difference is observed in the three groups (P <0.05).No significant differences were observed between rejected foods. As a result, the feed of group 1 is the most rejected by the rabbits with an average of 285 g per week, followed by group 2 with an average of 238 g and then group 3 with an average of 204 g.

Feed efficiency

For the first week of the experiment, the feed efficiency was significantly different for the three batches of rabbits (P <0.05). Thus, the highest feed efficiency was recorded in young rabbits of group 1. The average feed efficiency of young rabbits of groups 1, 2 and 3 were 5. 54 g DM / g LW, 8.08 g DM / g LW and 4.53 g DM / g LW respectively, see Table 5.

Table 5. Weekly Feed efficiency of rabbits (g DM/ g LW).

Weeks	Diet 1	Deit 2	Diet 3	SEM	**P**
1	1.9 [a]	1.2 [b]	1.42 [b]	0.11	0.001
2	5.10 [a]	3.51 [a]	0.75 [a]	1.48	0.13
3	4.05 [a]	2.4vi0 [a]	2.67 [a]	0.95	0.56
4	3.99 [a]	4.80 [a]	6.38 [a]	1.07	0.34
5	6.47 [a]	16.4 [a]	4.43 [a]	4.02	0.41
6	11.4 [a]	6.47 [a]	5.24 [a]	2.41	0.30
7	10.3 [a]	7.67 [a]	6.12 [a]	3.44	0.51
8	11.2 [a]	22.0 [a]	9.23 [a]	8.92	0.43
Means	5.54 [a]	8.05 [a]	4.53 [a]	2.8	0.36

Means along the same row with different superscript letters are significantly different (P <0.05).

Effect of substitution on growth performance

At the beginning of the experiment, no significant difference (P> 0.05) was observed between the average weights of rabbits (Table 6). These weights were respectively 523 g; 524 g and 525 g for groups 1, 2 and 3. Indeed, during the 8 weeks of the test, the weights of the rabbits were not significantly different (P> 0.05). However, from day 7 to day 14, the weekly weight of rabbits fed R2 was slightly higher than those fed R1 and R3. From the 21st day to 56th day, the rabbits nourished with the food R3 had a higher weight than the others, followed by the rabbits nourished with food R1 then R3. Table 7 shows the weekly weights of the rabbits according to the diet.

Effect of substitution on the average daily gain

The average weight gains at the end of the experiment for young rabbits in groups 1, 2 and 3 were 1338 g, 1318 g and 1445 g, respectively, and the absolute weight gains were 828.3 g for group 1812.4 g for 2 and 934 g for group 3 respectively.

Table 6. Average live weight of rabbits according to the diet (g).

Weights	Diet 1	Diet 2	Diet 3	SEM	P
P0	509	505	511	48.5	0.99
P7	677	724	711	54.1	0.76
P14	786	846	840	56.4	0.71
P21	928	933	964	55.4	0.9
P28	1056	1043	1078	60.4	0.92
P35	1139	1123	1199	60.4	0.68
P42	1221	1193	1278	62,5	0,64
P49	1292	1267	1381	65	0,46
P56	1338	1318	1445	68,4	0,39

These results are not significantly different (P> 0.05) (Table 8). The intermediate weight was obtained by the young rabbits of group 1. The young rabbits of group 3 showed the best weight gain and those of group 1 the smallest weight gain. During the eight weeks of the experiment, no significant difference (P> 0.05) was observed with the ADGs. On average, they were 16.7 g/d for group 3.14.5 g / d for group 2 and 14.8 g / d for group 1.

The highest ADG was observed in the four first weeks with the rabbits fed with food 3 is 20.2 g / d against 19.2 g/d and 19.5 g/d for groups 2 and 1 respectively. The trend was the same during the last four weeks and throughout the eight weeks of experimentation were 13.1 g / d, 9.80 g/d and 10.1 g /d respectively for Groups 3, 2 and 1. Intermediate ADGs were obtained with group 1 rabbits and come after group 2 rabbits.

Table 7. Average daily gain (ADG) of rabbits of the experimental diets.

ADG (g/j)	Diet 1	Diet 2	Diet 3	SEM	P
ADG 0-4	19,5	19,2	20,2	1,48	0,88
ADG 4-8	10,1	9,80	13,1	1,12	0,09
ADG 0-8	14,8	14,5	16,7	0,99	0,28

The results are expressed as a function of the mean ± standard error to mean (SEM).

Effect of Substitution on Butcher Performance

The butchering performance of the rabbits is shown in Table 8. The carcass yields obtained were 57.1% for the rabbits of the group 1 against 56.8% for those of the group 2 and 58, 4% for the rabbits of the group 3. No significant difference was observed between carcass yields (P> 0.05). The type of diet therefore had no effect on carcass yield of rabbits.

Mortality rate

The mortality rates were 14.58% for the young rabbits of group 1; 12.5% for the bunnies of the group 2 and 4.16 % for the bunnies of the group 3 (Table 9).

Several cases of pathologies were registered with mortalities. The completion of the autopsies allows to suspect: enterotoxemia and respiratory diseases since all diets were presented in floury form.

Table 8. Carcass yield and relative organ weights of rabbits.

Parameters	*Diet 1*	*Diet 2*	*Diet 3*	*SEM*	*P*
N	41	42	44		
Number of slaughtered Rabbits	12	12	12		
Live weight at 56 days, (g)	1403	1445	1455	88	0,91
Weight Yield (g)	804	824	849	66,3	0,89
Weight of fat (%)	2,72	1,28	1,16	0,12	0,88
Skin weight (%)	1,58	1,52	1,54	0,11	0,76
Net yield (%)	57,1	56,8	58,4	1,03	0,58

N = Number of rabbits at the end of experiment.

Economic profitability

The economic profitability of this study took into account the cost of food, veterinary fees, and the selling price of animals. The following table 10 presents the economic evaluation of our study.

The economic results presented in Table 10 indicate that the production costs were not similar in the three groups. The fundamental differences are in the food costs evaluated at 834 F CFA and 667 F CFA then 652 F CFA respectively for the rabbits of groups 1, 2 and 3. All the tested diets are economically profitable. Fattening rabbits with 100% okara generated the highest net income. Today, to reduce the cost of feeding rabbits, the use of okara can be considered regarding its purchase price.

Table 9. Mortality rates according to the diet.

	Diet 1	Diet 2	Diet 3
Mortality (%)	14.58	12.5	4.16

Discussion

Food value of okara

The use of okara in animal nutrition begins with the determination of its chemical composition and nutritional value, which depend on several factors such as the variety of soybeans factors related to its production and particularly the extraction technique of soy milk.

Previous bromatological analyzes of okara performed by different authors had indicated varying chemical compositions for this food residue. The results obtained in our present study agree with those of Mohammad *et al* (2008) for the dry matter (93.8% vs 93.77%), of Farhat *et al.* (1998) for crude protein and fat 34.5% vs. 34%, 11.3% vs. 12.7%. As for the raw energy the estimated content is identical to that found by Mohammad and Ahmed (2008) which was 4488Kcal / kg DM.

Table 10. Cost advantage of okara use (in F CFA per rabbit).

Parameters	Diet 1	Diet 2	Diet 3
Purchase price of rabbits (F CFA)	2 000	2 000	2 000
Cost of Diet (F CFA/kg)	230	210	186
Cost of feed (F CFA)	835	667	652
Cost of health veterinary (F CFA)	119	119	119
Total cost of production (F CFA)	953	786	771
Cost price (F CFA)	2953	2785	2770
Crude Income (F CFA)	3500	3500	3500
Net Income (F CFA)	546	714	729

1 FCFA = 0.00178 $.

Growth performance

No significant difference was observed in young rabbits from the three batches. The best performances of this test were induced by the diet R3. The final live weight of the rabbits of the three groups is not significantly different.

Fig. 1. Soybeans on the grind.

This average final weight was 1337.5 g for group 1; 1317 g for group 2 and 1448 g for group 3. These results are lower than those reported by Youssao *et al* (2010) who obtained a final weight of 1590 g with feed without okara and served under granulated form. In this trial, the results from weeks 1 to 4 show almost linear growth regardless of the type of food. However, there is a sharp fall in the ADG of the group 2 rabbits from the 4th to the 8th week, which can be related to the presentation form of the food.

Fig. 2. Pasty mixture from the milling.

Indeed, the flour food presented to the rabbits promotes the sorting of different food particles by the subjects. Amida (2005) reveals that the food remaining in the feeder is higher in fiber of the order of 19.9%. This sharp reduction in the amount of fiber ingested by rabbits leads to decreases in growth rate often associated with eating disorders or digestion and mortality by diarrhea. of the Similar observations were reported by Gidenne (2001) and Lebas (1991) who reported the role of fiber in the digestive safety of the growing rabbit. Low protein levels in foods can also lead to poor performance.

The results of the last 4 weeks allow us to claim that the food containing 10% okara is the most consumed and offers a better growth of the rabbits in fattening. Since the R1 and R3 foods induce the same growth rates during the trial period, it would be much more advisable to propose these two foods to the breeders.

Fig. 3. Filtering device.

The results of this study show a significant difference between the consumption indices only during the first week of study. Average feed efficiency of 5.54; 8.05 and 4.53 respectively in the young rabbits of groups 1, 2 and 3 are not significantly different (P> 0.05). However, the results of the last few weeks show higher consumption indices. This can be explained by the fact that rabbits have consumed enough without increasing weight. This same observation had already been made by Kpodékon *et al* (2009a) and (2009b). According to Lebas *et al* (1996) and Lebas (2000), the consumption index normally increases with age primarily because the fraction of the diet used for the simple maintenance of the body increases proportionally to the live weight while that required for the deposits corresponding to the weight gain remains fairly stable. As for the mortality rate, it was

respectively 14.58%, 12.5% and 4.16% for groups 1, 2 and 3. During this trial, and on the three groups, we recorded a loss of 17 rabbits on the 144 starting rabbits.

Fig. 4. Pasty Okara.

This represents a mortality rate of 11.8%. According to Perez *et al* (1996) a fairly high rate of cellulose (14 to 16%) is needed to reduce mortality. This rate was found in the three diets formulated, but this did not spare the cases of recorded mortalities.

Also, the recurring problem of the staining of cages by wasted forage stalks mixed with the excrement of rabbits has been avoided by the maintenance of a correct hygiene.

This study shows that the substitution of soybean meal with okara can be up to 10% to achieve the best feed ingestion performance, low waste, better average daily gain, better carcass yield and a better feed efficiency.

Fig. 5. Dry Okara.

Overall analysis of carcass yield data

No significant differences were observed between the three groups from the stopper yield point of view based on the results. Overall, group 3 rabbits rank first in terms of commercial carcass weight 849 g and carcass yield 58.4%. It appears from these results, especially for groups 1 and 2, that the lightest rabbits at slaughter are those with the highest carcass yield. This may be related to the proportion of the skin and head of these rabbits that would be lower. Other authors report that purebred rabbits have the lowest growth and carcass quality performance except for carcass yield (Prayaga and Eady, 2003; Lukefahr *et al.*, 1983; Ouyed and Brun, 2008). The results obtained in this study corroborate some of those reported by these authors with respect to carcass yield.

Conclusion

This residue from the manufacture of tofu substituted or incorporated at different rates in rabbit fattening feeds had no adverse effects on consumption, health and improved growth and carcass yield. Okara is an alternative source of cheaper protein for substituting commonly used protein raw materials. Its use can make it possible to achieve sustainable and economically profitable production objectives.

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