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Effect of fortified palm oil on growth performance, health and financial losses related to mortality of Rabbits

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Abstract

The perceptible growth delays and financial losses in the Beninese cuniculture farms are often the result of inadequate feeding and high mortality rates. The aim of this study was to contribute to improve the zootechnical performances and the profitability of the cuniculture farms. Thus, a trial was carried out on four lots of 28 rabbits (male and female) aged from 35 to 40 days with homogeneous average weights (456.155±0.355 g).Each lot was fed with a specific amount (0%, 1%, 3% and 5%) of food supplied with palm oil. After 63 days of experimentation, no difference (p>0.05) was observed between ingestions, daily average gain and consumption indices of the different lots. However, during the last five weeks of the experiment, there was recorded higher (p<0.05) intake among animal fed with 3% of palm oil (93.06 g) in comparison to those fed with a supply of 0% (85.74 g), 1% (88.49 g) and 5% (91.31 g). Considering, the initial tested animal number, the average mortality rate recorded is equivalent to 12.5%. The health risk indexes of the four foods were as follows: 46.43% (+0% of palm oil), 28.59%(+1% of palm oil), 10.74%(+3% of palm oil) and 17.41% (+5% of palm oil). To end, the minimum financial losses related to mortality in lot feed without palm oil supply (0%) were equivalent to 46.72% of total (~16696FCFA) where30.77% (+1% of palm oil), 8.45% (+3% of palm oil) and 14.06% (+5% of palm oil) were recorded for the other lots. The palm red oil (at 3%) contributes to the improvement of animal health and reduces financial losses related to mortality.

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Introduction

Cuniculture, a formerly marginalized activity in Benin, is increasingly positioning itself as one of the most important breeding activities (Djossa, 1995). However, the sustainability of cuniculture farms is negatively influenced by the high cost of food and the high mortality rates recorded in those animals' husbandries. This double problem could be solved by developing local food resources including fodder, in feeding rabbits (Dahouda *et al.*, 2013). Nevertheless, incorporation of the high-fiber and low-energy fodder into rabbit's complete food requires it energy density rebalancing. The coverage of this energy deficit could be achieved by increasing the incorporation rates of starchy foods. In consideration of the health risks associated with an excessively high concentration of starch in rabbit feeding (Gidenne *et al.*, 2000; Pérez *et al.*, 2000), the coverage of energy deficit by lipids (oil) appears to be a judicious solution. Indeed, a part of it capability to increase the energy density of foods, oil could also contribute to strengthening animal health (Corent *et al.*, 2007).

In Benin, there is a wild range use in human feeding. Thus, among oils that can be used to supply rabbits feeding, palm oil has many advantages. Indeed, this oil, produced throughout the southern region of the country, is available for most of the year at a relatively affordable cost. In addition, unlike other oils (soybean or peanut oil), the red palm oil has high fatty acid content, many nutritional benefits linked to its concentration in vitamin (A, K and E), antioxidants (tocopherols and tocotriols) and other phytonutrients (carotenoids) that can help to improve the protection of rabbit intestinal mucosa against parasites and strengthen their immune systems (Engelberts *et al.*, 1993; Goh *et al.*, 1994, Kusum *et al.*, 2011; Drogule, 2004). So, because of its dietary qualities, the use of red palm oil in the rabbit's diet could help to improve the profitability of farms and thus to consolidate their sustainability. Thus, the aim of our study was to evaluate the effect of palm oil introduction in the rabbit's diet focusing to its dietary value and effects on the health of rabbits.

Material and methods

Experimental design

This trial was carried out for 63 days (3 July to 6 September 2012) on the experimental farm of the Technical Center for Poultry and Small Animal Breeding at Abomey-Calavi (Benin). A total of 112 young rabbits (male and female) were divided into four (4) lots of 28 with homogeneous weights (455.80-456.51 g). The rabbits were housed by groups of 4 rabbits into gridded cages of 0.35 m^2 each equipped with a water trough and an artisanal cement feeder. In each cage were grouped the animals having the closest possible weights. To avoid the effect of uncontrolled factors that could have influenced the quality of the results, a randomization of the cages allocated to each of the lots was done inside the nursery.

Two periods were observed: a period of food adaptation (7 days) and a period of data collection (56 days). Between those two periods, a 24 h food fast was observed. During the food transition, experimental foods were incorporated into the diet progressively: 25% (2 days), 50% (2 days), 75% (2 days) and 100% (1 days).

Feeding

The information provided by Sauvant *et al.* (2004), on the feed value of raw materials, were used to produce four food formulation with difference amount of palm oil (food+0% of palm oil, +1% of palm oil, +3% of palm oil and +5% of palm oil). Then, each lot was fed with one food formulation. The protein levels of the four foods were similar and ranged from 17.04% to 17.41% but the food differed by energy levels (Table 1).

During the experiment, the animals were fed and watered at will. The distribution of food and drinking water was carried out twice a day: in the morning (between 07:00AM and 08:00AM) and in the afternoon (between 04:00PM and 5:00PM). Every afternoon, all the animals lots received supplemental fodder consisting of local *Panicum maximum*, leaf of *Tridax procumbens* or *Elaeis guineensis*.

Prophylactic measures

At the beginning of the adaptation phase, the animals were dewormed with Alfamizol® (levamisol, Alfasan Holand, 1 g/1.5 L of water per day) and anticox® (sulfamidine, Laprovet, France, 4g/20 L of water for 3 days). As an anti-stress treatment, a vitamin treatment based on Amin'total® (Laprvet, France, 5 g/20 L of water for 3 days) was used.

Data collection

The weighing operations were carried out using a scale (Kern 440-47N, Max. 2000 g, accuracy: 0.1 g). The quantities of food (served and refused) were weighed daily by cage whereas the weights of the animals were taken weekly (each 7 days). The apparent symptoms of illnesses and deaths are automatically recorded as soon as observed. Also, the weights of the dead animals were taken before burying. Consumption (C), Daily Average Gain (DAG) and Consumption Index (CI) were calculated for each estimate period (Day 1 - 28, Day 29 - 63 and Day 1 - 63) per cage. The mortality rates (MR), morbidity rate (MbR), health risk index (HRI), food cost per kg (FC), and minimum mortality losses (MML) were assessed over the period from 1stto 63th days. The CI calculated here corresponds to the true consumption index which does not take mortality into account (Gidenne *et al.*, 2013). For this purpose, it was considered that a dead animal did not consume the food during the two days preceding death (Gidenne, 1995). Therefore, the daily consumption was evaluated in rabbit-day. The food cost per kg was calculated by making the product between the total weight of the animals and the price of kg live weight of the rabbit at the time of the experiment.

Statistical analysis

Statistical analysis was performed using the SPSS software (version 12.0, SPSS Inc., Chicago, IL, USA) using a mono-factorial variance analysis model to evaluate feeding effect. The identification of the difference levels between mean was made following the Duncan means comparison test at the probability of 5%.

Results

Weight performance

At the end of the food transition phase, the average weight of the animals in the lots was homogeneous ($p > 0.05$) and ranged between 665 and 665.71 g (Table 2). There was no significant variation ($p > 0.05$) of weight during the experiment and at its end (1639.35± 55.65 g). Like the weights, growth rates recorded in the four lots were similar for the three considered assessment periods ($p > 0.05$). The growth rates recorded over the assessment periods were between 16.89 g/day and 17.86 g/day.

Ingestion, consumption index and growth food cost per kg

The table 3 shows that no difference was observed between the food consumptions of the different lots during the experiment ($p > 0.05$). However, during the last four weeks, feed ingestion of animals from lot fed with 3% of palm oil (93.06 g/day) was higher than that of lot of young rabbits fed with 1% of palm oil (85.74 g / d) ($p < 0.05$). Meanwhile, during this period, there was novariation ($p > 0.05$) observed between the lot fed without palm oil (88.49 g/day) and the one feed with 5% of palm oil (91.31 g/day).Independently to the estimation period, the lot consumption index were similar ($p > 0.05$) and ranged between 4.58 and 5.00 during the trial. There was no significant variation between the weight food costs per kg (between 832.5 FCFA/kg PV and 964.82 FCFA/ kg PV) of considered lots ($p > 0.05$).

Mortality rate and Minimum financial losses due to mortality

For all batches, the Health Risk Index, the morbidity and mortality rates were 25.89%, 13.39% and 12.5%, respectively (Table 4). The values of these parameters were highest in the lot fed without palm oil in comparison with those fed with palm oil. Indeed, for this lot, the values are as follows 21.43% (Health Risk Index), 25.00% (the morbidity) and 46.43% (mortality rates) (Table 4). Diarrhea was the main symptom in sick and/or dead animals (86.21% of cases). The other cases of morbidity and mortality were related to injuries due to fights observed during the last two weeks prior to the end of the experiment. In addition, 65.52% of morbidity and mortality cases were recorded between the 1stand 28thdays of experimentation.

Table 1. Centesimal composition and theoretical chemical composition of the tested food.

	HR0	HR1	HR3	HR5
Centesimal Composition				
Maize	1	4	2	0
Bran of wheat	19	19	19	19
Bran of rice	16	16	16	16
Bran of maize	10.5	10.5	10.5	10,5
Palm crab	32	32	32	32
Soya crab	7	7	7	7
Cotton crab	8	8	8	8
Coquille	1	1	1	1
Oil	0	1	3	5
Salt	0.25	0.25	0.25	0.25
Premix	0.25	0.25	0.25	0.25
Chemical Composition				
Dry matter (%)	89.39	89.36	89.30	89.24
Organic matter (%)	81.61	81.59	81.56	81.52
Total nitrogen (%)	17.42	17.35	17.21	17.07
NDF (%)	41.75	41.659	41.469	41.279
ADF (%)	20.92	20.895	20.845	20.795
Crude ash (%)	14.94	14.92	14.88	14.84
Fat (%)	6.68	7.64	9.57	11.5
Total ash (%)	7.78	7.77	7.74	7.72
DE(kcal/kg Dry matter)	2463.2	2516.9	2624.3	2731.7
DP (%)	12.20	12.15	12.04	11.94
DP/DE (g/1000kcal)	49.55	48.28	45.90	43.71

HR0: Food formulation containing 0% of red palm oil, HR1: Food formulation containing 1% of red palm oil, HR3: Food formulation containing 3% of red palm oil, HR5: Food formulation containing 5% of red palm oil, NDF: Neutral detergent fiber, ADF: Acid Detergent Fiber, CB: Crude Ash, DE: Digestible Energy, DP: Digestible Proteins.

The evaluation of the minimum financial losses related to mortality reveals that 46.72% of the total financial losses (16696 FCFA) are recorded in lot fed without palm oil supply against 30.77% (+ 1% of palm oil) , 8.45% (+ 3% of palm oil) and 14.06% (+ 5% of palm oil) (Table 4).

Discussion

Food consumption and zoo-technical performance

The homogeneity of food consumption among the four lots indicates that the oil did not influence food intake.

Thus, it was reported that there should be a decrease of food consumption when the rate of oil into food incorporation increase (Gidenne and Lebas, 2005; Gidenne *et al*., 2009; Knudsen *et al*., 2013). However, our results shows that the incorporation of oil specially palm red oil into the rabbit food cannot cause appetency problem and thus support the observations previously made by several authors (Cobos *et al*., 1994; Pla and Cervra, 1994).

It was also report by Gidenne *et al*. (2013) that in most cases where lipids replace starch in the food, and without changing the level of fiber, the rabbit does not reduce its consumption but increases it.

Table 2. Average daily gain and evolution of the weight throughout the experimental period.

Variables		HR0	HR1	HR3	HR5	Signification
Weight (g± SD)	w 1	665.71±20.23	650.36±25.68	664.64±23	665.00±30.60	ns
	w 2	760.96±23.19	755±28.32	752.86±24.13	762.41±30.69	ns
	w 3	906.82±24.64	857.14±31	888.08±23.91	859.26±32.84	ns
	w 4	1030.23±28.13	968.04±35.25	1021.80±26.58	988.70±35.71	ns
	w 5	1023.18±40.69	1082.86±44.20	1151±29.49	1102.41±40.77	ns
	w 6	1208.18±48.15	1183.04±47.45	1287.20±32.40	1233.15±47.18	ns
	w 7	1318.10±57.98	1313.75±55.97	1422±34.45	1372.22±52.55	ns
	w 8	1433.81±60.19.	1405.56±59.42	1491.67±34.72	1475.38±53.91	ns
	w 9	1613.64±36.163	1645.07±42.937	1695.00±47.229	1583.70±187.42	ns
ADG (g/j± SD)	ADG_{1-28}	17.74±1.06	16.36±1.23	17.25±0.70	15.66±0.81	ns
	ADG_{29-63}	15.62±1.21	16.18±1.12	16.87±0.71	17.52±0.83	ns
	ADG_{1-63}	17.05±0.92	16.89±1.30	17.30±0.57	17.86±0.71	ns

HR0: Food formulation containing 0% of red palm oil, HR1: Food formulation containing 1% of red palm oil, HR3: Food formulation containing 3% of red palm oil, HR5: Food formulation containing 5% of red palm oil, ADG: Average Daily Gain, w: weight; SD: Standard deviation.

It can therefore be hypothesized that in the presence of oil, the regulation of food intake in rabbits is less effective according to the energy level of food.

Although our oil-based foods formulation were in the form of flour, their intake levels are quite similar to the granulated foods (74.1 - 79.9 g/day) reported by Akoutey and Kpodékon (2012).

This could be explained by the fact that the oil would have contributed to reducing dust emissions by food, thus promoting their consumption by animals. This observation suggests the inclusion of oil in the rabbit feed to farmers who prefer the use of farinaceous foods on their farms because of the high cost and doubtful quality of commercially granulated foods (Dahouda *et al.*, 2013).

Table 3. Ingestion, consumption index and growth food cost per kg of the tested formulations.

Variables		HR0	HR1	HR3	HR5	*p*
Ingestions (g±SD)	Ing_{1-28}	60.10±2.17	61.10±2.69	63.50±2.05	64.63±2.22	ns
	Ing_{28-63}	88.49^{ab}±2.16	85.74^{a}±2.30	93.06^{b}±1.97	91.31^{ab}±1.57	*
	Ing_{1-63}	74.10±2.28	73.81±2.73	78.01±1.25	78.30±1.88	ns
Consummation Index	CI_{1-28}	3.66±0.27	4.26±0.43	3.83±0.21	4.34±0.26	ns
	CI_{28-63}	6.52±0.87	6.21±0.88	5.72±0.25	5.49±0.29	ns
	CI_{1-63}	4.58±0.33	5.00±0.74	4.61±0.17	4.76±0.22	ns
Growth food cost per kg: FC (FCFA/kg PV± SD)		893.69±84.96	852.26±62.81	832.50±35.36	964.82±64.18	ns

HR0: Food formulation containing 0% of red palm oil, HR1: Food formulation containing 1% of red palm oil, HR3: Food formulation containing 3% of red palm oil, HR5: Food formulation containing 5% of red palm oil, Ing.: Ingestion, CI: Consumption index, FC: Food cost; SD: Standard deviation; a, b: the averages of the same column assigned by the same letter are similar, ns: p 0.05, *: p 0.05.

The data recorded related weight and average daily gain suggest that the food are very similar because there was no significant difference of food consumptions between the four lots. In fact, as the food consumptions of the four lots are similar, the nutrients ingestions might also be identical (the energy values is their main difference).

However, a slight difference was recorded between the Average daily gain of animals in lots fed with palm oil (+ 1%, 3% and 5% of red palm oil) compared with those without palm oil (0% palm oil) could be attributed to palm oil. Thus, the beneficial effect of a more energy-intensive diet on food efficiency seems more interesting in the finishing phase (Corent *et al.*, 2007).

The positive effect of palm oil on animal growth could therefore have been better perceived if the data had been collected over a longer period. However, the low weight growth recorded in lot fed with 1% of palm oil supply compared to those of highest rate of palm oil (3 and 5%)could be the consequence of an unfavorable health condition of the animals of that lot (1% palm oil).

The average daily gain recorded in all lots were lower than those (23.4 g / day) obtained after eight weeks by Kpodékon *et al.* (2009) with farinaceous foods. The difference observed between the two studies may not only be due to the differences in the chemical compositions of foods but also to the differences between raw materials used in food production and/or the disparities between farming conditions (temperature, humidity, climatic conditions etc.). Meanwhile, our result seems very comparable to those reported in the same experimentation field on animals feed with food containing 10% (17.4 g/day) and 30% (17.0 g /day) *Moringa oleifera* leaves (Dahouda *et al.*, 2013). In spite of the fact that the *Moringa oleifera* base foods were more concentrated in energy and protein than the one we use in our study, we observe better valued by animals. Thus, compared to linseed oil (Verdelhan *et al.*, 2005), red palm oil seems having a better feeding interest in rabbits.

Table 4. Morbidity rate (Mb R), mortality rate (MR), Health Risk Index (HRI), Weight loss related to mortality and minimal financial loss related to mortality (MFL) recorded during the study.

Variables		HR0	HR1	HR3	HR5	Total
Morbidity	n	6	4	2	3	15
	MbR (%)	21.43	14.29	7.14	10.71	13.39
Mortality	n	7	4	1	2	14
	MR (%)	25.00	14.28	3.57	7.14	12.5
Heath Risk Index	n	13	8	3	5	29
	HRI (%)	46.43	28.59	10.74	17.81	25.89
Weight loss related to mortality	weight (kg)	5.2	3.43	0.94	1.57	11.14
	%	46.68	30.79	8.44	14.09	-
Minimalfinancial loss related to Mortality	MFL (FCFA)	7800	5138	1410	2348	16696
	%	46.72	30.77	8.45	14.06	-

HR0: Food formulation containing 0% of red palm oil, HR1: Food formulation containing 1% of red palm oil, HR3: Food formulation containing 3% of red palm oil, HR5: Food formulation containing 5% of red palm oil, NB. In lots, MbR, MR and HRI are calculated based on the number of animals per batch (28). The global mortality rate was evaluated on the basis of the total number of animals tested.

Our data shows a best consumption index values between the 1stand the 28thday indicating better feeding efficiency in young rabbits (Fortun-Lamothe and Gidenne, 2003). As a food consumption index is linked to its intake levels and to the weight performance of the animals, the similarity between the food intake and the average daily gain of the four animals treatments can explains the consumption values recorded. However, these results do not corroborate those reporting that an addition of oil to the rabbit diet was accompanied by an improvement in the consumption index (Gidenne *et al.*, 2009). Thus, the high consumption index values recorded in lots fed without palm oil and with 1% of palm oil could be attributed to the morbidity and mortality observed in these two lots. The consumption index recorded among the lots fed with foods supply of palm oil (3 and 5%) are close to those obtained by Dahouda *et al.* (2013). But, our consumption index are less interesting than those obtained by previous authors with foods containing *Moringa* (3.49-4.02) and *Pueraria phaseoloides* (2.8 to 3.8) leaves (Akoutey and Kpodékon, 2012; Dahouda *et al.*, 2013).

Animals' health status

The mortality rates recorded during the study were higher (+2.5%) than the mortality rate (< 10%) economically acceptable for fattening, on cunicole farms reported by Djago *et al.* (2007). However, this rate is within the limits (10-14%) recommended elsewhere (Cuniculture Magasine, 2005).

The mortality rate (25%) obtained with the oil-free food, is very higher than the acceptable averages contrary to the oil supply foods. The proportions of sick animals and the health risk indexes recorded per lot corroborate the results obtained concerning the mortality rates. This suggests that the palm oil has positively influenced the health of animals. The global mortality rate (12.5%) obtained during the experiment was lower than the 45.8% (Kpodékon *et al.*, 2009) and 26.39% (Dahouda *et al.*, 2013) previously recorded in Benin. However, the mortality rates recorded in all lots of animals' fed with palm oil-enriched foods are lower than 10.4% recorded with linseed oil (Verdelhan *et al.*, 2005).

The health benefit of the oil on the health of livestock has been reported by several scientists (Omole and Onwudike, 1983; Kelly *et al.*, 1988; Lessire *et al.*, 2003, Verdelhan *et al.*, 2005). Indeed, diets rich in polyunsaturated fatty acids are known to reduce the atherosclerosis developing risk (Aguilera, 2001). These fatty acids also are analgesic and involve in enhancing the immune defenses of animals (Crevel and Saul 1992; Klasing and Leshchinsky, 2000). Thus, they are essential for cell membranes constitution and phospholipids renewal and also help to protect the skin and hair (Djakalia *et al.*, 2011). The richness of palm oil in monounsaturated fatty acids allows it to exert a preventive action against cardiovascular diseases by decreasing the cholesterol level (Hachicha *et al.*, 2007). The supply of palm red oil may then induced the enrichment of the food in these essential fatty acids because this oil contains important amount of monounsaturated acid (40%) and linoleic acid (10%).

The improved health status of animals consuming oil-based foods may also have been promoted by the concentration of these foods in β-carotene.

Indeed, palm oil is characterized by its richness in carotenoids (precursors of vitamin A) and more particularly in β-carotene (Wong *et al.*, 1988). Vitamin A, has a stimulating effect on the immune system, reduces the risk of heart disease and intervenes in the protection of vision (Kusum *et al.*, 2011). In addition, carotenoids contained in the red oil can better protected the intestinal mucosa of animals (Drogul *et al.*, 2004) and then reducing the risk of gastrointestinal pathologies in lots of animals fed with palm red oil-based foods.

The amount of antioxidants in palm red oil, especially tocopherols, physiologically more active than vitamin E (Cottrell, 1991), may have contributed to the resistance of animals to pathologies. Indeed, antioxidants and particularly tocopherols and tocotrienols are reported to protect against oxidative damage (Serbinoya *et al.*, 1992), to reduce aggregation (Qureshi *et al.*, 1991) and protect against atherogenesis and cancer (Hasselwander *et al.*, 2002). Those antioxidant prevent the accumulation of cholesterol in the liver (Choi *et al.*, 1993).

Food costs and financial losses related to mortality

Although there were no significant differences between the food costs in the four lots, the expenditure for one kg of PV in the animals of lots supplied with 1% and 3% of palm oil is slightly lower than those recorded in the without and + 5% of palm oil. The higher food costs obtained in lot with 5% of palm oil suggest that the economic profitability rate of palm oil incorporation is 3%. The results of the financial losses related to mortality also confirm this hypothesis since the lowest financial losses were recorded in lot containing 3% of palm oil.

The food cost recorded in the lots of animals fed with oil-fortified foods are lower than those previously evaluated with a commercial food (953.50 FCFA / kg of live weight gain) in Benin by Dahouda *et al.* (2013). However, the obtained values are higher than those obtained (354.00 FCA to 685.10 FCFA) using *Moringa oleifera* (Dahouda *et al.*, 2013), *Pueraria phaseoloides* (Akoutey and Kpodekon, 2013) and fibrous residues resulting from the extraction of palm oil (Houndonnougbo *et al.*, 2014).

The differences between these results and ours could be explained by the differences in food costs and thus the price of the raw materials used.

Conclusion

The feeding of rabbits must no longer be directed solely to satisfying the nutritional needs of animals. It should contribute to improving the sustainability of cuniculture farms.

The results of this study are consistent with this objective, since it has been shown that palm red oil contributes to the improvement of animal health and reduces financial losses related to mortality. At the end of the study, the rate of incorporation of palm oil into the feed of rabbits which allow the best compromise between the zootechnical performances and the financial profitability of the cunicole farms is 3%.

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