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Research article

Digestibility of feeds in rabbit (*0ryctolagus cuniculus* linnaeus, 1758) in Africa: A review

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Abstract

Feed digestibility indicates how much the body uses feed and its nutrients. This study aims to make a literature review on the digestibility of balanced feed given to farmed rabbits in Africa. Data used for this literature review were collected through many scientific papers published from 2008 to 2018 and uploaded to Google Scholar, Pubmed, Agora search engines and in national university libraries. Numerous scientific studies in this field indicate that more than thirty feedstuffs are commonly used to formulate balanced feed delivered to rabbits in Africa. Feed digestibility is generally assessed *in vivo* by the direct method in farmed rabbits. The data compiled shows that the digestibility of feed by rabbits varies enormously depending on the feedstuffs in balanced feed and also on their incorporation rate. The data recorded by the various authors' show that balanced feeds with an Apparent Digestibility greater than 50%.

Keywords: Balanced feed, In vivo digestibility, Farmed rabbit, Africa

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Introduction

To meet the animal protein requirements of West African populations, emphasis has been placed on the development of production and the health of short-cycle animals (Gbangboché et al., 2005), including rabbit breeding (*Oryctolagus cuniculus* linnaeus, 1758). Indeed, rabbits breeding is a breeding that generates a lot of income in a short time (Lebas, 2007). Its meat has exceptional qualities that distinguish it from others meats. Its flesh is tasty and resembles that of chicken. It is digestible, rich in water, proteins, essential amino acids, iron and vitamins. It is low in fat and sodium and has a good index of initiation (Lebas, 2007). In traditional and rational breeding, balanced feed including crop and by-products, minerals and vitamins are used to feed farmed rabbit. Thus, balanced feed delivered to rabbits may vary depending on the available feedstuffs. However, the balanced feed delivered can be digested differently by rabbits. "Feed digestibility" indicates how much the body uses feed or nutrients (Deiltel et al., 2012). The present article summarizes results of different feeding studies on the digestibility of balanced feed with both conventional and unconventional feedstuffs in farmed rabbits.

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Materials and Methods

Data used for this literature review were collected and processed mainly through:
- A literature search that collected information and data on feed digestibility in farmed rabbits in Africa, mainly from twenty-nine (29) scientific papers published from 2008 to 2018 and uploaded to Google Scholar, Pubmed, Agora search engines and in national university libraries.
- A bibliographic analysis which consisted of the manual counting, the synthesis of the information and data collected and the compilation of feed digestibility's recorded in the farmed rabbit by the different authors.

Results and Discussion

Concentrated feedstuffs in rabbits balanced feed in Africa

The rich tropical biodiversity, the great diversity of agricultural production systems in African countries in general and the presence of small agro-processing units contribute to a wide range of feedstuffs that can be used by animals (Archimède et al., 2011). The diet of chicken and rabbit generally involves two main types of concentrated feedstuffs (CFS): cereals and by-products. These CFS include crop products; agro-industrial food and animal products and by-products. Their use depends mainly on their availability in the region, the season, the price and their ability to be kept for a long time (Toléba et al., 2007). Thirty-three (33) different CFS used in rabbits feeding in Africa and listed in this literature review are: Barley, Berseem hay, Brewers dried grain, Burukutu spent grain, Cassava root meal, Cocoa shell, Copra meal cake, Corn bran, Corn, Cotton meal, Cotton waste cake, Cottonseed cake, Full-fat-soyabean, Fish meal, Groundnut cake, Ground haulms, Groundnut haulms, Groundnut husk, Maize bran, Maize grains, Maize offal, Maize, Millet mash residue, Molasses, Palm kernel cake, Rice bran, Rice husk, Rice straw, Roasted full fat soyabean, Soya bean, Soyabean meal, Wheat bran, Wheat flour, Wheat offal, Whole soyabean, Yellow maize.

Moreover, in the extensive production, the diet of rabbit is also based on the use of some vitamins, minerals amino acids and pigments (N'gom, 2004, Guindjoumbi, 2007, Kpodékon et al., 2009). In this category, twenty-one (21) feedstuffs are commonly used in Africa. These feedstuffs are: Bi/Di Calcium Phosphate, Calcium Carbonate Dibasic Calcium, Limestone, DL-Methionine, Lysine, Premix, Vitamin premix, Concentrate flesh, Iron sulfate, Palm oil, Sawdust, Sugar, Blood meal, Bone ash, Bone meal, Common salt, Iodized salt, Oyster shell, Oxyboldin, PCP, PKC.

Indeed, according to Lebas et al., (2007), the advantage of pellet is that it is manufactured according to the specific needs of the animal and it cannot sort, consumes exactly diet planned for him. Also, the rabbit prefers a pellet to a meal feed.

Feed digestibility in rabbits and balanced experiment

The feed ingested by rabbit is not entirely used by his bod y. A part of "ingestats" passes through the digestive tract and is found in the faeces. The digestible fraction of a feed is the part of "ingestats" that is not found in the faeces. It is a quantitative concept that results in the Digestive Utilization Coefficient (D.U.C) or Digestibility Coefficient (D.C). In other words, it is the proportion of the various constituents of a feed that is retained by bod y. Digestibility is therefore an index of the disappearance of the feed in the intestine, but not of the efficiency of use of the feed by the metabolism of the animal. Thus, a feed can be very digestible without providing enough nutrients to meet the requirement of the animal.

According to Rivière, 1991, feed digestibility can be determined from three (03) groups of methods: (i) In vivo methods; (ii) in vitro methods (laboratory method); iii) Mathematical or prediction methods. In rabbits, direct method *in vivo* is preferably used for assessing digestibility.

It is based on faecal digestibility measurements, the method of which was standardized in 1995 b y the EGRAN group (Guermah, 2012). Representative sampling is used because slight differences can be recorded in digestive function in rabbit of the same breed, age and sex. Repetitions allow the detection of errors (Rivière, 1991).

Feed samples as well as faeces samples are dried and used in laboratory to determine their chemical composition according to the methods recommended by AOAC (1991); AOAC (1997). The chemical composition includes nutrients such as Dry Matter (DM), Organic Matter (OM), Crude Protein (CP), Fatty Matter (EE), and Crude Fiber (CF).

Most studies on rabbits in Africa focus on feed apparent digestibility with direct method *in vivo*, limiting themselves to the balance between the nutrients of ingestats and excretas.

A typical in vivo digestibility experiment is conducted over a period of seven (07) to ten (10) days by feeding daily experimental rabbit. To the experimental period are added stages of droppings drying, grinding and analysis (Bourdillon et al., 1990). Experiment on the assessment of feed digestibility in farmed rabbits is carried out in digestibility cages equipped with a faeces collection device, on rabbits that age and sex are known. This device makes it possible not to mix the faeces with the urine of rabbits. Rabbits are individually arranged per digestibility cage and data is collected daily by rabbit. Thus, the quantities of feed delivered and refused as well as those of faeces are weighed and recorded daily.

After evaluation of the chemical composition of samples of feed served, refused and faeces, Apparent Digestibility of the experimental diet in its nutrients is calculated by its following formula:

Apparent digestibility = [(Nutrients Content in feed x FI) – (Nutrients Content in faeces x FO)] x100/ Nutrients Content in feed x FI;
Where **FI**= Feed Intake and **FO**= Faecal Output.

Apparent digestibility of balanced feed in rabbit

In Africa, several authors studied feed digestibility in rabbits fed with balanced diets based on conventional and unconventional concentrated feedstuffs. Table 1 presents the digestibility of balanced feeds in rabbits in Africa. The apparent digestibility varied according to incorporation rate of the feedstuff in study. Indeed, most of these digestibilities have been evaluated following the use of a feedstuff at different levels of incorporation into a basic diet formula. Majority of nutrients in balanced feeds delivered to rabbits in Africa are well digested. Digestibility Coefficient of the dry matter in balanced feed varied greatly from a study to another: the highest are above 50% and range from 53 to 99% while the lowest are between 39 and 48%. The digestibility of crude protein, varies from 55 to 97%. However, a very low protein digestibility around 29% was recorded in some studies. The digestibility coefficient of organic matter in balanced feed is above 40% and reaches 85%. The fat digestibility varies from 57% to 93%. Crude fiber that are essential for the proper functioning of the rabbit's digestive system are digested at a rate ranging from 50 to 97%. However, some low digestibilities of crude fiber ranging from 24 to 49% are recorded in some balanced feed.

Table 1: Apparent digestibility of some balanced feeds in rabbit in Africa

Experimental Feedstuffs (Rate in the feed)	Feed composition	DDM (%)	DCP (%)	DOM (%)	DEE (%)	DCF (%)	Authors (Country)
Lablab seed (0; 19,92; 23,01; 20,59; 23,43 kg/100 kg)	Lablab seed (raw, decorticated, toasted), Maize, Full-fat-soyabean, Rice husk, Brewers dried grain, Bone ash, Salt, Premix)	61.68 – 80.82	67.38 – 78.92	ND	44.64 – 81.06	24.02 – 62.08	Shaahu et al., 2014 (Nigéria)
Acacia saligna, Leuceana. leucocephala, Moringa. Oleifera dried foliages (15 kg/100 kg)	*Acacia saligna, Leuceana. leucocephala, Moringa oleifera* dried foliages, Barley, Soybean meal, Wheat bran, Berseem hay, Molasses, Calcium carbonate, Di-calcium phosphate, Salt, Premix, DL-méthionine)	53.0 - 61.8	56.2 - 64.7	56.2 - 64.4	76.3 - 82.3	36.5 - 44.9	Abu Hafsa et al., 2016 (Egypte)
Wild sunflower leaf meal (0; 5; 10; 15 kg/100 kg)	Wild sunflower leaf meal, Maize, Corn bran, Groundnut husk, Palm kernel cake, Fish meal, Bone meal, Premix, Salt	44.30-60.46	29.4-55.0	ND	9.70-10.89	8.33-12.28	Adam, 2013 (Ghana)
Vitamine E, Vitamine C (0; 200; 400 mg/100 kg)	Vitamine E, Vitamine C, Maize, Wheat offal, Soya bean, PKC, Fish meal, Groundnut cake, Bone meal, Iodized salt, Vit-mineral mix	98.17-99.33	43.73-55.03	ND	65.29-95.43	63.10-75.13	Okachi and Ani, 2016 (Nigeria)
Pineapple peels (0; 10; 20; 30 kg/100 kg)	Pineapple peels, Maize, cottonseed cake, soybean meal, sawdust, wheat bran, Salt, Oyster shell, Panicum maximum	62-67.7	ND	ND	ND	ND	Aboh et al., 2013 (Bénin)
Pellets of *Moringa oleifera* (0; 10; 15 kg/100 kg)	Pellets of Moringa oleifera, Maize, Palm kernel cake, Soybean meal, Rice bran, Oyster, shell, Sawdust, Salt	52.3-57.07	66.12-74.97	54.26-61.25	ND	ND	Dougnon et al., 2012 (Bénin)
Sundried *Tridax procumbens* (0; 5; 10; 15; 20 kg/100 kg)	Sundried Tridax procumbens, Cassava root meal, Roasted full fat soyabean, Burukutu spent grain, Rice husk, Bone meal, Palm oil, Salt, Sugar, Premix, Coccidiostat	79.68-82.79	70.76-81.79	ND	71.47-87.11	39.33-43.65	Anthony et al., 2016 (Nigéria)
Sundried Cocoa Pod Husk Meal (0; 12,50; 25; 37,50 kg/100 kg)	Sundried Cocoa Pod Husk Meal, Yellow maize, Soybean, Fish meal, PKC, Wheat offal, Rice husk, Bone meal, Palm oil, Methionine, Lysine, Salt, Premix	95.41-96.43	75.07-78.54	ND	71.51-83.57	74.50-78.44	Ozung et al., 2017 (Nigeria)

Experimental Feedstuffs (Rate in the feed)	**Feed composition**	**DDM (%)**	**DCP (%)**	**DOM (%)**	**DEE (%)**	**DCF (%)**	**Authors (Country)**
Hot Cocoa Pod Husk Meal (0; 12,50; 25; 37,50 kg/100 kg)	Hot Cocoa Pod Husk Meal, Yellow maize, Soybean, Fish meal, PKC, Wheat offal, Rice husk, Bone meal, Palm oil, Methionine, Lysine, Salt, Premix	96.27-96.43	73.31-77.74	ND	74.77-82.03	77.42-85.97	Ozung et al., 2017 (Nigeria)
Fermented Cocoa Pod Husk Meal (0; 12,50; 25; 37,50 kg/100 kg)	Fermented Cocoa Pod Husk Meal, Yellow maize, Soybean, Fish meal, PKC, Wheat offal, Rice husk, Bone meal, Palm oil, Methionine, Lysine, Salt, Premix	96.33-96.58	72.18-78.54	ND	76.26-82.39	61.14-76.79	Ozung et al., 2017 (Nigeria)
Sorghum "Chakalere" Sorghum "Jigare" (0; 17; 34 kg/100 kg)	Sorghum "Chakalere", Sorghum "Jigare", Maize, Wheat offal, Groundnut cake, Fish meal, Groundnut haulms, Limestone, Salt, Premix	66.47-79.48	69.28-84.47	ND	57.97-74.81	30.37-42.88	Igwebuike et al., 2013 (Nigéria)
Breadfruit meal (0; 9; 12; 15; 18; 21 kg/100 kg)	Breadfruit meal, Maize, Soybean meal, Wheat offal, Corn bran, Palm kernel meal, Fish meal, Rice husk, Bone meal, Salt, Vit/Premix	60.10-63.50	67.10-70.80	ND	70.25-74.23	49.32-55.10	Oladunjoye and Ojebiyi, 2011 (Nigéria)
Sundried *Digitaria iburua* (0; 20; 40 kg/100 kg)	Sundried Digitaria iburua, Maize, Soybean meal, Fish meal, Wheat offal, Bone meal, Premix Salt	72.99-76.33	73.22-75.05	ND	ND	64.04-67.35	Oke et al., 2016 (Nigéria)
Raw Kapok seed meal (0; 5; 10; 15; 20 kg/100 kg)	Raw Kapok seed meal, Maize, Soybean meal, Fish meal, Maize offal, Wheat offal, Methionine, Lysine, Salt, Premix	60.45-88.89	60.45-84.84	ND	57.27-74.47	58.14-76.09	Wafar et al., 2017 (Nigéria)
Sundried Sorghum offal (0; 11,94; 24,60;35,62;47,56 kg/100 kg)	Sundried Sorghum offal, Maize, Groundnut cake, Wheat offal, Rice bran, Bone meal, Blood meal, Premix, Lysine, Methionine, Salt	60.14-74.34	58.54-76.83	ND	66.73-76.39	28.14-39.31	Ogunsipe et al., 2014 (Nigéria)
Cassava peel residue (0; 10, 25; 20,5; 30,75, 41 kg/100 kg)	Cassava peel residue, Maize, Soyabean meal, Palm kernel cake, Wheat offal, Bone meal, Limestone, Premix, Salt	56.2-65.9	54.2-65.7	ND	79.9-93.6	78.6-90.3	Osakwe et al., 2008 (Nigéria)
Cowpea pods (0; 5; 10; 15 kg/100 kg)	Cowpea pods, Maize grains, Wheat bran, Soybean meal, Cotton meal, Palm-Kernel meal, Oyster shell, Lysine, Methionine; PCP, Salt, Premix, Iron Sulphate	78.78-83.57	55.47-60.57	81.47-84.50	ND	ND	Kpomasse et al., 2015 (Bénin)
Cowpea pod shell (0; 10 kg/100 kg) Soybean pod shell (0, 10 kg/100 kg)	Cowpea pod shell, Soybean pod shell, Maize, Wheat bran, Soybean meal, Cotton meal, Plam meal, Oyster shell, Lysine, Methionine, Phosohate bicalcium, Salt, Concentrate flesh, Iron sulfate	39.02-52.70	ND	ND	ND	ND	Koura et al., 2015 (Bénin)
Sundried breadfruit meal (0; 10; 20; 30 kg/100 kg)	Sundried breadfruit meal, Maize, Soybean, Wheat offal, Fish meal, Palm Kernel cake, Bone meal, Oyster shell, Premix, Salt	71.20-83.98	70.24-79.79	ND	68.10-74.44	57.50-66.41	Oladele-Oso et al., 2010 (Nigéria)
Raw baobab seed meal (0; 10; 20; 30 kg/100 kg)	Raw baobab seed meal, Maize, Soybean, Ground haulms, Wheat offal, Fishmeal, Bone meal, Premix, Salt, Methionine	55.40-67.20	55.39-64.37	ND	69.03-70.54	55.94-67.77	Abdullahi et al., 2017 (Nigéria)
Dried *Acacia albida* pods (10; 20; 30; 40 kg/100 kg)	Dried Acacia albida pods, Maize, Maize bran, Groundnut haulms, Groudnut cake, Palm oil, Bone meal, Salt, Premix	68.16-79.49	71.06-80.38	ND	82.09-84.34	28.40-50.29	Igwebuike et al., 2008 (Nigéria)

Experimental Feedstuffs (Rate in the feed)	Feed composition	DDM (%)	DCP (%)	DOM (%)	DEE (%)	DCF (%)	Authors (Country)
Millet residue meal (83; 74; 76 kg/100 kg)	Millet residue meal, Fish meal, Soybean meal, DCP, Vitamin/mineral premix, Common salt	70.8-82.7	82.5-90.7	ND	ND	ND	Karikari et al., 2011 (Ghana)
Soybean pod (0; 5; 10; 15 kg/100 kg)	Soybean pod, Maize,Wheat bran, Soybean meal, Cotton meal, palm Kernel meal, Oyster shell, Lysine, Methionine, Bi-calcium Phosphate, Salt, Premix, Iron sulphate	77.62-85.99	63.20-72.23	77.74-86.07	ND	ND	Badet et al., 2015 (Bénin)
Cottonseed cake (0; 5; 10; 15 kg/100 kg)	Cottonseed cake, Maize, Groundnut cake, Rice husk, Fishmeal, Bonemeal, Oyster shell, Vitamin/mineral premix, Salt	69.92-75.92	83.52-86.30	ND	67.96-90.24	87.25-91.82	Amao et al., 2012 (Nigéria)
Prosopis africana pulp (0; 10; 20; 30, 40%)	Proposis africana pulp, Maize and conventional ingredient	59.08-66.95	72.26-79.32	ND	61.11-70.27	34.49-38.41	Adamu et al., 2011 (Nigéria)
Moringa leaf meal (0; 5; 10; 15; 20 kg/100 kg)	Moringa leaf meal, Milletmash residue, Soyabean meal, DCP, Vitamin-mineral premix, Salt	65.02-78.40	65.10-87.80	ND	70.00-77.50	50.01-55	Nuhu, 2010 (Ghana)
Moringa powder (0; 1,50; 3,0 kg/100 kg)	Moringa powder, Corn, Wheat bran, Rice bran, Rice straw, Cocoa shell, Soya bean meal flour, Cotton waste cake, Copra meal cake, Shells of oysters, Methionine, Lysine, Dibasic calcium, Vitamin premix, Oxyboldine	ND	80.85-85.00	ND	67.00-68.70	ND	Djakalia et al., 2011 (Côte d'Ivoire)
Moringa leaf meal (0; 5; 10; 15; 20 kg/100 kg)	Moringa leaf meal, Maize, Wheat offal, Soya meal Palm kernel cake, Groundnut cake, DCP, Lysine, Methionine, Premix, Salt	56.10-80.7	65.13-89.2	ND	71.20-77.2	50.18-56.2	Olatunji et al., 2016 (Nigéria)
Moringa leaf meal (0; 1,50; 3,00; 4,50 kg/100 kg)	Moringa leaf meal, Maize, Soybean meal, Groundnut cake, Palm kernel cake, Wheat offal, Bone meal, Oyster shell, Salt, Vitamin-mineral premix, Lysine, Methionine	53.17-55.31	68.25-71.36	ND	80.80-83.31	74.61-78.87	Ayo-Ajasa et al., 2017 (Nigéria)
Leafy vegetables (0; 50 %)	Leafy vegetables, Commercial pelleted	65.49-87.86	86.73-96.22	ND	ND	ND	Yao Konan et al., 2016 (Côte d'Ivoire)
Pachyrhizus. erosus chips (0; 10; 20 kg/100 kg)	*Pachyrhizus erosus* chips, Maize, Rice bran, Wheat flour, Cottonseed cake, Soybean meal, Palm kernel meal, Oyster shell, Salt, Sawdust	48.13-61.58	64.17-69.01	42.12-58.34	ND	ND	Atchadé, 2012 (Bénin)
Maize bran (5,5; 11; 16,5 kg/100 kg)	Maize bran, Maize, Soyabean meal, Cottonseed cake, Palm kernel meal, Shell, Lysine, Methionine, DCP, Nacl, Premix, Iron sulphate	60.18-67.23	93.34-97.14	ND	ND	91.94-97.06	Tchibozo et al., 2017 (Bénin)

DDM= Dry Matter Digestibility; DCP= Digestibility Crude Protein; DOM= Organic Matter Digestibility; DEE=: Ether Extract Digestibility; DCF= Crude Fiber Digestibility; ND= Not Determined.

Conclusion

A total of 33 scientific articles were used to provide information on balanced feed digestibility in farmed rabbits in Africa. The data demonstrate that the compound feeds delivered to farmed rabbits are often digestible. This inventory will be useful to assess the digestibility of each concentrated feedstuff in farmed rabbits to develop a table of their nutritional composition in Benin.

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