
Sjournals
ISSN 2322-2433
Scientific Journal of
Review
S
J
R
Sjournals Publishing Company | www.sjournals.com

Scientific Journal of Review (2017) 6(1) 509-518
ISSN 2322-2433
doi: 10.14196/sjr.v6i1.2393

Contents lists available at Sjournals

Scientific Journal of **Review**

Journal homepage: www.Sjournals.com

Review article

Baobab seeds as an alternative protein source in poultry feed

Prince Chisoro[a], Tinashe Kaguru[a], Never Assan[b,*]

[a]*Department of Livestock and Pasture Science, University of Fort Hare, Private Bag X1314, Alice, Eastern Cape, South Africa.*

[b]*Zimbabwe Open University, Department of Agriculture Management, Faculty of Agriculture, Bulawayo Regional Campus, Box 3550, Bulawayo, Zimbabwe.*

*Corresponding author; neverassan@gmail.com

A R T I C L E I N F O

Article history,
Received 20 December 2016
Accepted 21 January 2017
Available online 27 January 2017
iThenticate screening 22 December 2016
English editing 19 January 2017
Quality control 25 January 2017

Keywords,
Baobab seed
Protein source
Anti-nutritional factors
Poultry feed

A B S T R A C T

Alternative cheap sources of protein in poultry diets are desired hinged on feed safety, production cost and nutritional quality. The preceding review looks at how baobab seeds have featured as an alternative protein source in poultry diets. This is on the backdrop that the cost of compound feeds continue to be on the rise due to the high expense of conventional protein sources used in manufacturing animal feed. Soya bean has been the predominantly used and most expensive conventional protein source used in the manufacturing of compound feeds. It is suffice to suggest that there is an urgent need to accord adequate consideration to alternative cheap protein sources, and baobab seeds are one such alternatives. Previous studies have shown that baobab seeds have excellent nutritive value, despite containing inconsiderable levels of anti-nutritional factors. Baobab seeds contain some anti-nutritional factors, such as phytate (2%), oxalate (10%), tannins and saponins (3-7%) which reduces digestive efficiency and utilization of dietary nutrients in poultry. However, these anti-nutritional factor levels are generally assumed to be low enough not to cause any adverse effects in avian species. The seeds have a protein value that ranges from 20-36 % CP and an energy level of 4.19-16.75 kJ/kg, which is comparable to sunflower meal (24.4-36.7 CP and 19.1-20.2 kJ/kg) and soybean hulls (10.5-19.2 CP and 17.5-18.7 kJ/kg). It is apparent from previous studies that inclusion of baobab seeds at

5-10% level in poultry diets improves performance of broilers in terms of growth rate. Inclusion of the baobab seeds as partial replacers of soybean meal can be cost effective by inevitability reducing the escalating costs of poultry feed.

1. Introduction

Recently, there has been an increased competition for feed ingredients that are used in manufacturing animal feed since some of these ingredients are also used as human food (Gadzirayi et al., 2012). The population of the world is expected to increase by about 29% from the current 7 billion to 9 billion in 2050 (Meissner et al., 2013). Hence, there is great need to look for alternatives that can compensate the high demands for such ingredients. Some multipurpose trees have nutritional properties that can be beneficial if incorporated in livestock feed. Utilising some of these properties to their full potential can result to sustainable livestock production (Melesse et al., 2011). One such example is the baobab tree it has been used for many traditional purposes but little has been said about its potential as an animal feed resource (Osman, 2004). It is one such tree that can grow for years and capable of adapting to harsh conditions. Feed constitutes about 70% of the entire production and of the total cost; up to 95% is required to meet the protein and energy requirements (Gadzirayi et al., 2012; Mohanta, 2012). Voluntary intake, feed digestibility and animal performance can be improved by using alternative low quality multipurpose trees (Melesse et al., 2011). Seed and leaf meals function as protein sources and aid in providing some essential vitamins, minerals, oxycaretenoids as well as bioactive compounds that function at cellular level (Melesse et al., 2013). African baobab seeds have been shown to be a superb source of protein, with most of the essential and non-essential amino acids (De Caluwé et al., 2010). From previous reports the baobab seed cake is a potential low-cost and locally available protein source for livestock feeding (Chimvuramahwe et al., 2011). Baobab seed meal is one such probable alternative feed resource; however, there is limited literature on its potential use in poultry production hence the preceding review looks at how baobab seeds have featured as an alternative protein source in poultry diets.

2. The baobab (Adansonia digitata L.)

The baobab tree is a fruit-producing tree which belongs to the family Bombacaceae (Gebauer et al., 2002). The tree has an outstandingly wide variety of uses which range from food, beverages and medicinal uses (Gebauer et al., 2002; Sidibe and Williams, 2002). The tree is of importance to the livelihood of people especially those in arid areas of Africa (De Caluwé et al., 2010). Due to their large size and peculiar shapes, baobabs are often at most the prominent tree species where they grow. In traditional dishes usually the tubers, fruits, twigs, seeds, flowers and leaves of the baobab are recognized as regular ingredients in rural areas (Venter, 2012).

2.1. Botanical description

The baobab is a gigantic, deciduous, majestic tree which reaches heights of up to 25 m high and can live for up to a 1000 years (Gebauer et al., 2002). In short, the tree has angular, thick, broad spreading branches with an undersized, stout trunk that reaches 10-14 m at times more in girth may often grow to be deeply fluted. The figure of the baobab trunk usually varies. Young trees are usually conical; mature trees can be bottle shaped and cylindrical (Assogbadjo et al., 2006). Crown shapes of the baobab usually range from depressed ovoid through globose to obovoid (Chadare et al., 2009). The bark of the tree is smooth, greyish-brown, reddish-brown, soft, and fibrous (Sidibe and Williams, 2002). At the beginning of the season the leaves are 2-3 foliate and are early deciduous; the more fully grown ones are 5-9 foliate (Assogbadjo et al., 2006; Assogbadjo et al., 2008). Baobab fruits are very inconsistent, usually they are globose to ovoid but at times oblong-cylindrical, often asymmetrical in shape, apex pointed, or obtuse, covered with velvety greenish or yellowish hairs (Chadare et al., 2009; Assogbadjo et al., 2010).

2.2. Ecology, distribution and fruiting

Baobabs are widespread all over the hot, drier regions of tropical Africa and are prevalent south of the Sahara and are commonly considered as an African symbol (Gebauer et al., 2002). The tree occurs in the mature woodlands of Namibia and also as an element of the savannah ecosystem throughout the northern part of South Africa, eastern and western region of Zimbabwe and in the ecosystems of Angola (Venter, 2012). Regions where the tree can grow are usually limited to the ones with not above one day of frost per annum (Mpofu et al., 2012). It endures best in arid climates and withstands fire (Sidibe and Williams, 2002). These adaptations permit the tree to grow in regions with 100–1000 mm yearly precipitation.

A. digitata L. typically grows on free-draining sandy-textured soils except on deep sand, where it is capable to acquire adequate moisture or anchorage (Baum et al., 1998). Baobab trees are not sensitive to soil pH and endure shallow lateritic soils. They also grow on rocky hillsides, in calcareous soils, on spots receiving run-off (Sidibe and Williams, 2002). The baobab only spends four months of the year in leaf, since some photosynthesis is carried out by the trunk and branches throughout the eight-month leafless period, utilising the water accumulated in the trunk (Baum et al., 1998; Chadare et al., 2009; Mpofu et al., 2012). Flowering was observed to occur around May and July with fruiting extending from August to October in central Africa (Assogbadjo et al., 2006; Assogbadjo et al., 2008). In Southern Africa ripening of the baobab fruit starts around April and May, maturing in between June and July (Venter, 2012). Pollination is usually done by bats and insects nevertheless the baobab is adapted to wind pollination (Mpofu et al., 2012).

3. The baobab seeds

3.1. Nutritional composition

On dry matter basis the undecorticated baobab seeds contain about 13-18% crude protein, 26% crude fibre and 10-13% oil (Osman, 2004). Decorticating the seeds, results in an increment of the crude protein (26-38%), reduced crude fibre (17%) and richer oil content of 23-24% on dry matter basis (Igboeli et al., 1997). The nutritional value of the baobab seed oilcake depends on the processing of the seeds. On dry matter basis it contains 17-36% crude protein, 15-25% crude fibre and 5-14% residual oil (Madzimure et al., 2011). The oilcake may also contain some anti-nutritional factors. Osman (2004) noted that the seeds are processed for oil; nevertheless, the by-product, which is the oilseed meal, is typically under-used. Madzimure et al. (2011) also noted that the oilseed cake is discarded regardless of its prospective significance as a livestock feed. Table 1 shows the proximate composition of the baobab seeds and oilcake.

Table 1
Proximate composition of the Baobab seeds.

Constituent	A	B	C	D	E	F	G	H
Dry matter	-	-	-	90.6	-	-	89.30	-
Moisture	6.38	4.3	-	-	3.8	5.37	-	4.3
Crude protein	26.70	18.4	16.60	16.9	19.5	20.13	11.7	18.4
Crude fat	23.50	12.2	17.50	5.26	13.4	24.72	9.67	12.2
Ash	5.50	3.8	5.50	4.57	3.1	7.36	6.03	3.8
Crude fibre	-	16.2	14.94	15.61	15.6	7.89	20.52	16.2
Carbohydrate	37.92	45.1	60.40	-	44.6	39.90	-	49
Metabolizable energy, kcal/100 g	469.98	363.8	450	-	-	462.60	433.2	363.8

The - denotes that value is not available. Source: A, (Igboeli et al., 1997) dehulled seeds; B, (Osman, 2004) whole seeds; C, (Ezeagu, 2005) whole seeds; D, (Madzimure et al., 2011) seed cake; E, (Oyeleke et al., 2012) seed meal; F, (Danbature et al., 2014) whole seeds; G, (Oladunjoye et al., 2014) pulp and Seed meal; H, (Anene et al., 2012) whole seeds.

3.2. Amino acid profile

A number of chemicals have been characterised and isolated from A. digitata L. seeds. Their classes are flavonoids, vitamins, steroids, terpenoids, carbohydrates, amino acids, and lipids (Oyeleke et al., 2012). The seeds have high values for fibre, fats (oils), proteins, and most minerals (Osman, 2004). Ten of the 18 observed amino acids in A. digitata L. seeds are categorized as essential; threonine, tyrosine, methionine, valine, phenylalanine, isoleucine, leucine, histadine, lysine and tryptophan and have been identified at relatively high amounts (Glew et al., 1997). Ezeagu (2005) also confirmed the high levels of thiamine, and lysine presence in the seeds. De Caluwé et al. (2010) reported that in comparison to other oilseed protein profiles, A. digitata L. seeds have an appreciable amount of lysine. Since this is one of the limited amino acid in most cereal plants, Osman (2004) stated that it might be possible to use A. digitata L. seed protein in a way to alleviate cereal protein quality. The proteins also have a high solubility at alkaline and acidic pH suggesting that they can be an adequate food ingredient (De Caluwé et al., 2010). Table 2 shows the amino acid profile of A. digitata L. seeds.

3.3. Mineral composition

According to Nkafamiya et al. (2007) report macro-minerals that are found in high quantities in the baobab seeds are calcium, phosphorous and potassium. Potassium (K), Calcium (Ca) and magnesium (Mg) are the most significant minerals in baobab seeds. Most studies noted that the seeds are poor in micro-minerals such as copper, iron and zinc (Glew et al., 1997; Osman, 2004). As noted in the review by Chadare et al. (2009) variations in the mineral compositions of the baobab seeds is mainly attributed to the different methods of analysis that were used. The mineral compositions as noted by various authors are presented in table 3.

Table 2
Composition of amino acids in Baobab seeds.

Amino acid	A	B	C
Alanine	10.60	7.1	-
Arginine	2.21	8.0	-
Aspartic acid	21.10	10.3	-
Cysteic acid	3.60	1.5	1.92
Glutamic acid	48.90	23.7	-
Glycine	10.40	8.6	-
Histidine	5.05	2.2	1.98
Isoleucine	8.27	3.6	3.54
Leucine	14.00	7.0	6.54
Lysine	11.20	5.0	3.73
Methionine	2.29	1.0	1.25
Phenylalanine	10.30	4.0	4.54
Proline	9.55	6.9	-
Serine	11.40	6.1	-
Threonine	6.98	3.8	2.91
Tryptophan	2.81	-	1.38
Tyrosine	5.59	1.5	2.72
Valine	11.60	5.9	4.99
Crude protein (Total Protein)	170.00	-	-

The - denotes that value is not available. Source: A, (Glew et al., 1997)/(mg/g dw); B, (Osman, 2004)/(gm/100 gm); C, (Ezeagu, 2005)/(g/100g).

3.4. Fatty acid profile

The seed contains an appreciable quantity of oil (29.7%, dry weight basis) (Nnam and Obiakor, 2003). In classifying the baobab seeds, they are both protein- and oil-rich. The seed oil is an exceptional source of mono-and polyunsaturated fatty acids (Osman, 2004). According to Ezeagu et al. (1998) of all the fatty acids 26.89% are saturated while 73.11% are unsaturated. Oleic and linoleic acid are contained at high proportions in the seed oil and as well as α-linolenic and palmitic acid (Ezeagu, 2005) (Table 4). De Caluwé et al. (2010) documented that oleic (26.07%) and linoleic (39.42%) acids are the key fatty acids in the baobab oil. In modulation of the human metabolism, polyunsaturated fatty acids have an important role that they play hence the high linoleic acid content has nutritive significance. According to Ezeagu et al. (1998) since some unsaturated vegetable oils have the ability to reduce serum cholesterol levels attention to focus on the baobab seed oil is recommended. There is a chance that it might also exhibit the some properties as vegetable oil. The high content of mono- and polyunsaturated fatty acids makes the A. digitata L. seed oil to be useful as food oil (Osman, 2004). Nkafamiya et al. (2007) reported that the seed oil has a high saponification value, which suggests that the oil may be suitable for soap making. Table 4 shows the fatty acid profile of baobab seeds.

3.5. Anti-nutritional factors

As stated by Igboeli et al. (1997); Oyeleke et al. (2012) the optimal utilization and acceptability of the baobab seeds as a source protein is restricted by the presence of anti-nutritional elements such as phytate, protease inhibitors, tannins, amylase inhibitors, phytic acid, oxalate, trypsin inhibitors and alkaloids. They can be inactivated or removed by various processing procedures (Chadare et al., 2009). According to the investigation by Osman (2004) the anti-nutritional factors that are found in baobab seeds are phytic acid (73 mg/100 g), a Trypsin Inhibitor Activity (5.7 TIU/mg sample), and catechin equivalent of tannin (23%). Processing techniques that can work on the composition of tannins within the baobab seeds are cold and hot water, acid and hot alkali treatments (Igboeli et al., 1997). Dehulling is another technique that can be used but does not significantly reduce tannins but the activity of amylase inhibitors is significantly reduced by dehulling, hot alkali treatments and cold water (Chadare et al., 2009). Additionally, Nnam and Obiakor (2003) found that phytate and tannins of baobab seeds can be reduced by fermentation. Obizoba and Anyika (1994) found that a 6-day fermentation appears to be the most promising procedure for making nutritious feed products from baobab seeds. Table 5 shows the anti-nutritional components of the baobab seed.

Table 3
Mineral composition of the Baobab seeds.

Element	A	B	C
Macro-elements (mg/100 g)			
Potassium	910	1429.0	875.15
Sodium	28.3	228.0	40.72
Calcium	410	212.0	521.10
Magnesium	270	353.0	315.17
Phosphorus	-	924.5	125.50
Micro-elements (mg/100 g)			
Iron	6.4	11.13	0.12
Copper	2.6	2.55	-
Zinc	5.2	8.41	-
Manganese	-	2.10	-

The - denotes that value is not available. Source: A, (Osman, 2004); B, (Ezeagu 2005); C, (Oyeleke et al., 2012).

4. Growth promoting efficacy of the baobab seed meal

The baobab seeds if incorporated in livestock diets can provide some of the necessary minerals, vitamins, fibre and amino acids, in particular, methionine and lysine which are usually the limiting amino acids in most cereals but vital for livestock production (Glew et al., 1997; Osman, 2004). As a result, they are capable of complementing the maize protein content in poultry diets (Chimvuramahwe et al., 2011). As was noted by Mwale et al. (2008); Chimvuramahwe et al. (2011); Sola-Ojo et al. (2013) and Saulawa et al. (2014) the baobab seed meal can be incorporated in diets of non-ruminants at 5-10% as a protein source devoid of any undesirable effects. Inclusion levels that are beyond 10% in a monogastric animal diet can result in a decline in intake and conversion rate of feed (Mwale et al., 2008; Chimvuramahwe et al., 2011; Sola-Ojo et al., 2013; Saulawa et al., 2014). It is because the seeds has an unappreciable amount of fibre and some anti-nutritional factors that are discouraged for poultry diets. Therefore inclusion rates higher than 10% cause a cumulative increase in fibre and anti-nutritional factor levels that cause detrimental effects on poultry performance and even increase mortality rates (Osman, 2004; Nkafamiya et al., 2007; Mwale et al., 2008; Ezeagu, 2009; Gadzirayi et al., 2012). According to Mwale et al. (2008) and Chimvuramahwe et al. (2011) the effects of these nutritional factors of the baobab seed meal on growth, nutrient digestibility and meat quality of broilers is scarce and unidentified. Even though the best performance is noted when birds are fed diets at 5-10% inclusion levels, Chimvuramahwe et al. (2011) and

Saulawa et al. (2014) noted that even higher inclusion levels above 10% chicks can still tolerate the diet. This is due to the good aroma of the baobab seed meal which improves feed intake (Mwale et al., 2008; Belawu and Ibikunle, 2009; Chimvuramahwe et al., 2011; Madzimure et al., 2011; Saulawa et al., 2014). The other contributing factor to having an inclusion level of 5-10% is due to the fat content of the baobab seed oilcake. Increased inclusion levels result in lowered feed intake since birds are known to consume feed principally to meet their energy requirements. High energy diets in birds, frequently as a result of the relative fat content, on average have, reduced feed intakes owing to the decreased ease of passage rate of digesta though the gut (Nahashon et al., 2006). Therefore, there is an inverse relationship between the energy content of the diet and bird feed intake. Nahashon et al. (2006) and Nkafamiya et al. (2007) noted that feed intake in meat-type birds is an important factor that has influence on both body weight gains and feed conversion rates.

5. Cost benefits of the partial replacement of soybean meal with baobab seed cake

The main limiting factors in any poultry enterprise are nutrition and diseases, since feed costs alone accounts for approximately 70% of the total production costs (Olugbemi et al., 2010; Bale et al., 2013; Melesse et al., 2013). Soybean meal is the most usually used plant protein source for broiler feeds. Currently there is persistent scarcity and subsequent elevated prices of soybean meal for livestock in tropical regions and this obstructs broiler farming (Gadzirayi et al., 2012; Melesse et al., 2013). Most studies that have been done using the baobab seeds as a protein source have shown its potential in alleviating poultry feed costs (Bale et al., 2013; Saulawa et al., 2014). They showed that feed cost per gain tend to decline with increasing inclusion levels of the baobab seed meal (Chimvuramahwe et al., 2011; Mwale et al., 2008; Bale et al., 2013). The implication of this is that it may be cheaper to use baobab seed meal as a protein source for broiler diets in comparison to commonly used conventional feed ingredients in particular soybean meal which has increased in its price (Archimède et al., 2011; Bale et al., 2013). The sharp increase and shortages in soybean meal has forced poultry producers to refocus on their feeding expenditures in an aim to raise efficiency targets (Melesse et al., 2013). Furthermore, price increases of conventional poultry feed ingredients has been known to mostly occur during the dry season when supplies are low (Saulawa et al., 2014). The use of non-conventional feed ingredients (leaf meals, legume seed meals and tree seed cakes) that are not highly edible for human nutrition but readily accessible has proven to reduce feed costs and maximize production returns in any poultry enterprise (Olugbemi et al., 2010; Aderinola et al., 2013). The availability of an optimum crude protein content and availability of essential amino acid in the baobab seed meal can be taken to an advantage at low inclusion levels in broiler diets and cut down costs (Mwale et al., 2008). A practical approach in cutting down nutrition costs for broiler chicks is by the supplementation or replacement of conventional feed ingredients by high protein products such as the baobab seed meal (Chimvuramahwe et al., 2011; Bale et al., 2013).

6. Baobab seeds in different poultry diets

Various studies have been done with the utilization of the baobab oilseed meal as poultry feed ingredient with varying degrees of success. The oilcake has been investigated in young guinea fowls and the results showed no effects on growth and feed intake at 5% inclusion rate, with a considerable reduction in body weight of 9% at 6 weeks of age at 10% and 15% inclusion rates of the oilcake in the diet (Mwale et al., 2008). Another study in scavenging chickens showed a 60% lower body weight gain and higher mortality weights when fed a diet containing 25% raw baobab seeds and 75% maize grain as compared to those that were fed on a commercial diet (Anjos, 2005). It was noted that the cause might had been the anti-nutritional factors since they were fed raw and no processing of the seeds was done to reduce their effects. Another study also tested the oilcake in broilers and the study results showed that the seed oilcake can be included in broiler diets at 10% inclusion rate without any detrimental effects on growth performance (Chimvuramahwe et al., 2011). The results also showed that inclusion rate beyond 10% had a detrimental effect on feed intake and conversion rates (Chimvuramahwe et al., 2011). A study by Sola-Ojo et al. (2013) showed that DURBSM (decorticated undefatted roasted baobab seed meal) improved the performance of broilers and reduced oxidative spoilage of broiler chicken meat. The study showed that DURBSM might well be incorporated in poultry diets up to 7.5 % as a partial replacer of soybean meal in broiler finishers devoid of any detrimental effects on performance and carcass quality in broilers. Saulawa et al. (2014) postulated that inclusion of RBSM (roasted baobab seed meal) at levels up to 10% in broiler starter diets resulted in better productive performance among the chicks. These studies show that baobab seed meal can be incorporated in poultry diets at 5-10% devoid of adverse detrimental effects on their performance.

Table 4
Reported fatty acid content of Baobab whole seeds.

Fatty acids	A	B	C
Saturated			
C14:0 Myristic	1.90	0.2	0.25
C16:0 palmitic	155.00	24.2	22.06
C18:0 stearic	31.20	4.6	4.02
C20:0 Arachidic	7.40	1.3	0.86
C22:0 Benhenic	-	0.7	0.42
C24:0 Lignoceric	-	0.2	-
Monounsaturated			
C16:1 palmitoleic	2.00	-	0.27
C17:1 Heptadecenoic	-	0.3	-
C18:1 oleic	246.90	35.8	34.97
C20:1 Gadoleic	1.90	0.9	0.22
Polyunsaturated			
C16:2 Hexadecadienic	-	-	0.95
C18:2 linoleic	191.10	30.7	26.14
C18:3 linolenic	15.80	1.0	2.49

The - denotes that value is not available. Source: A, (Ezeagu et al., 1998); B, (Osman, 2004); C, (Ezeagu, 2005).

Table 5
Anti-nutritional components of the baobab seed.

Parameters	Baobab seed
Tannin, mg/g	0.29
Phytate, g/100g	1.20
Phytate-phosphorus	0.34
Phytate-P as % total P	1.0
Trypsin inhibitor, TIU/mg	Not Detected
Haemagglutinins, HU/mg	0.250
Cyanide, mg/100g	0.25
Total oxalate, mg/100g	42.0
Water soluble Oxalate	26.0
Soluble oxalate as % of total oxalate	61.9
Nitrate, mg/g	19.45
Nitrite, mg/g	0.104

Source: Adapted from (Ezeagu, 2005).

7. Effects of nutrition on broiler growth

According to Nkukwana et al. (2014) the commercial broiler of today in the most efficient ever, it represents combined efforts of genetics and advanced operational managerial practices, with the most outstanding growth ability of 70-75g per day occurring in the first week. In general, most poultry producers implement feeding schemes that intend to exploit economic efficiency by providing the necessary nutrients at levels as close to the animals' needs as possible (Bhat et al., 2010). This is done with the aim to not to cause wastages that may be costly by reductions in productivity by underfeeding or overfeeding. Lawrie and Ledward (2006) reported that all animals species go through an increase in weight and size, a process termed as growth, as well as changes in conformation, body shape, and function of organs and systems and this is termed as development. For animal growth to occur the main determinant is nutrition. this is so since the provision of sufficient nutrition has a direct effect on the realisation of the genetic growth potential of an animal (Wen-qian and Fu-chang, 2010). According to the report by Hossner (2005) of all the parameters that directly influence growth of animals, nutrition questionably has the greatest impact because the quantity and quality of feed is the most essential aspect in the regulation of animal growth rate. In addition, different nutrients in the feed have different ways by which they influence growth in animals.

Generally for optimal broiler growth the nutrients required are water, amino acids, fatty acids, macro and micro minerals, vitamins and carbohydrates (Lammers et al., 2007; Novak et al., 2007). Broilers at different growth stages and during different stages of production have different nutrient requirements. In addition the feed intake of broilers is not only dependent on their nutritional requirements, but also on the quality of the diet in terms of the digestibility and availability of dietary nutrients as well as the presence of antinutritional factors, mycotoxins, fibre or inhibitors (Bhat et al., 2010). The energy level of the diet is known to influence broiler feed intake (Nkafamiya et al., 2007). When growing broilers are given ad libitum feed, their feed intake and feed conversion greatly depends on the energy level of the feed (Rostagno et al., 2005). The protein level of the diet plays a very significant role in broiler growth, as the main function for protein in the body is growth. Sufficient intake of amino acids is mandatory in order to maximise protein accumulation rate and growth rate; inadequate levels of amino acids would result in slower growth rates and results in carcases with more fat and lower body weights in broilers (Pettigrew and Esnaola, 2001). Even though amino acids are essential for protein deposition and growth, they are not the only nutrients responsible for growth. For broilers the mineral levels in the diet are to be in appropriate levels to assist in bone formation and growth. According to Pettigrew and Esnaola (2001) consumption of both amino acids and energy is required for the deposition of protein in the animal's body such that a limitation of energy and an increase in amino acid levels in the diet does not increase protein deposition and the opposite is true for protein.

8. Conclusion

Previous studies have shown that there is overwhelming potential in the usage of baobab seeds as an alternative protein source in poultry feed that can result in a significant increase in animal growth rate, meanwhile reducing cost of production. It can be concluded that inclusion of baobab seeds at 5% to 25% levels in varying poultry diets can improve poultry performance. This implies that baobab seeds have the capacity to partially replace convectional protein sources used in formulating poultry diets. However, treatment of the baobab seeds is a necessity in order to destroy or reduce the negative effects of anti-nutritional factors.

References

Aderinola, O.A., Rafiu, T.A., Akinwumi, A.O., Alabi, T.A., Adeagbo, O.A., 2013. Utilization of Moringa oleifera leaf as feed suppliment in broiler diet. Int. J. Food. Agr. Vet. Sci., 3(3), 94-102.

Anene, A., Olivia, C., Anene, A., Onyekachi, C., 2012. Nutritive value and utilization of Baobab (Adansonia digitata) seed meal as plant protein source in the diet of juveniles of Clarias gariepinus. J. Res. Biol., 2(4), 348-354.

Anjos, F.R. dos., 2005. Effect of three different diets (baobab, cowpea and papaya) on the dynamic of the gastrointestinal helminths and on weight in chickens. In: Effect of scavenging feed resource base on the prevalence of parasites and performance of chickens in Sussundenga D. University Maputo, Mozambique. MSc Thesis.

Archimède, H., Régnier, C., Marie-magdeleine Chevry, C., Gourdine, J.L., Rodriguez, L., Gonzalez, E., 2011. The alternatives to soybeans for animal feed in the tropics. In: P.T.-B. Ng, ed. Soybean-Applications and Technology. Guadeloupe French West Indies, France, 276-286.

Assogbadjo, A.E., Glèlè Kakaï, R., Chadare, F.J., Thomson, L., Kyndt, T., Sinsin, B., Van Damme, P., 2008. Folk classification, perception, and preferences of baobab products in west Africa: Consequences for species conservation. Econ. Bot., 62(1), 74-84.

Assogbadjo, A.E., Kakai, R.G., Kyndt, T., Sinsin, B., 2010. Conservation genetics of Baobab (Adansonia digitata L.) in the parklands agroforestry systems of Benin (West Africa), Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 38(2), 136-140.

Assogbadjo, A.E., Kyndt, T., Sinsin, B., Gheysen, G., van Damme, P., 2006. Patterns of genetic and morphometric diversity in Baobab (Adansonia digitata) populations across different climatic zones of Benin (West Africa). Ann. Bot., 97(5), 819-30.

Bale, J.S., Mancha, Y.P., Sanusi, M., Doma, U.D., 2013. Effect of graded levels of Baobab (Adansonia digitata) seed meal on the growth performance and production economic analysis of broiler chickens. Int. J. Poult. Sci., 12(5), 273-276.

Baum, D.A., Small, R.L., Wendel, J.F., 1998. Biogeography and floral evolution of Baobabs (Adansonia, Bombacaceae) as inferred from multiple data sets. Syst. Biol., 47(2), 181-207.

Belawu, M.A., Ibikunle, M.A., 2009. Potential of lesser known seed meal in the diet of sheep. Green Farming, 2(10), 694-695.

Bezard, J., Cao, J.M., Gresti, J., Blond, J., 1996. Effects of cyclopropenoid fatty acids on the fatty acid profile of lipids from different tissues in the rat. J. Food. Lipid., 3, 73-86.

Bianchini, J., Ralaimanarivo, A., Gaydou, E.M., Waegell, B., 1987. Sterols and tocopherols the seeds of six Adansonia species. Phytochem., 21(8), 1981-1987.

Chadare, F.J., Linnemann, A.R., Hounhouigan, J.D., Nout, M.J.R., Van Boekel, M.A.J.S., 2009. Baobab food products: A review on their composition and nutritional value. Crit. Rev. Food. Sci. Nutr., 49(3), 254-74.

Chimvuramahwe, J., Musara, J.P., Mujuru, L., Gadzirayi, C.T., Nyakudya, I.W., 2011. Effect of feeding graded levels of Adansonia digitata (baobab) seed cake on the performance of broilers. J. Anim. Plant. Sci., 11(3), 1442-1449.

Danbature, W.L., Fai, F.Y., Abubakar, A.U., Ayim, P., 2014. Nutritional evaluation of baobab seed. Int. J. Res. Agr. Food. Sci., 2(2), 2311-2476.

De Caluwé, E., Halamova, K., Van Damme, P., 2010. Adansonia digitata L.: A review of traditional uses, phytochemistry and pharmacology. Afrika Focus, 23(1), 11-51.

Ezeagu, I.E., 2005. Baobab (Adansonia digitata L.) seed protein utilization in young albino rats I: Biochemical ingredients and perfomance characteristics. Anim. Res. Int., 2(1), 240-245.

Ezeagu, I.E., 2009. Nutritional value of tropical plant seeds. In: Modification of seed composition to promote health and nutrition. Agronomy Monograph 51. Madison, USA: American Society of Agronomy, Crop Science Society of America, Soil Science Society of America, 39-54.

Ezeagu, I.E., Petzke, K.J., Lange, E., Metges, C.C., 1998. Fat content and fatty acid composition of oils extracted from selected wild-gathered tropical plant seeds from Nigeria. J. Am. Oil. Chem. Soc., 75(8), 1031-1035.

Gadzirayi, C.T., Masamha, B., Mupangwa, J.F., Washaya, S., 2012. Performance of broiler chickens fed on mature Moringa oleifera leaf meal as a protein supplement to soyabean meal. Int. J. Poult. Sci., 11(1), 5-10.

Gajana, C.S., Nkukwana, T.T., Marume, U., Muchenje, V., 2013. Effects of transportation time, distance, stocking density, temperature and lairage time on incidences of pale soft exudative (PSE) and the physico-chemical characteristics of pork. Meat. Sci., 95(3), 520-5.

Gaydou, E.M., Andrianaivo-Rafehivola, A.A., Siess, M.H., 1995. Modifications of hepatic drug metabolising enzyme activities in rats fed baobab seed oil containing cyclopropenoid fatty acids. Food. Chem. Toxicol., 33(5), 377.

Gebauer, J., El-Siddig, K., Ebert, G., 2002. Baobab (Adansonia digitata L.): A review on a multipurpose tree with promising future in the Sudan. Gartenbauwissenschaft, 67(4), 155-160.

Glew, R.H., Vanderjagt, D.J., Lockett, C., Grivetti, L.E., Smith, G.C., Pastuszyn, A., Millson, M., 1997. Amino acid, fatty acid, and mineral composition of 24 indigenous plants of Burkina Faso. J. Food. Compos. Anal., 10(3), 205-217.

Gray, D.O., Hayman, A.R., 1986. O-acetylethanolamine, a natural product from the leguminosae. Phytochem., 26(3), 839-841.

Igboeli, L.C., Addy, E.O.H., Salami, L.I., 1997. Effects of some processing techniques on the antinutrient contents of baobab seeds (Adansonia digitata). Bioresour. Technol., 59, 29-31.

Kamatou, G.P.P., Vermaak, I., Viljoen, A.M., 2011. An updated review of Adansonia digitata: A commercially important African tree. S. Afr. J. Bot., 77(4), 908-919.

Madzimure, J., Musimurimwa, C., Chivandi, E., Gwiriri, L., Mamhare, E., 2011. Milk yield and quality in Guernsey cows fed cottonseed cake-based diets partially substituted with baobab (Adansonia digitata L.) seed cake. Trop. Anim. Health. Prod., 43(1), 77-82.

Meissner, H., Ryssen, J. Van, Webb, E., Rust, T., Toit, L., 2013. Special issue: A balanced perspective on animal production, from environment to human health. S. Afr. J. Anim. Sci., 43(3), 229-232.

Melesse, A., Getye, Y., Berihun, K., Banerjee, S., 2013. Effect of feeding graded levels of Moringa stenopetala leaf meal on growth performance, carcass traits and some serum biochemical parameters of Koekoek chickens. Livest. Sci., 157(2-3), 498-505.

Melesse, A., Tiruneh, W., Negesse, T., 2011. Effects of feeding Moringa stenopetala leaf meal on nutrient intake and growth performance of Rhode Island red chicks under tropical climate. Trop. Subtrop. Agroecosyst., 14, 485-492.

Mohanta, K.N., 2012. Evaluation of different animal protein sources in formulating the diets for blue Gourami, Trichogaster trichopterus fingerlings. J. Aquaculture Res. Dev., 4(2), 1-7.

Mpofu, E., Gandiwa, E., Zisadza-gandiwa, P., Zinhiva, H., 2012. Abundance, distribution and status of African baobab (Adansonia digitata L.) in dry savanna woodlands in southern Gonarezhou National Park, southeast Zimbabwe. Trop. Ecol., 53(1), 119-124.

Mwale, M., Mupangwa, J.F., Mapiye, C., Saina, H., Chimvuramahwe, J., 2008. Growth performance of Guinea fowl keets fed graded levels of baobab seed cake diets. Int. J. Poult. Sci., 7(5), 429-432.

Nahashon, S.N., Adefope, N., Amenyenu, A., Wright, D., 2006. Effect of dietary metabolizable energy and crude protein concentration in diets of pear gray guinea fowl pullets. Growth perfomance. Poult. Sci., 85, 1847-1854.

Nkafamiya, I.I., Osemeahon, S.A., Dahiru, D., Umaru, H.A., 2007. Studies on the chemical composition and physio-chemical properties of the seeds of baobab (Adansonia digitata). Afr. J. Biotechnol., 6, 756-759.

Nnam, N.M., Obiakor, P.N., 2003. Effect of fermentation on the nutrient and antinutrient composition of baobab (Adansonia digitata) seeds and rice (Oryza sativa) grains. Ecol. Food. Nutr., 42(4-5), 265-77.

Obizoba, I.C., Anyika, J.U., 1994. Nutritive value of baobab milk (gubdi) and mixtures of Baobab (Adansonia digitata L.) and hungry rice, Acha (Digitaria exilis) flours. Plant. Food. Hum. Nutr., 46, 157-165.

Oladunjoye, I.O., Akinlade, M., Lawal, Z., 2014. Performance, digestibility, carcass and blood profile of grower rabbits fed Baobab (Adansonia digitata) pulp and seed meal. India. J. Fund. Appl. Life Sci., 4(2), 234-240.

Olugbemi, T., Mutayoba, S., Lekule, F., 2010. Effect of Moringa (Moringa oleifera) inclusion in cassava based diets fed to broiler chickens. Int. J. Poult. Sci., 9(4), 363-367.

Osman, M., 2004. Chemical and nutrient analysis of Baobab (Adansonia digitata) fruit and seed protein solubility. Plant. Food. Hum. Nutr., 59(1), 29-33.

Oyeleke, G.O., Salam, M.A., Adetoro, R.O., 2012. Some aspects of nutrient analysis of seed, pulp and oil of Baobab (Adansonia digitata L.). J. Environ. Sci., Toxicol. Food. Technol., 1(4), 32-35.

Saulawa, L.A., Ukachukwu, S.N., Onwudike, O.C., Garba, M.G., Aruwayo, A., State, K., Science, F., State, A., 2014. Quantitative substitution of raw Baobab (Adansonia digitata) seed meal for soyabean meal in broiler starter diet. Int. J. Poult. Sci., 13(6), 335-339.

Sidibe, M., Williams, J.T., 2002. Baobab (Adansonia digitata L.). Fruits for the future 4. Southampton, UK: International Centre for Underutilised Crops.

Sola-Ojo, F.E., Adeyemi, K.D., Toye, A.A., Bolu, S.A., Fayeye, T.R., Annongu, A.A., Garba, S.O., Karim, R.O., 2013. Performance, carcass profile and oxidative stability of broiler chickens fed processed baobab seed meal. Bulletin of Environment, Pharmacology and Life Sciences, 2(10), 94-99.

Venter, S.M., 2012. The ecology of Baobabs (Adansonia digitata L.) in relation to sustainable utilization in northern, south Africa. University of the Witwatersrand, Johannesburg, South Africa. PhD Thesis.

How to cite this article: Chisoro, P., Kaguru, T., Assan, N., 2017. Baobab seeds as an alternative protein source in poultry feed. Scientific Journal of Review, 6(1), 509-518.