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Environmental, Ecological and Anti-Nutritional Factors for Cashew Utilization in Rabbit Production – A Review

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Abstract

A review including the environmental, ecological and anti-nutritional factors for cashew utilization in rabbit production is reported. Cashew apple has multi-purpose; it can be processed to obtain human food. The process of cashewapple into several by-products can affect its nutritional, microbiological and sensorial quality attributes. The fruits if not properly put in place can cause environmental hazards. Therefore, clarification methods, thermal treatment and high hydrostatic pressure modify nutritional, microbiological, anti-nutritional and sensorial attributes of cashew apple products. Moreover, the storage stability of cashew apple juice depends on the preservative methods used. Cashew apple is usually used in the fortification of the nutritional quality of some tropical foods because of its high percentage of vitamin C. Cashew apple juice has great potential for bioprocess to obtain fermented products .Cashew apple contains phenolic compounds generally related to antioxidant. The valorization of cashew apples in developing countries by the improvement of the process of cashew apples available in these countries can contribute to cover the nutritional needs of the populations.

Keywords: *Environmental, Ecological, Anti-Nutritional Factors, Cashew Utilization, Dutch Rabbits.*

Introduction

Cashew (*Anacardium occidentale* L.) is a tropical fruit native from Brazil, principally grown in the North and Northeast regions. The pseudo-fruits, known as the cashew apple are the part of the tree that connects it to the cashew nut, the real fruit, a well-known product worldwide (Zepka and Mercadante, 2009). The cashew nuts represent only 10% of the total fruit weight, and large amounts of cashew apples are left in the field after the removal of the nut (Honorato *et al.*, 2007a).

The cashew tree grows even on poor soils with low rainfall and is cultivated in 32 countries around the world, with Brazil, India, Vietnam, and Nigeria as the mainproducers (Rabelo *et al.*, 2009). Cashew apple is thepeduncle of the cashew fruit, which is rich in reducing sugars (fructose and glucose), vitamins, minerals, and some amino acids, carotenoids, phenolics, organic acids and antioxidants, and also considered as a source of energy (Oliveira *et al.*, 2002; Campos et al., 2002;Trevisan et al., 2006; Carvalho *et al.*, 2007; Honorato *etal.*, 2007a). It can be processed to obtain juice, ice cream, and other foodstuffs (Dèdéhou *et al.*, 2015a).

Astringency of cashew apple undertakes consumption, due to polyphenols, tannins (0.35%), and unknown oily substances (3%) present in the waxy layer of the skin (Michodjehoun-Mestres *et al.*, 2009a).Many factors, such as the seasonal nature of the cashew trees produce, the extreme perishable character of apples hindering it full utilization (Bidaisee and Badrie,2001).Thermal processing has a negative effect on the sensory and nutritional characteristics of the juice as the compounds responsible for aroma and flavor are volatile and some vitamins are thermo sensitive (Polydera *et al.*,2003).

On the other hand, the biological composition of cashew can be influenced by variety, geographic locality and ripening stage (Low or and Agyente-Badu, 2009;Sivagurunathan *et al.*, 2010; Adou *et al.*, 2011a;Gordon*et al.*, 2012).Some studies focused on the physico-chemical characteristics of cashew apple (Assuncao and Mercadante, 2003; Lavinas*et al.*, 2006; Brito et al., 2007;Silva *et al.*, 2008; Michodjehoun-Mestres *et al.*, 2009a;Adou *et al.*, 2011a,b, 2012) and also on the effects of postharvest process on the physico-chemical quality attributes of cashew (Souza *et al.*,1999, 2009; Falade *et al.*, 2003; Figueiredo *et al.*, 2007; Marques *et al.*, 2007;Martins, *et al.*, 2008; Lima *et al.*, 2010); the effects of processing methods, such as clarification by membrane and enzymatic methods or the use of clarifying agents on the nutritional quality of cashew apple juice have also been investigated.

Furthermore, the effect of thermal treatment and high hydrostatic pressure on cashew apple juice have been reported by various workers (Campos *etal.*, 2002; Couri*et al*., 2003; Jayalekshmy and John,2004; Abreu *et al*., 2005; Cianci *et al*., 2005; Castro *et al*.,2007; Damasceno *et al*., 2008; Zepka and Mercadante,2009; Sampaio *et al*., 2011; Gyedu-Akoto, 2011; Talasila *et al*., 2011). Other studies on the storage stability of cashew apple juice by using artificial preservative or microfiltration (Talasila *et al*., 2012) and the effect of storage conditions on cashew apple juice stability were reported (Lavinas *et al.*, 2006; Queiroz *et al.*, 2008). On the other hand, cashew apple was used in the fortification of the nutritional quality of some tropical foods by mixing the apple juice or powder with other tropical food to increase it vitamins and minerals level for example(Akinwale, 2000; de Carvalho *et al.*, 2006; Silva *et al*.,2008; Queiroz*et al*., 2008; Gyedu-Akoto, 2011; Talasila *et al*., 2011; Gao and Rupasinghe, 2012; Talasila*et al*.,2012) and in the processing of added values fermented products because of it high content of reducing sugars(Osho, 1995; Melo and Macedo, 2008; Giro et al., 2009;Venkatesh*et al.,* 2009; Honorato and Rodrigues, 2010;Lima *et al*., 2010; Vergara *et al.*, 2010; Kuila*et al*., 2011;Silveira*et al*., 2012).

The valorization of cashew products especially cashew apple in developing countries is a relevant topic. In order to improve the valorization of cashew products, it is necessary to find out what is already done in this respect. This review aims to give information on the physicochemical characteristics of cashew (*A. occidentale*) apple and the effects of some processing methods on the quality of cashew apple juice.

Physico-Chemical Characteristics Of Cashew (A. Occidentale) Apple

Geographical and Varietal Effects

Biochemical profile of the apples of different species of cashew grown in some area of Ivory Coast on specific soils and climate in the various producing regions were evaluated (Adou *et al.*, 2011a). The analyses of the juices found 10 minerals of which seven were macro-minerals and three were trace elements. The macro-minerals in order of occurrence were K>P>Mg>S>Na>Si>Cl; the distribution of the three trace elements was not uniform in all the analyzed juice samples. In addition, the minerals were not free, but in the oxidized state with oxide contents in the apples. In Ghana, the juices, from both there and yellow cashew apples from three agro ecological zones, mineral composition (mg/100 ml) showed potassium (76.0) to be the highest, followed by calcium(43.0), magnesium (10.92), phosphorous (0.79), and sodium (0.41). While, zinc, copper, and iron concentrations were lower and ranged from 0.05 to 0.08mg/100 ml.

Phenol and tannin contents in the juice showed significant ($p<0.05$) variation among the ecological zones (Agostini-Costa *et al.*, 2002; Low or and Agyente-Badu, 2009). Moreover, protein, reducing sugars, total sugars showed significant ($p<0.05$) variation among the ecological zones except the pH value (Adou *et al.*, 2011a). The variations in the physico-chemical characteristics of cashew apple juices from the different locations is associated with changes in soil conditions, cultural practices and other climatic conditions such as temperature and humidity (Egbekun and Otiri, 2010).The results of vitamin C content, total sugars, concentrations of glucose, fructose and sucrose, level of organic acids, citric acid, tartaric acid, acetic acid, oxalic acid, fumaric acid, pH, titra table acidity, total soluble solid content, dry matter, ash, protein content, and amino acids showed that except pH, the color of apples influenced significantly ($p<0.05$) the parameters analyzed(Adou et al., 2012).

In general, elongated red variety showed higher carotenoid levels than the yellow one. In contrast, ascorbic acid values were higher in the yellow variety from both regions (Assuncao and Mercadante,2003).Physical-chemical determinations were done in cashew apples, randomly at interval period of 15 days (during 75 days). Chemical analysis evaluated the total acidity, reduced content, not reduced and total sugars, vitamin C, phenolic compounds(tannins), pH, soluble solids, moisture, ash, protein, fiber, iron, calcium, and phosphorus (Maia *et al.*, 2004). The authors concluded that the stems of different cashew clones differ in acidity, moisture, and tannin content, being good source of sugar and excellent vitamin C.

The Cashew Plant - Origin and Botany of Cashew

Cashew belongs to the family *Anacardiaceae*. It is a native of the American tropics but it has since become naturalized in many lowland tropical areas. It spread within these countries with the aid of elephants that ate the bright cashew fruit along with the attached nut. The nut was too hard to digest and was later expelled with the droppings.

It is grown locally in many other lowland tropics and elevations of up to 1000 m. Since the crop must be harvested by hand, production is dependent on inexpensive labor for harvesting. The overall requirement for growing the crop, however, are low and plants will grow in relatively dry, infertile soils. The tree is a spreading, fast growing evergreen and up to 12 m in height. Leaves are leathery and ovate with prominent veins. Flowers are borne on terminal inflorescence, which consists of a mixture of male and hermaphrodite flowers (Edet *et al*., 2010). The cashew tree bears a false fruit known as the cashew apple from which the nut protrudes. The cashew apple is about 6-9 cm long and has a smooth, shiny skin that turns from green to bright red, orange or yellow in color as it matures. It has a pulpy, juicy structure with a pleasant but strong astringent flavor (Yao *et al*., 2013).

The main chemicals found in the cashew fruit are *alanine, alpha-catechin, alpha-linolenic acid, anacardic acids, anacardol, antimony, arabinose, caprylic acid, cardanol, cardol, europium, folacin, gadoleic acid,gallic acid, gingkol, glucuronic acid, glutamic acid, hafnium, hexanal, histidine, hydroxybenzoic acid, isoleucine, kaempferols, L-epicatechin, lauric acid, leucine, leucocyanidin, leucopelargonidine, limonene, linoleic acid, methylglucuronic acid, myristic acid, naringenin, oleic acid, oxalic acid, palmitic acid, palmitoleic acid, phenylalanine, phytosterols, proline, quercetin-glycoside, salicylic acid, samarium, scandium, serine, squalene, stearic acid, tannin, and trans-hex-2-enal tryptophan* (Heuze *et al*., 2017 and Fanimo *et al*,. 2004).

Effect of Ripening Stage

Cashew apples at three different maturity stages (Unripe fruits grew for 33 to 36 days, medium-ripe fruits 45 to 50days and ripe fruits 52 days) were examined according to their ascorbic acid content, phenolic compounds and antioxidant capacity (Gordon *et al.*, 2012). The results showed that the quantities of phenolic compounds were higher in immature cashews and decreased during the ripening process. *Myricetin-3-O-rhamnoside, 3-Ogalactoside quercetin, and quercetin 3-O-rhamnoside*were the main *flavonoid* present in all phases. The antioxidant capacity and the concentration of ascorbicacid increased in the course of ripening. The anti oxidant activity was significantly ($p < 0.05$) influenced by ascorbic acid, more than the content of phenolic compounds.

Environmental and Ecological Factors for Cashew Development

The best soils for cashew are deep friable, well-drained, loamy soils and sandy loams without hardpan with water table of 5 to 10 meters. Cashew also thrives on pure sandy soils as well as lateritic soils poor in fertility, though productivity may register a decline. Cashew trees have low tolerance to salinity; however, differences of tolerance exist between trees. Under very poor soils, cashew responds well to fertilizers if the ecological conditions are adequate. High yields are obtained if fertilizers are applied when cashew trees are more than 5 years old. Fertilizers such as muriate of potash, rock phosphate and urea may be applied (Vasconcelos*et al.*, 2002). Land is a very important factor for a viable cashew industry in Ghana and the Brong-Ahafo region has the largest land area under cashew production; this has been estimated to be about 4000 ha in 2003 (Armah, 2011).

Cashew can grow within a wider range of temperatures. It is assumed that optimum monthly average temperature may be near 27°C. Cashew is very sensitive to frost when young. The plant can withstand temperatures approaching 0°C for short periods but one could hardly expect to grow cashew economically in areas with the mean temperature not higher than 20°C. Kankam-Boadu, (2000) also stated that cashew can withstand harsh environmental conditions. In most important cashew growing areas, mean daily minimum temperatures are between 15°C - 25°C and mean daily maximum temperatures are between 25°C to 35°C. The absolute minimum and maximum are about 5°C and 45°C, respectively. Cashew does well in a rainfall range from 800mm to 2000 mm per annum and a dry season of about 6 months. A shorter dry season induces the flowering and fruiting period, whereas a longer dry season may create a drought stress (Bi-Calho, 2001).

Cashew Apple

The pseudo-fruit, the large pulpy and juicy part, have a fine sweet flavor and is commonly referred to as the "cashew fruit" or the "cashew apple". Fresh or frozen cashew fruit concentrate is as common a juice product in South American food stores as orange juice is in the United States. However, it is very perishable and therefore, no fresh cashew fruit is exported into the United States or Europe from South America. In addition to being delicious, the cashew fruit is a rich source of vitamins, minerals, and other essential nutrients. It has up to five times more vitamin C than oranges and contains a high amount of mineral salts. Volatile compounds present in the fruit include esters, terpenes, and carboxylic acids (Heuze *et al.*, 2017)

Table1. *Food Value (Per 100 g) of fresh cashew apple*

Moisture	84.4-88.7 g
Protein	0.101-0.162 g
Fat	0.05-0.50 g
Carbohydrates	9.08-9.75 g
Fiber	0.4-1.0 g
Ash	0.19-0.34 g
Calcium	0.9-5.4 mg
Phosphorus	6.1-21.4 mg
Iron	0.19-0.71 mg
Carotene	0.03-0.742 mg
Thiamine	0.023-0.03 mg
Riboflavin	0.13-0.4 mg
Niacin	0.13-0.539 mg
Ascorbic Acid	146.6-372.0 mg

The apple and nut fall together when both are ripe and, in commercial nut plantations, it is most practical to twist off the nut and leave the apple on the ground for later grazing by cattle or pigs. But, where labor costs are very low, the apples may be gathered up and taken to markets or processing plants. In the field, the fruits are picked up and chewed for refreshment, the juice swallowed, and the fibrous residue discarded. In the home and, in a limited way for commercial purposes, the cashew apples are preserved in syrup in glass jars. Fresh apples are highly perishable. Various species of yeast and fungi cause spoilage after the first day at room temperature. Food technologists in India have found that good condition can be maintained for 5 weeks at 32º to 35º F (0º-1.67º C) and relative humidity of 85% to 90%. In as much as the juice is astringent and somewhat acrid due to 35% tannin content (in the red: less in the yellow) and 3% of an oily substance, the fruit is pressure-steamed for 5 to 15 minutes before candying or making into jam or chutney or extracting the juice for carbonated beverages, syrup or wine. Efforts are made to retain as much as possible of the ascorbic acid.

However, cashew apple juice, without removal of tannin, is prescribed as a remedy for sore throat and chronic dysentery in Cuba and Brazil. Fresh or distilled, it is a potent diuretic and is said to possess sudorific properties.

Feeding Value of the Cashew Apple

Fanimo *et al.* (2004) studied the growth performance, nutrient digestibility and carcass characteristics of growing rabbits fed cashew apple waste (CAW) and found that rabbits fed diets with 20 and 30% CAW gained weight ($P < 0.05$) faster than those fed the control diet. Feed efficiency increased with increasing levels of CAW in the diets with rabbits on 30% CAW being most efficient. Crude protein digestibility decreased ($P < 0.05$) with increased level of CAW. There were no significant differences ($P < 0.05$) in the blood metabolites except cholesterol level which increased ($P < 0.05$) with CAW inclusion in the diets. Inclusion of CAW also increased ($P < 0.05$) the relative weights of kidney, liver and carcass characteristics. It was inferred that dried CAW can be included in growing rabbit diets at levels up to 30% of the dry matter. In examining the chemical composition of cashew apple and cashew apple waste ensiled with poultry litter, Fanimo *et al.* (2003) found that cashew apple fruit and cashew apple waste (after juice extraction) can be preserved for a long term use by anaerobic ensiling and that there appeared to be little advantage in mixing them with poultry litter before ensiling. The conversion of the soluble sugars into organic acids and alcohol may have negative effects on nutritive value. They, however, concluded that several feeding trials are necessary to substantiate their findings.

Constraints in the Use of Non-Conventional Feedstuffs

The slow growth rates of livestock when fed by-products of dried cashew apple have been attributed to poor feed intake and digestibility. Several processing methods have been suggested. However, chemicals for the processing are expensive and are all harmful. Thus, the technology of processing must be carefully coasted and programmed to fit within the income and competence limits of the poor farmer. Feed analysis is becoming very expensive in terms of reagents and equipment repair. In this regard, simple, cheap basic analytical procedures must be sought to give the needed research data. Although there are large quantities of by-products available, the collection and transportation of these from production sites is tedious and time consuming. There is also great variability in these products from different sources as the planting and harvesting of crops is not synchronized. There is also variability in the soil nutrient composition which varies the nutrient content of these by-products.

Table2. *Summary of various feedstuffs used as feed ingredients in Rabbit Production*

Feed Ingredients	Factors Affecting Inclusion Rate
*Palm kernel meal	Could go rancid or mouldy
*Oil palm slurry	Could go mouldy or rancid. High moisture content
*Cocoa pod husk	Contains theobromine. High fibre content
*Groundnut skin meal	Could go rancid. Presence of aflatoxin could result in poor growth
*Sheanut cake	Contains tannins and saponins
Dried beet pulp	High fibre content; low digestibility; acts as a laxative
Dried brewer's grains,	High fibre content; low energy; low lysine; source of B vitamins
Corn gluten feed	Low lysine; high fibre; low energy; variable nutrient content; unpalatable; bulky
Soybean meal	With (44%) or without (48%) hulls; good amino acid balance in combination with corn; palatable

The chemical composition of DCA is shown in Table 3 along with data on maize which it replaced in the experimental diets, for comparison.

Table3. *Chemical composition of DCP and maize (g kg-1 DM)*

Component	DCP1	Maize	DCP : Maize
Proximate composition			
Dry matter	810	887.5*	0.91
Crude Protein	86.0	89.2*	0.96
Ether extract	99.6	44.8*	2.22
Crude fibre	38.0	19.3*	2.00
Ash	38.0	19.0*	2.00
Nitrogen-free extractives	660.4	715.2*	0.92
Fibre Component			
Acid detergent fibre	121.7	32.3	3.77
Neutral detergent fibre	206.8	108.4	1.90
Hemicellulose	85.1	62.5	1.36
Mineral elements			
Calcium	7.2	0.3	24.0
Phosphorus	6.0	2.8	2.14
Potassium	16.5	3.3	5.00
Sodium	5.6	0.1	56.00
Digestible energy (MJ kg-1 DM)2	14.0	13.7	1.02

Anti- Nutritional Factors

Major constraint in the use of non-conventional feedstuffs is the anti-nutritional factors contained in them. Anti-nutritional factors may be defined as the chemical constituent of a feedstuff, which interferes in the normal digestion, absorption and metabolism of feeds, some of which may have deleterious effects on the animal's digestive system. Some inherent chemical constituents present in different kinds of feedstuffs interfere in the optimum utilization of nutrients and some are also toxic in high concentrations. Although anti-nutritional factors are present in many conventional feeds, these are more common in most of the non-conventional feeds (FAO, 2000). These anti-nutritional factors need to be removed or inactivated by various procedures before the use of the ingredients in the diet (Alawa and Oyarole, 2004). Many seeds, which were once used in traditional human and animal diets, have now fallen into disuse as agricultural and nutritional needs are re-assessed (Aletor *et al.*, 2007). Seeds often contain factors such as lectins, which are deleterious or toxic to animal or man (FAO, 2000). Seed lectins present major problems as they are resistant to heat treatment and some seeds such as kidney bean, have to be heated for several hours at temperatures above 80 ºC or boiled for 10-20 minutes to ensure the elimination of their lectin activity. Great caution should therefore be taken in the use of these seeds as dietary materials. This is particularly important since recent studies suggest that long-term exposure to relatively low levels of some anti-nutritional or toxic factors may have deleterious effects on body metabolism (Onu *et al.*, 2008).

Classification of Anti-Nutritional Factors

The various anti-nutritional factors in feedstuffs may be classified (by different ways) on the basis of the chemical nature into acids, enzymes, nitrogenous compounds, saponins, tannins, glucosinolates and phenolic compounds (FAO, 2000). Others are classified as follows:

- Tannins
- Saponins
- Trypsin or protease inhibitors
- Haemagglutinins

Factors Interfering with the Digestion and Utilization of Dietary Proteins and Carbohydrates

Tannins

These are polyphenol compounds of higher molecular weight (500-3000 dalton) and contain large numbers of reactive phenolic hydroxyl groups. They are broadly classified into hydrolysable and condensed tannins (Santos *et al.*, 2007). The tannins form complexes with protein, cellulose, hemicellulose, lignin and starch and interfere with their optimum utilization in the digestive tract and systems. A number of chemical treatments have been found to remove considerable amounts but none has been commercially utilized due to laborious processing techniques and the cost of chemicals (Santos-Lima *et al.*, 2012).

Saponins

On the basis of the chemical nature, saponins may be divided into two groups namely, steroids and phenoids. They are bitter and this reduces palatability. They also cause bloat in cattle. Saponins combine with cholesterol and reduce its activity. They are haemolytic and are fatal when injected into the blood (Santos – Filho *et al.*, 2005). They are widely distributed in plants like lucerne, white clover, red clover, soya-bean and mahuna seed cake. Saponins are water soluble and soaking of feed ingredients in water removes them.

Trypsin or Protease Inhibitors

The feed constituents interfering with the proteolytic enzymes are known as protease inhibitors and in poultry; trypsin inhibitor is due to specific activity on trypsin amino acid. Raw soybean cakes are rich in trypsin inhibitors. These inhibitors are easily inactivated by suitable heat treatment. Roasting, toasting, popping and cooking are effective treatments for the inactivation of protease inhibiting properties in feeds (Sengupta, 2007).

Haemagglutinins

The common agglutinins likely to affect animals are *ricin* in castor bean, phaseolotoxin in *Phaseolus vulgaris* and haemagglutinins in soybean. These are protein in nature and resistant to the action of pancreatic juice. They produce anti-nutritional factors, which produce inflammatory reactions causing oedema and clotting of blood in capillaries. Most of them are inactivated by moist cooking in two percent sodium hydroxide solution or by autoclaving (Silva *et al*., 2008).

Factors Interfering With The Availability Of Minerals

Phytase

Phytase are the salts of phytic acid and are found in almost all feeds of plant origin. The phytase are present in association with protein and generally high protein feeds contain high levels of phytase, for example groundnut cake, mustard cake, soya-bean cake, sesame cake, cotton seed cake and wheat bran (Silva *et al.*, 2011). Phytic acid possesses high chelating ability and in plants it is found as phytase of many minerals which are mostly not available to monogastric animals as they lack the phytase enzyme. The use of the enzyme, phytase as a feed additive has been made feasible in some countries due to its cheaper commercial production with the application of biotechnological processes (Silva *et al.*, 2013).

Oxalic Acid

Oxalic acid is an organic di-carboxylic acid that readily forms insoluble salts with calcium and magnesium. Oxalic acid and its soluble salts are both corrosive and poisonous. Their anti-nutritive effect is mainly through completing with calcium. The acid precipitates calcium and renders it less available for absorption. In pigs and poultry diets containing oxalic acid, there is depression in growth and a reduction in calcium retention (Sogunle *et al*., 2009). Oxalic acid is found in free form but mostly as salts (oxalates). Oxalic acid forms insoluble salts with calcium and magnesium and imparts anti-nutritional action. Paddy straw and wild paddies are the richest sources of oxalates (Small, 2011).

Glucosinolates

Plants, seeds and oil cakes of different mustard and rape varieties are rich sources of glucosinolates. These compounds reduce the incorporation of iodine into the precursor of thyroxin resulting in iodine deficiency and development of goiter. Prolong water soaking or cooking of feeds inactivates the effects of goiterogens (Rodrigues *et al.* 2011). Glucosinolates are responsible for the pungent flavour found in some cultivated plants belonging to the *Cruciferae*, which includes rapeseed and mustard seed.

Their main biological effect is to depress the synthesis of the thyroid hormones, thus producing goiter in animals fed on seed meals containing them (Rodrigues *et al.*, 2003). Apart from restrictions on use imposed by compositional factors such as toxins or physical factors that might be associated with rapid deterioration, it is important to assess the feed value of by-products in relation to the type of animal and the system of production in which the material is to be used (Rodrigues *et al.*,2010).

Gossypol

Gossypol is a toxic phenolic compound found in cottonseed. Ferrous salts can form a complex with free gossypol and reduce its harmful effects (Ribeiro – Filho *et al.*, 2012). High levels of calcium, magnesium, sodium and protein are also helpful in reducing the adverse effect of gossypol. Heat treatment considerably destroys gossypol but availability of lysine is greatly reduced and needs supplementation (Yidana 2000).

Phytoestrogens

Some chemical compounds with oestrogenic activities are integral constituents of many plants and in some legumes their concentration is high enough to produce harmful effects on health and productivity (Agbede and Aletor, 2003). Phosphorus deficiency and some climatic conditions favour the synthesis of phytoestrogens. Many reproductive problems develop on the extensive feeding of feeds containing phytoestrogens (Aroyeun, 2009).

Anti-Vitamins

Anti-vitamin activities against vitamin A and D have been observed in soya bean, against vitamin B in kidney bean, against vitamin K in sweet clover and against pyridoxine in linseed cake (Aremu *et al*, 2006).

Cyanogen

Cynogenic compounds are present in sorghum, grass, maize, etc. These glycosides are non-toxic but during droughts they produce hydrogen cyanide (HCN) which is toxic and results in the death of the animals. So far no method of removal of cyanogen from herbages has been developed but boiling has been found to be satisfactory for removing or destroying these from linseed meal (Okai *et al*., 2005).

Lathyrogens

The Lathyrogens are protein in nature and neurotoxins. Prolonged cooking or roasting of lathyrus seeds in hot sand has been found to destroy most of the Lathyrogens (Ranjhan, 2001).

Nitrates and Nitrites

The nitrates are found in plants and these nitrates can be converted to nitrites during storage and when this is fed, it is toxic to the animals (Omosuli *et al.*, 2009).

Techniques for Processing of By-Products for Feeding Purposes

Auto-Claving under Pressure at 115º-140º C

Autoclaving under pressure at 115º-140º C followed by drying and removal of fat by pressing or extraction is carried out in this process. This is used to obtain various kinds of animal protein meals such as meat and bone, poultry, fish, feathers and other meals produced from dead and condemned animals or carcasses (Ogunjobi and Ogunwolu, 2010).

Hydrothermal, Acid and Alkali Hydrolysis

These are used for processing wastes rich in keratin e.g. feathers, hooves, animal hair, tannery waste or some plant products containing glycosides such as rapeseed meal (Ojewola *et al.*, 2004).

Mechanical or Thermal Condensation and Drying

Centrifugation, pressing, or condensation in a vacuum evaporator is followed by spray, roller, flash or drum drying is carried out in this process. These techniques are used for yeasts, grains, potatoes, molasses, brewery waste, oil seed meals and also blood of slaughtered animals. (Odunsi 2002)

Microbiological and Chemical Souring

These techniques are used to prepare the by-products and are effective methods of removing harmful substances, for example, isothiocyanates from rape, souring of skim milk and whey, preserving by-products of animal origin: blood, rumen content, animal and poultry excrements which are now used as feed ingredients (Oddoye *et al.*, 2011).

Table4. *Flavonoids components detected in cashew apple (Brito et al., 2007).*

Compound	Cashew apple (mg/g)
Myricetin 3-O-galactoside	0.0532
Myricetin 3-O-glucoside	0.0274
Myricetin 3-O-xylopyranoside	0.0124
Myricetin 3-O-arabinopyrannoside	0.0104
Myricetin 3-O-arabinofuranoside	0.0097
Myricetin 3-O-rhamnoside	0.0400
Total myricetin glycosides	0.1511
Quercetin 3-O-galactoside	0.0465
Quercetin 3-O-glucoside	0.0144
Quercetin 3-O-xylopyranoside	0.0116
Quercetin 3-O-arabinopyrannoside	0.0108
Quercetin 3-O-arabinofuranoside	0.0079
Quercetin 3-O-rhamnoside	0.0227
Total quercetin glycosides	0.1139
Kaempferol 3-O-glucoside	Trace amount
5-Methylcyanidin 3-O-hexoside	0.0197
Total glycosylatedflavonoids	0.2847

In addition, it was reported that the various types of tannins were unequally distributed in the skin and the flesh of cashew apples (Michodjehoun-Mestres et al.,2009b). Results showed that both skin and flesh tannins contained high percentages of (-)-epigallocatechin and (-)-epigallocatechin-O-gallate, followed by low quantities of(-)-epicatechin and (-)-epicatechin-3-O-gallate; 100% of the compounds were 2,3-cis configuration. Skin tannins were half as galley lated (20%) than flesh tannins (40%).The 14 flavonoids determined in cashew apple by Britoet al. (2007) are shown in Table 4. The results showed that one anthocyanin and thirteen glycosylated flavones were detected in cashew apple methanol-water extract. This study demonstrated that cashew apple is a good source of flavonoids. Indeed, flavonoid of food plants has been reported to offer biological benefits, such as reduced risk of cancer and cardiovascular disease.

Flavor Chemistry of Cashew Juice

The evaluation of the volatile flavor compounds from cashew juice by the Osme gas chromatography/olfactometry technique showed that ethyl 3-methylbutanoate (16.70%), *trans*-2-hexenal (14.27%), methyl 3-methyl butanoate (9.72%), 2-methyl-2-pentenal (9.27%),ethyl but anoate (8.47%), hexanal (7.68%), 2- butoxy ethanol (3.35%), 3-methyl-1-butanol (3.23%), and2-methyl butanoic acid (3.01%) were the major compounds (Garruti et al., 2003).

Protein Concentration of Dried Cashew Pulp

The protein concentration of dried cashew pulp is slightly lower but the crude fibre, ether extract and ash contents as well as the digestible energy values are higher than maize. Even though the DCP contains higher amount of fibre (38.0 g kg-1 DM) compared to maize (19.3 g kg-1 DM), it had the higher energy content of 14.0 MJ/kg-1. The ADF fraction consists of lignin and cellulose, while the NDF fraction corresponds mainly to the sum of cellulose, hemi cellulose and lignin values. Fibre level has been found to be inversely related to energy content. This accrues at least in part from the low digestibility of the fibre component of the ingredients. The energy content of DCP, with its higher fibre content, was therefore expected to be the lower instead of being the higher when compared to that of maize. This could be explained by the fact that in addition to fibre, other chemical compounds can have a large effect on energy value (Aremu *et al.*, 2006). For example, the ether extract (fats and oils) which was higher for DCP, contains 2.25 times the energy of proteins and carbohydrates while ash contributes no energy. This might have influenced the energy content of DCP.

Cashew Toxicity

The study of *in vivo* toxicity of mixture of "cashew apple juice and milk" on mice to confirm or refute the idea that the cashew apple juice consumed with milk would be fatal showed that there was no toxicity of apple “juice milk” mixture. Instead, the richness of the mixture positively affects erythropoiesis in the studied mice. For the authors, the toxicity of the mixture is not proven on mice; it is permissible to conclude that it is not fatal also for human. So, the idea that the cashew apple juice consumed with milk would be fatal is refuted (Adou *et al.*,2013).

Results revealed that at 7% alcohol content and above it caused the distortion of the liver architecture of animals, indicator of toxicity (Awe *et al.*, 2013). Dare et al. (2011) investigated the effects of aqueous extract of *A.occidentale* leaf on pregnancy outcome of Wistar rats. The results showed that the extract of *A. occidentale* should not be taken by pregnant women, even if they suffer of diabetes (Dare *et al.*, 2011). Indeed, for example, intravenous administration of the hexane extract of the bark of (cashew) in normal, healthy dogs produced a significant lowering of the blood glucose levels probably due to the presence of stigmast-4-en-3-oland stigmast-4-en-3-one (Alexander-Lindo *et al.*, 2004).

Conclusion

Cashew (*A.occidentale*L.) apple is a good source of antioxidant compounds, reducing sugars, minerals, and some amino acids. Several parameters, such as genetic and climatic variations as well as ecological zones and ripening stage can significantly affect the chemical composition of cashew apples. The quality of post harvested cashew apples has been influenced by the production systems. Cashew apple is subjected to several processes after the harvest which influences its physico-chemical characteristics and quality attributes. It is important to encourage the valorization of cashew apples in developing countries by the improvement of the process of cashew apples available in these countries in order to contribute to the nutritional needs of the populations.

References

[1] Abdulraheem MO, Aberuagba F, Oka for JO and Otaru AJ (2013). Physio chemical properties of malted sorghum as material for mucamaltusing cashew apple juice extract as vitamin C fortifier. J. Appl. Chem.4(2):67-78.

[2] Abreu F, Perez AM, Dornier M and Reynes M (2005). Application of cross flow microfiltration in the production of clarified cashew juice by means of mineral membranes. Fruits 60(1):33-40.

[3] Acero, L. H. ; Lagan, C. G. and Padul, M. A. C., (2013). Growth performance of fattening hogs fed with fresh and dried cashew apple. In: Juan, L. (Ed.), Int. Proc. Chem., Biol. Env. Eng. (IPCBEE), 51 (5): 23-27

[4] Adeyeye, S. A. ; Onibi, G. E. ; Agbede, J. O. and Aletor, V. A.,(2007). Meat quality of broilers fed discarded cashew nut meal in place of soyabean meal. J. Anim. Veter. Adv., 6 (2): 242-248

[5] Adou M, Kouassi DA, Tetchi FA andAmani NG (2011a). Phenolic profile ofcashew apple juice (AnacardiumoccidentaleL.) from Yamoussoukroand Korhogo (Côte d"Ivoire). J. Appl. Biosci. 49:3331-3338.

[6] Adou M, Tetchi FA, Gbane M, Koffi PVN and Amani NG (2011b). Mineralscomposition of

the cashew apple juice (Anacardium occidentale L) ofYamoussoukro, Côte d'Ivoire. Pak. J. Nutr. 10(12):1109-1114.

[7] Adou M, Tetchi FA, Gbané M, Kouassi KNandAmani NG (2012). Physicochemicalcharacterization of cashew apple juice(AnacardiumoccidentaleL.) from Yamoussoukro (Ivory Coast). Innov.Rom. Food Biotechnol. 11:32-43.

[8] Adou M, Tetchi FA, Kouadio JAand Amani NG (2013). Preliminary study ofin vivo toxicity of mixture "cashew apple juice-milk" on mice. Int. J.Pharm. Pharm. Sci. Res. 3(1):41-47.

[9] Agbede, J.O and Aletor, V.A. (2003). Evaluation of fishmeal replaced with protein concentrate from Glyricidia in diets for broiler-chicks: Effect on performance, muscle growth, hematology and serum metabolites. International Journal of Poultry Science 2, 242 – 252.

[10] Agostini-Costa, TS, Lima MV, Lima A, Aguiar MJ, de Lima JB andPaiva J(2002). Taninoempedúnculos de caju: efeito de algumasvariaçõesgenéticas e climáticas. B. Ceppa, Curitiba 20(2):267-278.

[11] Ahaotu, E.O,Akinfemi, A and Obih, T.K.O (2013a). Effects of processed ripe banana peel meal (Musa sapentum) as energy source for growing rabbits. Proc. 38th Conf., Nig . Soc. Anim. Prod. 17-20 March, 2013. Pp 275-277.

[12] Ahaotu, E.O, Ihezuo, J.P, Ahumibe, K, Anumihe, E.C, Ayo -Enwerem, C.M, Iwuanyanwu, U.P and Ehirim, V.I (2013b). Partial replacement value of sun dried Layers droppings for groundnut (Arachis hypogea) cake on the performance of Chinchilla Rabbits. Proc.38th Conf., Nig. Soc. Anim.Prod. 17-20 March, 2013. Pp 282 - 285.

[13] Ahaotu, E.Oand Onu, P.N (2013). Effects of Repeated Coitus on Luteining Hormone and Reproductive Performance in the Rabbits. Inter J Vet Sci. 2 (2): 68 - 70 .

[14] Ahaotu, E.O,Onuwka, C. F. and Ayo-Enwerem C. M. (2008). Commercial Rabbit Production. Jeolas Press, Owerri, Nigeria. 87 pp.

[15] Akande, T. ; Akinwumi, A. and Abegunde, T., (2015). Nutritional and economic implications of cashew reject meal in diets of laying chickens. Tropentag 2014, Prague, Czech Republic. 123pp.

[16] Akande T.O., Odunsi A.A, Olabode O.S. and Ojediran T.K. (2012). Physical and Nutrient Characterisation of Raw and Processed Castor Seeds in Nigeria. World Journal of Agricultural Sciences 8 (1): 89-95

[17] Akinwale TO (2000). Cashew apple juice: Its use in fortifying thenutritional quality of some tropical fruits. Euro. Food Res Technol.211:205-211.

[18] Alawa, J.P. and F.T. Oyarole, (2004). The effect of varying the roughage to concentrate ratio on the performance of growing rabbits. Bulletin of Animal Health and Production in Africa, 52: 263-265

[19] Aletor, O, Agbede, J.O, Adeyeye, S.Aand Aletor, V.A. (2007).Chemical and physio-chemical Characterization of the Flours and Oils from Whole and Rejected Cashew Nuts Cultivated in Southwest Nigeria. Pakistan Journal of Nutrition 6, 89-93.

[20] Alexander-Lindo RL, Morrison EYA and Nair MG (2004). HypoglycaemicEffect of Stigmast-4-en-3-one and its Corresponding Alcohol from theBark of Anacardiumoccidentale (Cashew). Phytother. Res.18:403-407.

[21] Almeida Lopes MM, de Miranda MRA, Moura CFH and Filho JE (2012).Bioactive compounds and total antioxidant capacity of cashew apples(Anacardium occidentalel.) during the ripening of early dwarf cashewclones. Ciênc. Agrotec. 36(3):325-332.

[22] Andrade APS, de Oliveira VH, Innecco R andSilva EO (2008). Qualidadede cajus-de-mesa obtidosnos sistemas de produçãointegrada econvencional. Rev. Bras. Frutic. 30(1):176-179.

[23] Anucha, V.A and Egbunwoke, C (2012). Effects of Ripe Plantain Peel Meal on the Performance of Weaner New Zealand White Rabbits. Student Project, Department of Animal Production and Health Technology, Imo State Polytechnic Umuagwo, Nigeria. 61 pp.

[24] AOAC (2001). Official methods of analysis, revised edition. Association of Official Analytical

Chemists. Washington D.C

[25] Aremu M.O, Olonisakin A, Bako D.A and Madu P.O (2006). Compositional studies and physico-chemical characteristics of cashew nut (Anacardium occidentale) flour. Pakistan Journal of Nutrition, 5(4), 328 –333.

[26] Armah, I.N.A. (2011).The effect of starter-grower pigs fed diets containing varying levels of dried cashew (Anarcadium Occidentale L.) pulp. PhD thesis, Kwame Nkrumah University of science and technology of Kumasi, Ghana, 180 pp.

[27] Aroyeun S.O (2009). Utilization of cashew kernel meals in the nutritional enrichment of biscuit. African Journal of Food Science, 3(10), 316 – 319.

[28] Assuncao RB and Mercadante AZ (2003). Carotenoids and ascorbic acidfrom cashew apple (AnacardiumoccidentaleL.): variety

andgeographic effects. Food Chem. 81:495-502.

[29] Awe S, Sani, A, Eniola, KIT andKayode, RMO (2013). Toxicological Assessment of locally produced cashew wine. IJRRAS 15(1):125-131.

[30] Bi-calho, B. (2001). Volatile compounds of cashew apple (Anacardium occidentale L.). Z. Naturforsch Journal, 56 (1–2): 35–39.

[31] Bidaisee G and Badrie N (2001). Osmotic dehydration of cashew apple(Anacardiumoccidentale L.): quality evaluation of candied cashewapples. Int. J. Food Sci. Technol. 36:71-78.

[32] Bouafou, K. G. M. ; Konan, B. A. ; Zannou-Tchoko, V. and Kati-Coulibally, S., (2011). Cashew in breeding: research synthesis. Int. J. Agron. Agric. Res, 1 (1): 1-8

[33] Brasil, A. F., (2003). Effect of cashew nuts in dairy cow diets on their post partum reproduction activity. Dissertação (MestradoemCiênciasVeterinárias) UniversidadeEstadual do Ceará, Fortaleza-Ceará, 46p

[34] Brito ES, Araujo MCP, Lin LZ andHarnly J (2007). Determination of theflavonoid components of cashew apple (Anacardium occidentale) byLC-DAD-ESI/MS. Food Chem. 105: 1112-1118.

[35] Campos DCP, Santos AS, Wolkoff DB, Matta VM, Cabral LMC, Couri S(2002). Cashew apple juice stabilization by microfiltration.Desalination 148:61-65

[36] Carvalho JM, Maia GA, Figueiredo RW, Brito ES, Rodrigues S (2007).Storage stability of a stimulant coconut-cashew apple juice beverage.J. Food Process. Pres. 31:178-189.

[37] Carvalho JM, Maia GA, Figueiredo RW, Brito ES andRordrigues S (2006).Development of a blended beverage consisting of coconut water andcashew apple juice containing caffeine. Int. J. Food Sci.Technol.42:1195-1200

[38] Castro TR, de Abreu FAP andCarioca JOB (2007). Obtenção de sucoclarificado de caju (Anacardium occidentale, L) utilizan do processosde separaçãopormembranas. Rev. Ciênc. Agron. 38(2):164-168.

[39] Cianci FC, Silva LFM, Cabral LMC and Matta, VM (2005). Clarification andconcentration of cashew applejuice by membrane processes. Ciênc.Tecnol. Aliment. 25(3):579-583

[40] Cormier R (2008). Clarification of Cashew Apple Juice and CommercialApplications. Oxfarm Quebec, Benin, West Africa. pp. 1-9

[41] Couri S, Ferreira de Menezes L, Saavedra Pinto GA, Souza MLM and Pereira F S (2003).Comparison of the cashew apple(Anacardium occidentale L.) juice clarification with tannase andgelatin. Boletim do Centro de Pesquisa e Processamento deAlimentos. 20(1):41-54

[42] Cruz, C. E. B. ; Freitas, E. R. ; Xavier, R. P. S. ; Fernandes, D. R. ; Nascimento, G. A. G. and Watanabe, P. H., (2015). Cashew nut meal in the feeding of brown laying hens. Ciênc

[43] Damasceno JJA and Bezerra FC (2002). Qualidade de pedúnculo decajueiro-anãoprecocecultivadosobirrigação e submetido adiferentes sistemas de condução e espaçamento. Rev. Bras. Frutic.24(1):258-262.

[44] Damasceno LF, Fernandes FANM and Brito ES (2008). Evaluation andoptimization of non-enzymatic browning of“cajuina” during thermaltreatment. Braz. J. Chem. Eng. 25(2):313-320.

[45] Dantas– Filho, L. A. ; Lopes, J. B. ; Vasconcelos, V. R. ; Oliveira, M. E. de ; Alves, A. A. ; Araujo and D. L. da C. ; Conceicao, W. L. F., (2007). Effects of feeding dried cashew pulp on performance, digestibility and nitrogen balance in sheep. Rev. Bras. Zootec., 36 (1): 147-154

[46] Dare SS, Hamman WO, Musa S, Goji ADT, Oyewale AA, Abba S andEzekiel I (2011). Effects of Aqueous Extract of Anacardiumoccidentale (Cashew) Leaf on Pregnancy Outcome of Wistar Rats. Int. J. Anim. Vet. Adv. 3(2):77-82

[47] Davis L., Stonehouse W., du Loots T., Mukuddem-Petersen J., van der Westhuizen F. HandHanekom S. M., (2007). The effects of high walnut and cashew nut diets on the antioxidant status of subjects with metabolic syndrome. Eur. J. Nutr. 46:155–164.

[48] Dèdéhou ESCA, Dossou J, Ahohuendo B, Saïdou A, Ahanchédé A and Soumanou MM(2015a).Optimizationofcashew(Anacardiumoccidentale L.) apple juices clarification process by using cassava and rice starch. J. Appl. Biosci. 95:8989-9002.

[49] Dèdéhou ESCA, Dossou J andSoumanou MM (2015b). Etudediagnostique des technologies de transformation de la pomme decajou en jus au Bénin. Int. J. Biol. Chem. Sci. 9(1):371-387.

[50] Ebere C.O, Emelike N.J.T and Kiin-Kabari D.B (2015). Physico-chemical and sensory properties of cookies prepared from wheat flour and cashew-apple residue as a source of fibre. Asia Journal of Agriculture and Food Science, 3(2), 213-218.

[51] Edet, E.A. (2007).Chemical Evaluation of the Nutritional value of raw and roasted cashew nut. M.Sc Thesis, University of Calabar, Nigeria, 120-130.

[52] Edet, E.A, Ibok, I.U and Edward, A.C. (2010).Evaluation of protein quality of raw and roasted cashew nuts (Anacardium occidentale)

using weanling albino rats. Nigerian Journal of Agriculture, Food and Environment. 6, 90-93.

[53] Egbekun MK and Otiri AO (2010). Changes in ascorbic acid contents inoranges and cashew apples with maturity. Ecol. Food Nutr. 38:275-284.

[54] Emelike N.J.T and Ebere C.O (2015). Effect of packaging materials, storage time and temperature on the colour and sensory characteristics of cashew (Anacardium occidentale L.) apple juice.Journal of Food and Nutrition Research, 3(7), 410 – 414.

[55] Falade KO, Akinwale TO andAdedokun OO (2003).Effect of dryingmethods on osmotically dehydrated cashew apples. Eur. Food Res.Technol. 216(6):500-504.

[56] Fanimo, A.O., Oduguwa, O.O., Adewunmi, T.E and Lawal, A.I. (2004). Utilization of diets containing cashew-nut reject meal by weaner pigs. Nig J. Anim. Prod., 3(1):22-26.

[57] Fanimo, O. A., Oduguwa, O.O., Alade, A. A., Ogunnaike T.O. and Adesehinwa, A.K. (2003). Growth performance, nutrient digestibility and carcass characteristics of growing rabbits fed cashew apple waste. National Agricultural Extension and Research Liaison Services, South West Zone, Nigeria.

[58] Figueiredo RW, Lajolo FM, Alves RE, Filgueiras HAC, Maia GAand deSousa PHM (2007). Qualidade de pedúnculos de cajusubmetidos àaplicaçãopós-colheita de cálcio e armazenados sob refrigeração.Pesq. Agropec. Bras. 42(4):475-482.

[59] Food and Agriculture Organization (FAO) (2000). Cashew Production in Africa. FAO, Crop Production Health Division, Rome, Italy. Franca. Pp 56-87.

[60] Gao J andRupasinghe HPV (2012). Nutritional, Physicochemical andMicrobial Quality of Ultrasound-Treated Apple-Carrot Juice Blends.Food Nutr. Sci. 3:212-218.

[61] Garruti DS, Franco MRB, da Silva MAAP, Janzantti NS and Alves GL(2003). Evaluation of volatile flavour compounds from cashew apple(Anacardium occidentale) juice by the Osme gaschromatography/olfactometry technique. J. Sci. Food Agric. 83:1455-1462.

[62] Giro MEA, Martins JJL, Rocha MVP, Melo VMM andGonçalves LRB(2009). Clarified cashew apple juice as alternative raw material forbiosurfactant production by Bacillus subtilis in a batch bioreactor.Biotechnol. J. 4:738-747.

[63] Gordon, S. P and Gordon, F. S. (2004). Contemporary Statistics: A Computer Approach. McGraw – Hill Publishers, U.S.A. pp 46 -54

[64] Gordon A, Friedrich M, da Matta VM, Moura CFH and Marx F (2012).Changes in phenolic composition, ascorbic acid and antioxidantcapacity in cashew apple (Anacardium occidentale L.) duringripening. Fruits 67:267-276.

[65] Gyedu-Akoto E (2011). Utilization of some cashew by-products. Nutr.Food Sci. 41(8):393-400.

[66] Heuzé V., Tran G., Hassoun P., Bastianelli D. and Lebas F., (2017). Cashew (Anacardium occidentale) nuts and by-products. Feedipedia, a programme by INRA, CIRAD, AFZ and FAO. http://www.feedipedia.org/node/56Last updated on March 30, 2017, 16:17

[67] Honorato TL, Rabelo MC, Goncalves LRB, Pinto GAS andRodrigues S(2007a). Fermentation of cashew apple juice to produce high addedvalue products. World J. Microbiol. Biotechnol. 23:1409-1415.

[68] Honorato TL, Rabelo MC, Pinto GA S andRodrigues S (2007b). Produçãode ácidolático e dextranautilizandosuco de cajucomosubstrato.Ciênc. Tecnol. Aliment. 27:787-792.

[69] Honorato TL and Rodrigues S (2010). Dextransucrase Stability in CashewApple Juice. Food Bioprocess Technol. 3:105-110.

[70] IMLS (2010): Imo State Ministry of lands and survey – Detailed Atlas of the State.

[71] Jayalekshmy VG and John PS (2004). Sago‟- a natural product for cashewapple juice clarification. J. Trop. Agric. 42:67-68.

[72] Kankam – Boadu, I. (2000). Nutrient Requirement on the Growth , Development and Yield of Cashew (Anarcadium occidentale). BSc. (Hons) Agriculture Dissertation. KNUST, Kumasi, Unpublished. 119 pp.

[73] Kazimerz S. (2003). A comparison of sun-cured and dehydrated alfalfa meal in the diet of chicks. Poultry Sci., 22 : 659.

[74] Kuila A, Singh A, Mukhopadhyay M andBanerjee R (2011). Processoptimization for aqueous extraction of reducing sugar from cashewapple bagasse: A potential, low cost substrate. Food Sci. Technol.44:62-66.

[75] Lavinas FC, de Almeida NC, Miguel MAL, Lopes MLM and Valente-Mesquita VL (2006). Estudo da estabilidadequímica e microbiológicado suco de cajuinnaturaarmazenadoemdiferentescondições de estocagem. Ciênc. Tecnol. Aliment. 26(4):875-83.

[76] Lima JR, Elizondo NJ andBohuon P (2010). Kinetics of ascorbic aciddegradation and colour change in ground cashew apples treated athigh temperatures (100-180°C). Int. J. Food Sci. Technol. 45:1724-1731.

[77] Lowor STand Agyente-Badu CK (2009). Mineral and proximatecomposition of cashew

apple (Anacardiumoccidentale L.): Juice fromNorthern Savannah, Forest and Coastal Savannah Regions in Ghana. Am. J. Food Technol. 4:154-161.

[78] Luciano, R. C. ; Araújo, L. de F. ; Aguiar, E. M. ; Pinheiro, E. L and Nascimento, D. S. do, (2011). Review of the potentiality of the cashew peduncle in animal feed. Tecnol. Ciên. Agropec., 5 (3): 53-59

[79] Maia GA, de Sousa Filho M, de Figueiredo RW, Montenegro Brasil I(2004). Caracterizaçãoquímica de pedúnculos de diferentes clonesde cajueiroanãoprecoce (Anacardium occidentale, L.). Rev. Ciênc. Agron. 35:272-278.

[80] Marques LF, Duarte MEM, Costa TL and Sousa JDS (2007). Efeito daconcentração do xaropenadesidrataçãoosmótica e nacaracterizaçãofísico-química do caju. Rev. Biol. Ciênc. Terra 7(2):147-152.

[81] Martins MCP, Cunha TL and Silva MR (2008).Effect of dehydration osmotic conditions on the quality of cashew apple from cerrado. Ciênc. Tecnol. Aliment. (28):158-165.

[82] Mbaegbu, I (2012). Effects of Water Leaf (Talinum triangulare) Shoot Meal on the Performance of Weaner Rabbits.Student Project, Department of Animal Health Technology, Imo State Polytechnic Umuagwo, Nigeria. 57 pp.

[83] Melo SSF and de Macedo GR (2008). Aplicação da metodologiadesuperfície de respostanoestudo da produção e extraçãodapoligalacturonase. Quim. Nova 31(8): 1973-1978.

[84] Mesquita PC, Maia GA, Souza FMM andNassu RT (2003). Microbiological,physico-chemical and sensorial stability of cashew apples(Anacardium occidentale L.) processed by combined methods. Ciênc.Tecnol. Aliment. 23(3):366-369.

[85] Michodjehoun-Mestres L, Souquet JM, Fulcrand H, BouchutC,Reynesa M and Brillouet JM (2009a). Monomeric phenols of cashewapple (Anacardium occidentale L). Food Chem. 112:851-857.

[86] Michodjehoun-Mestres L, Souquet JM, Fulcrand H, Meudec E, ReynesM, and Brillouet JM (2009b). Characterisation of highly polymerizedprodelphinidins from skin and flesh of four cashew apple(Anacardium occidentale L.) genotypes. Food Chem. 114:989-995.

[87] Moreira AP, El-Aouar A, Tonon R V, Kurozawa LE, Antonio GC, MurrFEX and Park KJ (2009). Effect of osmotic dehydration on the dryingkinetics and quality of cashew apple. Int. J. Food Sci. Technol. 44:980-986

[88] Neelakandan T and Usharani G (2009). Optimization and Production ofBioethanol from Cashew Apple Juice Using Immobilized Yeast Cellsby Saccharomyces cerevisiae. Am. Eurasian J. Sci. Res. 4:85-88.

[89] Okai, D.B., Abora, P.K.B., Davis, T and Martin, A. (2005). Nutrient composition, availability, current and potential uses of “Dusa”: A cereal by-product obtained from “koko” (porridge) production. Journal of Science and Technology, 25:33-38.

[90] Oliveira MEB, Oliveira GSF, Maia GA and Moreira RA (2002). Aminoácidosmajoritários no suco de caju: Variaçãoaolongo da safra. Rev. Bras.Frutic. 24:133-137.

[91] Omosuli S.V, Ibrahim T.A and Oloye D. (2009). Proximate and mineral composition of roasted and defatted cashew nut flour. Patistan Journal of Nutrition, 8(10), 1649 – 1651.

[92] Onu, P.N,Ahaotu, E.O and Ayo – Enwerem, C.M (2013). Effects of feed restrictions on growth performance, carcass traits and meat quality of growing rabbits. Inter J Agri Biosci, 2(4): 144-148

[93] Onu, P.N, Otuma, M.O, Nwakpu, P.E andAhaotu, E.O (2008). Enzyme and Probiotic Supplementation of Maize Processing waste based diets for weaned Rabbits. Proc. 42nd Annual Conf. Agricultural Society of Nigeria (ASN). October 19th – 23rd 2008. Ebonyi State University, Abakiliki, Nigeria.

[94] Onyekwere, M.U, Okechukwu, S.O, Akakemo, B.N andAhaotu, E.O(2011). Performance andnutrient evaluation of toasted velvet beans (Mucuna utilis) meal fed weaner rabbits. Proc. 36th conf., Nig. Soc. For Anim. Prod. 13 – 16 March, 2011, Abuja, Nigeria. Pp 744-746.

[95] Osho A (1995). Evaluation of cashew apple juice for single cell proteinand wine production. Nahrung 39:521-529.

[96] Pereira ALF, Maciel TC and Rodrigues S (2011). Probiotic beverage fromcashew apple juice fermented with Lactobacillus casei. Food Res. Int.44(5):1276-1283.

[97] Polydera AC, Stoforos NG and Taoukis PS (2003). Comparative shelf lifestudy and vitamin C loss kinetics in pasteurized and high pressureprocessed reconstituted orange juice. J. Food Eng. 60:21-29.

[98] Queiroz PC, Lavinas FC, Lopes MLM and Valente-Mesquita VL (2008).Industrialized cashew juices: variation of ascorbic acid and otherphysicochemical parameters. Ciênc. Tecnol. Aliment. Campinas 28:266-270.

[99] Quoc AL, Fustier P, Couture R, Castaigne F and Makhlouf J (1999). Effectof various

clarification agents on tannin removal, chemicalcomposition and stability of cashew juice. Sci. Aliments 18(4):375-391.

[100] Rabelo MC, Fontes CPML, and Rodrigues S (2009). Enzyme synthesis ofoligosaccharides using cashew apple juice as substrate.Bioresour.Technol.100:5574-5580

[101] Ranjhan S.K. (2001). Animal Nutrition in the Tropics. (6th Edition). Vikas Publishing House. PVT Ltd, New Dehli India. pp. 209,466

[102] Ribeiro Filho, M. R. and Soto-Blanco, B., (2012). Poisoning by cashew apple (Anacardium occidentale L.) in cattle. Acta Scientiae Veterinariae, 40 (4): art. 1083.

[103] Rocha MVP, Oliveira AH, Souza MCM andGonçalves LRB (2006). Naturalcashew apple juice as fermentation medium for bio surfactant production by Acineto bactercalco aceticus. World J. Microbiol. Biotechnol. 22(12):1295-1299.

[104] Rodrigues, M. de M. ; Neiva, J. N. M. ; Vasconcelos, V. R. de ; Lobo, R. N .B. ; Pimentel, J. C. M. ; Moura, A and de A. A. N, (2003). Levels of cashew nuts meal in diets for feedlot sheep. Rev. Bras. Zootec., 23 (1): 240-248

[105] Rodrigues, M. R. C.; Rondina, D.; Araujo, A. de A.; Arruda, I. J.; Silva, L. M.; Nunes-Pinheiro, D. C. and Fernandes, A. A. O, (2010). Use of dehydrated cashew apple pomace (Anacardium occidentale) the feeding of lambs weaning puberty: metabolic responses and sex hormone. Cien. Anim., 20 (1): 17-26

[106] Rodrigues, M. R. C. ; Rondina, D. ; Araujo, A. A. ; Souza, A. L. ; Nunes-Pinheiro, D. C. ; Fernandes, A. A. O. and Ibiapina, F. L., (2011). Reproductive and metabolic responses of ewes fed dehydrated cashew apple bagasse during the postpartum period. Arq. Bras. Med. Vet. Zootec., 63 (1): 171-179

[107] Sampaio KL, Garruti DS, Franco MRB, Janzanttic NS and da Silva MAAP(2011). Aroma volatiles recovered in the water phase of cashewapple (Anacardium occidentaleL.) juice during concentration. J. Sci.Food Agric. 91:1801-1809.

[108] Santos, R. P.; Santiago, A. A. X.; Gadelha, C. A. A.; Cajazeiras, J. B.; Cavada, B. S.; Martins, J. L.; Oliveira, T. M.; Bezerra, G. A.; Santos, R. P. and Freire, V. N., (2007). Production and characterization of the cashew (Anacardium occidentale L.)peduncle bagasse ashes. J. Food Engineer., 79: 1432–1437

[109] Santos Lima, F. C. dos ; Silva, F. L. H. da ; Gomes, J. P. ; Silva Neto and J. M. da, (2012). Chemical composition of the cashew apple biogases and potential use for ethanol production. Adv. Chem. Eng. Sci.,2(4):519-523

[110] Santos-Filho, J. M. ; Morais, S. M. ; Rondina, D. ; Beserra, F. J. ; Neiva, J. N. M. and Magalhaes, E. F., (2005). Effect of cashew nut supplemented diet, castration, and time of storage on fatty acid composition and cholesterol content of goat meat. Small Rum. Res., 57 (1): 51-56

[111] Silva, R. B. ; Freitas, E. R. ; Fuentes, M. F. F. ; Lopes, I. R. V. ; Lima, R. C. and Bezerra, R. M., (2008). Chemical composition and values of metabolizable energy of alternative feedstuffs determined with different birds. Acta Sci. Anim. Sci., 30 (3): 269-275

[112] Silva, L. M. ; Oliveira, C. H. A. ; Rodrigues, F. V. ; Rodrigues, M. R. C. ; Beserra, F. J. ; Silva, A. M. ; Lemos, J. C. ; Fernandes, A. A. O. and Rondina, D., (2011). Performance in vivo and carcass characteristics of lambs fed with cashew apple bagasse. Arch. Zootec., 60 (231): 777-786

[113] Silva, V. L.; Rogerio, M. C. P.; Bomfim, M. A. D.; Leite, E. R.; Landim, A. V.; Alves, A. A.; Costa, H. H. A and Freire, A. P. A., (2013). Intake and digestibility of dietary nutrients in lambs of different genetic groups fed with cashew nut meal. Rev. Bras. Saúde Prod. Anim., 14 (4): 695-709

[114] Sivagurunathan P, Sivasankari S and Muthukkaruppan SM (2010).Characterisation of cashew apple (AnacardiumoccidentaleL.) fruitscollected from Ariyalur District. J. Biosci. Res. 1(2):101-107.

[115] Small, E., (2011). Top 100 exotic food plants. CRC Press, Taylor and Francis Group, Boca Raton, USA

[116] Sogunle, O. M. ; Fanimo, A. O. ; Abiola, S. S. and Bamgbose, A. M., (2009). Performance of growing pullets fed cassava peel meal diet supplemented with cashew nut reject meal. Arch. Zootec., 58 (221): 23-31

[117] Souza ARM, Brazaca SGC, Arthur V, Oliveira AGC and Spoto MHF(2009). Efeito da radiaçãogama e do armazenament on a qualidadede pedúnculos de caju (Anacardium occidentale L.). Ciênc. Agrotec.33(3):848-854

[118] Souza Filho MSM, Lima JR, Souza, ACR, Souza Neto MA and Costa MC(1999). Efeito do branqueamento, processo osmótico, tratamentotérmicoarmazenamentonaestabilidade da vitamina C depedúnculos de cajuprocessadospormétodoscombinados.Ciênc. Tecnol. Aliment.19(2):211-213.

[119] Steel, R. G., and Torrie, J. H. (1980). Principles and Procedures of Statistics: A biometrical approach. 3rdEdition.McGraw – Hill Book Coy, N.Y. U.S.A.

[120] Talasila U, Vechalapua RR andShaik KB (2011). Preservation and shelf life extension of

cashew apple juice.Int. J. Food Safe. 13:275-280.

[121] Talasila U, Vechalapua RR andShaik KB (2012).Storage stability ofcashew apple juice - Use of artificial preservatives. J. Food Process.Technol. 10(4):117-123.

[122] Trevisan MTS, Pfundstein B, Haubner R, Wurtele G, Spiegelhalder B,Bartsch H and Owen RW (2006). Characterization of alkyl

[123]phenols incashew (Anacardium occidentale) products and of their antioxidant capacity. Food ChemToxicol. 44:188-197.

[124] Tuah A.K., Okai, D.B., Osei, S.A., Atuahene, C.C., Ampomsem, K.B., Barnes A.R., Rhule S.W.A. and Adomako, D. (2003). Utilisation of cocoa pod husk in animal feeding systems in Ghana. In: Proceedings of the international Workshop on the Utilization of Cocoa By-products." Enhancing farmers' incomes through the processing of cocoa by-products",Accra Ghana.

[125] Uchoa AMA, da Costa JMC, Maia GA, Meira TR, Sousa PHM and Brasil IM(2009).Formulation and Physico-chemical and Sensorial Evaluation ofBiscuit-Type Cookies Supplemented with Fruit Powders Plant FoodsHum. Nutr. 64(2):153-159.

[126] Vasconcelos, V. R. ; Leite, E. R. ; Rogerio, M. C. P. ; Pimentel, J. C. M. and Neiva, J. N. M., (2002). Utilization of by-products of the fruit industry in goat and sheep feeding Documentos - EmbrapaCaprinos, 42, 36 pp.

[127] Venkatesh M, Pushpalatha PB, Sheela KB andGirija D (2009). Microbialpectinase from tropical fruit wastes. J. Trop. Agric. 47(1-2):67-69.

[128] Vergara CMAC, Honorato TL, Maia GA and Rodrigues S (2010). Prebioticeffect of fermented cashew apple(Anacardium occidentale L) juice.Food Sci. Technol. 43:141-145.

[129] Yao, K. S. A. ; Kimse, M. ; Soro, D. and Fantodji, A., (2013). Effect of incorporation of cashews in food rations on growth performance of pigs: phases and post-weaning growth. Int. J. Biol. Chem. Sci., 7 (2): 479-488

[130] Yidana, J. A. (2000). Report on Development of Cashew as a High Horticultural Crop. National Agricultural Research Programme (NARP). Technical Report.

[131] Zepka LQ and Mercadante AZ (2009). Degradation compounds ofcarotenoids formed during heating of a simulated cashew apple juice.Food Chem.117:28-34.

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