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 cashew apple 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 main producers (Rabelo et al., 2009). Cashew apple is the peduncle 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 et al., 2007a). It can be processed to obtain juice, ice cream, and other foodstuffs (Dédéhou 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; Gordonet 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, 2003).
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 et al., 2002; Couriet 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; Queirozet 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; Venkateshet al., 2009; Honorato and Rodrigues, 2010; Lima et al., 2010; Vergara et al., 2010; Kulaet al., 2011; Silveiraet 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 Aygente-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 physicochemical 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, capryllic acid, cardanol, cardol, europium, folacin, gadoic acid, gallic acid, gingkol, glucuronic acid, glutamic acid, hafnium, hexanal, histidine, hydroxybenzoic acid, isoleucine, kaempferols, L-epicatechin, lauric acid, lecine, 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 50 days 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 quercitin, and quercetin 3-O-rhamnosidewere the main flavonoid present in all phases. The antioxidant capacity and the concentration of ascorbic acid 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).

**Table 1. Food Value (Per 100 g) of fresh cashew apple**

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>84.4-88.7 g</td>
</tr>
<tr>
<td>Protein</td>
<td>0.101-0.162 g</td>
</tr>
<tr>
<td>Fat</td>
<td>0.05-0.50 g</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>9.08-9.75 g</td>
</tr>
<tr>
<td>Fiber</td>
<td>0.4-1.0 g</td>
</tr>
<tr>
<td>Ash</td>
<td>0.19-0.34 g</td>
</tr>
<tr>
<td>Calcium</td>
<td>0.9-5.4 mg</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>6.1-21.4 mg</td>
</tr>
<tr>
<td>Iron</td>
<td>0.19-0.71 mg</td>
</tr>
<tr>
<td>Carotene</td>
<td>0.03-0.742 mg</td>
</tr>
<tr>
<td>Thiamine</td>
<td>0.023-0.03 mg</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>0.13-0.4 mg</td>
</tr>
<tr>
<td>Niacin</td>
<td>0.13-0.539 mg</td>
</tr>
<tr>
<td>Ascorbic Acid</td>
<td>146.6-372.0 mg</td>
</tr>
</tbody>
</table>

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 32° to 35° F (0°-1.67° 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
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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 coated 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.

Table 2. Summary of various feedstuffs used as feed ingredients in Rabbit Production

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

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

Table 3. Chemical composition of DCP and maize (g kg⁻¹ DM)

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

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 °C 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
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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 competing 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 herbage 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 115°-140°C**

Autoclaving under pressure at 115°-140°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., 2009).

**Results**

Brito et al. (2007) are shown in Table 4. The flavonoids determined in cashew apple by Brito et al. (2007) showed that both skin and flesh 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 Brito et 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

<table>
<thead>
<tr>
<th>Compound</th>
<th>Cashew apple (mg/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myricetin 3-O-galactoside</td>
<td>0.0532</td>
</tr>
<tr>
<td>Myricetin 3-O-glucoside</td>
<td>0.0274</td>
</tr>
<tr>
<td>Myricetin 3-O-xylopyranoside</td>
<td>0.0124</td>
</tr>
<tr>
<td>Myricetin 3-O-arabinopyranoside</td>
<td>0.0104</td>
</tr>
<tr>
<td>Myricetin 3-O-arabinofuranoside</td>
<td>0.0097</td>
</tr>
<tr>
<td>Myricetin 3-O-rhamnoside</td>
<td>0.0400</td>
</tr>
<tr>
<td>Total myricetin glycosides</td>
<td>0.1511</td>
</tr>
<tr>
<td>Quercetin 3-O-galactoside</td>
<td>0.0465</td>
</tr>
<tr>
<td>Quercetin 3-O-glucoside</td>
<td>0.0144</td>
</tr>
<tr>
<td>Quercetin 3-O-xylopyranoside</td>
<td>0.0116</td>
</tr>
<tr>
<td>Quercetin 3-O-arabinopyranoside</td>
<td>0.0108</td>
</tr>
<tr>
<td>Quercetin 3-O-arabinofuranoside</td>
<td>0.0079</td>
</tr>
<tr>
<td>Quercetin 3-O-rhamnoside</td>
<td>0.0227</td>
</tr>
<tr>
<td>Total quercetin glycosides</td>
<td>0.1139</td>
</tr>
<tr>
<td>Kaempferol 3-O-glucoside</td>
<td>Trace amount</td>
</tr>
<tr>
<td>5-Methylcyananidin 3-O-hexoside</td>
<td>0.0197</td>
</tr>
<tr>
<td>Total glycosylated flavonoids</td>
<td>0.2847</td>
</tr>
</tbody>
</table>
A. occidentale, 2- butoxy ethanol (3.35%), 3-methyl-1-butanol (3.23%), and 2-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 accures 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-ol and 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.

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