ANTI-QUALITY AN TOXIC COMPONENTS IN SOME FOOD PLANTS CONSUMED BY HUMANS AND LIVESTOCK IN THE SOUTH PACIFIC REGION: A REVIEW

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ABSTRACT

*A number of foods in the South Pacific region are rich sources of carbohydrates and proteins. Most contain anti-quality and toxic components which make them unsafe as protein and carbohydrate sources in human and livestock nutrition. The presence of saponins, haemagglutinins, tannins (total and condensed), trypsin inhibitors, cyanogenic glucoside (HCN), alkaloids and other compounds in cassava and by-products (*Manihot esculenta *Crantiz); cocoyams: taro or tannia (*Colocasia esculenta *(L.) Schott and* Tannia (Xanthosoma*); cowpeas (*Vignia unguiculate *Walp): banana/plantains (*Musa *spp.): cocoa beans and cocoa husk (*Theobroma cacao*); coffee pulp meal (*Coffee arabica*) and copra meal and other coconut by-products (*Cocos nucifera) *are not uncommon. The presence of anti-quality and toxic components make diets prepared with them unpalatable and unacceptable to humans and llivestock, and inferfere with nutrient bioavailability and utilization. Cooking, drying, soaking, steeping and fermentation are simple means of detoxifying and reducing the presence of anti-quality and toxic components in these food sources*

***Key words**: Anti-quality, toxic components, foods, human, livestock, South Pacific*

INTRODUCTION

Many food sources for humans and livestock contain anti-quality and toxic factors which when consumed could lead to toxicity and sudden death (Aregheore and Agunbiade 1991). Anti-quality components (factors) are substances which either by themselves, or through their metabolic products, interfere with food utilization and affect the health and production of animals (Makkar 1993) and humans. However, other anti-quality factors such as gossypol (from cotton seed meal) and HCN have direct effects on cellullar function of animals and humans. Kumar (1992) defined them as "those substances generated as in natural feed stuffs by the normal metabolism of species and by different mechanisms which exert effects contrary to optimum nutrition". They reduce human and animal productivity and may also cause toxicity during periods of scarcity. This also applies to animals in confinement when feed rich in these substances are consumed in large quantities (Benjamin 1995). Efforts are being made to identify and detoxify the toxic and anti-quality factors in food and feed stuffs to improve their nutritional value using chemical or biotechnological means (Makkar 1993).

Anti-quality components in food and feed stuffs can affect protein utilization and digestion, metal on utilization, anti-vitamins and other metabolic processes (Makkar 1993). The mode of action of most toxic and anti-quality components have been documented by Makkar (1991) and their biosynthesis by Harborne (1989). This review deals specifically with those that affect protein utilization and metabolic processes. It is also aimed as a quick reference material for recommending the use of these food and feed stuffs as protein and carbohydrate sources to humans and small livestock owners.

In particular the review examines the implications of toxic and anti-quality components present in cassava and cassava leaf meal, (*Manihot esculenta* Crantx), cocoyams (*Colocasia* spp. and *Tannia xanthosoma*), cowpea (*Vignia unguiculate* Walp), banana/plantain (*Musa* spp.), cocoa beans and

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cocoa by-product meal (*Theobroma cacao*), coffee pulp meal (*Coffea arabica*) and copra meal and coconut by-products - penu (*Cocos nucifera*) used in the nutrition of humans and livestock. These cultivated plants grow abundantly in the South Pacific islands and simple methods that could be used for the detoxification of anti-quality and toxic components them are discussed.

CASSAVA

Cassava (*Maniholt esculenta* Crantz) is an important component of the diet in the South Pacific just as in other parts of the world. It is an ubiquitous crop and the demand for it is increasing particularly during the economic recession in most developing countries. Cassava's low cost has necessitated the increased use of it in both human and livestock nutrition. Except for the stem, virtually every part of cassava plant is used in human and livestock nutrition.

Cassava root meal

Fresh and dried cassava root is an excellent energy source for livestock (Naidu 1989). It has a high concentration of cyanogenetic glucosides (hydrogen cyanides, HCN), linamarin and lotaustralin. Nartey (1968), reported that linamarin accounts for 93% and lotaustralin, 7% of the total cyanogenetic glucosides present in cassava. Its pressence varies widely and is dependent on the variety (sweet or bitter), climate and cultural conditions. The inclusion of cassava in the diets of pigs and poultry at high concentrations resulted in reduced growth rate because of its low protein content (Job 1975).

Although there is little informaton on cyanide toxicity in livesotck (Aregheore 1992), Alfonso and Ayala (1991) gave the toxic level of cyanide in ruminant animal foods as 200 mg/kg fresh mass. Consequently, Montgomery (1965) and Oke (1969) have reviewed the basic role of HCN in human nutrition. The concentration of HCN which causes toxicity in man is not documented (Aregheore and Agunbiade 1991), however, HCN interferes with body's oxidative processes. Oyenuga (1968) reported that traces of HCN in the blood and cells of tissues paralyse the enzyme cytochrome oxidase and this suppresses tissue oxidative processes which lead to tissue suffocation and death.

The degree of cassava toxicity varies directly with the concentration of the free HCN present which may be between 10-370 mg HCN/kg of fresh root (Bolhuis 1954). Improper processing of cassava into the different consumable by-products may leave traces of HCN, in particular linamarin making the final product unsafe for consumption by humans and livestock. The use of cassava as a cheap source of carbnodydrate appears promising however, its toxic factors should be taken into account.

Cassava leaf meal

The leaves of cassava are relished as vegetable in human and livestock nutrition. It has been demonstrated that cassava leaf meal could be successfully used as a protein, mineral and xanthophyll source in poultry diets (Agudu 1972, Ravindran *et al.* 1986). Available ingredients determine the level of cassava leaf meal inclusion in poultry diets. Ross and Enrinquez (1969) demonstrated that at low levels of inclusion, the feeding value of the meal is similar to alfalfa meal. Also Ravindran *et al* (1986) and Ravindran (1993) indicated that as a substitute for coconut meal or cottonseed meal, it can be used up to levels of 10-15 g kg^{-1} (10-15%) with no adverse effects on performance of poultry. Cassava leaf meal has an appreciable amount of metabolizable energy for poultry with a range of 6.65-7.95 MJ kg^{-1} (Hutagalung *et al.* 1974). At high dietary levels, the meal has an unfavourable effects due to bulkiness, reduced energy intake and methionine deficiency.

In pigs, the feeding of fresh cassava leaves resulted in depressed palatability. Growth performance was also lowered with increasing proportions of leaves in diets (Manendranathan 1971; Alhassan and Odoi 1982). The adverse effects were evident due to high hydrocyanic acid levels in fresh leaves (Ravindran 1993). Although, cassava leaves have a great potential in human, monogastric and ruminant nutrition, the high fibre and cyanide contents limits their use as a major source of protein. The leaves of cassava also contain condensed tannins (Ravindran 1993), and their presence in cassava leaves is a concern (Reed *et al.* 1982) when used in monogastric or ruminant nutrition. Tannin contents in cassava leaves however, increase with maturity of the plant (Ravindran and Ravindran 1988) and also varies between cultivars (Padmaja 1989). Tannins have the ability to lower protein digestibility and amino acid availability by forming indigestible complexes with dietary proteins or by inactivation of proteolytic enzymes (Kumar and Singh 1984, Makkar 1993). Cassava leaves are also known to have high fibre content and this affects its digestibility (Oke 1978).

Detoxification of cassava root meal and leaves

Processing is a key element in reducing HCN concentrations in cassava tubers and leaves. Chopping or grating the roots and sun drying (10-15 days) helps to remove toxic factors present in the root. Fermentation of the tubes after grating also helps to remove toxic components. Storage time has also proved to be effective in the detoxifixation of cassava leaf meal (Ravindran 1993) for livestock and humans. With proper fortification of cassava with high quality proteins such as sulphur amino acids might help to overcome toxicity problems. (Job 1975). Also the use of elemental sulphur is very effective with ruminants (Job 1975). The anti-quality and toxic components present in the leaves of cassava such as HCN and tannins can be removed or reduced to tolerable level by wilting of the fresh leaves. Simple sun drying also help to remove the mentioned components. The use of alkalis such as NaOH is very effect in removing tannins from tannin rich leaves (Makkar and Singh 1992), and this method could also be applied to remove tannins from cassava leaf meal.

COCOYAMS: TARO AND TANNIA

(*Colocasia esculenta* (L.) Schott and *Tannia xanthosoma*)

Almost all parts of cocoyams are of value in human and livestock nutrition. Cocoyam corm contains significant amounts of vitamin C, thiamine, riboflavin, niacin, and carotene. The starch content of taro is low and more easily digestible than those of yams, cassava or sweet potato. The young leaves are taken as spinach (vegetable), being a valuable source of protein, minerals and vitamins. The corms, cormels and leaves are also used in livestock feeding. The utilization of the entire plant directly from harvesting for livestock feeding warrants research in view of the potentially high calorific value of the plant.

However, there are some limitations to the nutritional value of cocoyams. Some sources of taro have high contents fo calcium oxalate in the form of raphides (Calcium stones) which have an irritating effect on the mucous membrane when consumed (Onwueme and Sinha 1991).

Detoxification

Coursey and Booth (1977) reported that in normal culinary practice, the calcium oxalate content can be reduced by prolonged boiling (30-45 minutes), followed by pounding or maceration. Also, Oyenuga (1968) suggested that cocoyams should be cooked before being fed to livestock, since the plant contain an acid substance which is irritating to the digestive tract and may be poisonous.

COWPEA *(Vignia unguiculata* (Ll) Walp)

The seeds of cowpea are used in human nutrition, while the stems/leaves and husk are used for livestock. The seeds are high in protein and soluble carbohydrate, low in fibre and oil, and contain a fair amount of minerals. The fresh seeds and immature pods are eaten as vegetables. Like soyabean, different by-products are derived from cowpea. The stems/leaves and husk are grazed in situ by livestock immediately after harvesting. In some situations they are harvested and fed to livestock in stalls especially during the dry season.

Being a legume, it contains various natural costituents which affect its nutritional qualiy. Some of these components are proteins which inhibit specific enzyme activities e.g. the inhibitors of proteases and amylases (Whitaker and Feeney 1973). Others are the haemaglutinins, saponins and anti-vitamins (Liener 1969). Phytic acid interferes with mineral element absorption and utilization, and reacts with proteins to form complex products which have inhibitory effects o peptic digestion (Cuthbertson 1968; Barre 1956). Some have polyphenols and trypsin inhibitors, and flatus producing raffinose oligosaccharides (Amuti and Pollard 1977). Also raw cowpeas contain small quantities of oxalic acid and minute to fairly high levels of HCN (Oke 1967).

Detoxification

Heat treatment will effectively eliminate most of these undesirable substances. Other processes such as cooking, soaking, steeping, decorticating and germination are effective in reducing toxic components (Ologhobo and Fetuga 1983) and improves its digestibility.

BANANA/PLANTAINS (*Musa* spp.)

Banana/plantain is grown in many tropical countries and is an important source of carbohydrate for humans (Swennen 1990). Also, different parts of banana./plantain are used in ruminant and mongastric nutrition. While it is not advisable to feed banana/plantain pulp to livestock, their peels, leaves and stems could be processed and used as cheap sources of carbohydrates in their diets. In the unripe form the fingers, leaves and pseudostems of banana/plantain have bitter/astringent taste suggesting the presence of tannins and saponins. Saponins are associated with bitterness in forages and herbs and their presence in forages reduces feed intake in animals. Saponins also exhibit characteristics such as strong foaming power in aqueous solutions. High levels of saponins impair growth and causes bloating in animals especially in ruminants (Milgate and Roberts 1995).

Detoxification

Cooking of the unripe fingers removes the bitter/astringent taste and therefore remove tannins and saponins. Cutting of the fingers and storing them for a period of 2-3 days before feeding reduces the bitter/astrigent taste caused by presence of saponins and tannins (Aregheore 1998).

COCOA BY-PRODUCTS MEAL *(Theobroma cacao)*

After drying, cocoa beans are eaten as snacks by humans. Also several by-products that are of value to livestock are generated from the cocoa processing industry. Cocoa shells are waste from the chocolate manufacturing industry (Oyenuga 1968). The value of this fraction as a possible livestock feed has received very little attention in tropical countries. However, it is a good source of animal feed especially for ruminants (Oyenuga 1968). When fed to cows it increases the butter fat and vitamin D content of the milk. The bean of cocoa after fermentation and drying constitute the cocoa of commerce which is used in the manufacture of chocolate, cocoa beverage and cocoa butter (Oyenuga 1968). Cocoa bean is high in oil, therefore very small amount should be used in livestock rations to reduce the risk of rancidity.

Cocoa husk when dried and milled is a suitable meal to meet the maintenance and perhaps part of the production rations of sheep, goats and cattle (Aregheore 1994). It has also been used in poultry rations (Adeyanju *et al.* 1978). Cocoa beans and shells are high in the alkaloid, theobromine. The presence of this alkaloid reduces its incorporation in large quantities in compound rations. Theobromine has an unpalatable taste. Palatability and toxicity problems usually occur when large quantities of either the beans/or shells are used in stock nutrition (Devendra 1978). The husk is free of theobromine but high in fibre content and this is responsible for its less efficient utilization when incorporated in high levels in poultry rations (Devendra 1978). It has been suggested that the husk is better fed on a cafeteria basis since its inclusion on an isocaloric and isonitrogenous basis was consistently uneconomical (Sonaiya 1995).

Detoxification

Absolute drying removes to a large extent, the presence of theobromine and other alkaloids in the shells and beans. Inclusion level in ruminants diets should be between 25-35% (Aregheore 1994).

COFFEE PULP MEAL (*Coffee arabica*)

Coffee is one of the economic crops grown in the South Pacific. Its pulp represents a major agricultural waste of great potential for use as an animal feed. The pulp, a major waste from the wet processing method, forms 40% of the weight of the coffee fruit (Carlos *et al.* 1982). For economic and environmental reasons, attempts have been made to utilize coffee pulp as a feed for cattle, pig and poultry but with little success (Clifford and Ramirez-Martinez 1991). The use of coffee pulp as an animal feed is associated with a number of problems, although it has a good amino acids profile (Morgan and Trinder 1980). The fresh pulp has a cruide protein content that ranges between 2.1 - 3.2%, while the dehydrated pulp has 11.2 - 12% cruid protein. If coffee pulp is used in excess of 20% of normal rations, feed utilization and growth rate are impaired due to the presence of ill-defined antiquality and toxic components.

Various components, including caffeine, low molecular mass phenols and tannins have been blamed for the undesirable effects. Caffeine level and its effects depend on the variety. In ruminants coffee pulp produces a diuretic effects reportedly due to caffeine and the unavailability of lignified protein (Mbugua 1985). Ruminant rations that contains more than 20% coffee pulp resulted in low voluntary feed intake due to poor palatablity. In pigs and poultry rations it cannot exceed 16 and 6-8%, respectively, due to the toxic effects of caffeine, chlorogenic acids, tannins and high fibre (Mbugua 1990). Tannins interfere with protein and dry matter digestibilities by inhibiting protease and other enzymes or by forming indigestible complexes with dietary protein.

Detoxification

Ensiling improves the digestibility of the pulp for ruminants. For monogastric animals it is advisable to use the fungi *Pleurotus flabllatus* (Oyster mushrooms) and *Penicicillium crustosum* in solid state fermentation to destroy the undesirable toxic components including the chlorogenic acids plus caffeine in the pulp. The use of culture derived from ensiled coffee pulp is most efficient in growth and acidification of coffee pulp (Morgan and Trinder 1980).

COPRA CAKE AND OTHER COCONUT BY-PRODUCTS *(Cocos nucifera)*

Copra cake, the residual product after the extaction of oil from the dried meat of coconut is the most abundant and perhaps the cheapest protein and energy source available in the South Pacific region (Ochetim 1987). Depending on the method of oil extraction the cake could contain between 20-30% protein, 1-7% oil and about 7-10% crude fibre (Creswell and Brooks 1971). Levels higher than 15% in poultry diets could result in poor growth, poor feed efficiency and high mortality (Ochetim 1987). Dietary fibre and rancidity are major problems associated with the cake. Copra cake is high in fibre. Dietary fibre interferes with the absorption of other nutrients and in their macro-molecular form are anti-nutritional due to gel formation (dehydrated polysaccharides). Also the residual oil in the cake has a tendency to become rancid thereby reducing appetite for diets prepared with it. As a feed ingredient for animals, it should not be more than 15% in the diet composition (Thomas and Scott 1962).

Detoxification

Effective drying is the only means through which its rancidity (free fatty acids) can be reduced. Milling of the dry product could help to break down the cell wall constituents and assist in the safe utilization of available dietary fibre by monogastric animals.

CONCLUSIONS

The presence of tannins, saponins, lectins, trysin inhibitors, cynogenic glucoside, phytate and other compounds reduce the use of food and feed stuffs in human and livestock nutrition. Most of the food and feed stuffs are rich in protein and carbohydrate. The presence of antiquality and toxic components reduce the bioavailability of protein and other nutrients when they are used in rations for livestock. Detoxification is the only alternative to make them safe for humans and livestock. Boiling, drying, soaking, steeping, and fermentation are recommended as means to reduce antiquality and toxic components. The indigenous food and feed stuffs are abundant in the South Pacific region and simple detoxification methods will make them safe and enhance their availability as plant protein sources.

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