



## The potential of false yam as livestock feed: A review

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### ABSTRACT

*False yam is a perennial shrub native to the savannah areas of West and Central Africa yielding large tubers which can weigh over 50 kg and contain high amounts of carbohydrates and other nutrients. The tuber, seeds and fruits have been used as food for humans across West to Central Africa especially during periods of famine. The leaves and tuber have also been used as a livestock feed. Extracts from the plant have antimalarial, antimicrobial, antioxidant, antidiabetic, anti-inflammatory properties as well as a pesticide. However, the plant contains toxic compounds referred to as anti-nutritional factors which limit its utilization as a feed material. These anti-nutritional factors reduce the palatability, intake, growth performance and may even be lethal when taken beyond certain quantities. To enhance its usage as feed material, methods such as soaking, boiling, fermentation and/or a combination of these methods as well as the addition of additives have been studied by various researchers as a way of reducing or eliminating these toxic compounds and improving its nutritional content. The main aim of this review is to give an overview of the use of parts of the plant in feeding livestock and the processing methods employed to improve on its utilization. The false yam is an underexplored plant hence this review would provide literature on the utilization of the false yam plant as a potential source of feed and help open research gaps for further studies to enhance its utilization.*

**Keywords:** *Anti-nutritional factors, Digestibility, False yam, Feed intake, Icacina,*

### INTRODUCTION

False yam (*Icacina oliviformis*) is a perennial plant that belongs to the family *Icacinaceae*. About eight species have been found to belong to the genus *Icacina* but five have been named and accepted. These include *Icacina oliviformis* (Poir) J. Raynal, *Icacina trichantha* Oliv., *Icacina guessfeldtii* Asch., *Icacina mannii* Oliv., *Icacina claessensii* De Wild. (<http://www.theplantlist.org>). However, *Icacina oliviformis* (synonym *Icacina*

*senegalensis* A. Juss) and *Icacina trichantha* are the two common species found to be prevalent in West and Central Africa from Senegal, Guinea, The Gambia, Ghana, Benin, Nigeria, Congo, Central African Republic and parts of Sudan where they grow wild in light sandy soils in savannah and forest areas (Fay, 1987; National Research Council, 2008). It is commonly referred to as false yam but different countries and tribes across West and Central Africa have different names for it. In Ghana,

the Dagombas call it “*tankoro*” whereas the Asantes call it “*Abubu ntope*”, meaning “break hoe” probably due to the difficulty in digging out the tuber whereas the Igbos of Nigeria call it “*Akwukwo ogiri*”; the Badyaras in Senegal call it “*Manassa*” and the Banda of Central African Republic call it “*basouna*” (Fay, 1987). The plant blossoms during the dry season when almost all grasses and shrubs have withered due to drought and bushfires. Hence farmers consider it as a nuisance during land preparation at the onset of the cropping season. However, its drought-tolerance could be advantageous when its utilization is well explored and may serve as a feed resource for both humans and animals especially in areas where food supply is often limited particularly in the arid and semi-arid parts of Africa. Conventional feedstuffs for ruminants such as natural pasture and crop residues usually decline in quantity and quality during the dry season to the extent where they are unable to support optimum animal growth (Akinfala and Tewe, 2002; Annor and Adongo, 1992). In the non-ruminant industry such as poultry and pig farming, there is often a shortage or scarcity of feed ingredients such as maize and soymeal. This is due to the competition between livestock and humans especially in the developing countries in Africa and Asia where the human population is increasing rapidly. According to Bell and Weaver (2002), maize alone contributes about 85% of the world chicken dietary energy. The increasing prices and occasional shortage of maize are major contributory factors that inhibit the expansion of commercial poultry production in Ghana (Aning, 2006). The tuber and seeds of false yam are rich in carbohydrates and other nutrients such as crude protein (CP) and minerals hence may serve as a good source of energy in the livestock industry particularly monogastrics. For instance, the tuber contains 91.9% carbohydrates and 5.3% CP (Sunday *et al.*, 2016) whereas the seed contains 80.7% nitrogen-free extract and 14.0% CP (Mbatchou

and Dawda, 2012). Its utilization as feed is under-explored. Notwithstanding the high carbohydrate content, all parts of the plant contain anti-nutrient factors which limit its utilization as livestock feed. Data by the National Research Institute (1987) showed that the tuber contains 9-28 g/kg bitter and toxic compounds which have been identified to be terpenes (Vanhaelen *et al.*, 1987). The plant contains hydrocyanic acid, phytic acid and oxalic acid similar to the bitter compounds found in bitter cassava (Antai and Nkwelang, 1998). Okoronkwo *et al.* (2014) reported values of 3.4, 2.2, 2.2 and 5.8 g/100g respectively for HCN, oxalate, phytate and tannins while Sunday *et al.* (2016) reported 12.9, 0.5, 1.7 and 1.0 mg/100g respectively from extracts of the plant. Excessive consumption of these compounds has toxicological and biochemical effects on the body. For instance, excessive consumption of HCN may result in health-related problems such as goitre, cretinism, tropical ataxic neuropathy, respiratory and cardiovascular diseases in humans (Bolarinwa *et al.*, 2016). Terpenes may be poisonous and inhibit growth (Gershenson and Dudareva, 2007). Apart from the toxicological effects, these compounds may also affect feed intake, bio-availability and utilization of nutrients, and growth (Okaka and Okaka, 2005). To improve the utilization of the plant as humans and animal feed, processing methods such as soaking (Dei *et al.*, 2015b; Mohammed (2015), boiling (David-Oku *et al.*, 2018a; Dei *et al.*, 2011a) fermentation (Mohammed *et al.*, 2017) and additives (Roessler *et al.*, 2017) have been used either individually or in combinations to reduce these compounds while improving its nutritional content.

#### **Nutritional composition of the false yam tuber and seed**

According to Woot-Tsuen *et al.* (1968), false yam tuber flour contains water (11.7%), carbohydrates (74.5%), protein (10.3%), fats

(0.7%) and ash (0.5%). In the Central African Republic, Mbatchou and Dawda (2012) also reported that the tuberous roots contain 84.5% of NFE, 4.4% of CP and 1.6% of crude fat. Sunday *et al.* (2016) reported moisture (40%), protein (5.3%), crude lipid (0.9%) and carbohydrate (91.9%). Table 1 gives a summary of studies done on the nutritional composition of the tuber and seed reported by different authors over the years. Comparing the

proximate values of the tuber to the seed, the tuber has higher carbohydrate content whereas the seed has a relatively higher CP value. However, the values for the moisture content and the crude fat content are comparable. The differences in values reported by the different authors over the years could be due to the different methods used for the analysis, the location, the soil on which the plant grows and the age of the plant.

**TABLE1: Proximate composition of unprocessed false yam tuber and seed**

Source	Moisture	Crude protein	Ether extract	Carbohydrates	Ash
<b>Tuber (% DM)</b>					
Fay (1991)	11.7	10.3	0.7	74.5	2.8
NAS (2008)	-	4.4	1.6	84.5	-
Adeti (2010)	-	6.5	0.9	37.4	2.76
Dei <i>et al.</i> (2011a)	13.5	5.4	1.6	*53.1	2.8
Umoh and Iwe (2014)	32	3.4	2.1	93.3	0.89
Sunday <i>et al.</i> (2016)	40	5.3	0.9	91.9	1.15
Fay (1991)	13	8.0	0.1	72-73	-
<b>Seed (% DM)</b>					
NAS (2008)	13	8.0	0.1	72	-
Mbatchou and Dawda (2002)	-	14	0.5	80.5	-
Okoronkwo <i>et al.</i> (2014)	12.9	5.4	28.7	2.8	48.7
Salifu <i>et al.</i> (2015)	7.2	13.1	0.83	-	2.0

\* Starch

Apart from having a high carbohydrate content and some amount of CP, the false yam tuber and seed also contains appreciable levels of macro- and micronutrients that are necessary for human and animal nutrition including sodium (Na), potassium (K), calcium (Ca) and zinc (Zn).

**TABLE 2: Mineral composition of false yam tuber and seed**

Source	Mineral Component (mg/100g)							
	Na	K	Ca	Zn	Fe	P	Mn	Mg
<b>Tuber</b>								
Sunday <i>et al.</i> (2016)	16.66	9.99	18.74	0.48	1.00	0.49	-	13.20
Umoh and Iwe (2014)	18.89	31.51	98.32	1.90	2.84	0.12	0.93	-
<b>Seed</b>								
Okoronkwo <i>et al.</i> (2014)	18.37	9.64	309.71	10.10	71.19	19.14	-	139.15

False yam also contains appreciable levels of both macro and micro minerals that are required for human and animal nutrition (Table 2). The seed contains more minerals (Calcium, Zinc, iron, phosphorus and magnesium) compared to the tuber. The tuber and seed could serve as a good source of alternative foodstuff for human and livestock.

### **False yam as human food**

Parts of the plant such as the tuber, seeds and fruits have been used as food for humans across West to Central Africa where the plant is prevalent. Dalziel (1937) reported that during periods of famine, the tuber served as a source of carbohydrates or starch even though it has been proven to be toxic in some cases. In West and Central Africa, the fruit is enjoyed as a snack, the seed is utilized as a staple, and the tuberous root is eaten as an emergency food when other crops have failed and communities are threatened with famine (Turner, 1978). The tuberous root is a rich source of starch or carbohydrate and eaten in times of famine whereas the bright-red and plum-seeds taste sweet and are often consumed fresh (Fay, 1987). The ripe fruits are used as a source of food especially during the dry season when food supply is scarce (Irvine, 2001). In Senegal, the tuber meal can be mixed with millet or beans to make a thick yellowish flour known as 'enap' and used for porridge and was found to contain about 10% protein (National Academy of Sciences, 2008). The starchy root tuber is edible and contains considerable quantities of protein, calcium and iron and serve as a source of food especially when there is a short supply of yam (Purseglove, 1991).

### **False yam as livestock feed**

As a result of the high cost and occasional shortage of conventional feed ingredients such as maize and soymeal, the use of cheap and locally available non-conventional feed ingredients is a potential way of reducing the

high cost and addressing the shortage of conventional feed ingredients. Feed alone accounts for a huge part (70-80%) of the recurrent cost of production especially in monogastric animals which depend mainly on grains (Ademola and Farinu, 2006). False yam has the potential of being a major feed ingredient in the diets of farm animals considering its rich nutrient composition. Much research has gone into the use of parts of false yam to feed livestock especially monogastrics either as a partial substitute for the main ingredient or as a sole diet. Dei *et al.* (2011a) evaluated the nutritive value of false yam tuber meal for broiler chickens and concluded that the tuber meal contained 5.4% protein and 53.1% carbohydrates. These are comparable to the nutrient content of other root and tuber crops such as cassava and can partially replace maize in broiler diets. Soaked tuber meal could also be fed up to 9.0% as a partial replacement for maize in broiler chicken diets without any adverse effects on growth performance (Dei *et al.*, 2013). Soaking false yam tuber in a solution of saltpetre was found to improve its utilization by broilers and replaced maize up to 12.0% without adverse effect on growth performance (Dei *et al.*, 2015a). Mohammed *et al.* (2017) reported that aerobic fermentation improved the nutritive value of soaked false yam seed meal for feeding laying chickens and could be fed up to 12% without any deleterious effect on egg production. Also, parboiled and sun-dried false yam meal could replace maize up to 25% for optimal growth performance whereas rabbits fed the meal can tolerate 75% replacement in their diets without adverse effects on blood metabolites (Okosun *et al.*, 2018a).

Blood has frequently been used as a medium to assess the health status of animals. In a study to evaluate the haematology and blood serum chemistry of Albino rats fed false yam tuber at varying replacement levels for maize

showed that, oven-dried false yam tuber meal enhanced the blood quality of the experimental animals (Okosun *et al.*, 2018b). In Wister rats, the inclusion of graded levels of flour from soaked and dried or boiled false yam tuber resulted in significant improvements in the nutritional status and red blood cell indices of the animals such as packed cell volume, mean corpuscular haemoglobin, mean corpuscular volume, and mean corpuscular haemoglobin concentration compared to the control (David-Oku *et al.*, 2018a). This indicates an improvement in volume, size, and concentration of haemoglobin in the red blood cells. However, there was a reduction in the levels of white blood cells and platelets, contrary to what was reported in broiler chicken fed false yam tuber meal (Dei *et al.*, 2011b). This could be caused by an underlying disease related to the liver, spleen, abnormal metabolism or short supply of nutrients such as vitamins and minerals. Also, there was significant weight loss accompanied by increased blood glucose levels observed in some of the groups that were fed with the soaked and boiled false yam tuber diet. The weight lost in the false yam fed groups could be due to increased anti-nutritional factors which National Research Institute (1987) reported to affect weight gain and other growth parameters in monogastric animals. Salifu *et al.* (2015) determined the effects of different processing methods of false yam seeds on growth performance of albino rats. The findings showed that soaking resulted in the highest feed intake, growth rate and other carcass parameters similar to the control compared to roasting and boiling. Therefore, they concluded that soaking was the best processing method for false yam seeds and recommended farmers to use false yam seeds as a cheaper source of feed ingredient in the diets of monogastric animals. In the diet of weaner pigs, soaked false yam tuber meal can

replace 10% of maize without any negative effects on growth performance (Dei *et al.*, 2013).

The leaves have also been used for feeding both ruminants and non-ruminants either as a main diet or in combination with other feedstuff. Ansah and Aboagye (2011) reported that the leaves of false yam can be a low-cost alternative feedstuff for rabbit production as the feeding of 5-10% of the leaves to weaner rabbits led to increased erythrocytes while the other blood parameters fell within the normal ranges, indicating that there is no negative effect on the animals. This suggests that the feeding of false yam leaves to rabbits did not have toxicological effects on the rabbits. Feeding false yam leaves at 5% was able to improve feed intake, digestibility and weight gain in rabbits (Ansah *et al.*, 2012). The authors recommended that the inclusion of 5% false yam leaves in the diet of rabbits save cost. In a study to determine the nutrient composition and *in vitro* digestibility of 3 neglected and underutilized browse species in the dry savannah zone of Ghana, it was found that false yam (leaves and seed) has nutritional potential for use in ruminant diets (Ansah, 2018). Taken together, tuber, leave and seed are a potential feed for both humans and animals especially non-ruminants. However, the utilization of the false yam is limited by the presence of anti-nutrient factors. Therefore, processing to remove these anti-nutrient factors is important to enhance the feeding value of the tuber and seed of the false yam.

#### **The anti-nutrient composition of false yam**

The false yam plant contains anti-nutritional factors such as hydrogen cyanide, tannin, phytate, oxalate, alkaloids and flavonoids. The tuber contains 9-28 g/kg bitter and toxic compounds identified to belong to the terpenoid group (National Research Institute,

1987; Vanhaelen *et al.*, 1987). Similar to the compounds found in bitter cassava, Antai and Nkwelang (1998) reported that the tuber contains hydrocyanic, phytic and oxalic acids. Table 3 gives a summary of the anti-nutritional composition of the tuber reported

by different authors. The difference in the values reported by the different authors could be attributed to the method used for the analysis, the age of the plant, soil and the location where it grows.

**TABLE 3: Anti-nutrient composition of unprocessed false yam tuber**

Component	*Umoh (2013)	#Okoronkwo <i>et al.</i> (2014)	*Sunday <i>et al.</i> (2016)
Oxalate	98.25	2.02	0.48
Tannin	21.68	5.84	1.00
Saponin	-	2.59	-
Phytate	3.85	2.17	1.74
Alkaloid	3.12	3.92	-
HCN	0.53	3.39	12.9
Flavonoid	-	2.82	-

Unit of measurement; \*: mg/100 g; #: g/100 g.

### Biochemical and toxicological effects of the anti-nutrient factors

Notwithstanding the potential of false yam as a feed resource, some of the phytochemicals contained in the plant could result in negative effects on the body when taken above certain quantities. These compounds, such as hydrogen cyanide are often the plant's natural mechanism used to deter animals and other predators from feeding on it (Poulton, 1990; Zagrobelny *et al.*, 2008). Due to the ubiquitous occurrence of phytochemicals in plants, the usage of such plants is limited by the capability of these phytochemicals to elicit deleterious effects in humans and livestock (Kubmarawa *et al.*, 2008). These anti-nutrient components could cause toxicity in humans and animals as well as lead to decreased bioavailability and/or utilization of the nutrients contained in various parts of the plants (Okaka and Okaka, 2005). Gershenzon and Dudareva (2007) reported that some terpenes are poisonous and inhibit growth. Also, high consumptions of tannins by humans could lead to toxic or lethal effects (Ferreira *et al.*, 2008). Increased consumption of anti-nutritional factors in

diets of monogastric animals affect their feed intake; weight gain and other growth parameters (National Research Institute, 1987). Some also interfere with the absorption and metabolism of essential nutrients. Aletor (1993) reported that tannins can lead to decreased feed intake in animals, bind dietary proteins and digestive enzymes forming complexes making protein indigestible. The anti-nutritional factors in raw false yam meals negatively affected growth and carcass characteristics of broiler chickens, when fed beyond 5% (Teye *et al.*, 2011). The reduced growth rate of animals could be attributed to the anti-nutrient factors, especially the saponin component as Cheeke and Shull (1985) reported that saponins caused decreased growth rate due to reduced feed intake in non-ruminants. However, saponins do not affect the growth rate of ruminants because they probably undergo microbial degradation in the rumen hence making them non-poisonous. Naude *et al.* (1992) reported the toxicity of many phytochemicals on ruminants is lesser because of their degradation or the binding of the toxins by the rumen microflora.

Excessive consumption of some of the phytochemicals inhibits the digestibility of some nutrients. For instance, saponins can form complexes with proteins which reduces protein digestibility (Shimoyamada *et al.*, 1998). Phytates are inositol hexaphosphoric acids which form complexes with salts of calcium, zinc, magnesium and iron and render them unavailable for absorption and utilization in the body (D'Mello, 2000). The same effect is observed in oxalate where it forms complex with elements and inhibits their bioavailability and absorption. This suggests that their excessive consumption can cause mineral deficiency when consumed by both humans and animals. Phytic acid also affects protein metabolism by forming electrostatic linkages with lysine, arginine, and histidine, hence inhibits the activity of proteolytic enzymes (Oomah, 2001).

Besides the effect of the phytochemicals on the bioavailability and digestibility of some nutrients and growth performance of animals, they can also cause health-related problems in livestock and humans. Phytochemicals such as polyphenols and flavonoids may serve as pro-oxidants when ingested in large amounts (Halliwell, 2007). Pro-oxidants are chemical components that can induce oxidative stress through the generation of reactive oxygen species (ROS) or by inhibiting antioxidant systems (Puglia and Powell, 1984). James *et al.* (2003) reported that the oxidative stress caused by these pro-oxidants can result in damage to cells and tissues, such as the liver damage caused by ROS in acetaminophen overdose. Apart from causing cell or tissue injury, ROS can promote inflammation by enhancing the

activation of the nuclear factor KB (NF-kB), a transcription factor that controls the formation of cytokines, chemokines, and adhesion molecules (Jaeschke, 2000). The liver is a primary target of the toxicity of drugs, xenobiotics, and oxidative stress. Despite their medical uses, alkaloids can cause gastrointestinal upsets and neurological disorders when taken above certain levels (Aletor, 1993; Ogbuagu, 2008). Alkaloids such as teratogenic alkaloids can lead to abnormal foetal developments in animals (Mulvihill, 1972). Some phytochemicals are also phytotoxins, and can cause toxicity in humans when consumed in high quantities. Hydrogen cyanide (HCN) is toxic when ingested by monogastric animals in large quantities and can even be lethal (Obadoni and Ochuko, 2001). A lethal dose range between 0.5 to 3.5mg/kg bodyweight of HCN was reported in humans hence anything above this range will have deleterious effects (Brandbury, 1991). Consuming plants containing cyanogenic constituents could cause cretinism, goitre, tropical ataxic neuropathy, respiratory and cardiovascular weaknesses (Bolarinwa *et al.*, 2016). Other symptoms of cyanide poisoning include headache, drowsiness, vertigo, weak and rapid pulse, deep and rapid breathing, nausea and vomiting. The levels of HCN in false yam reported so far are beyond the lethal dose range reported by Brandbury (1991) hence can cause death when consumed by humans and animals if not processed to reduce or eliminate them. Table 4 gives a summary of the anti-nutrient factors and their *in vivo* effect on livestock reported by different authors.

TABLE 4: Anti-nutrient factors and their in vivo effects on animals

ANFs <sup>#</sup>	Effects	Source
Phytic acid	Form complexes with mineral and protein. Depress absorption of minerals. Affects protein metabolism.	Huisman and Tolman (1992); D'Mello (2000); Oomah (2001)
Tannins	Form complexes with proteins and carbohydrates Interfere with protein and carbohydrate digestibility. Reduce feed intake Cause abnormal foetal development Causes toxicity and can result in death	Huisman and Tolman (1992); Aletor (1993); Ferreira <i>et al.</i> (2008)
Hydrogen Cyanide	Impair iodine utilization. Reduce palatability. Causes nausea and vomiting. Cause cyanide poisoning. Cause ataxic neuropathy. Cause respiratory and cardiovascular weaknesses. Can even result in death.	Huisman and Tolman. (1992); Brandbury (1991); Obadoni and Ochuko (2001); Bolarinwa <i>et al.</i> (2016)
Gum resins	Causes poisoning. Reduces nutrient digestibility.	Fay (1987)
Saponins	Form complexes with proteins Reduce protein digestibility Reduced growth rate	Cheeke and Shull (1985) Shimoyamada <i>et al.</i> (1998)
Alkaloids	Reduces digestibility Neurological disorders Gastrointestinal disorders	Mulvihill (1972) Aletor (1993) Ogbuagu (2008)
Phenols	Decreases digestibility of protein, carbohydrates Lower the activity of digestive enzymes. Cause damage to the mucosa of the digestive tract	Huisman and Tolman (1992)
Trypsin inhibitors	Reduction of the activity of chymotrypsin Pancreas hypertrophy	Huisman and Tolman (1992)

\*Modified from Huisman and Tolman (1992).

<sup>#</sup>ANFs: Anti-nutritional factor

### Processing to reduce the anti-nutrient factors and improve the nutritive value of tuber and seed

Processing is used to reduce the phytotoxins or anti-nutrients and improve the nutritive value of the false yam. An effective processing method is one that can drastically reduce the anti-nutrient factors to make the

material safe for consumption and/or improve its nutritive value. National Research Institute (1987) reported that traditional processing methods such as soaking have been used to remove the bitter principles in the tuber. The finding showed that boiling eliminated 50, 99, and 50% of oxalate, cyanate and phytate respectively



from false yam root tuber. According to Antai and Nkwelang (1998), fermentation of paste from the tuber for 6 days with *Saccharomyces cerevisiae* resulted in a significant reduction in the level of toxicants such as hydrocyanic acid (from 178 mg/kg to 70 mg/kg), oxalic acid (from 638 mg/kg to 463 mg/kg) and phytic acid (from 49 mg/kg to 21mg/kg). Boiling remarkably reduced the total concentration in the tuber by 39% compared to sun-drying (Dei *et al.*, 2011a), suggesting that these anti-nutrient factors may have leached into the water used for the boiling or volatilised due to the heat. The toxic effects of oxalate, phytate and tannins could be ameliorated when the plant material is boiled with water before consumption (Enechi and Odonwodu, 2003). A combination of fermentation and boiling remarkably reduced the anti-nutrients such as hydrogen cyanate, phytic acid and oxalate present in the tuber by 99, 62 and 67% respectively compared to the unprocessed tuber and the methods individually. Addition of feed additives can also help in reducing the toxic or bitter compounds found in parts of the false yam to improve its feeding value. According to Gerlach and Schmidt (2012), adding or supplementation with activated charcoal or biochar could remove toxins by binding to these toxins, hence inhibiting their potency. Therefore, biochar can serve as a detoxifier for the toxins contained in the false yam. Roessler *et al.* (2017) determined the effects of adding biochar to false yam tuber meals on broiler chicken production and blood parameters and reported that including biochar to false yam tuber meals reduced the anti-nutritive effects of the tuber. However, the addition of the biochar reduced the energy and nutrient density per unit feed and this reduction manifested in the lower final body weights and blood protein in the groups fed that meal. Processing can also improve the nutritional value of the seed and tuber. David-Oku *et al.* (2018a) compared the

effects of oven drying, boiling and fermentation on vitamins, amino acids and mineral profile of tuber flours of false yam. The results showed that boiling was able to preserve  $\beta$ -carotene and improved amino acids profile whereas fermentation improved fat-soluble vitamins and mineral content. Therefore, for a good nutritional balance, the authors suggested that processed flours should be enriched with water-soluble vitamins and other essential nutrients. Soaking the false yam tuber in water for three days and drying or further boiling was able to improve the nutrient quality of the resultant flour (David-Oku *et al.*, 2018b). Mohammed (2015) also found that soaking false yam seeds improved the feeding value of the seed meal for layer chickens. Soaking false yam tuber in 0.1% saltpetre solution improved its utilisation by broilers in terms of weight gains and carcass yields hence the treated product can be fed up to 12.0% without adverse effect on performance (Dei *et al.*, 2015b). However, there was a slight depression in feed efficiency for all birds fed the treated tuber meal. Table 5 summarises the effect of different processing methods (boiling, soaking, fermentation and a combination of boiling and fermentation) on the proximate and anti-nutrient compositions of false yam tuber. The three methods of processing were able to improve the CP and carbohydrate content of the false yam tuber compared to the raw tuber (Table 5). A combination of fermentation and boiling was the most effective in improving the protein and carbohydrate contents and reducing the anti-nutrient factors of the false yam tuber compared to the unprocessed, boiled and fermented tuber (David-Oku *et al.*, 2018a). Also, boiling was able to improve the CP and energy content of the tuber as compared to soaking (David -Oku *et al.*, 2018b; Dei *et al.*, 2011b). This suggests that a combination of two or more processing methods may be more effective at improving the feeding value

and reducing the anti-nutrient content of the tuber.

**TABLE 5: Effects of different processing methods on proximate and ANFs compositions of false yam tuber.**

Component (%)	David-Oku <i>et al.</i> (2018a)				David-Oku <i>et al.</i> (2018b)		Dei <i>et al.</i> (2011b)	
	RD	BD	FD	FBD	SD	SB	SFYTM	BFYTM
Moisture	10.78	5.55	11.39	6.61	10.59	6.28	13.54	14.27
CP	3.36	3.39	3.64	4.03	3.64	5.03	5.41	6.46
Crude Fat	7.48	2.50	3.73	1.00	3.85	1.56	1.60	0.98
Crude Fibre	7.64	7.49	7.51	6.26	8.27	5.96	28.61*	32.37*
Crude Ash	3.17	3.04	3.67	3.95	3.82	4.56	2.19	2.78
Carbohydrate	68.27	76.66	70.50	79.30	70.5	82.30	48.63 <sup>#</sup>	43.12 <sup>#</sup>
Energy	350	342	332	339	328.71	350.84	4,067 <sup>ψ</sup>	4,139 <sup>ψ</sup>
Anti-nutritional factors (mg/100g)								
Oxalate	0.49	0.24	0.38	0.16	-	-	-	-
HCN	0.67	0.01	0.03	0.01	-	-	-	-
Phytate	0.70	0.35	0.31	0.26	-	-	-	-

HCN, Hydrogen cyanate; RD: Raw-Dried; BD: Boiled-Dried; FD: Fermented-Dried; FBD: Fermented-Boiled-Dried; SD: Soaked-Dried; SB: Soaked-Boiled-Dried; SFYTM: Soaked false yam tuber meal; BFYTM: Boiled false yam tuber meal; \* Neutral detergent fibre; <sup>#</sup> Starch; <sup>ψ</sup> Energy measured in kcal/kg DM.

Table 6 shows a summary of the effect of three processing methods on the overall CP content and on the constitution of essential amino acids in the tuber and seed (Dei *et al.*, 2011b). In general, the seed has higher CP content compared to the tuber. Interestingly, the CP content in the raw tuber meal (7.03) was higher compared to boiled (4.54) and soaked (3.22) tuber meals (Table 6). This suggests that boiling or soaking has a little or negative effect on the CP content probably due to leaching out or volatilization of the amino acids and other nutrients such as

vitamins. However, most of the individual essential amino acid values are higher in the boiled tuber compared to the other two processing methods. Also, boiled false yam seed had improved CP content (13.5) compared to soaked (7.2) and raw seed (11.8). The same trend is observed in the composition of the individual amino acids (Table 6), suggesting that boiling is a suitable method to use in improving the CP content of the seed.

**TABLE 6: Crude protein and essential amino acid concentrations (% as fed basis) of false yam tuber and seed meals.**

Component	Tuber			Seed		
	Raw	Boiled	Soaked*	Raw	Boiled	Soaked*
Crude Protein	7.0	4.54	3.22	11.77	13.48	7.18
Essential amino acids						
Methionine	0.01	0.03	0.02	0.05	0.07	0.04
Lysine	0.16	0.19	0.21	0.29	0.42	0.21
Threonine	0.06	0.08	0.06	0.36	0.46	0.25
Tryptophan	<0.04	0.04	<0.04	0.08	0.12	0.01
Arginine	0.46	0.23	0.07	0.94	1.21	0.56
Isoleucine	0.07	0.09	0.08	0.62	0.86	0.46
Leucine	0.11	0.15	0.12	0.75	0.98	0.54
Valine	0.10	0.13	0.11	0.46	0.64	0.36
Histidine	0.10	0.11	0.13	0.21	0.31	0.17
Phenylalanine	0.06	0.08	0.06	0.44	0.59	0.34
Glycine	0.08	0.10	0.07	0.45	0.59	0.34

\* Adopted and modified from Dei *et al.* (2011b).

#Mean of values from three different durations (9, 12 and 15 days).

## CONCLUSION

A major challenge to the use of false yam as foodstuff for humans and livestock is the presence of anti-nutrient components. Processing by boiling, soaking and fermentation can appreciably reduce anti-nutrient components of false yam to enhance its utilization. It is obvious from the studies that a combination of more than one method is effective and preferable compared to the use of a single method in increasing the nutritional value and reducing the anti-nutrient factors. However, a few of the studies we reviewed dealt with the toxicological effect of feeding false yam to the animal itself over extended periods. This area needs further research over longer periods to be able to categorically declare

false yam as safe for feeding animals since some of the anti-nutritional factors have deleterious effects on livestock and livestock products. Also, all the technologies used only reduced the amount of anti-nutritional factors in the false but did not eliminate them. Hence, more effort needs to be put into developing technologies that will eliminate the ANFs in the false yam to make it safer as foodstuff for humans and livestock. False yam can be exploited as an alternative to the expensive conventional feedstuffs such as maize, for the livestock industry especially in developing countries where the plant grows abundantly.

## Conflict of interest

The authors declare no conflict of interest.

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