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PROXIMATE AND PHYTOCHEMICAL CHANGES IN HYDROTHERMALLY PROCESSED ORANGE (*Citrus sinensis*) PULP MEAL

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Abstract. Orange pulp is a large by–product of orange processing industries, hence an important source of unconventional feeds stuff of agro by–product origin, however, it contain antinutritional factors which limits it utilization on a large scale in animal nutrition, this study seeks to improve the nutritional value of orange pulp meal though hydrothermal processing. Fresh orange pulp were collected from orange sellers in Makurdi town, and divided into five batches, four of these batches were subjected to varying period of hydrothermal processing namely, 5, 10, 15 and 20 minutes, while one of batch was kept as control without processing. Result reveals significant reduction in Oxalate, Tannin and Phytic acid as the time of processing progressed, however, crude protein increased till the 10th min and significantly reduced thereafter, contrary to this, fat and Ash significantly reduce as the time increases, nutritional trials with various animals are recommended to evaluate feed utilization as a result of this processing method.
Keyword*:* Tannin, Crude protein, Antinutritional factor, Unconventional feed stuff.

Introduction

The importance of artificial feeding in the production of animals cannot be over emphasized. It promotes faster growth, allows higher stocking density and shorter rearing periods.

However, the unavailability and affordability of adequate feed has significantly affected the development of both animal and aquaculture sector in Nigeria [UKAGHA, 2003].

The high cost of conventional feed ingredients such as soybean, groundnut cake, maize and sorghum makes commercial production of animal capital intensive as it accounts for between 30 and 60 % of variable operating cost [DESILVA and ANDERSON 1995. BOSTAN *et al.*, 2013].

Furthermore, the competitive interest by man and industries for convention feed ingredients has necessitated research into search for, local, cheap alternative source that are unconventional so as to reduce production cost without compromising the health of the animal.

These sources should have the potential to supplement, totally or partly replace the conventional feed sources and can be of animal or plant origin [ROBERTS, 1989, BUTNARIU and CAUNII, 2013, RASHED and BUTNARIU, 2014].

Citrus (*Citrus* spp.) is one of most important fruits crop worldwide [CRAWSHAW, 2004, BUTNARIU *et al.*, 2012, PUTNOKY *et al.*, 2013].

Oranges In 2010, oranges accounted for 61 % of the world citrus production (82 million T) [USDA–FAS, 2010]. About 30 % of the production of citrus fruits (and 40 % of orange production) is processed [USDA–FAS, 2010, BUTNARIU and GIUCHICI, 2011], principally to make juice, and results in large quantities of by–products.

Agro–industrial and domestic by–products or wastes from citrus includes, citrus pulp, citrus meals, citrus seed meal, citrus molasses and citrus peels [OLUREMI *et al.*, 2007, BAGIU *et al.*, 2012, BUTNARIU *et al.*, 2006].

Citrus pulp is the solid residue that remains after fresh fruits are squeezed for their juice. It amounts to 50–70 % of the fresh weight of the original fruit and contains the peel (60–65 %), internal tissues (30–35 %) and seeds (0–10 %) [CRAWSHAW, 2004; GÖHL, 1978, CAUNII *et al.*, 2015].

Citrus pulp is usually made from oranges but may also contain by–products of other citrus fruits, notably grapefruits and lemons [CRAWSHAW, 2004], like other unconventional feed stuff, citrus by–products contain antinutrient that limit their utilization in animal feeds on a large scale [OLUREMI *et al.*, 2007, BUTNARIU, 2012].

Hence, this study was designed to investigate nutritional improvement of citrus pulp as a result of hydrothermal processing.

Material and methods

Orange pulps were collected from Orange sellers in makurdi and transferred to the University of Agriculture Makurdi for Processing and Storage.

The orange pulps were cleaned, and divided into five batches (2 kg each); four of these batches were subjected to varying period of hydrothermal processing namely, 5, 10, 15 and 20 minutes, while one of batch was kept as control without processing.

Hydrothermal processing was performed by boiling the pulp in cooking pots using kerosene stove.

After boiling, the water was drained off the pulps and sun dried until constant weight is obtained. The dried pulps were milled in a hammer mill machine and stored in an air tight and moisture free containers separately, same procedure of drying and milling and storage was used for the control treatment.

Both raw and hydrothermally processed Orange pulps meal processed as described above were chemically analysed to determine changes in the proximate composition using the method described by Association of Official Analytical Chemist, [AOAC, 2001].

Also, quantitative determinations of phytonutrients was done according to the methods described by Harborne [HARBORNE, 1973], Sofowora [SOFOWORA, 1993] and Trease & Evans [TREASE and EVANS, 1989] to determine the effect of processing on the anti–nutritional factors in the orange pulp.

Results and discussion

The result of phyto–chemical analysis of orange pulp meal is presented in Table 1, result obtained reveals the present of oxalate (550.13), phytic acid (7.64), and Tannin (144.38) in raw orange pulp meal, values of this anti–nutrients generally reduce with increasing time of hydrothermal processing with 20 mins of boiling having the least (457.57, 6.33, and 83.62 respectively).

Table 1.

Phytochemical analysis of hydrothermally processed Orange pulp

Parameters	TRT 1	TRT 2	TRT 3	TRT 4	TRT 5	P–Value
Oxalate	550.13±0.13[a]	527.68±2.46[b]	494.69±0.31[c]	479.82±9.28[c]	457.57±0.58[d]	0.001
Phytic acid	7.64±0.19[a]	7.32±0.12[ab]	7.06±0.07[bc]	6.69±0.19[cd]	6.33±0.16[d]	0.001
Tannin	144.38±0.32[a]	134.44±0.66[b]	130.18±0.73[c]	127.58±0.58[d]	83.62±0.56[e]	0.001

Mean in the same roll with different superscript differ significantly (P<0.05)

Proximate composition of diet reveals (Table 2) significant increase in the value of crude protein up to the 10th minute (7.19–8.72), beyond this point however, protein significantly reduced (7.77 and 7.18 for 15th and 20th mins respectively).

Table 2.

Proximate analysis of hydrothermally processed Orange pulp

Parameters	TRT 1	TRT 2	TRT 3	TRT 4	TRT 5	P–Value
Crude Protein	7.19±0.10[c]	8.34±0.12[a]	8.72±0.11[a]	7.77±0.07[b]	7.18±0.17[c]	0.001
Fat	2.61±0.11[a]	2.28±0.06[b]	2.42±0.08[ab]	2.21±0.09[bc]	1.92±0.09[c]	0.001
Ash	6.07±0.06[a]	5.77±0.11[ab]	5.44±0.06[bc]	5.17±0.05[c]	4.20±0.15[d]	0.001
Crude Fibre	9.05±0.29[a]	9.23±0.11[a]	8.07±0.04[b]	9.07±0.04[a]	9.52±0.11[a]	0.001
Moisture	5.43±0.12[a]	5.21±0.09[ab]	5.08± 0.04[ab]	4.87±0.09[bc]	4.55±0.13[c]	0.001
NFE	69.67±0.26[cd]	69.19±0.05[d]	70.29±0.23[bc]	70.92±0.26[b]	72.65±0.09[a]	0.001

Mean in the same roll with different superscript differ significantly (P<0.05)

A similar but opposite trend was observed in crude fibre as it reduces to the 10th mins (8.07) and thereafter increased with the highest value recorded in the 20th mins (9.52). Fat, Ash and moisture content in this study reduced continuously as the time of hydrothermal processing increased (2.61–1.92; 6.07–4.20 and 5.43–4.55 respectively for Fat, Ash and moisture).

Processing of feed stuff is targeted towards better nutritional utilization of feed stuff in animal nutrition, Tiamiyu and collab. [TIAMIYU *et al.*, 2015a, BUTNARIU and CORADINI, 2012] opined that it is important to determine optimum time for processing involving heat treatment; this is because overheating denatures essential nutritional content feed ingredients.

The present study shows that hydrothermally processing Citrus pulp up to 20 mins significantly affect both proximate and phytonutrients in the feed.

Crude protein increased and peaks at the 10th min but significantly reduced thereafter, however Fat and Ash significantly reduce as the time of hydrothermal processing increases.

Tiamiyu and collab. [TIAMIYU *et al.*, 2015b] had earlier reported continuous increase in crude protein content of hydrothermally processed watermelon seed meal up to 40 minutes.

Ndidi and collab. [NDIDI *et al.*, 2014] however reported that crude protein and fat of processed (boiled and roasted) *Sphenostylis stenocarpa* seeds were significantly lower compared to raw, and the report by Audu and Aremu [AUDU and AREMU, 2011] demonstrated significantly higher protein content of processed red kidney bean (*Phaseolus vulgaris* L.), while fat was reported to reduce with application of various processing methods.

Tiamiyu and collab. [TIAMIYU *et al.*, 2015b] opined that the decreased and shrink in moisture content and nitrogen free extract of the feed meal as a result of boiling probably led to increased crude protein levels.

While this hypothesis may be true till the 10th minute of boiling in this study, reduction thereafter could be attributed to protein denaturing as a result of overheating, this is justified by the reduction in fibre till the 10th mins and the increase observed thereafter.

According to Tiamiyu and collab. [TIAMIYU *et al.*, 2015a] reduction in fibre content of feed as a result of hydrothermal processing is largely as a result of shrinkage which makes the feed stuff softer and loosed.

It is however important to note that responses to heat treatment differ for different feed type due to the nature of the feed stuff, strains, environmental factors, and type of heat treatment as well as variation in time of treatment used, hence, the differences in the observation of these studies.

Result on phytochemical analysis reveals isolation of three anti–nutrient namely Oxalate, Tannin and Phytic acid, the presence of antinutritional factors in plants has been considered as an expression of the chemical warfare of plants against their predators [CARMONA; 1996]. Tannin has been reported to gives rise to a dry, pickery, astringent sensation in the mouth of animals [OLUREMI *et al.*, 2007] hence leading to reduced feed intake, dietary trial with tannin levels of 1–20 % commonly found in cereals and legumes has been reported to have detrimental effect on growth and feeding efficiency in non–ruminants [PRICE and BUTLER 1980].

However, in ruminants, dietary condensed tannins of 2–3 % have been shown to impart beneficial effects because they reduce the wasteful protein degradation in the rumen by the formation of a protein tannin complex [BARRY, 1987].

Phytate presence in feed is largely blamed for the complexing of dietary essential minerals in legumes and cereals and rendering them poorly available to monogastric animals.

Oxalate also (like phytate) can decrease the availability of dietary essential minerals such as Ca. At high concentrations, oxalate causes death in animals due to its corrosive effects [KUMAR; 1991, BUTNARIU *et al.*, 2014]. In small amounts, it causes a variety of pathological disorders including hyperoxaluria, pyridoxine deficiency, and calcium oxalate stones.

Efficient utilization of feeds can only be possible through the use of variety of processing methods such as cooking, fermentation, germination, solvent adsorption to mention but a few, these processes generally increase bioavailability of the nutrient in feed [CARMONA, 1996], hence increasing their utilization [BUTNARIU *et al.*, 2013, PETRACHE *et al.*, 2013].

The level of phytate observed in this study is lower than that previously reported in maize (146 and 353 mg %), sorghum (206 and 280 mg %), potato (14 mg %) by Concon [CONCON, 1988], and in cassava, cocoyam and yam, (624 mg %, 855 mg % and 637 mg % respectively) by Marfo and Oke [MARFO and OKE, 1988], hence can be better nutritional substitutes for this conventional energy sources in the diet of animals.

Conclusions

This study has demonstrated the efficiency of reducing anti–nutrient in citrus pulp using hydrothermal processing up to 20 mins.

Nutritional trials should be conducted to determine feed utilization of hydrothermally processed citrus pulp meal in animal nutrition.

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