ENSILING IMPROVES THE NUTRITIVE VALUE OF WATERMELON RINDS (*Citrullus lanatus*) FOR USE AS LIVESTOCK FEED.

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ABSTRACT
Harnessing agricultural wastes utilization in diets and drugs could improve food supply, health and the environment. Phenolic compounds in feed samples provide an idea of the pharmacologic dietary and antioxidant potentials of the feed sample. This study assessed the effect of processing on nutritive value and anti-nutrient properties of the rind of water melon (Citrus lanatus) which are usually discarded as food wastes in Nigeria, using standard protocol of AOAC. The milled water melon samples were subjected to sun drying, toasting, parboiling and ensiling. Processing methods significantly (P <0.05) improves crude protein and crude fibre content but has no effect on ether extract and nitrogen free extract. Tannin level decline from 3.35% in fresh sample to 2.8%, 2.6%, 2.0% and 1.2% following sun drying, toasting, parboiling and ensiling. Similarly, phytic acid level reduced by 51.43%, 68.57%, 78.7% and 81.42% following sun drying, toasting, parboiling and ensiling, respectively. It could be concluded that processing enhances crude protein and crude fibre content of water melon rinds. It also reduces anti-nutritional factors hence, improving the nutrient contents for utilization of water melon rinds as livestock feed.

Keywords: **dietary, wastes, watermelon, processing, anti-nutrients,**

INTRODUCTION

Nigeria as well as many other developing countries has for long been plagued with the challenges of inadequate consumption of animal proteins (WHO, 2019). The level of consumption of meat and other animal protein sources in Nigeria for instance, is estimated at 8 g per caput per day which is about 27 g less than the minimum requirement (35 g) recommended by the food and Agricultural Organization (FAO, 2019).

The World Health body warned of the danger if dietary animal protein merely contributes between 15 - 26 % of total protein intake of Nigerians (WHO, 2019). Several reasons have been advanced for these inadequacies which includes: poor quality yield (Banumathy *et al., 2013*), average low income level (Tijani *et al.*, 2011), inferior genetic merit of indigenous stock that produce most meat and milk source (Onasanya, 2015), high population increase rate (Onuwa *et al.*, 2020), poor feed quality (Carew *et al.*, 2014), seasonality of major feedstuffs and inefficiency in distribution of feeds. Animal feed plays a leading role in the global feed industry as such; effort is needed to develop means of reducing its cost.

Thus, exploring, potentials of agro industrial by products as alternative feedstuffs for use as livestock feed becomes the focus of animal nutritionists. Amadi *et al*.,(2018) also opined that one of the possible ways of overcoming food security challenges vis-a-vis growing population is the exploitation of the underutilized plants and animal foods (Obuh and Akindahunsi, 2015). Serious protein deficiencies and high cost of animal protein sources have stimulated research into developing new sources of protein from unexploited, underutilized seeds, browse, and wastes and by products. Utilization of some of these agro - industrial by products with considerable potentials in livestock feeding in recent past, has been the succour to these problem which had gulped a significant portion of farmers' profit (Ominiski *et al.*, 2021). One of such underutilized by product is watermelon (*Citrullus lanatus*) rind.

Water melon rind, an agro-industrial by product or household waste which is usually discarded or use as fertilizer has been reported to be of high nutritional value (Amadi *et al.*, 2018, Gladvin *et al, 2017)*. It is the skin of water melon fruits which on ripening turns pale green or yellowish green (Falade *et al.*, 2020). It is rich in vitamins source and has lycopene, a red carotenoid pigment that protect and act as bioactive against a growing list of cancer (USDA, 2019, Southern U.S, 2010). In some part of Nigeria also, watermelon rinds are fermented, blended and consumed as juice though on smaller scale (Egbuonu, 2015). Furthermore, Chen *et al.*, (2014) observed that it is an excellent source of amino acids, protein, micro nutrients and bioactive compounds that serves as antioxidants can be harnessed as livestock feed. Unwholesome fruits are used or directly fed to ruminants while immature fruits may be prepared into summer squash. The need therefore, to examine its nutritive value is inevitable as this can determine its ability to deliver nutrients to an animal for maintenance and growth.

Like most oil bearing seeds and legumes however, they contain anti-nutrients or anti-nutritive factors (tannin, oxalate, phytic acid, citrulline) which have been reported in various literatures to have negative effect on absorption of certain minerals apart, from their protective nature. Anti-nutrients impair majorly the digestion of crude protein in feeds by forming complexes with nutrients, as chelators rendering them indigestible by proteolytic enzymes (Ani, 2019, Abdul, 2017). They have been reported to limit rumen microbial activity at high dosage.

Similarly, Abeke, (2017) observed that a well formulated and mixed diets may not give the desired results in terms of adequate performance because of the presence of antinutrients in form of chemical compound present in the feed ingredients. On the contrary, reports have shown that condensed tannin and oxalate at low dosage and PH has beneficial effect in diets of farm animals (Matthieu, 2017, Zein, 2017).

Neutralizing anti-nutrients in feeds is inevitable. As such, Animal Nutritionists have employed various post harvest processing techniques toward reducing the levels of tannin, phytic acids, and oxalates in livestock diets or overcome deleterious effects. Such methods includes: (1) cooking (Adekola *et al*., 2022, Thani *et al*., 2022).(2) parboiling (Agbana *et al*., 2012, Johnson e*t al*., 2012).(3) Sun drying (Ajagbe *et al.*, 2022). (4) Heat treatment /toasting. The availability of water melon rinds as wastes at season and it's widely distribution in the tropics and sub tropic regions all year round (Falade *et al*., 2020) spur interest in it. Their inclusion in livestock diets may help to reduce the cost of feed and subsequently, improve protein intake of an average Nigerian (Ani, 2019). 5) Soaking in water/ natural fermentation (Thani *et al*., 2022). 6). ensiling (Iyayi, 2018). 7). Solid state fermentation (Iyayi, 2018). 8). Enzyme/chemical treatment (Zuo *et al*., 2015, Iyayi, 2018).

Results from these researchers have yielded less satisfactory status and where proven right, it is expensive to practice. The length of fermentation that best yield result is still contradictory. Therefore, this study aimed at evaluating the effect of different processing methods on nutritive composition and levels of anti-nutrients in water melon rind.

MATERIALS AND METHODS

Description of experimental site

The study was conducted at the Biochemical Laboratory, Department of Animal Health and Production Technology, Kogi State Polytechnic, Itakpe Campus, which is located in the Guinea Savanna of coordinates Latitude 7.6384 ^{0} N and Longitude 6.335 ^{0} E. The temperature throughout the year ranges from 18.87 ^{0}C to 34.4 ^{0}C with an average of 26.64 ^{0}C and the average annual rainfall is 1280 mm (https://www.mindat.org/loc.3983 html).

Sample collection, preparation and processing.

Watermelon rinds were collected from a fruit vendor at Abobo, Okehi Local Government Area, Kogi State. The rinds were sorted, cleaned of dirt's, washed and sterilized in warm water to remove suspected bacteria and afterward, the rinds were chopped into tiny cubes and divided into five(s) batches. The first batch were milled fresh and kept in refrigerator, labelled as FWMR (Unprocessed).

The second batch were toasted for about 10 minutes in a flat open pan over an open fire by constant stirring until golden brownish colour was obtained then air dried at room temperature, bagged and labeled TWMR.

The third batch was kept in an air tight black polyethene bag to ferment for 3 days. The fermented rinds were sun dried for 3 days, bagged and labeled EWMR.

The fourth batch were poured into boiling water and allowed to stand in it for 15 minutes then sieved and sun dried for 3 days, bagged and labelled PWMR.

The fifth batch, were kept under the sun for 4 days until when dried and labelled as DWMR.

All samples were then milled to powder using a 2 mm hammer mill. Then, bagged separately and analyzed chemically in triplicates.

Sample Analysis

Determination of Nutrient composition

The nutrient composition of the differently processed and unprocessed watermelon rinds was determined according to Weendes proximate analytical techniques of standard methods of AOAC (2019). The analytical scheme resolves feedstuffs into: (1). crude protein - calculated by using Nitrogen content obtained by Micro Kjeldhal distillation protocol. A conversion of 6.25 was used for the calculation of protein content. (2). Ether extract / crude fat were measured by solvent extraction method in a soxhlet system, where n – hexane was used as solvent. (3). crude fibre was determined by extraction with ether, sulphuric acid and sodium hydroxide. (4). ash content was determined by muffle furnace ignition and (5). Nitrogen free extract was determined by subtracting the summation of all other proximate fractions from 100 %.

Determination of anti-nutritional factors.

The qualitative screening of some phytochemicals in freshly prepared and processed watermelon rind aqueous extracts was carried out for the presence of tannin, phytate and oxalate. Tannin content in each sample was determined by colorimetric method (AOAC). The absorbance of each sample was measured at 420 nm using spectrophotometer and the quantity of the anti-nutrients estimated from a standard curve obtained by plotting the concentration of the standard anti nutrient content against the absorbance (Zuo *et al*., 2015). Phytic acid was determined by the method of Idris *et al.*, (2020) using KH_2PO_4 as standard.

Statistical analysis

All triplicate values obtained from the analysis conducted for proximate and antinutrient compositions were subjected to a one way Analysis of variance

(ANOVA) and Significant means were compared and separated using the Duncan Multiple Range test (DMRT) as outlined by Steel and Torrie,(1990).

RESULTS AND DISCUSSION

The proximate composition of unprocessed & processed water melon rinds.

The result of the proximate composition of fresh and processed water melon rinds are presented in Table 1. Processing had a significant (P<0.05) effect on the crude protein content of watermelon rind. Ensiling increased the crude protein content to 13.82 % compared to parboiling (11.4 %), toasted (9.05 %), sun drying (8.90 %) and fresh (6.72 %), respectively. The significant increase in crude protein content of processed ensiled watermelon rind could be attributed to the activities of extracellular enzymes (protein) secreted by fermenting organisms (fungi) during their metabolic activities on the rinds whose proliferation, according to Akindahusi (2019) form a complex protein that contributes to the nutrient content and protein value of the mash. This corroborates the finding of Erukainure *et al.,* (2010) who reported an increase in crude protein content of water melon rinds subjected to *Saccharomyces* solid media fermentation. The observed crude protein contents of processed watermelon rinds compared with major conventional protein sources like cowpea (12.97 %), groundnut cake (14.62 %) and soya bean (13.80 %). hence, water melon acid may acts as protein substitute in diets of livestock.

Table 1: chemical compositions of differently processed watermelon rinds.

Parameters	FWMR	DWMR	TWMR	PWMR	EWMR	SEM
Organic matter (%)	88.70	88.72	88.83	88.68	88.76	0.52^{NS}
Crude Protein (%)	5.97^{e}	6.72^{e}	8.90^{d}	9.07^{c}	14.9^{a}	0.50*
Crude Fibre (%)	4.33^{b}	4.10^{c}	4.84^{a}	3.85^{d}	2.78^{e}	0.18*
Ash content (%)	4.00^{e}	4.81^{d}	6.56^{b}	5.85^{c}	6.97^{a}	0.02*
Ether extract (%)	9.05	10.02	11.54	11.87	13.84	15.0^{NS}
Nitrogen free extract (%)	70.00	65.03	63.33	61.52	44.73	0.10^{NS}

^{a,b,c} Mean value on the same row with different superscript differ significantly
*Significant, NS- non Significant, SEM-standard error of mean
FWMR-Fresh Watermelon rind *DWMR- Sundry Watermelon Rind*
TWMR- Toasted watermelon rind *EWMR-Ensiled Watermelon Rind*

Similarly, toasting (6.85%) and ensiling (6.97%) recorded similar and significant (P<0.05) increase in ash content compared to 5.86 %, 4.56 % and 4.81 % for boiling, sun drying and fresh, respectively. The marginal increase in ash content of toasted and ensiled watermelon rinds over other processing methods could be an indication of increased minerals contents in toasted samples as a result of heat treatment and possibly the enrichment of the watermelon rinds mash by minerals present in the mycelia of Fungi grown on the fermenting substrate. The result was similar to that reported by Bentil *et al., (2015)* who observed that fermented mash have richer supply of minerals which may be about 10 % ash on dry matter basis. On the contrary, Gladvin *et al.,*(2017) reported no significant difference in ash content of watermelon rinds subjected to some processing methods. The difference observed could be as a result of differences in cultivar of watermelon used for study or climatic conditions (Gusimini *et al.,* 2004).

Although, values recorded were higher and increases across treatments, processing methods has no significant (P > 0.05) effect on ether extract content. The observed similarity in values of ether extract among treatments implies that test ingredients are nutritively rich in fat. It may also be attributed to differences in climatic conditions, edaphic factors, harvesting stage of plant and laboratory analysis. The recorded values however, are higher than the range recorded for conventional protein sources such as ground nut cake (3.63 %), soybean (4.50 %) and Cowpea (8.45 %). Hence, watermelon rind could be examined for use as oil source.

Ensiling also, recorded the least significant (P<0.05) value for nitrogen free extract (carbohydrate). The least reduction in Nitrogen free extract (carbonhydrate) content in ensiled watermelon may be as a result of reduction in reducing sugars and total soluble sugars present in the substrate during fermentation (Odetokun,2015).

Crude fibre content also decreased considerably (P<0.05) following processing and was least in ensiling (2.78) followed by parboiling (3.85 %) , toasting (4.84%), fresh (4.88%) and sun drying (4.84%), respectively. The Crude fibre content that significantly reduced following ensiling may possibly be as a result of microbial enzymes degrading complex polysaccharides during fermentation process. This result is in consonance with the report of Yissa *et al.* (2022) who opined that processing reduces crude fibre values in Legumes. The crude fibre values obtained in this study however, are lower compared to those recorded for other conventional fruits like mango (6.56 %), tomatoes (5.90 %) and Jack fruit - 7.01 % (Dafwang *et al*. 2014). The lower crude fibre value suggests therefore, that watermelon rinds could be an advantage to Monogastric animals which are known to have little ability to digest fibrous materials.

Anti-nutrient analysis

Table 2 shows the results for the effect of processing methods on anti-nutrient contents of watermelon rinds. Tannin and phytic acid concentrations significantly (P<0.05) decreased, following processing. Ensiling recorded the least concentration of anti-nutrient content (tannin, phytic acid) followed by parboiling, toasting, sun drying, and fresh (control), respectively.

Table 2: Effect of processing methods on tannin and Phytic acid content

Parameters	Fresh	Sundried	Toasted	Parboiled	ensiled	SEM
Tannin	3.30 [a]	3.45[a]	2.80 [c]	2.60 [d]	1.17 [e]	0.12*
Phytic acid	1.42 [a]	1.40 [b]	0.60 [c]	0.44 [d]	0.21 [e]	0.05*

The significant decrease in values of tannin and phytic acid content in both ensiled and parboiled treatments may partly be as a result of heat action during parboiling. Studies have established that most anti-nutrients can be denatured by heat (Hurrell, 2004). Similarly, Obun and Akindahunsi (2017) reported a leaching of tannin in dry feed samples subjected to heat treatment that resulted in a change in solubility and chemical reactivity causing an apparent decrease in assayable phenol. Similarly, Fungi are capable of not only degrading lignocellulosics but, active in reducing anti-nutrients and other phenols present in agricultural wastes through enzymatic hydrolysis (Adamafio *et al.,* 2011). Ensiling process might have induce phytic acid hydrolysis via action of microbial enzymes, which would have hydrolyze phytic acid to lower inositol phosphate (Hurell, 2004, Erukainure *et al.,* 2015).The result recorded for this study corroborates the findings of Egbuonu, (2015), Amadi *et al.,* (2018) and Obun and Akindahunsi, (2017). They reported a reduction in tannin, oxalate and phytic acid contents in feed samples subjected to parboiling, ensiling and toasting processing methods, respectively. This observation is contrary to the report of Yissa *et al., (2022)* who opined that fermentation does not reduced tannin levels in diets and possibly, if it does, it must be diets having low levels of condensed tannin.

Recent studies suggested that free or protein complex condensed and hydrolysable tannins are more effective than small phenolics in antioxidant activities (Hurell, 2004). This gives credence to the investigation carried out in this study that processing reduces the levels of anti- nutrients in watermelon rinds and are nutritionally balanced.

The values obtained for Phytic acid (1.42) in unprocessed watermelon rinds was below 10 recommended by World Health Organization as tolerable levels in mammals. Similarly, the values obtained for tannin is also lower than the lethal dosage (5 %) in which toxic effect of the anti-nutrients may occur in the digestive tracts and their metabolites. Thus, watermelon rinds could serve as important feed stuff comparable with maize, millet and maize bran as energy source and soybeans as protein source.

From table 3, tannin content decreased by 14.35 %, 18.15 %, 21.90 %, 63.96 % and 64.82 % following Sun drying, toasting, parboiling and ensiling, respectively. Similarly, Phytic acid percent reduction levels increased by 41.83 %, 51.43 %, 68.57 %, 81.42 % and 83.56 % following Sun drying, toasting, parboiling, ensiling, respectively with the highest level recorded for ensiling processing technique.

Table 3: Percent reduction of anti- nutrients in watermelon rinds after processing.

Processing methods	Tannin	(% Reduction)	Phytic acid	% Reduction
Fresh	3.45		1.42	
Sun dried	3.30	14.35	1.40	41.33
Toasted	2.80	18.15	0.60	51.43
Parboiled	2.60	21.90	0.44	68.57
Ensiled	1.19	64.82	0.21	83.56

CONCLUSION

The research established that processing can enhance crude protein and crude fibre values of most agro industrial by-products specifically, water melon rind. Ensiling (microbial fermentation) has the greatest effect in reducing crude fibre, tannin and phytic acid content of watermelon rinds over toasting, sun drying and fresh treatment groups.

Similarly, ensiling and parboiling best enhances the values of crude protein content of water melon rinds over toasting, sun drying and fresh (control). This implies that optimal bioavailability of nutrients could be achieved in watermelon rind if ensiled or parboiled. Hence, processing most agro-industrial by products through ensiling could reveal the potential of them being used as feed resource for livestock.

The finding of this study also revealed that watermelon rinds could compete favourably and even better in nutritional parameters than most conventional feedstuffs. Though, it has some content of polyphenols, they occur at an appreciable amount below the allowable limits.

RECOMMENDATIONS

Therefore, watermelon rinds can be exploited as an antioxidant in combating oxidative stress, malnutrition and for enhancing feed security. The cost and time involved in processing techniques need to be studied to justify their efficient use. Further research is needed on the degree of heat application during processing that could improve feedstuff value for livestock use.

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