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Effect of Processing on Sensory Characteristics and Chemical Composition of Cottonseed (*Gossypium hirsutum*) and Its Extract

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***Abstract*—**The seeds of cotton (*Gossypium hirsutum*) fall among the lesser known oil seeds. Cottonseeds are not normally consumed in their natural state due to their gossypol content, an antinutrient.

The effect of processing on the sensory characteristics and chemical composition of cottonseed and its extract was studied by subjecting the cottonseed extract to heat treatment (boiling) and the cottonseed to fermentation. The cottonseed extract was boiled using the open pot and the pressure pot for 30 minutes respectively. The fermentation of the cottonseed was carried out for 6 days with samples withdrawn at intervals of 2 days. The extract and fermented samples were subjected to chemical analysis and sensory evaluated for colour, aroma, taste, mouth feel, appearance and overall-acceptability.

The open pot sample was more preferred. Fermentation for 6 days resulted into a significant reduction in gossypol level of the cottonseed; however, sample fermented for 2 days was most preferred.

***Keywords*—**Cottonseed, boiling, extract, fermentation, True protein.

I. Introduction

FOR more than 200 years, cotton (genus *Gossypium*, family *Malvaceae)* has played a key role in the history and development of Agriculture. This important dual-use crop produces not only lint that is used to clothe the world's increasing population, but also a variety of products such as cooking oil, cottonseed meal and hulls that benefit both humans and livestock.

The invention of the cotton gin by Eli Whitney in 1793 resulted in the accumulation of cottonseed (*Gossypium hirsutum*). The seeds of cotton falls among the lesser well known oil seeds. It was used as a source of planting seed, but not for its nutritional value until the 1800s. Cottonseed is a rich source of energy, fibre, oil and a unique form of protein. Its oil contains fatty acids like myristic, palmitic, palmitoleic, stearic, oleic and linoleic acids. Studies have revealed that the Nigerian cottonseed contains crude protein that ranged between 5.46% in the hull to 3.07% in the kernel [1]. Cottonseed meal contains about 40% of protein [2]. About 17 different kinds of amino acids including the essential amino acids like isoleucine, leucine, threonine, methionine, phenylalanine, lysine, histidine and arginine have been isolated from cottonseed.

Post-harvest losses of cottonseed are considerably high. These include losses in transportation to ginneries, storage after delinting and before going to expellers. Storing cottonseed that is too wet at harvest may result in heating and/or molding which may predispose it to risks associated with aflatoxin and other mycotoxins.

All cottonseed contains gossypol, a naturally occurring plant pigment found most commonly in cotton plant and okra, as well as in most plants in the family *Malvaceae*. Gossypol is a polyphenolic compound that, in cotton is localized in pigment glands found throughout the plant. These glands are especially concentrated in the seed. Whole cottonseed typically contains 1.5-2.0% gossypol, all in the unbound form, but levels can vary to as low as 0.4% in some commercial species [3]. Cottonseeds are not normally used in their natural state because of their gossypol content which is an anti-nutritional factor that inhibits digestion [4]. Gossypol seems to disrupt oestrous cycles, pregnancy, and early embryo development in females of all non-ruminant species studied particularly in the monogastric species studied through its effect on hormonal secretion in the pituitary gland and the ovary [5]. The only way to improve the nutritional value of cotton seed is by reducing the free gossypol non-toxic in the products [1].

Processing of cottonseed will have a significant impact on the concentration of free gossypol. Cottonseed meal processed with heat and moisture is less hazardous than other forms of cottonseed. Exposure to heat alone appears to be ineffective in reducing free gossypol levels with reductions of between 9% reported [6]. However, studies have shown that a combination of heat and steam can result in marked reductions in free gossypol levels [2]. Establishing standards for processing of varieties of oil seeds is essential in order to ensure that foods consumed by humans and livestock are highly nutritious with low anti-nutritional factors and generally safe for consumption.

The objectives of this work therefore are to study:

- the effect of boiling cottonseed water-extract in open pan and pressure cooker on its sensory properties, chemical composition and anti-nutritional factor and
- the effect of fermentation on sensory properties, chemical composition and anti-nutritional factor of the whole cottonseed.

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II. Materials and Methods

A. Materials

Cottonseed was purchased at Bodija market in Ibadan, Nigeria. The seed had a small amount of lint around it and a lot of impurities adhered to it.

B. Methods

1. Production of Whole Cottonseed Extract.

The cottonseed was carefully washed in water to remove all adhering impurities such as sticks, stones, insect parts. While washing, the remaining lint still attached to the seed was also pulled out as much as possible to ensure easy crushing and extraction. The seeds were crushed using the household pestle and mortar. The seeds were pound thoroughly to ensure that all seeds were totally crushed to give a complete mash. Water was added to the mash and hand-pressed to remove the extract after which sieving was done. The extract has a dark-brown colour.

2. Boiling of Extract Using Open Pan and Pressure Pot

The liquid extract was divided into portions. A portion of the liquid extract was boiled using household cooking pot for 15 minutes and 30 minutes. Another portion was boiled using the pressure pot cooker for the same boiling time as the open pan; 15 minutes and 30 minutes. Fig. 1 represents the flow chart for the process of boiling the extract.

C. Chemical Analysis

The moisture content, crude protein, crude fat, crude fibre ash, and gossypol content were determined by using the AOAC official method [7]. The pH of the samples was determined using pH meter.

D. Sensory Evaluation

The cottonseed extract was used to prepare cottonseed soup, a native soup called "ikowu" in Nigeria, and sensory evaluated using a 6 point scale. 1being most acceptable and 6 being lowest preference

Fermented seed samples withdrawn at two days interval were evaluated as condiments.

Coded samples were given out to panelists in a ventilated room that was well lit. Water was provided for the panelists to rinse their mouth to ensure proper sensory evaluation. Preference test was conducted for cottonseed soup using the Simple Paired Comparison test Multiple Comparism test was conducted for the condiments obtained from the cotton seed, the data collected were analyzed using the analysis of variance with means separated using Duncan's Multiple Range test [8].

III. Results and Discussions

A. Effect of Fermentation on Chemical Composition of Cottonseed

There was increase in the quantity of the moisture content as fermentation continued for 6 days. The analysis of variance employed reveals that there was significant difference between the moisture content of the fermented seed samples (Table I). The increase in moisture content observed during fermentation is due to the moist solid nature of the fermentation and the hydrolytic decomposition of the fermenting substrate. This high moisture content observed during the fermentation makes the samples undergo spoilage very rapidly. However, the African people who are the custodians of the art of its fermentation adopt a direct heating method over charcoal heat, sun-drying or salting to prolong the shelf life of the product.

There was significant decrease in the values of the crude protein content of the fermented seeds from the beginning of the fermentation as shown in Table I. The decrease in the crude protein during the fermentation process could be due to several factors such as the loss of ammonia during fermentation, or the hydrolysis of the protein in the seed, which subsequently provides excellent sources of nitrogen for microbial growth [1]. The growth of microorganism invariably means increase in the activity of converting the hydrolyzed protein into amino acids [9]. The extent to which the insoluble protein is hydrolyzed is of immense importance to the nutritive value and flavor of most of the fermented vegetable proteins.

There was significant decrease in the values of the crude fat content of the fermented seeds from the beginning of the fermentation as shown in table1. The decrease in the crude fat content in the fermented sample could be attributed to its utilization by the associated microorganisms during fermentation [1].

There was also significant decrease in the values of the ash and crude fibre content of the fermented seeds from the beginning of the fermentation as shown in table II. The decrease in the ash content could be related to the decrease in the crude fibre value. According to the suggestion of [10], the fermentative activity of the associated microorganisms could have led to the breakdown of the fibre content of cotton seed with eventual utilization by the microbes.

There was decrease in the values of the gossypol content of the fermented seeds when compared with the unfermented seed. The substantial decrease in gossypol, a toxic and anti-nutritional component of cotton seed most especially in the fermented seed sample, is one of the most important, beneficial effects of the fermentation of the seeds. As fermentation days increased, the level of gossypol reduced and the gossypol level were almost eliminated as the fermentation was allowed to continue for a longer period. The analysis of variance reveals that there was no significant difference in pH values of the samples but Duncan's Multiple Range test reveals that the sample at day 4 was not significantly different from that of day 2 and 6.

There were increases in pH values of the fermented cottonseed as fermentation process continued giving an alkaline condition. The increase in pH during the fermentation of the sample on dried basis agreed with the descriptions of other researchers that increase in pH usually accompanies vegetables protein fermentation which could have resulted

from the production of amines and ammonia by the hydrolytic activity of the microorganisms [9].

It is necessary to state that the inconsistency in products quality and variety, sources and mineral composition of water used, microbial biomass of the wrapping leaves, the amount of moisture retained in the seeds before fermentation and the extent of hydrolytic decomposition of substrate affects the values of these elements and biochemical composition of the cotton seed. The increase or decrease in values of these elements and biochemical composition vary mostly in different batch samples unless the processing is optimized. However, the significant contribution of the fermentation is that the biochemical components of cottonseed, which are normally not available for utilization in its natural state, are now readily available [1].

It has been reported that fermented vegetable proteins contain most of the important elements in relatively higher amounts when compared with the substrate [11].

B. Sensory Evaluation of Fermented Cottonseed Samples

Table II shows the sensory evaluation of the fermented cottonseed samples. The cottonseed sample fermented for 2 days was significantly different from the others in terms of the aroma, taste, mouth feel and appearance and overall acceptability. There was no significant difference between the samples fermented for 4 days and 6 days. Sample fermented for 2 days was the most acceptable.

C.Effect of Open Pot and Pressure Pot Boiling on Chemical Composition of Cottonseed Extract

The heat treatment carried out by using both the open pot and the pressure pot caused a significant decrease in the chemical composition of the cottonseed extract. There was significant decrease in the values of crude protein, crude fat, crude fibre, ash, moisture content and gossypol for both open pot and pressure pot samples as the time of boiling increased.

There was increase initially in the quantity of moisture when boiling commenced but the moisture began to reduce as the boiling time increased. There was a general decrease in the moisture content of both the open pot and the pressure pot samples but the open pot sample had a higher decrease in moisture than the pressure pot sample at both 15 minutes and 30 minutes (Table III).

There was significant reduction in the value of the crude protein, and the analysis of variance showed that pressure pot sample boiled for 15 minutes has significantly higher value than other boiled samples.

There were increases in pH values of samples with boiling (Table III).

The gossypol content reduced significantly. Greater reduction in the value of the gossypol was recorded in the open pot samples. Also, comparing the open pot and pressure pot in terms of their effect on the chemical composition of the cottonseed extract, the open pot samples had lower values of crude protein, crude fat, crude fibre, ash and gossypol as shown in Table III.

Gossypol is known to be sensitive to oxidation during processing particularly in respect to alkaline pH. As the heating time increases, gossypol complexes with some of the protein available and thus the proteins become denatured proteins [12]. This statement made by [12] agrees with the result shown in table III, as the heating time increased there was significant decrease in the values of the gossypol and protein as the pH value tends towards alkalinity.

D. Sensory Evaluation of Cottonseed Extract

Preference test was carried out on the data collected for the sensory evaluation of the cottonseed soup sensory evaluation and Simple Paired Comparison test was carried out to know the most preferred sample in terms of the colour, aroma, taste, mouth feel, appearance and overall acceptability. The comparison was done under the probability level of 5%.

In terms of the colour, there was no significant difference in the acceptability. The colour was generally not acceptable by most of the panellist. The unacceptability of the colour could probably be linked to the presence of free gossypol and other minor constituents which are greatly reduced and the free gossypol is either converted to bound form or oxidized, which results in darker colour. Heating of protein-containing cottonseed products, baked products or generally processed foods especially in the presence of water increases colour problem. Gossypol in both unbound and bound form remains the important potential colour-causing components in cottonseed products [11].

The aroma of the two samples was acceptable with no significant difference between them. There was significant difference in terms of the taste. The taste of the cottonseed soup prepared using the open pot was more preferred than that of the pressure pot. However this is unlike most foods processed using the pressure pot.

There was significant difference between the two samples in terms of the mouth feel, appearance and overall acceptability. The mouth feel, appearance and overall acceptability of the cottonseed soup prepared using the open pot was more preferred than that of the pressure pot. The pressure pot sample appeared darker in colour having some undesirable lumps thereby affecting the mouth feel, appearance and the overall acceptability.

IV. Conclusion

Establishing standards for processing of varieties of oil seeds is essential in order to ensure that foods consumed by humans and livestock are nutritious with low content level ofanti-nutritional factors and safe.

The use of cottonseed for the production of “ikowu” a native soup and for the production of fermented cottonseed known as “owoh” offers a method of utilization. It is an excellent source of edible oil and other major nutrients particularly protein. During processing, the seeds undergo changes in the chemical composition leading to changes in the level of both the nutritional and anti -nutritional components.

The heat treatment process that was used in this study showed that there was decrease in the percentage composition of most of its chemical constituents. As time of exposure to the heat increased, the percentage composition of the gossypol and protein reduced. Boiling of the extract using the open pot resulted into a lower percentage composition of gossypol and protein when compared with that of the pressure pot. The cottonseed soup made with the open pot was generally more acceptable.

The fermentation of the seed showed a decrease in the percentage composition of most of its chemical constituents most especially the level of gossypol and protein. As the fermentation days increased, the level of both the gossypol and the protein decreased. The gossypol level of the fermented seed on the last day of fermentation was almost completely eliminated. The sample with the fermented seed at the second day was generally more acceptable than that of the sixth day.

It is therefore recommended that when processing a food material using cottonseed as the major ingredients or one of the ingredients, the boiling or other forms of heat treatments should be done for at least 30 minutes. Also, when fermenting cottonseed, a minimum of about 2 days is recommended.

It is therefore also recommended that improvements be made on the use of open pot for boiling of cottonseed extract. Further studies should be done in the area of process optimization of the fermentation of cottonseed so as to eliminate the usual variability of product quality that normally occurs in different fermented batches.

TABLE I
CHEMICAL COMPOSITION OF FERMENTED COTTONSEED SAMPLES

SAMPLES	MOISTURE (%)	CRUDE PROTEIN (%)	CRUDE FAT (%)	CRUDE FIBRE (%)	ASH (%)	GOSSYPOL (%)	PH (%)
Fermented seed							
0 day	3.04^{d}	31.29^{a}	23.67^{a}	17.28^{a}	7.47^{a}	0.0013^{a}	7.34^{c}
2days	3.26^{b}	25.89^{b}	16.75^{b}	13.37^{b}	2.79^{b}	0.0007^{b}	7.45^{b}
4 days	3.18^{c}	22.67^{c}	13.28^{c}	11.86^{c}	2.68^{c}	0.0004^{bc}	7.25^{d}
6 days	3.41^{a}	17.88^{d}	10.67^{d}	8.85^{d}	2.61^{d}	0.0002^{c}	7.61^{a}

Means in the same column followed by the same letter are not significantly different from each other at $P \leq 0.05$.

TABLE II
SENSORY EVALUATION OF FERMENTED COTTONSEED SAMPLES

FERMENTATION PERIOD (DAY)	COLOUR	AROMA	TASTE	MOUTH FEEL	APPEARANCE	OVERALL ACCEPTABILITY
2	3.17a±1.2	2.10a±0.7	2.23a±0.9	2.77a±1.1	2.43a±0.8	2.63a±0.9
4	3.97b±1.1	3.13b±1.1	3.23b±1.2	3.70b±0.9	3.57b±0.7	3.97b±0.9
6	4.13b±1.4	3.77b±1.6	3.77b±1.5	4.10b±1.3	3.9b±0.8	4.33b±1.0

Means in the same column followed by the same letter are not significantly different from each other at $P \leq 0.05$. Lower values indicate greater preference.

TABLE III
CHANGES IN CHEMICAL COMPOSITION OF BOILED EXTRACT SAMPLES

SAMPLES	MOISTURE (%)	CRUDE PROTEIN (%)	CRUDE FAT (%)	CRUDE FIBRE (%)	ASH (%)	GOSSYPOL (%)	PH (%)
0 minute	61.62^{e}	13.88^{a}	3.04^{a}	0.89^{a}	2.86^{a}	0.0076^{a}	6.89^{b}
Open pot	76.72^{a}	12.37^{c}	2.04^{d}	0.65^{c}	1.82^{d}	0.0039^{c}	7.28^{a}
15 minutes	76.31^{b}	11.97^{c}	1.95^{e}	0.63^{d}	1.73^{e}	0.0027^{d}	7.34^{a}
30 minutes							
Pressure pot	74.29^{c}	12.89^{b}	2.72^{b}	0.79^{b}	2.48^{b}	0.0051^{b}	7.38^{a}
15 minutes	74.03^{d}	12.48^{c}	2.64^{c}	0.66^{c}	2.32^{c}	0.0038^{c}	7.16^{ab}
30 minutes							

Means in the same column followed by the same letter are not significantly different from each other at $P \leq 0.05$.

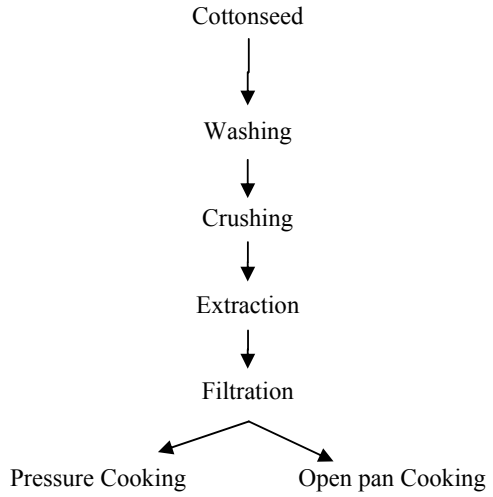

Fig. 1 Process Flow Chart for Production and Boiling of Extract

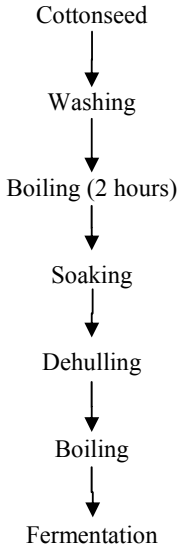

Fig. 2 Process Flow Chart for Cottonseed Fermentation

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