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## **Effect of Fermentation Process on the Nutritional Composition of “Etsew”, a Corn-Based Food**

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### **Author's contribution**

*The sole author designed, analysed, interpreted and prepared the manuscript.*

### **Article Information**

DOI:10.9734/AFSJ/2020/v16i130165

Editor(s):

(1) Dr. Olorunjuwon Omolaja Bello, University of Medical Sciences, Nigeria.

Reviewers:

(1) Emmanuel Otoo, Csir-Crops Research Institute, Ghana.

(2) Rodrigo Fernando dos Santos Salazar, University of Cruz Alta (Unicruz), Brazil .

Complete Peer review History: <http://www.sdiarticle4.com/review-history/57542>

**Original Research Article**

**Received 24 March 2020**

**Accepted 31 May 2020**

**Published 13 June 2020**

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### **ABSTRACT**

This study assesses the effect of fermentation process on the nutritional compositions of a corn-based food “Etsew”. Dried corn *Zea mays* var “*Obaatampa*” was used for the study. A total of 9 samples were collected and analyzed for a period of one month. These were dried corn, steeped corn, milled corn, three samples of corn dough with 1 day, 3 days and 5 days fermentation periods and three samples of “Etsew” made from the various fermented corn dough. The test was run on each sample three times to ensure the reliability of test results. Proximate analysis was done on the samples using standard methods. Results from the study show an increase in moisture, protein, fat, fibre and carbohydrate contents of the corn dough compared to the raw corn. The study also observed reduction in protein, carbohydrate, fat and energy value when heat was applied to the dough during “Etsew” preparation.

*Keywords: Fermentation; Etsew; AOAC; Obaatampa.*

### **1. INTRODUCTION**

Corn, scientifically known as *Zea mays* is a cereal commonly consumed worldwide. Corn is an important cereal crop produced in Ghana and

it is widely consumed as staple food across the country with a steady increase in production rate since 1965 [1]. The Ministry of Food and Agriculture records that the per capita consumption of corn in Ghana in the year 2000

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was estimated at 42.5 kg and an estimated national consumption of 943000 MT in 2006 [2]. The corn grain is made up of three physical parts, the outer covering, endosperm and germ or embryo.

Corn is usually processed into corn dough to prepare most local dishes. In preparing corn dough, the corn is cleaned by removing stones and all other materials which might have accidentally entered the corn from harvesting through drying or transport to the final consumer. After cleaning, the corn is washed, soaked in clean water for some hours (often between 24 to 48 hours) to get soft. It is then sieved and milled. The milled corn is made into dough by mixing with water and left for some days (often between 24 to 72 hours) to ferment. Fermentation is an important step in corn dough preparation if the dough is to be used in preparing local Ghanaian dishes like “*Kenkey*”, “*Abolo*”, “*Banku*”, “*Agidi*” and “*Koko*”[3]. However, [4], report that during the processing of cereals, considerable nutrient losses take place during processing stages such as, steeping (soaking), milling and sieving. Many studies, (eg [5] and [6]) also show that malnutrition among children in developing countries is mainly due to the consumption of cereal-based porridge which is bulky, low in energy and high in anti-nutrients. However, it has not yet been established whether the nutrient insufficiency is because of the processes involved in the preparation of the cereal based porridge.

In recent times, many households and food vendors in Ghana have adopted different processes for making fermented corn dough prior to being used for preparing food. With an increasing level of malnutrition and diabetes in Ghana (probably because many different indigenous or traditional processes currently used by many households to ferment corn dough are not enhancing the nutritional composition of the dough as it should) coupled with the fact that most women feed their families with fermented corn dough foods, it is important that these different processing methods be studied to evaluate their effect on the nutritional value of fermented corn dough. Usually, packaged foods found in shops in Ghana do have labels that inform consumers on nutrition and guide them to eat appropriately. This is not the case with most of the local foods prepared from fermented corn dough listed earlier. With a large number of Ghanaians eating fermented corn dough foods,

there is the need to determine the effect of fermentation process of “*Etsew*”, a corn-based food eaten by the people of the Central Region in Ghana.

### 1.1 Objectives of the Study

The aim of this study is to;

1. examine the nutritional composition of corn at different processing stages.
2. compare the level of nutritional composition of the corn dough after different fermentation days.
3. assess the level of nutritional composition of “*Etsew*” made from different fermented corn dough.

## 2. MATERIALS AND METHODS

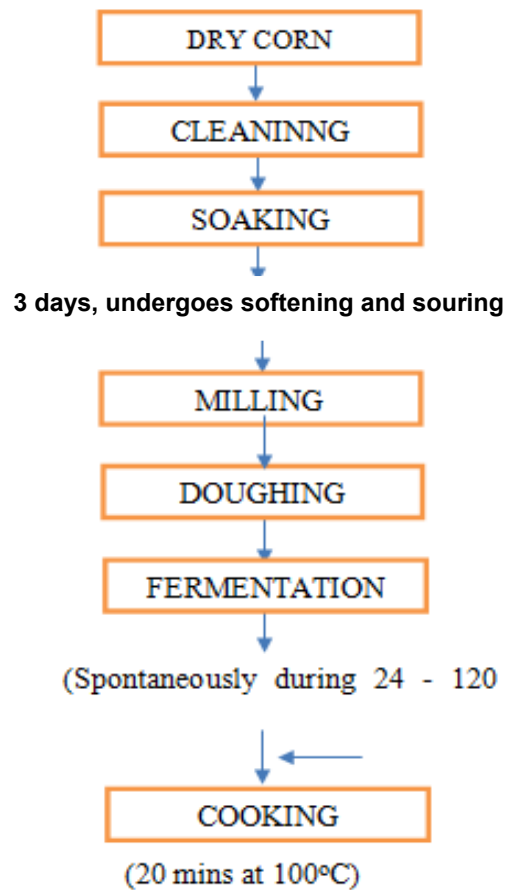
### 2.1 Sample Collection

Dried corn *Zea mays* var “*Obaatampa*” was purchased from the Ministry of Food and Agriculture (MOFA), Cape Coast. It was sorted and 9 kg weighed into a bowl and washed 3 times with distilled water. 9 kg of corn grains was used to get a commensurate amount of corn dough and “*Etsew*” for the study. It was then soaked in 9 L of water and covered for three days in the food laboratory of the University of Cape Coast. The 9L of water was used to allow the corn grains to be completely soaked in the water. The corn was then removed, washed in distilled water and milled into flour. It was divided into three parts with each part made into dough using 200 ml of distilled water and left to ferment for 1, 3 and 5 days respectively. The fermented dough samples were later used to prepare “*Etsew*”. Samples were collected and sent to the laboratory in sterile polythene bags. They were properly labelled for easy identification.

### 2.2 Preparation of “*Etsew*”

“*Etsew*” was prepared from the corn dough after it was fermented for a day, 3 days and 5 days. The corn dough was dissolved in water, mixed thoroughly and placed on fire to boil whilst stirring. The paste was stirred continuously till it was completely cooked and attained the desired hardness. The “*Etsew*” was molded into the portions of 200 g and then allowed to cool.

The process of corn dough preparation through to the cooking of “*Etsew*” is diagrammatically represented below.



**Fig. 1. Flow diagram for production of “Etsew”**  
 Source: Adopted from [8]

### 2.3 Proximate Determination

Proximate analysis was carried out on the “*Obaatanpa*” corn, steeped corn, milled corn, three samples of corn dough with 1 day, 3 days and 5 days fermentation periods and three samples of “*Etsew*” made from the various fermented corn dough. The proximate analysis of samples for moisture content, crude protein, ash and crude fibre was carried out on the corn and the acceptable products developed using the standard methods described by Asiedu et al. [7]. Crude fat was extracted using the Soxhlet procedure with petroleum ether (60-80°C) by Asiedu et al. [7]. Carbohydrate content was determined by difference.

### 2.4 Determination of Moisture Content

Analytical balance (AD HR-250AZ) was used to weigh 10 g of the samples into cleaned crucible. The samples were oven-dried at a temperature

of 105°C for 48 hours. The samples were then removed from the oven and immediately put in a desiccator to cool for 30 minutes. The dry weights of the samples were determined after cooling. The percentage moisture content of the samples was determined using the formula below.

$$\text{Moisture content (\%)} = \frac{\text{weight of fresh sample} - \text{weight of oven-dry sample (g)}}{\text{weight of oven-dry sample (g)}}$$

### 2.5 Determination of Ash Content

Approximately 0.2 g of the corn, fermented corn dough and “*Etsew*” samples were weighed into a pre-weighed empty crucible. The crucibles containing the sample were placed in the oven at 100°C for 24 hours. The crucibles were removed from the oven and then transferred to a furnace where the temperature was raised to 550°C. The temperature was maintained for 8 hours until a

white ash was obtained. The crucible was then removed from the furnace directly into a desiccator and allowed to cool for 30 mins and weighed. The percentage ash content of the sample was calculated using the formula below:

$$\text{Ash content (\%)} = \frac{\text{Ash weight}}{\text{Oven-dry weight}} \times 100$$

## 2.6 Determination of Protein

Nitrogen was determined by AOAC Kjeldahl method 979.09 using a nitrogen auto analyzer (Foss Electric, Denmark).

The percentage nitrogen in the samples tested was calculated using the formula below:

$$\% \text{ N} = \frac{(S-B) \times M \times 14.007}{\text{weight of sample (mg)}} \times 100 \times 100/20$$

The protein content was calculated using the formula: % protein = % N x 6.25, where 6.25 is the protein-nitrogen conversion factor and N is nitrogen.

## 2.7 Determination of Fats and Oil

Lipid content was determined by the AOAC Goldfish Method No. 945.16 and total carbohydrate and fiber calculated by difference.

## 2.8 Determination of Carbohydrate

Carbohydrate is determined by difference. This can be calculated using the formula:

$$\text{Soluble carbohydrates (\%)} = \frac{C \text{ (mg)} \times \text{extract volume}}{10 \times \text{aliquot volume} \times \text{sample weight}}$$

## 2.9 Determination of Energy Value

The method of Atwater and Snell as cited in [8] was employed to determine energy levels of the samples. This consisted of multiplying the values obtained from chemical analyses for protein, carbohydrate, and fat by factors of 4, 4, and 9 Kcals per gram, respectively.

## 2.10 Statistical Analysis

Concentrations of all nutrients in test samples were obtained from calculations using the listed standard equations and others calculated from the standard curve prepared. For each test, three

readings were obtained and the average calculated. Descriptive and inferential statistical tools were employed in the analysis and the interpretation of the data. For research objective one, Independent t-test was used to determine the significant difference between the soaked corn and the milled corn. For research objective two and three, comparisons between sample treatments were done using analysis of variance (ANOVA) to determine the treatment that was different from others in the various parameters tested.

## 3. RESULTS AND DISCUSSION

From the results in Table 1, the moisture, protein, fat and fibre compositions in the raw corn increased by 27.06%, 1.26%, 1.04% and 0.68% respectively after the corn had been soaked. The increase in protein could probably be due to the production of certain enzymes by the fermenting microorganisms. The enzymes are protein in nature, hence might have triggered the protein increase in the soaked corn. The increase in protein and fat content in the soaked corn is contrary to the findings of Marfo et al. [9] and Ojofeitimi and Abiose [10] who reported a decrease of more than 29% and 26% of crude protein and fat respectively in fermented corn compared to the raw corn. Following the results in Table 1, the raw corn showed a decrease of 0.51% and 0.05% in the ash and carbohydrate contents, respectively, after it had been soaked.

The decrease in ash of the soaked corn could probably be linked to leaching of some minerals into the soaked water. Whereas, the decrease in carbohydrate content could probably be due to activities of the microorganisms causing fermentation of the corn. These microorganisms often use the carbohydrate (in the form of sugar) as energy. Furthermore, the reported figures stated earlier were also contrary to that reported by Asiedu et al. [7]. They reported a decrease of 10% and 4% in ash and crude protein, respectively. Fat rather increased in the fermented corn, this corresponds with the findings of Asiedu et al. [7]. Irrespective of the fact that the content of certain nutrients in the fermented corn were found to be different from those which were found by the studies mentioned earlier, they were similar to what other studies found. Apena et al. [11], reported that when corn grains are fermented for 72 hours, the moisture, fibre and protein increase respectively but ash and carbohydrate decrease.

**Table 1. Effect of fermentation process on nutritional composition of “Etsew”**

Sampling Steps	Products	Moisture	Protein	Fats	Carbohydrate	Fibre	Ash	Energy value Kcal
<b>Corn</b>	Raw grains	15.24	9.21	3.57	28.76	0.64	1.15	184.03
<b>Soaking</b>	Soaked grains	42.30	10.47	4.62	28.71	2.32	0.64	198.26
<b>Milling</b>	Flour	41.75	10.86	2.77	33.12	2.14	0.59	200.83
<b>Fermentation</b>	Dough (day 1)	51.90	10.85	4.59	38.49	1.64	0.57	238.66
	Dough (day 3)	52.81	10.63	4.54	36.63	1.88	0.58	229.92
	Dough (day 5)	52.67	10.75	4.77	38.14	1.99	0.59	238.04
<b>Cooking</b>	Etsew (Day 1 dough)	73.10	10.50	1.29	36.48	2.11	0.73	203.50
	Etsew (Day 3 dough)	78.08	10.44	1.28	35.40	2.10	0.65	194.89
	Etsew (Day 5 dough)	75.08	10.60	1.26	40.73	2.26	0.81	216.71

Nonetheless, when the soaked corn was processed into flour and analyzed, the moisture, ash, fat and fibre were found to decrease by 0.54%, 0.05%, 1.84% and 0.17% respectively. This probably could be attributed to the impact of the heat produced by the grinding plates on the nutrients during milling of the corn grains into flour. However, the protein and the carbohydrate showed an increase in nutrients. The results from Table 1 showed that the energy value of corn increased when the corn was soaked and milled. Increase in the energy value of the corn could be linked to the corresponding increase in the fat and protein contents when the processing was complete.

The changes in the nutrients between the soaked and the milled corn were statistically significantly different ( $p < 0.05$ ) except ash and energy value that showed insignificant difference ( $p > 0.05$ ).

From the results in Table 1, the moisture content of the corn dough after the first day of fermentation increased sharply as compared to that of the corn grains. As the days of fermentation prolonged, the moisture content of the dough further increased slightly. The high moisture content in the three fermented dough may indicate a growth in the number of

fermenting microorganisms. A Scientific investigation reported that low moisture content in food samples enhance the shelf life of the food products [12] while high moisture content in foods encourage microbial growth, hence food spoilage [13]. This variation in moisture content of the corn grains and the corn dough may be due to the fact that some amount of water was added to the corn flour to make the dough. Increase in the water content resulted in an expected decrease in values for total dry matter in the corn dough.

There was an increase in protein, fat, fibre and carbohydrate of the corn dough compared to the raw corn on the first day of dough fermentation (Table 1). The observed increase in protein, fat and carbohydrate was contrary to the findings of Assouhoun et al. [8], which reported a decrease in protein, fat and carbohydrate content at 24 hours of corn dough fermentation. However, with respect to ash, there was a decrease compared to the corn grains when analyzed after the first day of fermentation.

It can be seen from Table 1 that protein and fat and oil unexpectedly decreased during the third day of fermentation. The reduction in the crude protein may be attributed to an increase in

protein catabolism by the fermenting microorganisms which led to the escape of the by-product of metabolic deamination of ammonia and to the utilization of sugars as a carbon source.

However, as the period of fermentation extended to the fifth day, there was a slight increase in the protein content again which could be attributed to the action of extracellular enzymes (proteases) produced by the fermenting microorganisms during fermentation. This implies that corn dough when fermented for a period of five days could increase in protein content. Fogarty and Griffin [14] reports that *Bacillus species* inoculated in seed during fermentation are important producers of proteases. These extracellular proteases easily hydrolyze complex plant proteins to amino acids and short chain peptides thereby causing an increase in total nitrogen.

On the other hand, the slight decrease in fat and oil in the corn dough during the third day of fermentation may have been due to the fermenting microorganisms using up the fat as an energy source whereas the unexpected increase in the fat and oil on the fifth day of fermentation might be as a result of increased activity of the lipolytic enzymes (lipase) in the fermentation medium which hydrolyse fat to glycerol and fatty acid [7]. This could also imply that corn dough can be fermented for a period of five days to increase the fat content. With respect to fibre content of the corn dough, findings showed an increased fibre content of the corn dough with time. The total carbohydrate decreased by 1.87% on the third day. As the period of fermentation progressed to the fifth day, there was a sudden increase in the total carbohydrate by 1.52%. The initial drop in carbohydrate on the third could be attributed to the action of microbial enzymes ( $\alpha$ - and  $\beta$ -amylase) which hydrolyses starch to simple sugar [15]. The sugar provides a source of energy for the fermenting microorganisms. The increase of carbohydrate on the fifth day could probably be due to the termination of starch degradation by low pH which inhibits amylase activity [16] and/or in the presence of tannins that inhibit amylolytic enzymes.

The changes in the level of nutritional composition of the three corn dough were significantly different ( $p < 0.05$ ). However, the protein contents of the corn dough were statistically the same ( $p > 0.05$ ).

The results obtained from Table 1 revealed that there was an increase in the moisture content in "Etsew" after different days of fermentation compared with the raw corn dough. This can be alluded to the fact that when the fermented dough was boiled in water at temperatures ranging from 165°F. to 210°F., some gelatinization occurred, which increased the water holding capacity. Increase in water content resulted in decreased values for total dry matter.

There was an increase in the ash content in the "Etsew" after day one, day three and day five fermentations compared to the corn dough fermented for varying periods. The increase in ash content in the "Etsew" probably could be attributed to the addition of common salt during processing.

The protein content in the "Etsew" after varying periods of fermentation decreased by 0.65%, 0.91% and 0.14% after day one, day three and day five fermentation periods respectively compared to the corn dough. The decrease in protein of the "Etsew" might be attributed to the high boiling temperatures which could denature some of the proteins while cooking.

Following the results Table 1, the amount of fat and oil in the "Etsew" decreased by 3.26%, 3.26% and 3.51% respectively after day one, day three and day five fermentation periods compared to the corn dough after the different fermentation days. According to Zeleny [17], fats in grain are readily broken down by lipases into free fatty acids and glycerol, particularly when the temperature and moisture content are high. Such changes may decrease the fat content either through loss of volatile fatty acids or the reconstitution of fatty acids and glycerol with other compounds to form non-fatty products.

The fibre composition of the "Etsew" after the first, third and fifth day of fermentation increased by 0.46%, 0.22% and 0.27%, respectively, compared to the raw corn dough after varying periods of fermentation. This implies that the "Etsew" has higher fibre content than the corn dough. This could probably be because of the chemical reaction (heat) initiated which could alter the composition of the "Etsew". The average crude fibre content in this case indicates the ability of the "Etsew" to maintain internal distension for a normal peristaltic movement of the intestinal tract: a physiological role which crude fibre plays.

Following the results in Table 1, the carbohydrate and the energy value decreased in the “*Etsew*” made from corn dough fermented after day one and day five compared to the corn dough in Table 1. The decrease in the energy value of the foods “*Etsew*” was as a result of a corresponding reduction in the protein, fat and carbohydrate content as well. The changes in the level of nutritional compositions of “*Etsew*” were significantly different ( $p < 0.05$ ) whereas, fibre content was statistically insignificant ( $p > 0.05$ ).

The decrease in protein, carbohydrate and the energy value in the various “*Etsew*” samples in the current study is similar to the findings of Assohoun et al. [7], who reported a decrease in proteins, carbohydrate and energy values in a corn-based food called “*doklu*” (kenkey) in Cote d’Ivoire after it has been fermented for different periods. However, their findings which reported an increase in fat and a decrease in ash is contrary to the present findings which showed a decrease in fat and an increase in ash.

#### 4. CONCLUSION

Soaking and milling of corn during the production of fermented corn dough increases most of its nutrients thus improving its nutritional value. Generally, fermentation was found to improve the nutritional quality of the dough with the one-day fermented dough showing the highest improvement. Although fermentation improved the nutritional value of the fermented corn dough, preparing it into “*Etsew*” by applying heat slightly reduced some of the nutrients but rather increased moisture, fibre and ash contents of the “*Etsew*”.

#### COMPETING INTERESTS

Author has declared that no competing interests exist.

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*The peer review history for this paper can be accessed here:*  
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