Journal of Dietitians Association of Nigeria (JDAN) Volume 12. December, 2021 Print ISSN: 2141-8209; eISSN: 2635-3326
***Available online at:* www.jdan.org.ng;** https://www.ajol.info/index.php/jdan/index
DOI: https://dx.doi.org/10.4314/jdan.v12i1.12

EFFECT OF FERMENTATION AND DRYING ON THE NUTRIENT AND ANTINUTRIENT COMPOSITION OF YELLOW AND WHITE MAIZE FLOURS

***Ufere, E. A., Onuoha, O. N. and Ezeja, P.**
Department of Nutrition and Dietetics, University of Nigeria, Nsukka

Correspondence author's email: ebyxcel@gmail.com

ABSTRACT
Background: Maize is the most abundant and available component of the locally prepared gruels for human consumption in Nigeria. It has been the basic source of meal for infants and breakfast for the average family. Pap in its current state cannot be stored at home for an extended period of time without spoiling or becoming contaminated.
Aim: The aim of this research was to investigate and compare the effect of fermentation and drying on the nutrient and antinutrient composition of the sieved and unsieved yellow and white maize flour.
Methods: The gains were divided into two portions and fermented for 48hrs. One portion was wet milled and sieved while the other portion was wet milled and unsieved. The slurries gotten were air- dried and sun-dried. The flours were analysis for proximate, vitamins minerals and antinutrient using standard methods.
Result: The study revealed that air dried unsieved yellow maize had an increased in protein, fibre and carbohydrate content of the flours while sun dried unsieved had an increase in fat, and ash. The air dried unsieved yellow flours had an increase in the minerals (calcium, iron and phosphorous) and vitamins (Vit A, Vit C and folate) content increased due to fermentation and unsieving. The tannin, phytate and oxalate levels were drastically reduced in the dried flours.
Conclusion: The yellow fermented unsieved air dried maize facilitates increased accessibility of nutrient and reduced anti-nutrient. Fermented unseived maize flour could therefore be used be adopted for preparation of maize pap.

Keywords: *proximate, minerals, vitamin, fermentation, maize*

INTRODUCTION

Freedom from hunger is the most fundamental human right that can be obtained if an individual is food secured. Africa is faced with food security challenge. Despite the fact that Africa remains the continent with greater arable land to feed its growing population and beyond, yet the continent remains the most impoverished in food security (1). Post-harvest food losses are on the rise, owing to limited food preservation capacity, and are now a major constraint to food and nutrition security in West African developing countries (2). Processing of agricultural products remains the most important food and nutrition security aspect in the modern world (3). The seasonality of agricultural produce also necessitates processing of products so that they are available throughout the year (4) by households and communities. This means in order to feed the world's population, most of the global production of maize, wheat, rice, sorghum and millet must be held in storage for some periods in time. In addition, food processing and preserving helps to increase food availability, thus, during the seasonal gap, foods persevered can help sustain life.

Maize (*Zea mays*) is one of the most widely grown grains in Nigeria. Maize, often known as corn, is a seasonal cereal crop that belongs to the Poaceae family (5). Maize is an important staple food for Africans to eat [5]. It's commonly made into a variety of tasty traditional dishes like ogi (West Africa), kenkey (Ghana), uji (Kenya), togwa (Tanzania), amahewu (South Africa), and mawé (Benin). The nutritive component of the plant, the maize kernel, contains phytochemicals such as carotenoids, phenolic compounds, and phytosterols (5). It's high in macronutrients like carbohydrate, fiber as well as micronutrients like vitamin B complex, carotenoids, and estimated mineral quantities like magnesium, zinc, phosphorus, and copper (5). Pap is a popular fermented semisolid food that comes in a variety of colors depending on the cereal used to make it: white and yellow for maize variety. Furthermore, pap is a cheap and readily available health-sustaining fermented food in Africa (6). In Africa, pap is an inexpensive and readily available fermented food that is good for your health (6). Pap in its current state cannot be stored at home for an extended period of time without spoiling or becoming contaminated. However, (7) stated that the agricultural practices such as (food preservation) that are sustainable are those of less energy intensive and less environmentally destructive. Pap production involves a lot of unit processes, which lowers the nutritional quality especially during steeping and sieving of the maize paste, a lot of nutrients including protein, vitamins, minerals are lost (8). Additionally, loss of these nutrients can be minimized by excluding the sieving stage (9).

Despite high maize yields, stored grains are attacked by weevil, *Sitophilus zeamais*. The maize weevil is a major pest of stored maize, resulting in significant qualitative and quantitative losses (10). Indigenous

DOI: https://dx.doi.org/10.4314/jdan.v12i1.12

processing techniques such as drying or fermentation is exclusively the women's task in rural community (11). Indigenous processing techniques provide inexpensive, safe, nutritious foods throughout the whole year and also contributes to diversify the diet of rural people in normal times and are crucial to their survival during times of food shortage. Thus, these processing techniques become basis of the survival of the rural community (1). As a result, more food is lost owing to a variety of problems such as poor infrastructure, low levels of technology, and low investment in food production systems, pests, insufficient policies, and storage, to name a few (12). Despite this, postharvest losses and storage technology have received little attention in studies on household grain management. Using indigenous knowledge to solve food shortages is still a viable option for ensuring family food security (11). The aim of this study was to compare the effect of fermentation and drying on the nutrient and antinutrient composition of the sieved and unsieved yellow and white maize flour.

MATERIALS AND METHODS

The yellow and white varieties of the maize used for this study were purchased from Ogbete main market, Enugu, in Enugu State, Nigeria.

Preparation of samples

The grains (yellow and white maize) were sifted to eliminate stones, broken grains, and other foreign contaminants. The sorted grains were thoroughly washed and steeped in tap water in appropriately labeled plastic buckets with lids at a ratio of 1:2 (w/v). The grains were fermented for 48 hours in water, fermentation took place naturally.

After the grains had fermented for 48 hours, half of each fermented variety was washed and wet milled twice into a fine slurry in an attrition mill, then sieved using a muslin cloth (200µm) to separate the pomace from the filtrate. The filter was allowed to settle for 8 hours, following which the water was decanted and the remaining mixture was scooped into a muslin bag. The muslin bag was knotted and let to drain 24hrs. The slurry was then split into two parts one of which was air-dried and the other of which was sun-dried into dry flour. This was packed separately in an airtight container and stored.

The remaining half of the fermented grain varieties were washed and milled in an attrition mill for eight times to obtain a smoother and finer slurry. The slurry was scooped into a muslin bag and allowed to drain for about 24hrs. Following that, each variety's slurry was split into two parts, with one portion being air-dried and the other being sun-dried into dry flour. This was packed separately and preserved airtight container.

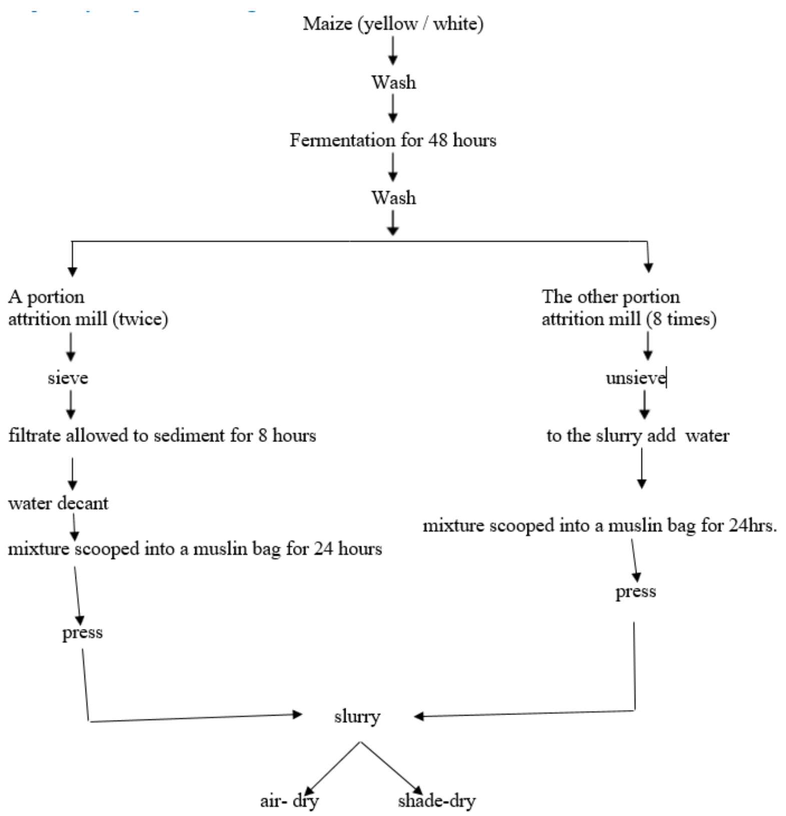

Figure 1: Processing of fermented maize flour

DOI: https://dx.doi.org/10.4314/jdan.v12i1.12

Proximate analysis of the samples
The hot air oven method (13) was used to determine moisture. Ash was determined in a muffle furnace as described by (13). Protein was determined using macro Kjedahl method (13). Fat was determined using Soxhlet fat extraction method (13). Crude fiber was determined by AOAC (13). The carbohydrate content was determined using a difference method (13).

Vitamin determination
Retinol concentration was analyzed by UV inactivation as described by Bassey, Lowry, Block and Lopez (14) using 180µl serum. Folate (Vitamin B_9) was determined with the method described by Pearson (15). The AOAC method (16) was used to determine Vitamin C levels

Mineral determination
Iron was determined by the phenonthroline method (13). The AOAC method (16) was used to analyze potassium content. Spectrophotometry (17) was used for calcium determination.

Antinutrients determination

Tannin determination
The spectrophotometric method of Folin-Denis (15) was employed for tannin determination. The AOAC (13) technique was used to determine the phytate level. The AOAC (13) technique was used to determine oxalate content.

Statistical Analysis
The data was analyzed using the Statistical Product for Service Solution (SPSS) version 22. Means and standard deviations were used to show the data. The Duncan New Multiple Range Test and analysis of variance (ANOVA) were used to separate and compare the means, respectively. $P < 0.05$ was used to determine significance.

RESULTS
Table 1 shows the proximate composition of the air-dried and sun- dried sieved and unsieved fermented yellow and white maize flour. The crude protein contents ranged from 2.29 ± 0.03% - 10.35± 0.05%. The maximum value (10.35%) was found in air-dried unsieved yellow maize, which was significantly different ($P < 0.05$) from the lowest value (2.29%) in sun dried sieved white maize. Ash contents from the various treatments (air-dried & sun-dried), states (sieved and unsieved) and varieties of maize and was significantly different ($P < 0.05$). Although, the ash content ranged from 0.38± 0.00% -0.60± 0.01%, with the sun-dried unsieved white maize having the highest value of (0.60%) was significantly different ($P < 0.05$) from the wet sieved white maize which had the least value of (0.10%). The fat content ranged from 3.60± 0.01% -5.46 ± 0.01%. The sun-dried unsieved yellow maize had the highest fat content (5.46%) and is significantly different ($P < 0.05$) from the Air-dried sieved white maize (3.60%) which had the least fat content. However, moisture content ranged from 8.31 ± 0.06% -5.84 ± 0.03. The air-dried sieved white maize had the highest moisture content (56.42%) and was significantly different ($P < 0.05$) from the sun- dried unsieved yellow maize (5.84%) which had the least moisture content. The crude fibre content varied from 4.64± 0.05%- 5.31± 0.04%. Although, the sun-dried unsieved yellow maize had the highest crude fibre content (5.31%) and was significantly different ($P < 0.05$) from air-dried sieved white maize (4.64%) which had the least crude fibre content. Carbohydrate contents varied from 71.35±0.01% - 80.48± 0.06%. However, the Air- dried unsieved white maize had the highest carbohydrate content (80.48%) and was significantly different ($P < 0.05$) from the air-dried unsieved yellow maize which had the least carbohydrate content (71.35%).

Table 1: Proximate composition of unsieved and sieved air-dried and sun-dried of fermented yellow and white maize flours in %

Sample	Crude protein	Ash	Crude Fat	Moisture	Crude Fibre	Carbohydrate
M	$2.29^a \pm 0.03$	$0.39^b \pm 0.01$	$3.84^a \pm 0.00$	$8.19^b \pm 0.03$	$4.83^c \pm 0.05$	$80.47^d \pm 0.04$
N	$6.61^b \pm 0.07$	$0.45^b \pm 0.06$	$3.60^a \pm 0.01$	$8.31^b \pm 0.06$	$4.64^c \pm 0.05$	$76.41^c \pm 0.09$
O	$7.72^b \pm 0.12$	$0.37^a \pm 0.01$	$5.28^c \pm 0.01$	$6.11^b \pm 0.01$	$5.23^d \pm 0.04$	$75.31^c \pm 0.09$
P	$7.81^b \pm 0.02$	$0.38^a \pm 0.00$	$5.04^c \pm 0.01$	$8.16^b \pm 0.01$	$4.82^c \pm 0.04$	$73.80^b \pm 0.02$
Q	$2.39^a \pm 0.03$	$0.48^c \pm 0.00$	$3.92^c \pm 0.02$	$7.83^b \pm 0.06$	$4.90^c \pm 0.05$	$80.48^d \pm 0.06$
R	$9.48^b \pm 0.07$	$0.60^d \pm 0.01$	$4.14^c \pm 0.00$	$6.38^b \pm 0.02$	$5.02^c \pm 0.04$	$74.40^b \pm 0.01$
S	$10.35^d \pm 0.05$	$0.55^c \pm 0.06$	$5.14^c \pm 0.06$	$7.65^b \pm 0.02$	$4.98^c \pm 0.03$	$71.35^a \pm 0.01$
T	$8.04^b \pm 0.04$	$0.58^d \pm 0.00$	$5.46^d \pm 0.01$	$5.84^a \pm 0.03$	$5.31^a \pm 0.04$	$74.78^b \pm 0.11$

mean values of different superscripts in the row are significant at $P < 0.05$
KEYS:M- Sun -dried sieved white maize, N – Air-dried sieved white maize, O - Sun-dried sieved yellow maize, P – Air-dried sieved yellow maize, Q – Air- dried unsieved white maize, R- Sun-dried unsieved white maize, S- Air-dried unsieved yellow maize, T - Sun-dried unsieved yellow maize.

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Table 2 shows the vitamin content in (µg/100g) of slurry, air-dried and sun-dried of fermented yellow and white maize flours. The vitamin A contents ranged from 9.40±0.00– 47.71± 0.01. The air-dried unsieved yellow maize had the highest value of (47.71 µg/100g) and was significantly different (P < 0.05) from the air-dried sieved white maize which had the least value of (9.40µg/100g). Folate contents ranged from 10.37 ± 0.04-30.13± 0.01. Folate value was significantly different among the samples. The air-dried unsieved yellow maize had the highest value of 30.13 µg/100g and was significantly different (P < 0.05) from air-dried sieved white maize which had the least value of 10.37µg/100g. Vitamin C contents ranged from 0.41± 0.01-1.12± 0.03. Vitamin C value was significantly different among the samples (P < 0.05). Moreover, the air-dried unsieved yellow maize had the highest value of (1.12 µg/100g) and the air-dried sieved white maize had the least value of (0.41µg/100g).

Table 2: Vitamins content in (µg/100g) of unsieved and sieved air-dried and sun-dried of fermented yellow and white maize flours

SAMPLE	VITAMIN A	FOLATE	VITAMIN C
M	$12.29^{c} \pm 0.10$	$12.18^{b} \pm 0.02$	$0.49^{ab} \pm 0.01$
N	$9.40^{a} \pm 0.00$	$10.37^{a} \pm 0.04$	$0.41^{a} \pm 0.01$
O	$39.5^{b} \pm 0.03$	$25.57^{cd} \pm 0.04$	$0.78^{c} \pm 0.03$
P	$35.8^{b} \pm 0.08$	$23.79^{c} \pm 0.01$	$0.68^{ab} \pm 0.00$
Q	$15.49^{c} \pm 0.16$	$17.50^{b} \pm 0.03$	$0.56^{b} \pm 0.00$
R	$13.48^{c} \pm 0.03$	$16.42^{b} \pm 0.03$	$0.39^{b} \pm 0.01$
S	$47.71^{d} \pm 0.01$	$30.13^{d} \pm 0.01$	$1.12^{d} \pm 0.03$
T	$44.23^{cd} \pm 0.04$	$26.25^{cd} \pm 0.04$	$0.91^{ab} \pm 0.01$

*mean values of different superscripts in the row are significant at P < 0.05
KEYS: M- Sun -dried sieved white maize, N – Air-dried sieved white maize, O - Sun-dried sieved yellow maize, P – Air-dried sieved yellow maize, Q – Air- dried unsieved white maize, R- Sun-dried unsieved white maize, S- Air-dried unsieved yellow maize, T - Sun-dried unsieved yellow maize

Table 3 shows the minerals content in (µg/100g) of unsieved and sieved air-dried and sun-dried fermented yellow and white maize flours. The phosphorous contents ranged from 163.00 ± 1.41– 300.00± 0.00. The air-dried unsieved yellow maize had the highest value of (300.00 µg/100g) and was significantly different (P < 0.05) from air-dried sieved white maize which had the least value (163.00µg/100g). The iron contents ranged from 1.02 ± 0.72– 4.34 ± 0.36. The Air- dried sieved white maize, had the highest value of (4.34 µg/100g) and was significantly different (P < 0.05) from the sun-dried sieved white maize which had the least value of (1.02 µg/100g). Air-dried sieved yellow maize was comparable to air dried unsieved white maize. The calcium contents ranged from 22.20 ± 0.00– 101.35 ± 5.87. Although, the air-dried unsieved white maize had the highest value of 101.35 µg/100g and was significantly different (P < 0.05) from the Sun -dried sieved white maize which had the least value of 22.20µg/100g. Sun-dried sieved white maize was comparable to Air-dried sieved yellow maize which had the same value of 22.20 µg/100g.

Table 3: Minerals content in (µg/100g) of unsieved and sieved air-dried and sun-dried of fermented yellow and white maize flours

SAMPLE	PHOSPHORUS	IRON	CALCIUM
M	$172.00^{b} \pm 0.00$	$1.02^{a} \pm 0.00$	$22.20^{a} \pm 0.00$
N	$163.00^{a} \pm 1.41$	$1.53^{b} \pm 0.00$	$31.95^{b} \pm 1.91$
O	$290.00^{c} \pm 0.00$	$3.83^{c} \pm 1.08$	$30.60^{b} \pm 0.00$
P	$265.00^{c} \pm 1.41$	$4.34^{d} \pm 0.37$	$22.20^{a} \pm 0.00$
Q	$183.00^{c} \pm 4.24$	$4.34^{d} \pm 0.36$	$101.35^{d} \pm 5.87$
R	$171.00^{b} \pm 1.41$	$1.02^{a} \pm 0.72$	$79.17^{c} \pm 9.85$
S	$300.00^{d} \pm 0.00$	$1.53^{b} \pm 0.00$	$101.38^{d} \pm 1.94$
T	$294.00^{c} \pm 2.83$	$1.02^{a} \pm 0.00$	$65.25^{c} \pm 5.87$

*mean values of different superscripts in the row are significant at P < 0.05
KEYS: M- Sun -dried sieved white maize, N – Air-dried sieved white maize, O - Sun-dried sieved yellow maize, P – Air-dried sieved yellow maize, Q– Air- dried unsieved white maize, R- Sun-dried unsieved white maize, S- Air-dried unsieved yellow maize, T- Sun-dried unsieved yellow maize

Table 4 shows the anti-nutrient composition (mg/100g) of unsieved and sieved air-dried and sun-dried of fermented yellow and white maize flours. The tannin, phytate and oxalate content were all significantly different from all the samples. Tannin content ranged from 0.32 ± 0.00-1.84± 0.03, with the air-dried unsieved yellow maize having the highest tannin content (1.84 mg/100g) and was significantly different (P < 0.05) from the Air-dried sieved white maize that had the least tannin content (0.32mg/100g). Phytate content ranged from 2.62 ± 0.03mg/100g – 7.34± 0.03 mg/100g. The air-dried unsieved yellow maize had the highest phytate content (7.34mg/100g) and was significantly different (P < 0.05) from the Air-dried sieved white maize (2.62mg/100g) that had the least phytate content. Oxalate content ranged from 0.62 ± 0.03–1.68± 0.00 mg/100g. The air-dried unsieved yellow maize had highest oxalate content (1.68mg/100g) while the Air-dried sieved white maize had the least oxalate content (0.62 mg/100g).

Table 4: Antinutrient composition (mg/100g) of unsieved and sieved, air-dried and sun-dried of fermented yellow and white maize flours

SAMPLE	TANNINS	PHYTATES	OXALATE
M	$0.45^{b} \pm 0.01$	$3.41^{b} \pm 0.01$	$0.72^{b} \pm 0.00$
N	$0.32^{a} \pm 0.00$	$2.62^{a} \pm 0.03$	$0.62^{a} \pm 0.03$
O	$1.48^{b} \pm 0.03$	$5.10^{c} \pm 0.03$	$1.08^{c} \pm 0.03$
P	$1.20^{ab} \pm 0.00$	$4.65^{cb} \pm 0.01$	$0.91^{b} \pm 0.01$
Q	$0.61^{b} \pm 0.01$	$4.24^{c} \pm 0.03$	$1.34^{cd} \pm 0.00$
R	$0.52^{b} \pm 0.00$	$3.13^{b} \pm 0.01$	$0.98^{b} \pm 0.03$
S	$1.84^{d} \pm 0.03$	$7.34^{d} \pm 0.03$	$1.68^{d} \pm 0.00$
T	$1.76^{c} \pm 0.03$	$6.39^{cd} \pm 0.00$	$1.55^{c} \pm 0.01$

*mean values of different superscripts in the row are significant at P < 0.05
KEYS: M- Sun -dried sieved white maize, N – Air-dried sieved white maize, O - Sun-dried sieved yellow maize, P – Air-dried sieved yellow maize, Q – Air- dried unsieved white maize, R- Sun-dried unsieved white maize, S- Air-dried unsieved yellow maize, T- Sun-dried unsieved yellow maize

DISCUSSION

The study revealed the unsieved air dried samples had significant increase in protein, fat, carbohydrate, moisture and fibre this could be as a result of drying and unsieving. Processing, according to (18) improves nutrient availability in dried food produce by concentrating nutrients as moisture (water) is removed. Proteins are essential in the body for the creation of hormones, digestive enzymes, DNA, vitamins, antibodies, and structural tissues (21). This agrees with the findings of (24) that fermentation increases the protein content of the sorghum. Sieving decreased the content of both nutrients and anti- nutrients in millet, maize and guinea corn (27). Crude fibers aid in food digestion, facilitate bowl movement, and aid in waste disposal (39). The carbohydrate composition of the samples was consistent with (19) findings, and the protein content of the samples was within the range reported for unsieved ogi (20). The unsieved ogi samples' high fibre content will offer them a high digestible quality, which will be beneficial to the consumers' health (20). The ash level of all the samples varied. Ash content is generally accepted as a quality indicator for assessing the functional characteristics of foods. It provides an indicator of the itinerant components of meals (40). Decreased in ash content may be due to soaking is as a result of components dissolving in the soaked water and enzymatic activities leading to low mineral content in maize and sorghum (22). The sun-dried unsieved white sorghum had the highest value of ash compared to the sun sieved white maize this was in line with, (23) reduced the ash content of the sieved samples may be due to loss of the bran. Sieving of cereal usually results in the loss of the outer components of the grain (bran). However, the sun dried sieved had a high value unlike the unsieved varieties. This could be as a result of drying and low moisture content is desirable because it enhances storability of the flours (25). Moisture affects the shelf life, the acceptability of flour and microbial growth during storage (26). The unsieved samples that were dried has significantly lower moisture contents compared with the sieved samples. The lower moisture content of the unsieved samples is as a result of the presence of fibre and germ in the samples, which binds the food matrix and thus reduces the accessibility and absorption of water (23). Carbohydrate content of all the samples were high. Carbohydrate supplies energy to cells such as the brain, muscles and blood. It contributes to fat metabolism and spares protein as an energy source. Carbohydrate acts as mild natural laxative for human beings and generally adds to the bulk of the diet (28). The sun-dried unsieved yellow maize had the highest value of crude fat. Generally, the process of sieving usually leads to the removal of the germ which is relatively high in oil, hence leading to a reduction in the fat content of the sieved samples. The fat component contributes to the calorific value of these flours. It suggests that pap made from the cereals would not be a good source of energy

Phosphorus on the other hand is concerned with growth, maintenance and repair of damaged body tissues and in conjunction with calcium and magnesium, support proper bone growth and maturation (29). Zinc ion, plays both catalytic and structural roles in enzyme activity. It is also an antioxidant capable of protecting cells from the damaging effects of oxygen radicals released during lymphocyte activation (29). Iron is an essential nutrient for transport of oxygen and cellular generation of energy (30). The unsieved air dried samples had higher values than the sundried this was in line with Sumayya et al. work which reported that loss of the fibre component of the cereal due to sieving may result in loss of some mineral (23). The Iron composition of all the samples were found to be low although, air-dried sieved yellow maize had the highest value. Samples that were sieved had a significantly ($P < 0.05$) lower mineral content across the samples compared to the unsieved samples, this may be due to the removal of the bran. The grain shape, texture and the technical conditions of milling, principally the extraction rate, are important in determining the extent of mineral loss (34).

Folate helps in the prevention of malformation of the neural tube (35) . Vitamin A supports proper bone formation and vision. It is an important antioxidant that helps maintain your healthy blood cells. It also helps with the maintenance of the heart, lungs, kidneys, and other vital organs (36). Vitamin C plays a pivotal role in body-building process and in disease prevention (36). The vitamin C, vitamin A and folate content of the air-dried unsieved yellow maize had the highest value unlike the sun dried which was in agreement with (23) they found out that sieving reduces the B vitamins, since the vitamins are found on the barn.

Phytic acid binds zinc, iron, magnesium and calcium to make complexes and reduces the bioavailability of these minerals through lower absorption rates (37). The lower oxalate content in the samples may have a positive impact on consumer health. In particular, the reduction of oxalate levels through fermentation is expected to improve the bioavailability of essential minerals in fermented maize and sorghum and reduce the risk of kidney stone formation among consumers. Tannin levels of sorghum and maize were significant lower despite the varieties, treatments and states. Tannin-rich foods are thought to have low nutritional value because they precipitate proteins, block digestive enzymes and iron absorption, and interfere with the use of vitamins and minerals from meals (38). The anti-nutrient composition, tannins was insignificant among the different drying methods, varieties and state (sieved and unsieved) this can be attributed to fermentation and soaking. This agrees to (31) that fermentation reduces the anti-nutrient content in cereals. Although, the yellow varieties of maize had the highest value compared to the white, this is in line with, reported red sorghum genetically has higher tannin compared to white sorghum (32). According to (33) fermentation reduces phytate content of sorghum flour to 77%, oxalate levels of sorghum and maize were insignificant despite the varieties, treatments and states, which is in accordance with (34) processing methods such as germination, fermentation, and boiling were found to reduce oxalate content to save level 80 mg/g. Related research report on malting of Kaura sorghum for 48 hours showed significant reduction (86.67%) of oxalate (33).

CONCLUSION

The findings revealed that drying processing methods helps retain the nutrients, indicating that drying methods can be utilized to conserve maize slurry to bridge the gap between times of plenty and scarcity, with air-drying being the best option. Although statistical analysis of the results shows no substantial mineral losses as a result of drying, the amount of nutrients kept could be useful, particularly in communities where alternate sources of these micronutrients are scarce. Traditional pap preparation involves milling and filtering fermenting corn, which results in nutritional loss could be excluded.

Declaration of interest: there is no conflict of interest

Authors contribution: Ufere, E.A. is the main researcher who designed and carried out the experiment. Onuoha, N.O. supervised the research. Ezeja, E.P. provided a preliminary review to the manuscript

Acknowledgement: The researcher acknowledges the Energy Research Centre for proving the facilities to carry out this research.

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