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Food Safety Processing and Evaluation of Powdered Pap from Maize and Malted Maize with Carrot

Emeka-Ike, P.C.[1], Ike, C.C.[2], Nwokorie, C.C.[3] and Ogwuegbu, H.O.[3]

[1]Department of Food Science and Technology, Imo State University, P.M.B. 2000, Owerri, Imo State, Nigeria.

[2]Department of Biological Sciences (Microbiology Programme), College of Basic and Applied Sciences, Rhema University, P.M.B. 7021, Aba, Abia State, Nigeria.

[3]Department of Microbiology, Abia State University, Uturu, P.M.B 2000 Uturu, Abia State, Nigeria.

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ABSTRACT

The food safety processing and evaluation of powdered pap from maize and malted maize with carrot were carried out. The standard operating procedures in flow chart for the processing of fermented maize flour (plain pap), malted maize flour and carrot powder were used. Recipe for the variables and mixing ratios was formulated. 100% fermented maize flour (plain akamu/ pap) was used as control against other variables (fermented maize flour - FMF, carrot powder - CP and malted maize flour -MMF). The variable with the ratio of 85:5:10 (FMF:CP:MMF) tagged "BOB" was found to be the most acceptable. Result showed that sample BOB pulled the following values to emerge the best in ratio composition: consistency (7.9±0.08), colour (8.3±0.41), taste (8.0±0.04), mouthfeel (7.8±0.11), aroma (7.6±0.02) and overall acceptability (8.0±0.06). Microbial assessment showed that counts were high above thresholds for coliforms ($1.9 \times 10^1 \pm 0.14$ to $2.0 \times 10^2 \pm 0.39$ CFU/g), and moderate for aerobic bacteria ($4.1 \times 10^3 \pm 0.37$ to $3.7 \times 10^4 \pm 0.14$ CFU/g) and fungi ($1.3 \times 10^2 \pm 0.12$ to $3.2 \times 10^3 \pm 0.10$ CFU/g). Five (5) bacterial and three fungal isolates were identified to include *Lactobacillus species*, *Bacillus species*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Escherichia coli; and Saccharomyces cerevisiae*, *Penicillium* species, *Aspergillus* species respectively. From the results obtained, it could be deduced that the problems of sour taste among infants consuming plain pap and malnutrition have been eliminated by blending with malted maize flour and carrot powder. These were achieved through the process of malting and enrichment with carrot powder which is a good source of beta carotene, a precursor of pro-vitamin A.

Introduction

In Nigeria, Pap is a common indigenous complementary food. It is called Akamu in Igbo, Ogi in Yoruba and Koko in Hausa. It is an extract of wet soluble carbohydrate (starch extract) from cereal grains. Pap (Akamu) has poor storage stability because of its high moisture level. Usually, it is prepared as a thin gruel. In the ancient times, pap was designed specifically to suit young children during feeding. But later the product is consumed by all groups of people. The wide range of acceptability was found to be attributed to sensory qualities such as taste and mouth feels [4].

Sometimes other products like ginger, carrot, garlic and others can be added to it at the processing stage for the purpose of improving its nutritional qualities and also its flavour. It is a semi-finished product but it can be transformed to the finished food by cooking its slurry in hot water [1]. After preparation to finished product, it becomes a viscous product, and its final viscosity is attributed to the volume of water added during preparation [2]. The food is considered a staple food in Africa, and it is used as a weaning food for infants and as breast milk enhancer for lactating mothers. It is also used as a breakfast cereal for children and a convenient food for convalescence because it digests faster [14]. This could be due to the effect of fermentation that causes break down of food to some level thereby increasing the rate of digestion of the food.

In Nigeria, as in most other developing countries, infant complementary food consist mainly of un-supplemented cereal pap made from maize, sorghum and are grossly inadequate in some macro and micro-nutrients [12]. Adequate processing and judicious blending of locally available foods could result in improved intake of nutrient to prevent malnutrition. Malting is the controlled germination of grains, followed by controlled drying of the kernels. The main reason for malting is to promote the development of hydrophilic enzymes which are not present in the non-germinated grain. Malting can improve protein and starch digestibility and also produce improvement in colour and flavour profile [17].

The processing of pap (akamu) is done mostly in an un-hygienic environment especially during processing and handling. As a result of the ubiquitous nature of microbes, pap could be prone to unintentional contamination from both handlers and environment, which include *Pseudomonas aeruginosa*, *Lactobacillus plantarum*, *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella aerogenes*, *Aspergillus* species, *Penicillium* species, *Fusarium oxysporium*, *stolonifer*, *Saccharomyces cerevisiae* and *Candida albican* [15].

Tele:
E-mail address: christian_ike@rhemauniversity.edu.ng

According to [13], *Lactobacillus* species, *Pseudomonas aeruginosa*, *Pseudomonas alkaligenes*, *Bacillus* species, *Candida* species, *Saccharomyces cerevisiae, Aspergillus* species, *Penicillium* species, *Rhizopus* species are microflora of maize. Of all the microbes listed above, Lactic acid bacteria (*Lactobacillus* species) and yeast (*Saccharomyces cerevisiae)* are the predominant microbial species during pap (akamu) fermentation.

Carrot (*Dacus carota* L) is one of the popular root vegetables grown throughout the world, and it is the most important source of dietary carotenoids in western countries [3]; [18]. Carrot contains high amount of pro-vitamin A in the form of beta carotene which when metabolized is converted to vitamin A in the liver. The seed oil contains vitamin B_6, potassium, copper, folic acid and thiamine [19]; [20]. A new product is a product which is introduced into the market and has been existing before, or existed but distinctly different from an existing food product in the market. It could be a product not previously marketed or manufactured by a company but modified to meet the need of consumers [7]. New products fails due to lack of differentiation between the product and other products in the market by real consumers, lack of identifying consumers wants, need or interest and poor implementation of marketing plan in the real world.

Most consumers are not aware of nutritionally deficient foods. They only have the notion that a good taste in the mouth depicts good nutrition. However, in developing countries, one of the greatest problems affecting millions of children especially infants is malnutrition. Therefore, this work is targeted towards food safety processing and evaluation of powdered pap from maize and malted maize with carrot.

Materials and Methods

Sample sources and collection

Yellow variety of maize (*Zea mays*) and carrot (*Dacus carota*) used for this production was bought from Relief market in Owerri municipal, Imo State, Nigeria.

Preparation of fermented maize flour

Two and half ($2^{1/2}$) kilograms of maize was prepared by the traditional wet milling process. In this process, the maize were sorted, washed and steeped in sufficient water at rooom temperature for 72 hours. The water for steeping was changed daily and on the 3rd day, it was drained and wet milled with a disc attrition mill. The wet milled slurry/ gruel was sieved using a muslin cloth. The slurry was allowed to settle overnight and the supernatant decanted. The wet cake was recovered by squeezing excess water with cheese cloth and sun-dried for three days. It was later dried in a cabinet drier at 50^0C for 8 hours. The dried meal was dried-milled with a hammer mill and sieved. The fermented maize flour were packed in cellophane and stored in a cool dry place until needed for product formulation.

Preparation for malting of maize

Two (2) kilogram of dried maize were cleaned, sorted and washed with water. The washed maize were steeped if fresh water for eight hours. They were drained and sprayed on a jute bag at room temperature for 72 hours to sprout. Water was sprinkled at intervals till the completion of sprouting operation. The sprouting operation was terminated by sun-drying for 2 days. Drying continued with a cabinet drier at 50^0C for eight hours, which gave the grain a light brown colour. The rootlets were removed, and the malted grains were dry-milled with disc attrition mill and then sieved. The malted maize were packed in cellophane and stored in a cool dry place until needed for product formulation.

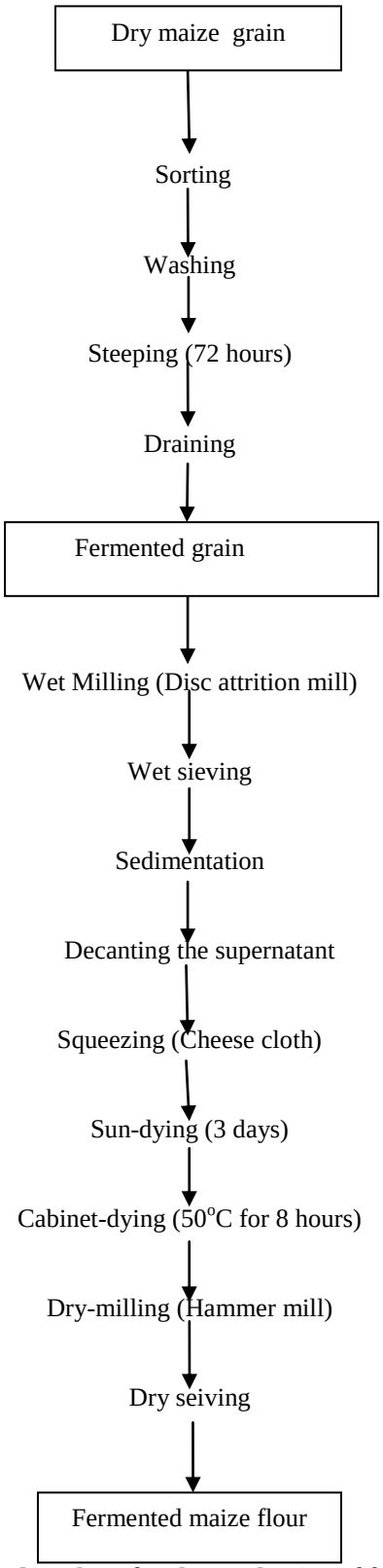

Figure 1. Flow chart for the production of fermented maize flour

Preparation of carrot flour

One (1) kilogram of carrot were cleaned, washed with water to remove soil. The cleaned carrots were diced and sun-dried. The sun-dried carrot was further dried with cabinet drier at 50^0C for eight hours, and thereafter were dry-milled with hammer mill and then sieved. The dried carrot meal was packed in cellophane for product formulation.

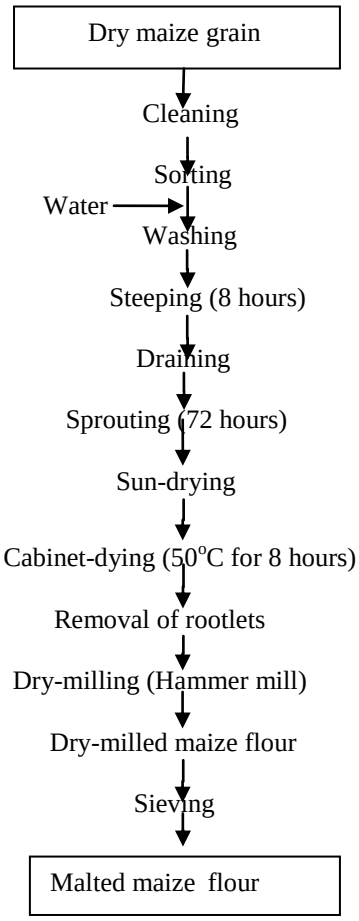

Figure 2. Flow chart for the production of malted maize flour

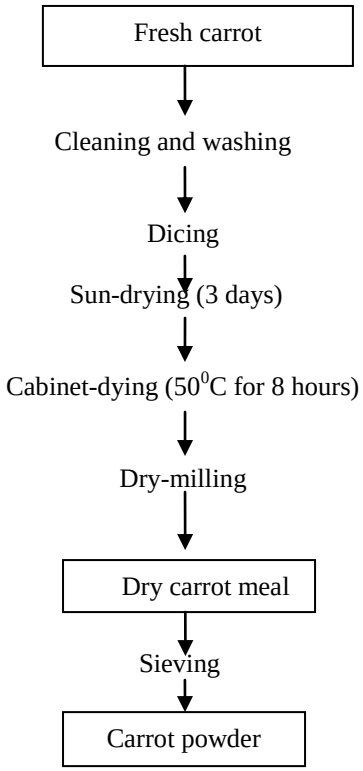

Figure 3. Flow chart for the production of carrot powder

Recipe formulation for the fermented maize flour, malted maize flour and carrot powdered pap.

The fermented maize flour was supplemented with different proportions of malted maize flour and carrot powder as shown in Table 1.

Table 1. Recipe (in percentage) for the formulation (fermented maize flour, malted maize flour and carrot powder).

Sample ID	FMF%	CP%	MMF%
EOE	100	0	0
AOA	90	5	5
BOB	85	5	10
COD	80	5	15
DOD	75	5	20

Legend: EOE -- control, AOA, BOB, COC, DOD – variants, FMF- fermented maize flour, CP- carrot powder, MMF- malted maize flour

Sensory analysis of the different formulations

Each of the various blends as shown in Table 1 was mixed with ten milliliters (10) of water to make slurry. Then an equal part of boiling water was added to the slurry with continuous stirring to obtain the fermented maize and malted maize carrot pap.

Sensory properties (color, consistency, taste, texture, mouthfeel and overall acceptability) of the pap from different formulations were carried out using a panel of five (5) assessors/ panelist. The panelist were regular customers of pap, mothers were preferred as they are the ones that make the choice of weaning foods for their infants. The sensory qualities were evaluated and coded samples were presented in random order and the scores were based on a 9-point hedonic scale, with the degree of likeness of the product attribute expressed as: 9- like extremely, 8- like very much, 7- like moderately, 6- like slightly, 5- neither like nor dislike, 4- dislike slightly, 3- dislike moderately, 2- dislike very much, 1- dislike extremely.

Microbiological studies

Sterilization and media preparation

The method as described by [5] was adopted. All glass wares used were washed in soapy water and rinsed, dried and then sterilized by dry-heat method in hot air oven at 160°C for 1½ hours. Wire loops and needles were sterilized by heating to red hot in open gas flame. The L-shaped glass rod was dipped into 70% $^{v}/_{v}$ ethanol before flaming to burn off the alcohol and then cooled beside the flame before use. The work bench was cleaned at intervals with a swab soaked in 70% $^{v}/_{v}$ ethanol, which helped in disinfecting the work bench.

The media used (Plate count agar, Sabouraud dextrose agar and Tergitol agar) were obtained in the commercially prepared powdered (dehydrated) form and were prepared according to the manufacturer's instructions. The powdered medium were reconstituted in 1000 ml distilled water in a conical flask and boiled at 100°C to dissolve properly. The flask was then stoppered and sterilized by autoclaving at 121°C (15psi) for 15 minutes. The media were allowed to cool to about 45 – 50°C before dispensing into pre-sterilized Petri dishes which were then placed on flat surface to solidify.

Preparation of sample and inoculation

Ten fold serial dilutions of samples were done using sterile peptone water as diluent. One (1) gramme of powdered pap sample was weighed and aseptically transferred to a sterile test tube containing 9.0ml of sterile peptone water as diluent, and was shaken vigorously to ensure adequate disengagement of microorganisms to obtain 10^{-1} dilution.

Serial dilutions of the homogenates were continued and made step-wisely till the fourth (4th) tube, to obtain dilutions of 10^{-2} to 10^{-4} dilutions. Spread plate techniques [5] were used to enumerate bacteria and fungi in the samples, and each dilution was plated in replicates using plate count agar for aerobic bacteria enumeration, tergitol agar for coliforms enumeration, and fortified sabouraud dextrose agar (SDA) for fungal enumeration. The plates were incubated at 35±2°C for 72 hours and 24 hours for bacterial and coliform counts respectively and 25±2°C for 120 hours for fungal counts. Pure bacterial isolates were identified using cultural, morphological and biochemical characterization, while purified fungal isolates were identified on the basis of macroscopic and microscopic characteristics by slide culture technique, and lactophenol staining.

Data analysis

Analysis of variance (ANOVA) was employed and used to analyze all data obtained from sensory evaluation and analytical determinations. Descriptive statistics in form of mean and standard deviation, and Duncan post hoc were also used to assess the data. The differences between the means were separated using the least significance difference (LSD). The analyses were done using **(**Statistical Product and Service Solutions) SPSS 16.

Results and Discussion

Result

Results of the sensory evaluation from panelist, analyzed statistically by analysis of variance (ANOVA) and mean differences separated using the least significance difference (LSD) procedure are presented in Table 2. Samples EOE (8.4±0.63) and AOA (8.4±0.44) recorded the highest value in consistency. Sample BOB had the highest value in colour (8.3±0.81), taste (8.0±0.04), mouthfeel (7.8±0.13), aroma (7.6±0.13). The overall acceptable (OA) sample was BOB (8.0±0.13). The least value in the assessed parameters in Table 2 was observed in consistency with sample DOD (4.5±0.02). The least significant difference (LSD) ranged between 0.4 to 1.

Also, the result of mean microbial count of various blended pap samples from fermented and malted maize flour with carrot powder are shown in Table 3. Mean aerobic bacteria counts had its highest count in sample DOD (3.7 $x10^4$ ±0.14) and its least count in sample AOA (4.1 $x10^3$ ±0.37), coliform counts had the highest count in sample COC (2.0 $x10^2$ ±0.39) and its least count in sample DOD (1.9 $x10^1$ ±0.14), and finally, fungal counts had its highest count in sample EOE (3.2 $x10^3$ ±0.10) and its least count in sample BOB (1.3 $x10^2$ ±0.12).

The percentage prevalence of different bacterial isolates is presented in Figure 4. *Lactobacillus* species had the highest (36%), followed by *Bacillus* species (25%), *Staphylococcus aureus* (16%), *Pseudomonas* species (12%) and *Escherichia coli* (11%).

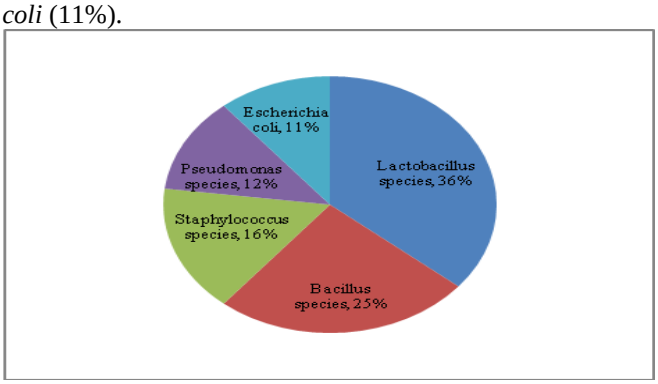

Figure 4. Percentage prevalence of bacterial isolates.

The percentage fungal prevalence is presented in Figure 5. *Saccharomyces cerevisiae* had the highest prevalence (62%), followed by *Penicillium* species (20%) and *Aspergillus* species (18%).

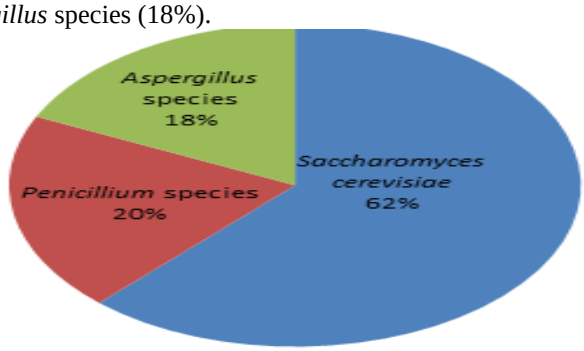

Figure 5. Percentage prevalence of fungal isolates.

Table 2. Results of sensory evaluation from panelist .

Samples	Consistency	Colour	Taste	Mouthfeel	Aroma	OA
EOE	8.4±0.63^{a}	6.3±0.19^{d}	5.6±0.08^{de}	6.2±0.16^{c}	6.0±0.07^{d}	7.5±0.15^{b}
AOA	8.4±0.44^{a}	7.0±0.22^{c}	7.0±0.51^{b}	6.6±0.03^{b}	6.5±0.12^{c}	7.0±0.21^{c}
BOB	7.9±0.08^{b}	8.3±0.41^{a}	8.0±0.04^{a}	7.8±0.11^{a}	7.6±0.02^{a}	8.0±0.06^{a}
COC	6.7±0.21^{c}	8.0±0.27^{ab}	6.5±0.71^{c}	6.0±0.05^{cd}	7.0±0.08^{b}	6.8±0.34^{c}
DOD	4.5±0.02^{d}	6.4±0.34^{d}	5.9±0.13^{d}	5.4±0.09^{e}	6.1±0.14^{d}	5.0±0.13^{d}
LSD	1.0	0.54	0.62	0.47	0.4	0.38

Mean values with different superscript along same column are significantly different ($p<0.05$), while mean values with similar superscript along same column are not significantly different ($p>0.05$). Legend: EOE- control, LSD- least significant difference, OA- overall acceptability.

Table 3. Mean microbial counts.

Samples	Microbial count (CFU/g)		
	Aerobic Bacteria Count	Coliform Count	Fungi Count
EOE	2.9 $x10^4$ ±0.31^{c}	1.2 $x10^2$ ±0.50^{c}	3.2 $x10^3$ ±0.10^{a}
AOA	4.1 $x10^3$ ±0.37^{e}	1.7 $x10^2$ ±0.19^{ab}	2.1 $x10^2$ ±0.07^{cd}
BOB	2.4 $x10^4$ ±0.15^{cd}	0.8 $x10^2$ ±0.10^{cd}	1.3 $x10^2$ ±0.12^{e}
COC	3.5 $x10^4$ ±0.26^{ab}	2.0 $x10^2$ ±0.39^{a}	2.4 $x10^2$ ±0.06^{c}
DOD	3.7 $x10^4$ ±0.14^{a}	1.9 $x10^1$ ±0.14^{e}	2.6 $x10^3$ ±0.09^{b}

Within column, mean values with different superscript along same column are significantly different ($p<0.05$), while mean values with similar superscript along same column are not significantly different ($p>0.05$). Standards: Aerobic bacteria count (ABC) = ≤ 10^5/g, Coliform count (CC) = < 100/g, Fungal count (FC) = ≤ 10^4/g (PHLS, 2000); (FSANZ, 2001).

Discussion

From the results presented in this study (Table 2), there were significant differences ($p<0.05$) among various samples when compared with control sample (EOE).Although, some samples such as AOA (consistency), and DOD (colour and aroma) did not show any significant difference with control ($p>0.05$). This showed that the higher the quantity of malted maize added, the better the color, taste, mouthful and aroma except at certain thresholds (COC). This result is in agreement with the works of [17] where they studied crop utilization and marketing; in food and nutrition quality of sorghum and millet. Also in agreement was the work of [10] during the study of proximate composition, nutritive and sensory properties of fermented maize, and full fat soy flour blends for "agidi" production. The addition of carrot powder also helped in the taste of the pap, and result showed that optimum ratio balance between fermented maize flour, carrot and malted maize flour is at 85:5:10 percent, which is with sample BOB. Sample BOB had the highest value in colour, taste, mouthfeel, aroma and in overall acceptability while EOE (control) and AOA had highest values in consistency. Therefore, from the overall assessment, BOB is the most acceptable sample having pulled the best in the various parameters when compared with other samples.

The microbial counts obtained in Table 3, though moderate but were high above thresholds for coliforms, and little below thresholds for aerobic bacterial and fungal counts. The implication of high counts for coliform is an indication of poor as well as unhygienic processing conditions and handling. However, moderate counts of aerobic bacteria and fungi are worrisome considering their differential margins from threshold. Most microbes especially bacteria replicate geometrically per second, and if nothing was done to check this trend, definitely there could be serious health risk.

Fermentation has always been employed to extend shelf life, inhibit spoilage, and other pathogenic microorganisms, and most importantly to impart desirable sensory qualities with improved nutritional value and digestibility [9]. Several microbes were isolated from this work. They include: *Lactobacillus* species, *Saccharomyces cerevisiae*, *Bacillus* species, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Escherichia coli*, *Penicillium* species and *Aspergillus* species. Out of which were five (5) bacterial species (*Lactobacillus* species, *Bacillus* species, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, and *Escherichia coli*), and three (3) fungal species (*Saccharomyces cerevisiae*, *Penicillium* species and *Aspergillus* species). Among the isolated microbial species, *Lactobacillus* species, *Saccharomyces cerevisiae*, and *Bacillus* species were identified as majors in the fermentation process and most prevalent (*Saccharomyces cerevisiae* (62%), *Lactobacillus* species (36%), and *Bacillus* species (25%). The results obtained in this study were in agreement with the works of [15], [13] and [8]. The above-mentioned isolates could be linked as either environmental contaminants, unhygienic processing contaminants or as inherent maize microflora. Also [9] reported *Bacillus* species as the most predominant fermenter of processed African oil bean seed (ugba), *Staphylococcus aureus* as normal flora of human skin and opportunistic microorganism, and *Escherichia coli* as indicative organisms for fecal contamination/ poor sanitary conditions.

Some challenges encountered during the study ranges from multiple iteration, discolouration, gritty appearance, environmental, microbiological, storage, sensory and sometimes nutritional deficiency. Therefore, there is need for modified-design of oven for better drying and monitoring to avoid discoloration of carrot shreds. The provision of hammer mill will enhance fine ground powder of carrot shreds and eliminate gritty appearance. [11] listed some of these problems during their study of Nigerian indigenous fermented foods: their traditional process operation, inherent problems, improvements and current status.

Conclusion

From the result it can be deduced that pap blended with malted maize flour and carrot powder will eliminate the evidenced sour taste of plain pap among infants. This could be achieved through the process of malting. It will also help in solving the problem of malnutrition among infants through the enrichment with carrot powder which is reported to be a good source of beta carotene a precursor of pro-vitamin A.

The microbes that facilitate fermentation of pap production are yeast (*Saccharamyces cerevisiae*) and lactic acid bacteria (*Lactobacillus* species). As fermentation proceeds, the microbial density also increases. Therefore, microbial safety is paramount and should be reduced to acceptable thresholds to ensure extended shelf life of the product. This could be achieved by ensuring food safety principles and good manufacturing practices are strictly implemented. The challenges encountered in this study to ensure safe and consumable pap devoid of any health risk ranges from environmental, microbiological, discolouration, storage, sensory and sometimes nutritional deficiency. There is need for modified-design of oven for better drying and monitoring to avoid discoloration of carrot shreds. Sensory and nutritional challenges were taken care of by the introduction of carrot powder and subsequent malting of the maize grains. The evident sour taste among fermented pap was eliminated with the introduction of blended portions of malted maize flour, while that of nutritional deficiency among vitamins was improved with the addition carrot powder. It is pertinent that hygienic conditions of the processing activities, surrounding environment be improved upon to ensure the emergence of safe and contaminant–free pap with good shelf life.

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