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Research Article

# Optimization of Nixtamal Maize Flour Fortified with Sweet Potato and Egg for *Masa* Production

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## Abstract

*Masa* is a Spanish word that connotes all kinds of dough. It is usually brown in colour and round in shape with smooth surfaces. It is also known as waina– a cereal-based yeast fermented recipe consumed in Nigeria and other West African countries. The focus of the research is to formulate and optimize nixtamal maize flour fortified with sweet potato and egg for instant *masa* production. The maize flour, sweet potato flour and egg flour was used as the mixture components at varying levels. Since *masa* as a staple food is majorly consumed by over 80% of Northern Nigeria and produced from common cereal such as maize *(Zee mays)*, rice *(Oriza sativa)*, sorghum *(sorghum vulgare)* or millet *(Pennisetum typhoideum)*. There is need for utilization of other available food component to enhance its nutritional content. D-optimal mixture experimental design was used with formulation constraints at varying levels: Nixtamal maize flour (40% – 80%), sweet potato flour (10% – 50%) and egg flour (10% – 30%). The maize flour was subjected to nixtamalization process using lime to enhance the nutritional composition of the produced fortified *masa* flour. The evaluated properties of the flours showed that the mixture components (nixtamal maize, sweet potatoes and egg flour) were compatible blends for the production of *masa*. Obtained result showed that nixtamalization as a process had a significant effect on the quality of fortified *masa* flour. The proximate and functional properties showed that the linear mixture terms were significant at $p< 0.05$. The optimum condition for the production of best fortified *masa* was found to be 71.8% nixtamal maize flour, 14.5% egg flour and 13.72% sweet potatoes flour with a desirability index of 0.582. It was concluded that nixtamal maize *masa* flour fortified with sweet potatoes and egg as a recipe was accepted because of its enhanced nutritional quality therefore recommended for *masa* production.

## Keywords

Nixtamalization, *Masa*, Micronutrient, Fortification, Flour

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# 1. Introduction

*Masa* is a Spanish word mostly referred to as all kind of dough. It is also known as *waina* which is a cereal-based spontaneously fermented cake popularly consumed in developing countries as snack or adjunct to breakfast porridges [1]. It is usually bread-like in nature, brown in colour with a round shape and smooth surfaces usually made from different types of cereal flour [2]. It can be consumed with a source because of its sour taste most times usually soup, honey or sugar [3]. *Masa* is a very famous diet that is edible by 80% of people living in the North part of Nigeria with a population of about 47 million; other countries that eat this meal include Mali, Niger, Burkina Faso and Ghana [4]. Some of the cereals used in the production of *masa* include; maize *(Zee mays)*, rice *(Oriza sativa)*, sorghum *(sorghum vulgare)* or millet *(Pennisetum typhoideum)*. Rosentrater in 2015 stated that the production of products derived from dough has been on the rise and bustling in developed nations such as the United States [5]. Since a period of 100 years now, dough from maize has being utilized to produce tortilla chips and maize snack meals by people of Mexico and Central America. Universally, there is a nourishment shift happening through a fast move and widespread of food makeup and lifestyle of the people – a call for fortification to ascertain a balanced diet for a sustainable development in combating malnutrition deficiency. The increment in prominent cases of micronutrient deficiency has been on the rise as reported by World health organization in 2002 [6]. The aftermath of the held convention pinpoints that zinc, iron, vitamin A and iodine are some of the greatest common deficiencies faced by the global populace [6]. These micronutrients are abundantly available in some locally crops such as sweet potato, carrot among others like eggs. *Masa* which is a staple food is usually produced from mono-grains cereals which are deficient in these micronutrients, hence the need for formulation with underutilized crops such as sweet potato as well as other food components. Aside the availability of sweet potato, it is also recognised because of its high percentage starchy content on dry basis and can be employed during preparation of some meals. Sweet potato is known to possess a very high yielding quantity of energy consumption per hectare per day among major food crops [7]. It is a good source of beta-carotene – a precursor to vitamin A [8, 10]. Hence, it is a compatible blend to formulate *masa* produced from nixtamal maize because of the available amount of vitamin A in sweet potato known to prevent malnutrition. It also contains some essential vitamins and minerals with several health benefits [9] as well as fibre [10]. As a tuberous crop, its ability to be developed and transformed to different kinds of products such as dried chips, starch and flour is enormous. In Nigeria and other developing countries, it is one among the consumed staple meal and has security via enhancing the tuberous crop in the nation, most importantly in Sub-Saharan Africa. Due to its nutritional potentials, it can be developed as an alternative into other products for diversification [11].

## 1.1. Food Vehicles for Masa Flour Formulation

A food vehicle is a carrier that serves as a suitable and compatible medium to facilitate formulation of *masa* flour [12]. Maize, sweet potatoe as well as other food components such as eggs can be utilized as food vehicle also known as fortificants.

According to [13], bulkiness and perishability affect post-harvest system of sweet potatoes as it has a shelf life of about one week after harvesting, hence, it becomes imperative to process sweet potato into storable products that can be used as food vehicle for instant *masa* flour production [14].

Egg as used in diet by human is dated back since the history of antiquity. Egg as food is usually consumed by many people in a variety of ways [15]. The properties of egg such as emulsification, foaming and thickening make it a good and compatible fortificant for the production of fortified *masa* flour. Also, incorporation of egg into *masa* will help solve the challenges of fragility, bulkiness and perishability characteristics. Eggs are highly nutritious and eaten by so many people universally. Therefore, incorporating egg into *masa* will make *masa* more acceptable by different categories of people [15]. To meet up with the rapid population growth in Africa, fortification of maize *masa* flour is a remedy towards meeting the projected demand for a balanced food towards sustainable development goal. Hence, the research seek to formulate and optimize nixtamal maize flour fortified with sweet potato and egg for instant *masa* production.

## 1.2. The Essence of Food Fortification

Fortification is the process of foodstuff enrichment with a mineral component or a vitamin of choice [16]. It simply means to cast up nutrients or non-nutrient bioactive components to edible products which could include food, food constituents, or supplements.

Food fortification as a concept is essential due to its ability to make use of staple foods consumed by a large segment of the population without forcing the people to change their original diet [12]. The concept of food fortification is recognized as one of the cost effective method with long term sustainability used in tackling malnutrition deficiency [17]. It is a valid process that is socially acceptable because it does not require changes in existing food pattern of the people thereby giving support to on going nutrition [6].

# 2. Materials and Methods

Maize (*zea mays*), sweet potatoes (*Ipomoea batatas L.*) and fresh egg was purchased at *Kure* market in Niger State and transported to Crop Processing Laboratory, Department of Agricultural and Bioresources Engineering, Federal University of Technology, Minna, Niger State. Other equipment used include; milling machine, measuring cylinder (200 ml), knife, muslin bag, soxhlet extracting apparatus, heating mantle, oven, centrifuge, burettes, volumetric flask (250 ml), desiccators and vis spectro photometer.

The reagents used for the research work include; 0.67g/L of lime, n-hexane, tetra-Oxo sulphate (IV) acid, indicator (methyl-orange), acetone.

## 2.1. Methods

Maize was sorted, cleaned with distilled water and cooked in a solution of 0.67g/L lime at temperature range above 85 ℃ for 5 - 40 min. The cooked maize was steeped and further washed two to three times to remove excess lime. The nixtamal maize was oven dried and milled using milling machine to obtain *masa* flour. The proximate and functional qualities were determined using the standard methods of Association of official analytical chemist, 2005 [18].

Sweet potato was processed into flour according to the method of Endrias with minor modifications [19]. Sweet potato was sorted, washed, peeled and sliced into thin pieces of about 2 mm. The sliced sweet potato was blanched by steaming at 100 ℃ for 3 minutes to prevent browning reactions. The blanched slices were then dried in a hot air oven at 60 ℃. Subsequently, the dried sliced sweet potatoes were milled, sieved with (212 µm sieve - US Standard Mesh No. 70) and packaged inside a plastic container for analysis.

Purchased eggs were washed and allowed to dry. The dried eggs were carefully deshelled to collect both the egg white, liquid and egg yolk liquid; it was later homogenized with a metal whisk to obtain a uniform solution. A foaming and stabilizing agent was added to the egg and foam-mat dried at 60 ℃ until dried. Obtained oven dried flakes were processed into flour through milling and sieving. The egg flour was packaged for further investigation.

## 2.2. Experimental Design for Fortified *Masa* Flour Production

The D-optimum mixture design was deployed for this research with a combination of mixture components at different level; Nixtamal maize flour ($x_1$) ranges between (40% – 80%), sweet potatoes flour ($x_2$) between (10% – 50%) and egg flour ($x_3$) between (10% – 30%).

# 3. Result and Discussion

The obtained result for the mixture design gave a total of 16 experimental runs using design expert software (version 13) as represented in Table 1. The result of Table 1 showed the mixture optimal design experiment for the fortified blends of flours from nixtamal maize, sweet potato and egg respectively.

***Table 1.*** *Mixture optimal design experiment for the fortified blends of flour.*

| Run | Maize flour | Sweet potato flour | Egg flour |
|---|---|---|---|
| 1 | 40.0 | 50.0 | 10.0 |
| 2 | 47.5 | 32.5 | 20.0 |
| 3 | 80.0 | 10.0 | 10.0 |
| 4 | 57.5 | 17.5 | 25.0 |
| 5 | 60.0 | 30.0 | 10.0 |
| 6 | 67.5 | 17.5 | 15.0 |
| 7 | 60.0 | 10.0 | 30.0 |
| 8 | 47.5 | 37.5 | 15.0 |
| 9 | 60.0 | 10.0 | 30.0 |
| 10 | 40.0 | 50.0 | 10.0 |
| 11 | 40.0 | 30.0 | 30.0 |
| 12 | 40.0 | 30.0 | 30.0 |
| 13 | 80.0 | 10.0 | 10.0 |
| 14 | 60.0 | 30.0 | 10.0 |
| 15 | 70.0 | 10.0 | 20.0 |
| 16 | 40.0 | 40.0 | 20.0 |

Obtained result for Table 2 showed that nixtamalization process had a significant effect on the quality of fortified *masa* flour produced. Also, the result showed the summary statistics for the regression analysis where the obtained analysed result showed that the linear mixture model was deployed for analysis of variance (ANOVA) and was significant for all the responses used at $p \leq 0.05$. The coefficient of determination ($R^2$) simply measures variation in each of the response variable that was accounted for by the mixture components namely; nixtamal maize, sweet potato and egg flour. This implies that about 37.43% variation in moisture content was explainable by the mixture components. The obtained result for carbohydrate showed that 86.07% variation was accounted for by the three mixture components.

This result is similar to the work of Ayo in 2008 where the relatively high carbohydrate content suggests the product was of significant source of energy to the consumers [4]. The result of the proximate composition of the study were similar to that of Sunico in 2021 [20].

Increase in moisture content was observed due to the increase in water uptake upon soaking maize in alkaline solutions [21-23].

The obtained result for the functional properties of the research revealed high potential for industrial applications of the flour particularly in the food systems for *masa* that require thickening and gelling [24].

***Table 2.*** *Analysis of variance (ANOVA) for proximate and functional properties of fortified masa flour.*

| Response | Model | F-value | p-value | $R^2$ | Adj $R^2$ | Pre $R^2$ | C.V. (%) | Adeq Precision |
|---|---|---|---|---|---|---|---|---|
| $Y_{mc}$ | Linear mixture | 3.89 | 0.0474 | 0.3743 | 0.2781 | 0.0366 | 49.03 | 5.0904 |
| $Y_{cf}$ | Linear mixture | 4.31 | 0.0244 | 0.6104 | 0.4687 | 0.0772 | 24.89 | 6.7095 |
| $Y_{fc}$ | Linear mixture | 6.91 | 0.0090 | 0.5152 | 0.4406 | 0.2330 | 10.96 | 7.0910 |
| $Y_{ac}$ | Linear mixture | 4.74 | 0.0181 | 0.6327 | 0.4992 | 0.0013 | 30.46 | 7.9663 |
| $Y_{cp}$ | Linear mixture | 5.18 | 0.0222 | 0.4435 | 0.3579 | 0.1760 | 22.72 | 6.0460 |
| $Y_{cho}$ | Linear mixture | 5.41 | 0.0192 | 0.8607 | 0.7015 | 0.3820 | 4.96 | 6.5306 |
| $Y_{wac}$ | Linear mixture | 4.06 | 0.0426 | 0.3846 | 0.2899 | 0.0876 | 10.10 | 4.5128 |
| $Y_{oac}$ | Linear mixture | 4.17 | 0.0262 | 0.6758 | 0.5137 | 0.2155 | 10.39 | 5.1478 |
| $Y_{sc}$ | Linear mixture | 3.41 | 0.0480 | 0.5534 | 0.3910 | 0.1246 | 18.67 | 5.5441 |
| $Y_{bc}$ | Linear mixture | 3.88 | 0.0453 | 0.8159 | 0.6056 | 0.3032 | 22.55 | 6.8901 |

$Y_{mc}$ = Moisture content, $Y_{ac}$ = Crude fibre, $Y_{fc}$ = Fat content, $Y_{ac}$ = Ash content, $Y_{cp}$ = Crude protein, $Y_{cho}$ = Carbohydrate, $Y_{wac}$ = Water absorption capacity, $Y_{oac}$ = Oil absorption capacity, $Y_{sc}$ = Swelling capacity and $Y_{bc}$ = Beta-carotene

The solutions of optimization result in Table 3 showed that the best optimal condition for the production of fortified *masa* among five solutions was 71.771% nixtamal maize, 13.727% sweet potato and 14.502% egg flour with a desirability index of 0.582. Based on the result of Table 3 on optimization solutions, the quality properties of optimal instant *masa* flour were: 5.869% moisture content, 0.108% fibre, 9.55% fat, 10.967% ash, 2.198% protein, 70.765% carbohydrate, 17.099g/$cm^3$ water absorption capacity, 13.123g/$cm^3$ oil absorption capacity, 20.997 g/g swelling capacity and 13.998 mg/100ml beta-carotene.

***Table 3.*** *Solutions of the optimization result for the formulated fortified masa flour.*

| S/No | Maize flour | Sweet Potato flour | Egg flour | MC % | Fibre% | Fat% | Ash% | protein% | CHO % | WAC g/$cm^3$ | OACg /$cm^3$ | SCg/g | BCmg/ 100ml | Desirability | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 71.771 | 13.727 | 14.503 | 5.869 | 0.108 | 9.55 | 10.967 | 2.198 | 70.765 | 17.099 | 13.124 | 20.997 | 13.998 | 0.582 | Selected |
| 2 | 66.468 | 10 | 23.532 | 8.905 | 0.166 | 10.427 | 13.481 | 2.578 | 69.696 | 15.775 | 13.282 | 17.434 | 14.728 | 0.571 | |
| 3 | 40 | 30 | 30 | 12.864 | 0.12 | 10.183 | 6.742 | 2.531 | 66.783 | 14.587 | 10.609 | 20.807 | 13.346 | 0.513 | |

| S/No | Maize flour | Sweet Potato flour | Egg flour | MC % | Fibre% | Fat% | Ash% | protein% | CHO % | WAC g/cm$^3$ | OACg /cm$^3$ | SCg/g | BCmg/ 100ml | Desirability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 77.599 | 12.401 | 10 | 4.104 | 0.1 | 9.235 | 5.018 | 2.053 | 78.926 | 17.792 | 10.947 | 20.874 | 15.013 | 0.437 |
| 5 | 40 | 48.916 | 11.084 | 7.379 | 0.12 | 7.92 | 5.943 | 1.578 | 76.73 | 17.241 | 13.212 | 23.492 | 7.582 | 0.436 |

Where MC, CHO WAC, OAC, SC and BC represent; moisture content, carbohydrate, water absorption capacity, oil absorption capacity, swelling capacity and beta carotene.

The response surface diagram of Figure 1 showed the graphical representation of the three mixture components in x-y-z plane showing the region of desirability at 0.582.

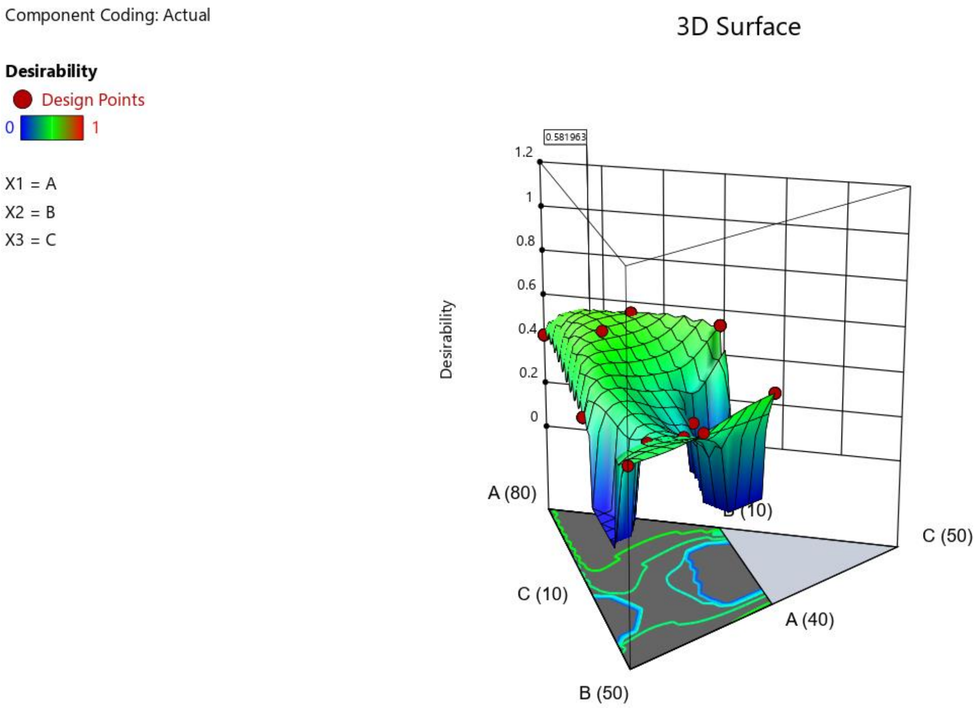


*Figure 1.* *Response surface diagram for desirability index.*

## 4. Conclusion

Obtained result of the research showed that the concept of food fortification was used to formulate *masa* flour. The formulated *masa* was characterized and optimized from the flours of three mixture components namely; nixtamal maize, sweet potato and egg. The D-optimal mixture design was used for the analysis where the optimum condition for the production of fortified *masa* flour was obtained to be; 71.771% nixtamal maize, 13.727% sweet potato and 14.502% egg flour with a desirability index of 0.582. The obtained result showed that beta-carotene been a pro vitamin A present in sweet potato can be utilized to combat cases of micronutrient deficiency as identified by the world health organization among other prevalent cases. Fortifying foods with roots and tuber such as sweet potatoes is good alternative that can be used as fortificant. The research tackled malnutrition cases as well as promotes utilization of underutilized foods for the production of local recipe. Also, other mixture components can be researched for the production of fortified *masa*.

## Abbreviations

| | |
|---|---|
| MC | Moisture Content |
| CHO | Carbohydrate |
| WAC | Water Absorption Capacity |
| OAC | Oil Absorption Capacity |
| SC | Swelling Capacity |
| BC | Beta Carotene |

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## Conflicts of Interest

The authors declare no conflicts of interest.

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