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Research Article

Physicochemical Characteristics, Anti-nutritional/ Phytochemical Properties of Germinated/ Malted Complementary Foods Based on Maize and Pigeon Pea Flour in Eastern Nigeria

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Abstract

Maize (zea-mays) and pigeon pea (cajanus cajan) were processed into flour samples by adopting a locally available methods called malting or germination. The flour samples were formulated into raw samples (RMF), (RPPF), germinated samples (GMF), (GPPF) and composite flour of the maize and pigeon pea D (75% GMF vs 25%GPPF), E (50%GMF vs 50%GPPF) and F (25% GMF vs 75% GPPF) respectively. Proximate composition, anti-nutritional /phytochemical composition and organoleptic properties of the flour samples were evaluated using standard analytical methods. Raw flour samples of the maize, pigeon pea and NUTREND (A commercial complementary food) were evaluated alongside with other samples to serve as CONTROL. Proximate composition of the samples recorded the highest protein content in the germinated pigeon pea flour (21.84%) and the lowest in the raw maize flour (6.32%). The range of Ether (5.28% - 8.25%), Ash (1.49-4.10%), Crude fibre (3.08% - 6.55%), Moisture (1.40-4.10%) and Nitrogen free extract (57.75%-79.87%) respectively. Anti-nutritional/ phytochemical composition evaluated were Oxalate (131.63-274.45)mg/100g, Saponin (1.37%-7.85%), Alkaloid (2.10%-4.30%), Cyanogenic glycoside (0.16-0.34%)mg/100g and phytate (0.31-0.69)g/100g respectively. Anti-nutritional factors were reduced due to the germination of the maize and pigeon pea seeds. Sensory scores revealed that samples E, D, F, RMF, RPPF were equally accepted. Samples formulated with 50% germinated pigeon pea scored higher than NUTREND (a commercial weaning food formulation). The study established that samples D and F can be recommended for complementary feeding.

INTRODUCTION

Cereal grains form a major producer of dietary foods like weaning formulae in Eastern part of Nigeria. People around the world rely on either fermented or germinated cereals for their sources of energy and nutrient [1].

Complementary foods are those foods given to a child in addition to the breast milk during the vulnerable time [2]. The process in which the food is administered is referred to as complementary feeding [3].

Malnutrition among young infants and young children is common in the developing countries like Nigeria. The high price of the commercial weaning food formulae, animal protein, non-availability of low priced nutritious foods, have warranted a research for low priced, readily available local foods that could be more nutritious to the child. Processing of cereal into different types is done to improve consumer acceptability while retaining it's nutritional value [4].

It appears that some processing methods such as malting/ germination can reduce anti-nutritional factors and enhances the nutrient availability of cereal grains [5].

Maize is a domesticated grass which is also referred to as corn and it is adaptable all over the world [6]. Maize kernel is composed of four (4) Primary structures from a processing perspective viz endosperm, germ, pericarp and tip cap making up 83%, 11%, 5% and 1% of the maize kernel [7]. Pigeon pea in the other hand is one of the most common tropical and subtropical legume cultivated for it's edible seeds, considered as the most important crop of food security [8].

The merits of germinating a seed used in the formulation of complementary foods are enormous. The seed are predigested thereby making it easier for child to digest and absorb nutrients from the food [9].

The process of germination has been observed to release phosphate, increase energy and nutrient density of infants diets, reduce milk and causes a quality of the complementary food formulation [10].

The combination of germinated maize-pigeon pea flour in the appropriate proportion will complement each other and increase the nutritional and biological contents of the food, thus making the nutrients bioavailable due to the processing technique (germination). This is the aim of the researcher.

MATERIALS AND METHODS

Yellow maize and brown-white pigeon pea seeds were purchased from the retail market at Eke Okigwe main market, Okigwe local government area of Imo State, Nigeria.

Preparation of Germinated Maize -Pigeon Pea Flour

The method of germinated of seeds described by Mallechi et al [11] was adopted. 10kg of cleaned maize and pigeon pea seeds were sorted manually to remove stones, weeds and spoilt grains. They were washed in potable water to remove dust and dirt and soaked separately in tap water at room temperature for 16hrs. The soaked grains were spread separately on a wet jut bags and the beds covered with moist muslin cloths and left to germinate. They were allowed to germinate for 48hours while water was sprayed at 2 hours interval to keep the germinated grains moist. The germinated grains were turned at 8hours interval to discourage the growth of moulds. At the end of the germination, the pigeon pea and maize were dehulled manually, cooked for 2hours, sundried sprouts for 2 days. The rootlets were removed manually. The malts were kilned in the oven at 650C for 20 minutes.

The kilned malts were ground with a local mill and sifted through 150µm sieve to obtain malted/germinated maize and pigeon pea flour respectively.

Mixing of the Germinated maize - pigeon pea Composite Flour

The finely ground maize-pigeon pea flour were mixed (weight/ weight) in the following proportions using RMF and RPPF as Raw maize and raw pigeon pea flour respectively.

D = 75% : 25% GMF: GPPF

E = 50%:50% GMF: GPPF

F = 25%:75% GMF: GPPF

RMF = Raw maize flour (control)

RPPF = Raw pigeon pea flour (control)

Proximate Composition of the Flour Samples

The samples were analyzed for the proximate composition i.e. Crude fibre, Crude fat, Crude protein and Moisture using the standard methods of AOAC [12]. The grain moisture was determined by drying them in oven at 105^{0}C for 4hours. Moisture content of each samples were calculated by the following:

$$\text{Moisture}(\%) = \frac{W1 - W2}{wt\ of\ samples}$$

W1 is the weight of petri-dish + sample before drying and W2 is the weight of petri-dish + sample after drying.

Crude fat was determined by Ether extract method using Soxhlet-apparatus. Percentage of fat in the samples was calculated as crude fat (%) =

$$\frac{\text{weight of the beaker} + \text{ether extract - weight of the beaker}}{\text{weight of the sample}} \times 100\%$$

The percentage crude fibre was calculated by the formular: crude fibre (%) = wt loss on ignition / wt of sample x 100

Protein content were determined by kjeldhal method which was calculated.

Crude protein (%) = % N x 6.25 (factor for cereals)

$$\%N = \frac{(s - B)xNx0.014xD}{wt\ of\ sample * v} x100$$

S = sample titration

D = dilution of sample after digestion

V = volume taken

N = the normality of Hcl

B = the blank titration

Determination of Anti-nutrients

Alkaloid was determined by the alkaline precipitation method of the Harbone [13]. Saponin content of the samples was determined by double extraction gravimetric method, Cyanogenic glycosides was determined using the alkaline picrate method described by Onwuka [14].

Phytate was determined through phytic acid process using the procedure described by Lucas and Markaka14. Oxalate was determined by the modified method described by Abiose and Ikujenlola [15].

Sensory Evaluation

The sensory assessments of the germinated complementary foods were performed on the samples prepared with boiling water. The gruel-like mass were stirred and allowed to cool at 400C. Twenty (20) semi-trained panelists were selected from staff and students of Food Microbiology Unit, Abia State University, Uturu. The judges rated the sample for taste, aroma, Color, texture and general acceptability in a 9-point hedonic scale where 9 = like extremely, I = dislike extremely and 5 = neither like nor dislike [16].

RESULTS

Mean with the same superscript in the same column are not significantly different (P>0.05)

Key: NFE = Nitrogen free extract

Ether extract = Fat

RMF = Raw maize flour (control)

RPPF = Raw pigeon pea flour (control)

GMF = Germinated maize flour

GPPF = Germinated pigeon pea flour

D = 75%:25%, GMF + GPPF

E = 50%:50% GMF + GPPF

F = 25%: 75% GMF + GPPF

Table 1 shows the proximate composition of raw and germinated maize-pigeon pea complementary food flour.

Table 1: Proximate composition of germinated complementary foods based on maize pigeon pea flour (%).

Samples	Crude protein(%)	Ether extract (%)	Ash(%)	Crude fiber(%)	Moisture(%)	NFE(%)
RMF	6.32 ± 0.49[a]	6.31±0.06[a]	2.21±0.15[a]	3.08 ± 0.21[a]	2.21 ± 0.16[a]	79.87±0.79[a]
RPPF	17.13±0.17[b]	8.25±0.09[a]	4.10±0.06[b]	6.55±0.85[b]	4.10±0.06[b]	59.87±0.46[b]
GMF	7.64±0.30[a]	6.40±0.09[a]	1.49±0.09[c]	4.51±0.03[a]	1.49±0.09[c]	78.47±0.06[a]
GPPF	21.84±0.26[b]	6.55±0.06[a]	3.80±0.03[b]	6.26±0.13[b]	3.80±0.03[b]	57.75±0.51[b]
D	6.56±0.65[a]	7.16±0.21[b]	2.29±0.07[b]	4.50±0.16[a]	2.29±0.05[b]	77.20±0.83[a]
E	13.02±0.127[b]	5.28±0.16[a]	2.47±0.09[a]	5.15±0.08[a]	2.47±0.09[a]	71.61±0.35[a]
F	15.15±0.60[b]	5.91±0.15[a]	2.57±0.05[a]	5.95±0.09[b]	2.57±0.05[a]	67.85±0.46[b]

The crude protein of raw maize flour 6.32%, GMF (7.64%), RPPF (17.13%), GPPF (21.84%), D (6.56%), E (13.02%), and F (7.64%) respectively. The increase of protein content of samples when germinated/malted is in line with the work of Lesekan [17]. Salunkhe et al [18], had earlier reported a protein increase during germination of the world oil seeds. The percentage of protein in raw pigeon pea (17.13%), is also in tandem with the previous work of Salunkhe et al., [18]. Differences where observed from the protein content of the composite blends which can be implicated from different mixing ratio adopted.

The percentage of Ether extract ranged from 6.31% to 8.25% as shown in table 1 above. There is a decrease in the percentage of ether extract in raw pigeon pea (8.25%) during germination GPPF (6.55%).

The reduction in fat content of the germinated seeds would be linked to increase in the activities of the lipolytic enzymes during malting of seeds. They can hydrolyze fats to simpler products which can be used as a source of energy and embryonic development [14]. Similar results was reported in Bambara groundnuts [19]. The reduction in fat level from raw to germinated sample was not unconnected with the use of nutrients for growth.

Ash content in table 1 ranged from 1.49% to 4.10%. Raw pigeon pea seeds recorded the highest ash content (4.10%) which reduced to 3.80% during germination. The percentage of ash content were merely stabilized during the composite blend formulation (2.29% - 2.57%) respectively. The low ash content observed is in line with the findings of Anigo et al [20] from malted cereals, soyabeans and groundnut seeds respectively.

Crude fibre in table 1 ranged from 3.08% to 6.98%. The increase of raw maize from 3.08% to 4.51% in germinated sample might be implicated to the microflora enzymes hydrolyzing complex carbohydrate to release fibre which may thereafter decrease carbohydrate [21].

The moisture content of the complementary food formulation based on maize pigeon pea (table 1) ranged from 1.49% to 3.80%, the result is low compared to the findings of Okoye et al [22] which ranged from 6.24% - 8.06% in maize and soyabean flour formulation. The low moisture content could be implicated to the sundrying and oven drying of seeds and flour samples during the processing stage. Low moisture content enhances the keeping quality of flour [23].

The carbohydrate content of maize pigeon pea flour (table 1) ranged from 59.87% - 79.87%. The carbohydrate (nitrogen free extract) was very high in raw maize flour (79.87%) but reduced during germination (78.47%). Raw pigeon pea flour (59.87%) also reduced to (57.75%) during germination. The reduction in the carbohydrate content of germinated seeds agreed with the observation of a decreased in carbohydrate content after germination [24,25]. The decrease carbohydrate levels of the germinated seeds could be implicated to increase in alpha amylase activity [18]. Alpha amylase breaks down complex carbohydrate to simpler and more absorbable sugars which are utilized by the growing seedlings during malting (Table 2).

Mean with the same superscript in a column are not significantly different (P>0.05)

Key: RMF = Raw maize flour (control)

RPPF = Raw pigeon pea flour (control)

GMF = Germinated maize flour

GPPF = Germinated pigeon pea flour

D = 75%:25% GMF + GPPF

E = 50%:50% GMF + GPPF

F = 25%: 75% GMF + GPPF

Anti-nutritional/phytochemical factors of complementary foods based on maize pigeon pea flour is as shown in Table 2 above.

Oxalate ranged from 131.63mg/100g - 274.45mg/100g and the level in raw pigeon pea flour 274.45mg/100g reduced to 197.45mg/100g due to germination of the seeds. The level of oxalate were generally low compared to its lethal dose in man (2.5kg in edible portion). The result corroborates with a decrease in oxalate as germination/malting advanced [26].

Saponins value (table 2) ranged from 1.37% in raw maize flour to 7.85% in raw pigeon pea flour. Differences exist between composite flour F and other samples except sample E (P > 0.05 level). Saponin are considered as major bioactive components. The increase in the saponin value from 1.37% in raw maize flour to 1.68% in germinated maize flour is in agreement with the findings of Yyothi et al [27] in the germination of soyabean.

Alkaloid content ranged from 2.10% - 4.30% (table 2). The level of alkaloid in raw pigeon pea flour (4.00%) reduced to 2.10% in germinated pigeon pea flour. Significance difference exist between germinated pigeon pea flour, sample F and other samples (P>0.05). Alkaloid affect a lot of metabolic processes in the body and most of them carry physiological activities hence

Table 2: Anti-nutritional /phytochemical factors of germinated complementary foods based on maize pigeon pea flour.

Samples	Oxalate (mg/100g)	Saponin (%)	Alkaloid (%)	Cyanogenic glycosides (mg/100g)	Phytate (g/100g)
RMF	153.56±0.63[a]	1.37±0.04[a]	3.50±0.14[a]	0.31±0.00[a]	0.33±0.04[a]
RPPF	274.45±0.77[b]	7.85±0.22[b]	4.00±0.14[a]	0.16±0.11[b]	0.69±0.02[b]
GMF	153.63±0.52[a]	1.68±2.57[a]	3.85±0.07[a]	0.34±0.19[a]	0.31±0.03[a]
GPPF	197.45±0.77[b]	6.03±0.55[b]	2.10±0.4[b]	0.16±0.0[b]	0.59±0.05[b]
D	141.63±0.83[d]	1.98±0.04[b]	2.30±0.14[a]	0.16±0.00[a]	0.59±0.02[a]
E	131.63±0.53[d]	4.35±0.07[c]	2.28±0.11[a]	0.16±0.00[a]	0.49±0.01[b]
F	181.78±0.39[b]	3.09±0.16[c]	4.30±0.14[c]	0.16±0.00[a]	0.61±0.04[a]

they are widely used in medicine [13]. Alkaloids are toxic to man in a high level, certain plant alkaloids causes intoxication in animals and humans which sometimes are mutagenic [28].

Cyanogenic glycosides level of the flour samples ranged from 0.16mg/100g to 0.34mg/100g (table 2). Differences were significantly observed at raw pigeon pea flour and germinated pigeon pea flour at 5% level of freedom. The low content of cyanogenic glycosides could be implicated to the soaking of the seeds before germination. Cyanogenic glycosides are water soluble, they may be leached out during soaking of seeds [29].

The phytate content (g/100g) ranged from 0.33g/100g raw maize flour to 0.69g/100g raw pigeon pea flour respectively (table 2). Phytate was considered anti-nutrient all along, but recent findings proved it's beneficial effect on health. It is said to be effective in prevention of coronary disease and has anticarcinogenic effects. It can boost immune system, it prevents colon cancer, liver cancer, lung cancer, skin cancer [30]. Significant difference do not exist between raw pigeon pea and germinated pigeon pea flour (Table 3).

Means with the same superscript in a column are not significant different (P>0.05)

Key: GMF: Germinated maize flour

GPPF: Germinated pigeon pea flour

D: 75%:25% (GMF: GPPF)

E: 50%:50% (GMF:GPPF)

F: 25%:75% (GMF: GPPF)

Hedonic scale: Staff and students who are conversant with infant foods were adopted in the ratings and they were semi-trained for this purpose.

Organoleptic/sensory properties of the complementary foods based on maize - pigeon pea were presented in table (3)

Sample E prepared from 50% germinated maize to 50% germinated pigeon pea flour scored higher (7.40%) than NUTRREND (6.60%) a commercial weaning food flour. Significant difference exist between NUTREND, sample E with other sample flour (P > 0.05)

In aroma, sample E prepared from 50% germinated maize to 50% germinated pigeon pea flour scored higher (6.80%) than NUTREND (a commercial complementary food flour). Sample E also compared favorably with NUTREND in terms of colour (6.35% versus 6.40%), the same trend followed in textural rating.

In the general acceptability, samples E and D compared favorably with NUTREND and was generally acceptable by panelists. The work agreed with findings of other researchers who variously wrote that composite blends of cereals and legumes flour can compare favorably with most of the commercial weaning foods available in the market [2, 31,32].

CONCLUSION AND RECOMMENDATION

Sample E is the flour formulated from 50% germinated maize and 50% germinated pigeon pea seeds whereas sample D is the flour formulated by 75% germinated maize and 25% germinated pigeon pea flour respectively. Despite the familiarity of NUTREND in our homes, similarities still exist between NUTREND and samples E and D. This supported the fact that maize and legumes (composite) is the major flour that has gained popularity for infant feeding in Nigeria [33]. The higher values observed in samples D and E suggested that they had an edge over other products with reference to overall acceptability. Comparable values for GMF, GPPF, and F samples suggest that the semi trained panelists equally accepted the products. Further work should be

Table 3: Organoleptic/sensory properties of germinated composite blends of complementary food based on maize pigeon pea flour on 9-point hedonic scale.

Samples	Taste	Aroma	Colour	Texture	General acceptability
GMF	5.70±1.797[a]	5.85±1.694[a]	5.85±.974[a]	5.50±1.752[a]	5.2±2.19[a]
GPPF	5.90±2.248[a]	6.20±1.908[b]	5.60±1.63[a]	5.50±1.469[a]	6.10±1.80s[c]
D	5.80±1.542[a]	5.35±1.814[a]	5.75±1.803[a]	5.75±1.743[a]	6.15±1.591[c]
E	7.40±1.273[b]	6.80±1.713[b]	6.35±1.576	6.45±1.50[b]	7.35±1.53[b]
F	5.20±1.881[a]	5.30±1.755[a]	5.60±1.729[a]	5.80±1.79[a]	5.30±1.638[a]
NUTREND	6.60±1.551[c]	6.75±1.556[b]	6.40±1.761[b]	6.40±2.26[b]	7.10±1.669[b]

geared towards the storage trial of complementary food flour to ascertain the keeping quality of this food.

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