American Journal of Science, Engineering and Technology
2026, Vol. 11, No. 2, pp. 56–66
https://doi.org/10.11648/j.ajset.20261102.12

SciencePG
Science Publishing Group

Research Article

Evaluation of Glycemic Index, Antinutritional and Sensory Properties of Fufu from Blends of Aerial Yam (AYF), Finger Millet (FMF) and Pro-Vitamin A Cassava Flours (PVACF)

Nwabueze Joseph Mbam[1, *], Francis Chiwendu Ekwu[2], Odo Micheal Odo[2], Gloria Ijeoma Gibson-Umeh[2], Ogah Anselem Ogah[3], Ugwu Ifeoma Mary[4]

[1]Chemical Engineering Department, Ebonyi State University, Abakaliki, Nigeria

[2]Food Science and Technology Department, Ebonyi State University, Abakaliki, Nigeria

[3]Polymer Engineering Department, Nnamdi Azikiwe University, Awka, Nigeria

[4]Entrepreneurship Education Department, Federal College of Education, Eha-Amufu, Nigeria

Abstract

The study x-rays the evaluation of glycemic index, Antinutritional and sensory properties of fufu blends of Aerial yam (*Dioscorea bulbifera*), finger millet (*Eleusine coracana*) and pro vitamin A cassava (*Manihot esculanta* "*Yellow cassava*"). The experiments were conducted using the simplex centroid design, 14 formulations were obtained using mixture response surface methodology as the optimizing technique. The formulated flour blends showed that there was significant difference (P<0.05) between the range of values 51.77-56.03 for Glycemic index and 14.14 -21.08 Glycemic load respectively. The anti-nutrients showed tannin, phytate, oxalate and total phenolic contents of 0.35-3.39, 1.07- 6.57, 0.84 - 3.43, and 0.59- 1.91mg/100g respectively. Significant differences did not exist (P>0.05) amongst the observed values for tannin, phytate, oxalate and phenol content. Results of the fufu blends revealed sensory score of the flour blends fufu for appearance, taste, mould ability, stickiness, consistency, colour and overall acceptability were 4.69-7.34; 4.02-5.57; 5.79-8.21; 3.80-7.71; 5.84-8.53; 2.33-7.13; and 6.33-8.20 respectively. The study showed that flour blends from aerial yam flour (AYF), finger millet flour (FMF) and pro vitamin A cassava flour (PVACF) have great potentials in the production of fufu with wide range of nutritional and sensory attributes, therefore can be used as nutritious and convenient functional foods. Enabling a new product (starch flour) source for the development of food products that can reduce dependence on other starch sources such as corn and rice.

Keywords

Glycemic Index, Aerial Yam, Finger Millets, Pro-Vitamin A Cassava, Antinutritional Properties

*Correspondence: Nwabueze Joseph Mbam (donjoe042004@gmail.com)

Received: 17 March 2026; **Accepted:** 28 March 2026; **Published:** 29 April 2026

1. Introduction

1.1. Aerial Yam

Aerial yam (*Dioscorea bulbifera)* is a species of yam in the family of *Dioscoreacea* (Kay) [21]. This species reproduces sexually by seeds and vegetative by underground and aerial tubers (bulbils) which enable it to spread rapidly and colonize entire forests in a single growing season (Langeland *et al.*) [23]. It is cultivated in Africa, Asia, and Nothern Australia where it is used for food and it provides substantial amount of calories and minerals such as iron, calcium, potassium, magnesium and phosphorous (Abara *et al.* [1]. Some varieties are eaten raw while others are by boiling or soaking. *D. bulbifera* has also been used in traditional medicine in Asia, Africa and Latin America to treat diarrhoea, dysentery, conjunctivitis, fatigue and depression among other ailments (Oboh *et al.*) [29].

1.2. Finger Millet

Finger millet (*Eleusine coracana L.*) is a cereal grown in Africa where the climatic conditions are adverse (Seunda *et al.*) [44]. Finger millet is rich in minerals like Calcium, Iron, Pottassium and Zinc. It is a very good source of natural iron and its consumption helps in recovery from anaemia (Seunda *et al.*) [44] and relaxing the body naturally. It is beneficial in conditions from anxiety, depression, insomnia and migraines. Finger millet phyto-chemicals help in digestion process. This helps in controlling blood sugar level in conditions of diabetes (Seunda *et al.*) [44]. It has been found that finger millets-based diet helps diabetic patients as it contains higher fibre than rice and wheat (Seunda *et al*). [44].

They exhibit antioxidant properties and free radical foraging activity that makes finger millets beneficial to health as a potential inhibitor towards biological oxidation that may reduce the cardiovascular health risk and acts as an anti-ageing food supplement (Seunda *et al*). [44].

1.3. Pro-Vitamin A Cassava

Cassava (*Manihot esculenta* Crantz) is one of the few most important root crops known and used in many countries of Africa, Latin America and some Asian countries (IITA) [19]. Though it has its origin in South America, cassava has become an indigenous crop in the tropics having been widely grown and used by over 500 million people in the developing world as a staple food (O'Hair) [32]. It has played vital roles in the diets of many African countries as a major source of low-cost carbohydrate (O'Hair) [32]. Cassava is valued for its outstanding ecological adaptation, low labour requirement, ease of cultivation and high yield. It is widely cultivated because it can grow in poor soils under marginal rainfall. It grows well where many other crops hardily survive. It gives good yield under marginal conditions, and when conditions are optimal, it produces more calories per hectare than most tropical crops (IITA) [19]. The above features make cassava a reliable food security crop, particularly for poor nations. The yield of improved varieties may be up to 30 to 45 tons/ha unlike local varieties, which yield 5-10 tons/ha and are susceptible to pests and diseases (Breckelbanm *et al.*) [9]. Some require 12-18 months after planting to attain optimum fresh weight [Eke-Okoro *et al. 15*; IITA, 19].

The objectives of this paper was to evaluate the glycemic index, antinutritional properties, and sensory properties of fufu from blends of Aerial yam, Finger millet and Pro vitamin A cassava flour that will produce fufu blend that will have high fibre, moderate/ low antinutrient, low glycemic index and acceptable organoleptic qualities. A response surface methodology approach.

2. Materials and Method

2.1. Source of Raw Materials

Aerial yam (*Dioscorea bulbifera*) and finger millet (*Eleusine coracana L.*) was purchased from kpirikpiri Market, Ebonyi L. G. A of Ebonyi State, Nigeria. Vitamin A cassava (*Manihot esculenta "Yellow Cassava"*) was purchased from Ebonyi State University, Biotechnology Research Centre, Ebonyi State, Nigeria.

2.2. Sample Preparation

The tubers of aerial yam *(D. bulbifera*) (Figure 1) were sorted, washed with clean water to remove adhering soil and other undesirable materials as described by Prince-will Ogbonna and Ezembaukwu, [38]. It was sorted and hand peeled using stainless steel knives and then sliced into sizes of 2 to 3 cm in thickness. The sliced yam was soaked in water at 50°C, while peeling to avoid enzymatic browning, also to remove the bitter compound from it. The slices were blanched with hot water at 80°C for 10 mins. The blanched yam slices were steeped in the water to undergo natural fermentation for 48 hours before it was drained. It was later sun dried to constant weight within 120 hours and milled using locally fabricated hammer mill and screened (1mm sieve) to produce aerial yam flour. It was stored in an air tight high density polyethylene (HDPE) prior to analysis.

2.3. Production of Germinated Finger Millet Flour

The malting of the finger millet (Figure 2) was carried out as described by Mbithi-Mwikya *et al* [25]. The finger millet grains were cleaned and sorted, (1 kg) was washed three times and steeped in 2 Litres of water for 24 h, which was changed after every 6 h. The grains were washed after steeping and germinated in ventilated cupboards for 48 h at an ambient temperature of 28 ± 2°C. Portable water was sprinkled on the germinating seeds regularly and then occasionally mixed. The germinated finger millet grains were removed and dried in an oven (escalibur dehydrator) oven at 48 ± 2°C for 24 h. The grains were milled using a locally fabricated hammer mill, 0.3 aparture opening screen was used. The finger millet flour was stored at room temperature in an air tight HDPE until further analysis.

2.4. Production of Pro-Vitamin A Cassava Flour

Figure 1. Aerial yam specie.

Figure 2. Finger millet.

Figure 3. Vitamin A Cassava.

The Pro-vitamin A cassava roots (Figure 3) were sorted, washed with potable water, manually peeled with a stainless steel knife, washed and sliced with a stainless steel knife into 1mm thickness as described by Adeshina and Bolaji, [5]. The slices were soaked in portable water for 24 hours, after which the water was drained using a palm frond weaved basket to reduce the process of fermentation. The drained cassava chips were removed and sun-dried during winter weather at average temp of 34.7°C and relative humidity of 46% for 72 h. The dried cassava chips were milled using a locally fabricated machine and were stored in HDPE at room temperature until further analysis.

2.5. Determination of Antinutritional Factor

2.5.1. Phenols

The total phenolic content of each flour blend was determined using the Folin-Ciocalteu method described by AOAC, [8]. A standard calibration curve was prepared using 25-350mg/mL gallic acid concentration in 50% (v/v) methanol. The sample was also diluted with 50% methanol to a concentration (5 ml) and centrifuged (Bosh, TLD-500, England) at 300 x g for 30 min at ambient temperature (28.0 ± 2°C). An aliquot (25mL) of Folin-Ciocalteu reagent was added to 0.25 mL of gallic acid solution and the flour sample, then mixed. After standing in the dark at room temperature for 5 min; 0.5 mL of 20% sodium carbonate solution was added followed by 4mL of double distilled water. The contents were mixed and incubated in the dark for 1h. The intensity of the green colour was then measured at 725nm using a UV-visible spectrophotometer. Total Phenol Content was expressed as milligrams gallic acid equivalent (GAE) per gram of the flour blend sample (mgGAE/g). The total phenolic content was evaluated with equation (1).

$$TPC = \frac{C1\, x\, V}{M} \tag{1}$$

Where TPC - Total phenolic content in mg/g in GAE

C_1 - Concentration of garlic acid established from the calibration curve in mg/ml

V - Volume of extract in ml

M - The weight of the plant extract in g

2.5.2. Tannins

Tannin content was determined by the AOAC, [8] method. The flour sample (0.5g) was dispensed in 50 ml (which was diluted to 5 mg/ml) of distilled water and shaken. The mixture was allowed to stand for 30 min at 28°C before it was filtered through What-man no. 4 grade of filter paper. The extract 2 ml standard tannin solution (1 mg/ml tannin acid) and 2 mL distilled water were put in a separate volumetric flask to serve as standard. 2.5ml of saturated sodium carbonate (Na_2CO_3) solution and 1ml of Folic-C reagent were added to each flask and volume made up to 50 mL and were mixed well. After standing for $1_{1/2}$ h, the sample was filtered using Whatman no. 4 grade of filter paper and the absorbance measured at 760 nm against reagent blank. The tannin content was evaluated with equation (2).

$$\text{Tannin content (mg/100g)} = \frac{\text{standard concentration x sample absorbance}}{\text{concentration of sample x standard absorbance}} \quad (2)$$

2.5.3. Phytate

The Phytate content was determined according to the method described by Vaintraub and Lapteva, [46] after extraction of a sample with 2.4% HCl for 1 h and centrifuged. Exactly 3 mL of the supernatant was added to 1mL of wade reagent (0.03% $FeCl_3.6H_2O$ and 0.3% sulphosalicyclic acid in distilled water). The absorbance of the mixture was measured at 500 nm wavelength using a UV-visible spectrophotometer. The value obtained was subtracted from the blank absorbance value and the phytate content (mg/100 g sample) was estimated from the phytic acid standard calibration curve (5-35mg/ kg) which was prepared in a similar way as the sample. As shown in equation (3).

$$\% \text{ Phytic Acid} = \frac{YVf}{100\ WVa} \quad (3)$$

Where Y= Conc. of phytic acid in the sample (mg/ml)
W= weight of sample used (g)
Vf= Total volume of extract (ml)
Va= aliquot volume analysed (ml)

2.5.4. Oxalates

Determination of Oxalates involved three major steps: Digestion, oxalates precipitation and permanganate titration as described by Oke, [34].

Digestion: Two and half (2.5) g of the flour formulation was mixed with 95 ml distilled water and 5 ml 6N HCl in a 250 ml beaker. The mixture was heated at 50 ºC for 2 hrs using a Thermostatic water bath, filtered with Whatman no. 4 grade filter paper and diluted to 125 mL with distilled water.

Oxalate Precipitation: Four (4) drops of methyl red indicator was added to 50 ml of the filtrate in a 100 ml beaker, evaporated to 25 ml volume and filtered with What-man no. 4 grade of filter paper. The filtrate was treated with 5 ml concentrated NH_4OH, heated again to 90°C 10 ml 5% $CaCl_2$ solution was added with constant stirring.

Permanganate Titration: Aliquot of 125 ml of the solution was heated to 90°C, titrated against 0.05 $NKMnO_4$ solution to a faint pink colour, and the calcium oxalate content calculated as shown in equation (4):

$$\text{10ml of 0.05 N } KMnO_4 = \frac{2.2\ mg}{L\ oxalate} \quad (4)$$

2.6. Sensory Evaluation

A consumer acceptance test was carried out to determine the acceptability of the formulation as described by Ihekronye and Ngody, [18]. Attributes such as colour, aroma, taste, consistency, appearance and overall acceptability were measured using standard methods. A sensory characteristic of experimental flours formulation into fufu was assessed by 30 Panellists. 1000 ml of water was heated to a boiling point, while 5kg of dry flour sample and blends were poured into the boiled water and stirred until a consistent gel (fufu) was produced. Sensory characteristics of each fufu was recorded using a 9 - point hedonic scale, where 9 represents extreme like, 1 represents extreme dislike and 5 represents neither like nor dislike was adopted according to Iwe, [20]. Each fufu blend prepared was labelled sample 1-t 14 and presented in a ceramic tray in a white lighted and quiet sensory evaluation room. The samples were served batch by batch in a randomized order with potable water and cup for rinsing of mouth in between tasting of samples to minimize rating errors, due to carry overs of perceived attributes of previous samples as reported by Nwabueze *et al.* [27].

2.7. Determination of Glycemic Index

Blood glucose curves were constructed from blood glucose values of animals at time 0, after 30, 60, 90-, 120-, 150- and 180-mins intervals after consumption of the glucose (control) and experimental food samples of each group. One hundred milligram (100 mg) of the samples was weighed into a large test tube, labelled and incubated with a solution containing 20 mg pepsin enzyme at 40 ºC for 60 mins to remove protein and the volume was made up to 25 ml with 0.2M tris-maleate buffer of pH 1.5 at a constant speed (13,500 rpm min^{-1}) for 1.5 min. The pH was then adjusted to 6.9 after adding Tris maleate buffer. 5ml of the prepared mixture containing 2.6 Iμ of α-amylase in Tris maleate buffer was added. The samples were incubated at 37 ºC for 3 h to hydrolyze the digestible starch in a shaking water bath (Ultra-Turrax T25, Janke & Kunkel). Aliquots of 1Ml (supernatant) were taken from the test tube every 30 min from 0-180 min (without disturbing the pellets), placed in separate tubes and incubated at 100°C for 5 min with vigorous shaking in a water bath to inactivate the enzyme. The digested starch was completely hydrolyzed using amyglucosidase, and glucose was determined as described below by calculating the digested starch as glucose 0.9. The rate of starch digestion was expressed as the percentage of TS hydrolyzed at different times. The area under the hydrolysis curve (AUC) was calculated using the first-order equation described by Goni *et al.* [16].

$$\text{AUC for refrence} = \frac{\Delta T}{2x\ (BG1+BG2+BG3+BG4+BGn} \quad (5)$$

$$iAUC = AUC - BG_0 \quad (6)$$

$$AUC = \frac{Cx\,(tf-t0)-Cx}{K\ [1-exp\ [-k(tf-to]} \quad (7)$$

Where;

C = The concentration at equilibrium (t_{180}),

Tf = The final time (180 min),

IAUC = The incremental area under curve,

BG_0 = The blood glucose of the refrence food (Control),

BG_1 + BG_2 + BG_3 + BG_4 + BG_n = The summation of the blood glucose samples at different time intervals,

t_0 = The initial time (0 min), and

K = The kinetic constant.

A hydrolysis index (HI) was calculated by comparison with the AUC of a reference food (fresh white bread) as described previously by Eke-Okoro *et al.* [15]. By using the in vitro starch HI values, the GI was estimated by equation (8) as established by Goni *et al.* [16].

$$GI = \frac{iAUC\ OF\ TEST\ FOOD}{iAUC\ OF\ REFRENCE\ FOOD} \times 100\% \quad (8)$$

2.8. Calculation of Glycemic Load

Glycemic load (GL) for each food sample was determined by the method of Salmeron *et al.* [42]. In each, individual glycemic load was calculated by taking the percentage of the foods carbohydrates content in a typical serving food and multiplying it by its glycemic index (GI) value. Equation (9) was used:

$$GL = \frac{Net\ Carbohydrate\ (g) \times GI}{100} \quad (9)$$

Net carbohydrates = Total carbohydrates – Dietary fibre (10)

Net carbs = Total carbohydrates in the food sample served. The GL was classified as follows: Low – GL ‹ 10, Medium – GL = 11-19, and High –GL = › 20 (Dona *et al.*) [13].

3. Results and Discussion

3.1. Antinutritional Composition

3.1.1. Tannin

The antinutritional composition of the blend (Table 1) revealed tannin contents range 0.35 to 3.39 mg/100g. The results of 3.39 mg/100 g for pro vitamin A Cassava flour (100PVACF) in this study are higher than the value of 1.83-3.45 mg/100 g reported by Adebowale *et al.* [3] for cassava flour and within the range of 2.45-4.50 mg/10 g for cassava flour as reported by Oyewole and Odunfa, [37]. The tannin contents of 0.35-3.39 mg/100 g for the blends in this study were significantly below reported safe levels set by World Health Organization [47] of 0.5- 1.5% (500-2000mg/100g), 1.02 -2.0% (1000 - 2000 mg/100g) and 0.5-1.2 (500 -1200 mg/100g) of WHO for cereals foods and AACC for flour blends respectively. The low tannin content reported in this study reveals its suitability for food applications and development. Dona *et al.* [13], reported that tannins can help alleviate hyperalgesia and allodynia symptoms associated with diabetic neurapetic pain (DNP) e.g epigallocatechin gallate (EGCG), and reduces inflammatory markers and oxidation. Significant differences ($P<0.05$) exist amongst the flour blend.

3.1.2. Phytate

The phytate content of the flour blends ranged from 1.07 to 6.57 mg/100g (Table 1), which were higher than the value of 0.36-4.94 mg/100g reported by Odimegwu *et al.* [31] for extruded pigeon peas. Sample 16.66AYF: 66.66FMF: 16.66PVACF had the least phytate content (1.07 mg/100 g) which is within the value of 0.36-4.94 mg/100g reported by Odimegwu *et al.* [31] Reduction of phytate in food flour implies the flour blends could be considered safe for human consumption and within the safe levels. The value of 6.57 mg/100g reported in this study for individual aerial yam flour (100AYF) was higher than the value of 1.26 mg/100g for fonio millet, 0.86 mg/100g oath flour, 1.44 mg/100g unripe plantain flour, 1.11 mg/100g wheat flour respectively Rasane *et al.* [40]. Reduction of phytate in food flour would enhance the bioavailability of minerals like zinc, and iron in the flour. This may further explain the reduction of phytate in flour blends of aerial yam flour (AYF), finger millet flour (FMF), and pro vitamin A cassava flour (PVACF). There were no significant differences ($P>0.05$) between them.

3.1.3. Oxalate

The values of oxalate ranged from 0.84-3.43 mg/100g (Table 1), which were not comparable to the values of 0.47-1.47 mg/100g observed by Usman *et al.* [45] for cereals made from blends of local rice, Soybean and coconut flour. It was also below the suggested safe levels 50-100 mg/day by National Kidney Foundation [26], 0.5-4.4 mg/100g by European Food Safety Authority [14]. The value 0.59 mg/100g for Sample 0AYF: 0FMF: 100PVACF were significantly lower than all the acceptable values 50 mg/100g reported by WHO, [47], 30 mg/100g ISO and general guidelines for cassava flour, 20 mg/100g (accessed 4th February, 2025) meaning that this food sample is nutritious and safe for consumption, particularly in areas where cassava is a staple food. The low oxalate content in this study implies that it reduces gastro intestinal irritation, improves bioavailability of nutrients, making them more easily absorbable. There were significant differences ($P<0.05$) amongst one another. Coe *et al.* [12] reported that 80% of all kidney stones were composed of calcium oxalate alone or surrounding a calcium phosphate core. Therefore, people who are pre-disposed to kidney stones are advised to avoid oxalate rich foods. On the other hand, people suffering from coronary heart diseases are encouraged to consume moderately oxalate rich foods as it helps to reduce cholesterol. This study reveals that the oxalate content in the flour blends is considered safe for human consumption.

3.1.4. Total Phenol

The total phenol content of the blends ranged from 0.59 to 1.91mg/100g (Table 1). Flour blend 0AYF: 50FMF: 50PVACF had the highest total phenolic content of (1.91 mg/100g) which was higher than the value of 0.64-1.35mg/100g reported by Bello *et al.* [10], for wheat, pigeon pea and plantain flour blends. High phenol content has been reported to adversely affect digestion as well as reduce bioavailability of minerals in foods (Achy *et al.*) [2].

The phenol levels of flour blends observed in this study were within the EFSA, [14] and ISO guide line values of 0-2.5 mg/100g (depending on the food type), the Australian NHMRC upper limit 0.1-1.0 mg/100g (Bello *et al.*) [10]. This study reveals that phenol content of the flour blends is generally considered within safe levels for the general population and most food applications. Flour blend 100AYF: 0FMF: 0PVACF had the least total phenolic content which suggests that addition of PVAC and FMF improves the phenolic compounds of the resulting flour. 0.59 mg/100g.

Table 1. *Anti-nutritional Properties of Aerial Yam, Finger Millet and Pro-vitamin A Cassava Flour Blends.*

AYF	FMF	PVACF	Tannin mg/100g	Phytate mg/100g	Oxalate mg/100g	Total phenol mg/100g
100	0	0	1.27e0.01	6.57a±0.09	2.77b±0.01	0.59i±0.01
0	100	0	0.36h±0.02	1.61e±0.23	2.51c±0.06	0.67h±0.02
0	0	100	3.39a±0.00	1.95c±0.15	3.43a±0.01	1.25c±0.01
50	0	50	2.32b±0.04	1.31f±0.09	2.38c±0.09	1.72b±0.01
0	50	50	1.91c±0.04	1.30f±0.09	1.18d±0.09	1.91a±0.01
50	50	0	0.65g±0.04	1.24f±0.09	1.11e±0.09	0.57i±0.02
33.33	33.33	33.33	1.81d±0.04	1.84d±0.09	1.34d±0.15	1.08e±0.02
66.66	16.66	16.66	1.27e±0.02	1.84d±0.00	2.34c±0.04	0.91f±0.02
16.66	16.66	66.66	2.29b±0.05	2.05b±0.09	0.84f±0.09	1.69b±0.01
16.66	66.66	16.66	1.04f±0.02	1.07f±0.04	1.34d±0.14	0.85g±0.00
50	50	0	0.65g±0.04	1.24f±0.09	1.11e±0.09	0.57i±0.02
0	0	100	3.37a±0.04	1.95c±0.15	3.43a±0.01	1.25c±0.01
100	0	0	1.27e±0.01	6.57a±0.09	2.77b±0.01	0.59i±0.01
0	100	0	0.35h±0.02	1.61e±0.23	2.51c±0.06	0.67h±0.02

Values are means of triplicate determination ± standard deviation. Values with the same superscript within the same column are not significantly different (P>0.05).
AYF- Aerial Yam flour, FMF- Finger Millets Flour, PVACF- Pro-Vitamin A Cassava Flour.

3.2. Glycemic Index

Odenigbo *et al.* [30] Stated that glycemic index (GI) is a property of starchy food, which describes the rate of blood glucose absorption after consumption. Based on standards as stated by Nyangono *et al.* [28], the glycemic index ranged 0-100 and can be classified as follows; low GI (0-55) foods cause a slower more gradual rise in blood sugar levels, Medium/moderate GI (56-69) foods cause a moderate increase in blood sugar, High GI (70- Above) foods causes a rapid spike in blood sugar levels.

The value of the glycemic index (GI) content of the samples (Table 2) showed that flour sample (100PVACF) had the highest glycemic index content 56.03, which were lower than the range value of (60-70) and (65-75) reported by Sanchez *et al.* [41] for glycemic index of bio fortified cassava. This implies that GI of pro vitamin A cassava (PVACF) flour in this study would have a relatively moderate effect on blood sugar levels compared to other starchy foods.

The value of 51.765 to 56.03 reported for the blends in this study was higher than the value of 40.03 to 46.41 reported by oluwole *et al.* [36], for blends of wheat, soybean, oat bran and rice bran flour. It was also observed that the value recorded in this study is higher than the reported value of 4.17-18.18% by Nyangono *et al.* [28], for the glycemic index of some Cameroonian local meals. Glycemic index is a measure providing details on the biological response following the ingestion of carbohydrates (Nyangono *et al.*) [28]. The variation in the glycemic index of foods is dependent on the quality and quantity of meal composition or ingredients (Pucheu) [39]. Foods rich in proteins, lipids, water, carbohydrates, mineral salts and fibres would influence the kinetics of glycemic index. Thus, the more carbohydrate a meal has, the more its glycemic index tends to increase (Nyangono *et al.*) [28]. There were significant differences (P<0.05) amongst the flour blends which indicate that the flours have distinct effects on blood sugar levels. The GI range of 51.765 to 56.028 is within a low moderate GI range, which suggests that the flour blends may have a moderate impact on blood sugar levels. This could be beneficial for individuals with diabetes or those who want to manage their blood sugar levels, research and development scientists could also explore its potential applications in nutrition and health.

3.3. Glycemic Load

The value of glycemic load ranged from 14.14 to 21.08 (Table 2), which shows that Flour blend 0AYF: 0FMF: 100PVACF had the highest glycemic load (GL) content 21.08, above the value 18.21 reported by oluwole *et al.* [36], for glycemic load of cassava varieties. The value of 21.02 for 100AYF: 0FMF: 0PVACF in this study was above the value 15.62 reported by Okoro *et al.* [35] for aerial yam flour. The value of 16.41 recorded for finger millet flour 100FMF in this study was above 5-10g/serving evaluated by Shobana *et al.* [43] and lower than the value of 22.11 reported by Igbeka *et al.* [17], for glycemic load of finger millet flour. Flour blend sample 16.66AYF: 66.66FMF: 16.66PVACF had the least Glycemic load content of 14.14 in this study, they were comparable to the range of value 9-14 g/serving for blends of fonio millets, Plantain and cassava flour blend as evaluated by Shobana *et al.* [43] and lower values of (17.3) reported by Igbeka *et al.* [17], for cassava varieties. There were significant differences (P<0.05) amongst the flour blends. The difference in the values recorded in this study were due to the adjustments in the blend ratios.

Table 2. *Glycemic Index of Aerial Yam, Finger Millet and Pro-vitamin A Cassava Fufu Blends.*

AY F (%)	FMF (%)	PVACF (%)	GI	GL
100	0	0	55.898b±0.02	21.02b±0.00
0	100	0	51.765i±0.01	16.41g±0.01
0	0	100	56.028a±0.01	21.08a±0.01
50	0	50	53.854f±0.01	15.94h±0.00
0	50	50	52.466h±0.01	15.48i±0.00
50	50	0	55.063c±0.01	19.44c±0.01
33.33	33.33	33.33	54.119e±0.01	18.09e±0.01
66.66	16.66	16.66	53.625g±0.01	17.38f±0.01
16.66	16.66	66.66	54.789d±0.01	18.79d±0.00
16.66	66.66	16.66	51.417i±0.01	14.14j±0.01
50	50	0	55.063c±0.01	19.45c±0.01
0	0	100	56.028a±0.01	21.07a±0.00
100	0	0	55.898b±0.01	21.03b±0.01
0	100	0	51.765i±0.01	16.40g±0.00

Values are means of triplicate determinations ± standard deviation.
Values with the same superscript within the same column are not significantly different (P>0.05).
AYF- Aerial Yam flour, FMF- Finger Millets Flour, PVACF- Pro-Vitamin A Cassava Flour.
GL – Glycemic Load, GI- Glycemic Index.

3.4. Sensory Properties

3.4.1. Appearance

The sensory properties of the flour blends (Table 3) showed that the appearance ranged from 4.69 to 7.34. Fufu sample 100AYF had the most preferred score 7.34 for appearance (moderately liked) amongst the fufu from the blends by the panelist. This score could be compared to the value (8.5) reported by Adeleke *et al.* [4], for aerial yam fufu and higher than the value (6.5) reported by Afolabi *et al.* [6]. This implies that the panelists preferred its visual attributes such as colour, texture and overall appearance. Fufu sample 100 PVACF had the least value (4.69) for appearance, suggesting that the panelist was less satisfied with its visual attributes. The value of 4.69 to 7.34 for the fufu blends in this study is within the value of 6.30-7.50 recorded by Anne *et al.* [7], for blends of yellow maize, soybean and unripe banana. The values are relatively low, indicating a darker appearance of the flour blend due to mallard reaction during heat treatment. There were significant differences (P<0.05) amongst the fufu blends.

3.4.2. Taste

Taste refers to the pleasantness of the food in the mouth. It is the most important attribute of food aside from its nutritional value. Taste is a code given to different foods by the sensorial palate when the food is ingested into the mouth and is usually expressed in categories; sour, sweet, salty and bitter (Blanca *et al.*) [11]. The results for taste of the fufu blend ranged from 4.02 to 5.57 (Table 3). This was lower than the value of (6.90) recorded by Anne *et al.* [7], for blends of yellow maize, soybean and unripe banana. Fufu from sample 50AYF: 0FMF: 50PVACF had the highest value 5.57 for taste, which was liked slightly in this study. Fufu samples (100FMF) had the least value 4.02 for taste, which was slightly disliked in this study. There were significant differences (P<0.05) amongst the fufu blends. The differences in taste ratings between the fufu blend could be attributed to the differences in blending ratios. It was observed that the flour blend 100AYF developed a bitter taste, presumably due to the yam content in the flour and the rate of browning that occurred during processing [33].

3.4.3. Mouldability

The mouldability value for the fufu and their blends ranged from 5.79 to 8.21 (Table 3). The value of 8.21 (like very much) for fufu sample 100AYF is higher than the value 6.21 reported by Adeleke *et al.* [3] for mouldability of aerial yam flour. This suggests that the 100AYF used in the study may have had a higher starch content, smaller particle size or other chemical and physical properties that contributed to its higher mouldability score in the study. Fufu blend 33.33AYF: 33.33FMF: 33.33PVACF had the least value for mouldability, suggesting that it is not suitable for products like fufu where mouldability is desirable. This could be attributed to the substitution of the individual flours at different ratios. The values varied significantly (P<0.05) amongst the flour blend.

3.4.4. Stickiness

Stickiness is the ability of the flour blend to form a cohesive mass or dough which enables them to cling together and form a sticky ball when pressed or manipulated. The results of the stickiness of the fufu blend (Table 3) showed the score range of 3.80 to 7.71, which was similar to the value of 7.10 recorded by Anne *et al.* [7], for the blend of yellow maize, soybean and unripe banana. This could be attributed to the damaged or gelatinized starch of fufu blend 100PVACF which were moderately liked by the panellist. Fufu sample 100AYF had the least value 3.8 for stickiness which could be attributed to reduced starch and moisture content of aerial yam flour. This value (3.8) cannot be compared to the value (6.8) and (6.5) recorded by Adeleke *et al.* [4], and Afolabi *et al.* [6] for aerial yam flour, respectively. The values varied significantly (P<0.05) amongst the flour blends which could be due to the consumers preference for products with specific texture or stickiness levels that influence their acceptance and loyalty to the product. Handling of these flours i.e mixing, kneading and shaping could also affect the stickiness of the flour blends product.

3.4.5. Consistency

The consistency value for the fufu and their blends ranged from 5.84 to 8.53 (Table 3). Consistency have been observed to have increased in Fufu sample 100PVACF due to higher starch (*amylopectin*) content, particle size and moisture content of cassava flour but decreased in fufu blend 16.66AYF: 66.66FMF: 16.66PVACF. This observation is likely to have resulted from coarseness of some of the flour blend. Sanchez *et al.* [41] Opined that the hard and irregular shaped particles are usually more readily detected in the mouth than softer and more rounded ones. Fufu sample 100PVACF was more preferred amongst the other fufu blends. The values varied significantly (P<0.05) amongst the fufu blends.

3.4.6. Colour

The results for colour of the fufu and their blends (Table 3) ranged from 2.33 to 7.13. Findings (2.93-3.6) reported by Igbeka *et al.* [17], for finger millets based composite food products and flour blends were below the result for this study. Variations in the rating in this study could be attributed to the chemical composition of the raw materials, the drying temperature and duration, as well as blending ratio of the individual flours. The increased dark colouration of fufu blend 50AYF: 0FMF: 50PVACF is an aggregate input of aerial yam flour AYF (*Dioscorea bulbifera*) and PVACF (*Manihot esculenta "yellow cassava flour"*) in the blends. This differs with the finding of Mbaeyi-Nwaoha and Odo [24]. The study revealed that colour is an important parameter in the choice of fufu prepared from the flour blends. Significant (P<0.05) difference exists among the fufu from the blends.

3.4.7. Overall Acceptability

The results of the overall acceptability of fufu (Table 3) ranged from 6.33 to 8.20, which showed the general idea of the panellist' total impression of the fufu blends. The overall acceptability of fufu sample 100PVACF had the highest mean value of 8.20 higher than 6.0-7.0 reported by Sanchez *et al.*

[41] for cassava varieties, representing liked very much. Fufu blend 0AYF: 50FMF: 50PVACF had the least mean score of 6.33 for overall acceptability, representing liked slightly. There was significant difference (P<0.05) among the fufu from the blends. According to Knuckles *et al.* [22], product attributes with a mean score greater than 5 were considered to be positive or liked by the consumers. While sensory attributes below 4 were deemed unacceptable by the panellist. All the fufu from the blends had a good rating for all the sensory attributes except the panellist means score for taste, stickiness, and colour which decreased with increasing addition of finger millet flour. The results recorded for overall acceptability in this study suggests that the values were within acceptable range, indicating that fufu produced from the flour blends were generally accepted and the blend is suitable for fufu.

Table 3. *Sensory properties of Aerial Yam, Finger Millet and Pro-vitamin A Cassava Fufu Blends.*

AYF (%)	FMF (%)	PVACF (%)	APPEARANCE	TASTE	MOULD-Ability	STICKNESS	CONSISTENCY	COLOUR	OVERALL ACCEPTABILITY
100	0	0	7.34a±0.01	4.56g±0.01	8.21a±0.01	3.81i±0.01	8.05c±0.10	6.67b±0.01	7.71b±0.01
0	100	0	4.94g±0.01	4.02i±0.01	8.07b±0.01	4.32h±0.02	8.17b±0.01	3.13h±0.01	7.13c±0.01
0	0	100	4.70h±0.00	5.03e±0.00	8.20a±0.00	7.71a±0.01	8.53a±0.01	6.00e±0.00	8.20a±0.00
50	0	50	6.74d±0.01	5.57a±0.01	5.93f±0.01	5.07f±0.00	6.51e±0.01	7.13a±0.01	6.77e±0.01
0	50	50	5.56e±0.01	4.93f±0.01	6.39c±0.01	5.22d±0.02	6.27i±0.01	4.73g±0.01	6.23j±0.01
50	50	0	6.77c±0.01	4.93f±0.00	5.80h±0.00	5.17e±0.01	6.36gh±0.01	6.44d±0.01	6.67f±0.01
33.33	33.33	33.33	6.77c±0.01	5.17c±0.00	5.79h±0.01	4.97g±0.00	6.43f±0.01	5.81f±0.01	6.47g±0.00
66.66	16.66	16.66	6.74d±0.01	5.07d±0.01	6.00e±0.00	5.21d±0.01	6.43f±0.00	6.00e±0.00	6.44h±0.01
16.66	16.66	66.66	6.96b±0.01	5.37b±0.01	6.33d±0.01	5.39c±0.01	6.61d±0.01	6.46c±0.01	6.81d±0.01
16.66	66.66	16.66	4.97f±0.01	4.50h±0.00	5.88g±0.01	5.42b±0.01	5.84j±0.01	2.33i±0.01	6.33i±0.00
50	50	0	6.77c±0.01	4.93f±0.01	5.81h±0.01	5.17e±0.01	6.37gh±0.01	6.44d±0.01	6.67±0.01
0	0	100	4.69h±0.01	5.02e±0.01	8.21a±0.01	7.70a±0.00	8.53a±0.01	6.00e±0.00	8.20a±0.00
100	0	0	7.33a±0.01	4.57g±0.01	8.20a±0.00	3.80i±0.00	8.05c±0.10	6.67b±0.01	7.71b±0.01
0	100	0	4.94g±0.01	4.03i±0.01	8.07b±0.01	4.31h±0.01	8.17b±0.01	3.13h±0.01	7.13c±0.00

Values are means of triplicate determination ± standard deviation. Values with the same superscript within the same column are not significantly different (P>0.05).

AYF- Aerial Yam flour, FMF- Finger Millet Flour, PVACF- Pro-Vitamin A Cassava Flour.

4. Conclusion

Fourteen flour formulations fufu were produced and were subjected to analysis for its anti-nutritional properties, glycemic index, and sensory evaluation. The study reveals significant differences (P<0.05) in the properties of the blends. The inclusion of (66.66 FMF) finger millet flour improved the textural quality of the fufu. The appearance, taste and overall acceptability of fufu produced with flour blend 16.66AYF: 16.66FMF: 66.66PVACF was most preferred among the blends. Sensory evaluation showed that the high rating for overall acceptability of the flour blends indicated low antinutrients, good sensory attributes and medium (moderate) glycemic index of the fufu blends. This study has also contributed meaningfully to the knowledge of nutrition therapy as a management tool for blood glucose level especially for diabetes.

Acknowledgments

The authors sincerely acknowledge Mr Micheal Adesokan and Mr Anthony Igboji for assisting me in the laboratory work; Prof Laura Chioma Okpala who taught me the statistical and optimization analysis, Associate Prof Ogah Anselem Ogah for guidance and my darling wife Mrs Anulika Ruth Mbam for her moral and spiritual support. The mover behind the mask.

Author Contributions

Nwabueze Joseph Mbam: Conceptualization, Writing – original draft, Resources, Writing – review & editing
Francis Chiwendu Ekwu: Supervision, Writing – review & editing
Odo Micheal Odo: Supervision
Gloria Ijeoma Gibson-Umeh: Resources
Ogah Anselem Ogah: Writing – review & editing
Ugwu Ifeoma Mary: Resources

Conflicts of Interest

The authors declared no conflicts of interest.

References

[1] Abara, S. E., Okezie, C. E. A., Nwosu, K. (2000). Effects of storage methods on the quality of aerial yam (*Dioscorea bulbifera*) tubers. *Journal of Food Technology in Africa,* 5(2): 54-56.

[2] Achy, J. Y., Koffi, P. K. B., Ekissi, G. S. E., Konan, H. K and Kouame, L. P. (2016). Assessment of physico-chemical properties of Anti-nutritional factors of flour from yam (*Dioscorea bulbifera*) Bulbils in Southeast Cote D'ivore. *Internal Journal of Adv. Res.* 4(12): 871-888.

[3] Adebowale, A. A., Sanusi, S. A., and Oladimeji, M. O. (2016). Proximate composition functional and pasting properties of cassava flour. *African Journal of Food Science* 10(3): 53-59.

[4] Adeleke, R. O., Oladapo, F. A., Olajide, A. (2017). Physicochemical properties of aerial yam flour. *Journal of Food Science and Technology,* 54(4): 1056-1063.

[5] Adeshina, B. S., and Bolaji, O. T. (2013). Effect of milling machines and sizes of cooked cassava flour quality, *Nigerian Food Journal.* 31(1): 115-119.

[6] Afolabi, T. A., Olamide. R. O., Oluwaseun, A. (2020). Evaluation of the physicochemical properties of aerial yam flour. *Journal of Food Measurement and Science,* 14(2): 149-157.

[7] Anne, P. E., Victor, E. N., and Kachataiya, G. T. (2020). In-vitro digestibility, glycemic index, Nutritional and sensory properties of Breakfast cereals developed from flour blends of yellow maize, soybean, and unripe Banana. *International Journal of Food Nutrition and Safety,* 11(1): 13-36.

[8] AOAC (2010). Official Methods of Analysis, 18th ed. Association of Official Analytical Washington D. C., USA.

[9] Breckenbanm, C. J., Hodgson, J. M., Jensen, L. A. (1978). Identification of weed seedlings. Iowa State University Press, vol 1: 1-215.

[10] Bello, F. A., Edeke, J. E., Sodipo, M. (2019). Evaluation of chemical, functional and sensory properties of flour blends from sorghum, African Yam Bean and Soybean for use as complementaryfeeding. *International Journal of Food Science and Biochemistry.* 4(3): 74-81.

[11] Blanca, J. V., Carleneth, P. F., Judith, C. A., Christle G. R. C. (2009). Relationship of PROP (6-N-PROPYLTHIOURACIL) Taster status with body mass index and food prefrences of FILIPINO adults, *Journal of sensory studies* 24(3): 354-371.

[12] Coe, F. I., Parks, J. H., Asplin, J. R (1992). The pathogenesis and treatment of kidney stones. *New English Journal of Medcine*. 327: 1141-1152.

[13] Dona, A. C., Pages, G., Gilbert, R. G, Kuchel, P. W. (2010). Digestion of starch: invivo and invitro kinetic models used to characterize oligosaccharide or glucose release, *Carbohydrate Polymers,* 80(3): 599-617.

[14] EFSA (2018). Technical report on notification of decorated grains of Digitaria exillis (Kippist) stapf as a traditional food from third country pursuant to article 14 of Regulation EU (2015/2283). Published 20 July, 2018.

[15] Eke-Okoro, O. N; Olojede, O. A. and Nnodu, E. C. (1999). The use of bulking rate in selecting early maturing cassava cultivars. *Journal of Sustainable Agriculture and Environment* 1: 34-137.

[16] Goni, I., Garcia-Diz, L., Manas, E., Saura-Calixto, F. A. (1996). Analysis of resistant starch: A method for foods and food products. *Food chemistry,* 56(4): 445-449.

[17] Igbeka, J. C., Nwosu, J. N., Nwakaudu, M. S (2019). Moisture content and other quality parameters of cassava flour produced from different cassava varieties. *Journal of Food Measurement and Science,* 13(2): 149-157.

[18] Ihekoronye, A. I. and P. O. Ngoddy, (1985). Integrated Food Science and Technology for the Tropics. 1st Edition, Macmillan Publishers, pp: 236-265, 283-292.

[19] IITA (1990). Cassava in tropical Africa: A reference manual, IITA, Ibadan, Nigeria. Pp. 87-120.

[20] Iwe, M. O. (2001). Organoleptic assessment of extruded blends of soy and sweet potato flour by response surface analysis. *Plants Food for human Nutrition* 60: 1-14.

[21] Kay, D. E. (1987). Tropical development and research institute, *Root crops,* in crop and product digest 2: 237-248.

[22] Knuckles, B., Hudson, C., Chiu, M., Sayre, R. (1997). Effect of B-glucan barley fractions in high fibre bread and pasta. *Cereals Foods World,* 42(2): 94-100.

[23] Langeland, K. A., Burks, K. C., Hall, D. W (1998). Identification and Biology of Non-Native Plants in Florida's Natural Areas. University of Florida / Institute of Food and Agricultural Sciences, volume 1: 1-165.

[24] Mbaeyi-Nwaoha, I. E., and Odo, J. E. (2018). Production and evaluation of breakfast cereals from blends of acha, mung bean, and orange fleshed sweet potato. *African Journal of Food Science and Technology*, 9(4): 9-14.

[25] Mbithi-Mwikya, S., Van Camp, J., Yiru, Y., and Huyghebaert, A. (2000). "Nutrient and Antinutrient Changes in Finger Millet (Eleusine coracan) during Sprouting." LWT- *Food Science and Technology* 33(1): 9-14.

[26] National kidney foundation, American Society of clinical pathology, leading laboratories and clinical Laboratory Societies Unit to diagonose chronic kidney disease. Embargoed: Febuary 21, 2018, 8. am EST.

[27] Nwabueze, T. U., Iwe, M. O. and Akobundu, E. N. T. (2018). Physical characteristics and acceptabilityof extruded African breadfruit – based snacks. *Journal of Food Quality,* 31(2): 142-155.

[28] Nyangono, B. C. F., Ntentie, F. R., Dakam, W., Magne, N. D., Ngobe, E. E. M., Nga, M. G. N., Guimatio, T. M., Salamatou, O., Dang, B. E., and Ngondi, J. I. (2022). Evaluation of glycemic of some Cameroonian local meals: A contribution to the management of metabolic syndrome. *Fortune Journal of Health Science,* 5(2): 407-425.

[29] Oboh, G., Ademiluyi, A. O., Akindahunsi, A. A. (2001). Nutritional and toxicological evaluation of *Dioscorea bulbifera* (Air potatoes). *Journal of Food Composition and Analysis,* 14(4): 361-368.

[30] Odenigbo, A. M., Ndingden, S. A., Nwankpa, C. A., Woin, N., and Ngadi, N. (2013). In vitro starch digestibility and nutritional composition of improved rice varieties from cameroun. *European Journal of Nutrition and Food safety,* 3(4): 134-145.

[31] Odimegwu, N. E., Ofoedu, C. E., Omeire, G. C., Umelo, M. C., Eluchie, C. N., Alagbaoso, S. O., Njoku, N. E., and Ozoani, P. O. (2019). Production and Evaluation of Breakfast Cereals from flour blends of Maize (*Zea mays)* and Jackfruits (*Artocarpus heterophyllus Lam.)* seeds. *Archives of current Research International,* 16(3): 1-16.

[32] O'Hair, S. K. (1990). Tropical root and tuber crops. Timber press, Portland, Pp: 424-428.

[33] Okaka, J. C. (2003). Food composition, spoilage, shelf-life extension. OCJANCO Academic Publishers, Independent layout, Enugu. Nigeria p. 57-58.

[34] Oke, O. L (1969). Oxalic acid in plants and in nutrition, world review of nutrition and diatectics. S. Karget Based (edition) P. 262.

[35] Okoro, C. E., Nwakaudu, M. S., Okoro, B. C. (2016). Quality characteristics of cassava flour produced from different cassava varieties. *Journal of Food Science and Technology*, 53(2): 1048-1055.

[36] Oluwole, S. I., Damilola, A. F., Timitehin, D. O. (2021). Nutrirional characteristics. Glycemic index and blood Glucose lowering property of gluten-free composite flour from wheat (*Triticum aestivuma)*, Soybean (*glycine max),* Oat bran (*Avena sativa) and rice bran* (Oriza sativa), Applied Food Research. 112: 1-13.

[37] Oyewole, O. B and Odunfa, S. A. (2015). Physicochemical and Functional properties of cassava flour. *Journal of Food Science and Technology*, 52(4): 2319-2326.

[38] Princewill- Ogbonna, I. L., and Ezembaukwu (2015). Effects of various processing methods on the pasting and functional properties of aerial yam (*Dioscorea bulbefera*) flour. *British Journal of Applied Sciences and Technology* 9(5): 517-526.

[39] Pucheu, N. G. (2005). Contribution to the study of the glycemic index and its application in domestic carnivores. National vertinary school of Toulouse. National Vertinary School 70.

[40] Rasane, P., Jha, P., Sabikh, L., Kumar, A., and Unnikrishnan, V. S (2013). Nutritional advantages of oaths and opportunities for its processing as value added foods- review. *Journal of food science and Technology* 52(2): 1- 12.

[41] Sanchez, T., Ceballos, H., and Dufour, D. (2016). Physicochemical and functional properties of pro- vitamin A cassava flour. *Journal of Food Science and Technology,* 53(4): 1933-1941.

[42] Salmeron, J., Manson, J. E., Stampfer, M. J., Colditz, G. A., Wing, A. L., Willet W. C. (1997). Dietary fibre, glycemic load, and risk of non –insulin dependent diabetes mellitus in woman. *Jama* 277(6): 472-477.

[43] Shobana, S., Lakshmipriya, N., Bai, M. R., Gayathri, R., Ruchi, V., Sudha, V., Malleshi, N. G., Krishanaswamy, K., Henry, C. K and Anjana, R. M. (2017). Even minimal polishing of an Indian parboiled brown Rice variety leads to increased glycemic responses. *Asian Pac. J. Clin. Nutr.* 26: 829-836.

[44] Syeunda, C. O., Anyango, J. O., Faraj, A. K., and Kimurto, P. K. (2020). "In Vitro Protein Digestibility of Finger Millet Complementary Porridge as Affected by Compositing Precooked Cowpea with Improved Malted Finger Millet." *Journal of Food Science and Technology* 1-10.

[45] Usman, G. O., Ameh, U. E., Alifa, O. N., and Babatunde, R. M. (2015). Proximate composition and antinutrional properties of breakfast cereal made from blends of local rice, soybeans, and coconut flour. *J. Food Nutri. And Food Sci.* S11: S11006.

[46] Vaintraub, I. A. and Lapteva, N. A. (1988). Calometric dtermination of phytate in unpurifid extracts, of seeds, and the products of their processing. *Analytical Biochemistry*, 175: 227-230.

[47] World Health Organization (1998). The world health Report: Reducing risk, promoting healthy life. WHO, Geneva, June, 2025.