

UNDER PEER REVIEW

Original Research Article

Production and Evaluation of Breakfast Cereals from Rice, African yam-bean and Orange-Fleshed Sweet Potato

Abstract

Aims: The aim was to produce and evaluate the properties (proximate and functional) of ready-to-eat breakfast cereals from blends of local rice (*Oryza sativa*), malted African yam-bean and orange-fleshed sweet potato [*Ipomoea batatas* (L) Lam.] (umusco/3 variety) flours as well as to evaluate the nutritional properties, microbiological quality and sensory attribute of the formulated breakfast cereals.

Study Design: The experimental design that was used is Completely Randomized Design.

Place and Duration of Study: The study took place at the Department of Food Science and Technology, University of Nigeria, Nsukka between December 2016 and September 2017.

Methodology: The study investigated the application of local rice, malted African yam bean and orange-fleshed sweet potato flour to develop ready-to-eat breakfast cereals rich in proteins and pro-vitamin A. The local rice and malted African yam bean flours were blended in the ratio of 100:0, 90:10, 80:20, 70:30, 60:40 and 50:50 to produce ready-to eat breakfast cereals which was subjected to sensory evaluation to isolate the best blend (90:10). From the preliminary study, composite flour was formulated by mixing rice flour and African yam bean flour from the best blend in different percentages. Samples of ready-to-eat breakfast cereals were formulated by mixing composite flour (rice and African yam bean best flour blend) with graded levels of orange fleshed sweet potato in the ratio of 90:10, 80:20, 70:30, 60:40 and 50:50 for samples RAYBF1+OPF1(90% rice +African yam bean best blend: 10% orange-fleshed sweet potato flour) , RAYBF2+OPF2 (80% rice +African yam bean best blend: 20% orange-fleshed sweet potato flour), RAYBF3+OPF3 (70% rice +African yam bean best blend: 30% orange-fleshed sweet potato flour), RAYBF4+OPF4 (60% rice +African yam bean best blend: 40% orange-fleshed sweet potato flour), and RAYBF5+OPF5(50% rice +African yam bean best blend: 50% orange-fleshed sweet potato flour) respectively with 100% rice flour as the control. The breakfast cereal products were subjected to proximate, pro-vitamin A, microbiological and sensory analysis using standard methods.

Results: The protein, ash, fiber and moisture contents of the blends were significantly ($p < 0.05$) higher than the control but their carbohydrate content were lower than the control. The protein content, fat, ash, crude fiber, moisture, and carbohydrate contents ranged from 6.82 to 11.21%, 0.20 to 1.21%, 4.03 to 15.81%, 1.31 to 2.80%, 6.61 to

Comment [a1]: Delete it

Comment [a2]: Space issue

Comment [a3]: Delete it. This is a repetition

Comment [a4]: And 100 % rice flour was used as the control sample.

Comment [a5]: Which blends?

40 10.92% and 63.07 to 80.22% respectively. The pro-vitamin content of the samples
41 ranged from 0.13 to 2.55 mg/100 g. There was an increase in the pro-vitamin A content
42 as the ratio of orange-fleshed sweet potato increased in the blend. The total viable
43 count ranged from 3.0×10^3 to 6.7×10^3 cfu/g while mould was not detected in any of
44 the samples. The microbial content of the samples were satisfactory and not high when
45 assessed using the guideline for microbiological quality of cereal products. The sensory
46 evaluation conducted showed that among the six ready-to-eat breakfast cereals, 100 %
47 adani rice breakfast cereals, samples RAYBF1+OPF1 and RAYBF5+OPF5 were highly
48 accepted.

49 **Conclusion:** The study has shown that acceptable ready-to-eat breakfast cereals could
50 be produced from blends of Adani rice, malted African yam bean and orange flesh
51 sweet potato flour. Among the different noodles, 100 % adani rice and sample
52 RAYBF1+OPF1 (90 % best blend + 10 % orange flesh sweet potato flour) were highly
53 accepted.

54
55 *Keywords: Rice; Ready-to-eat Breakfast cereal; Malted African yam beans; Orange-*
56 *fleshed sweet potato.*

57 58 59 1. INTRODUCTION

60 The word “breakfast” is a compound of “break” and “fast” which literally means
61 “breaking the fast” of the long night usually 10-12 hours. Nutritional experts have
62 referred to breakfast as the most important meal of the day, citing studies that found
63 people who skip breakfast to be disproportionately likely to have problems with
64 concentration, metabolism and weight [1]. Breakfast meals vary widely in different
65 cultures around the world. It often includes a carbohydrate source such as cereal, fruit
66 and or vegetable, protein, sometimes dairy and beverage.

67 Breakfast cereals are foods obtained by swelling, grinding, rolling or flaking of any
68 cereal [2]. Ready-to-eat (RTE) cereals ranks as one of the best choices available as
69 part of a nutritious breakfast. Ready-to-eat cereals facilitate independence because of
70 their ease of preparation which means that children and adolescents can be responsible
71 for their own breakfast or snacks [3]. Such foods may need to be reconstituted, pre-
72 heated in a vessel or allowed to thaw if frozen before consumption, or they may be
73 eaten directly without further treatment [4]. Almost all over the world, breakfast cereals
74 have become firmly established on breakfast tables. In addition to a wide variety of
75 forms, taste and colours, they are expected today to also meet a stringent nutritional
76 requirement. Breakfast cereals are basically produced from cereals which are the dry
77 seeds of the members of the grain family. Cereal is typically a low-fat, nutrient-dense
78 food with many essential vitamins and minerals such as zinc, phosphorus, and calcium.
79 The consumption of cereal based food product is very common and popular especially
80 in developing African countries where they constitute a major source of their staple food
81 [5]. Cereals are generally low in protein quality and are limiting in some essential amino
82 acids in particular, lysine and tryptophan. The amount of cereal grown in Nigeria is high
83 compared to its utilization. This is due to post harvest losses incurred from cereals, thus
84 there is need to diversify the use of cereals into producing some products which can be
85 made available all year. Rice is the seed of monocot plant of the genus *Oryza* and of

Comment [a6]: Mention as highest in which blend and lowest in which blend? Also mention one line about sensory evaluation

Comment [a7]: And/or

86 the grass family poaceae (formally *Graminae*) [6]. They are about twenty wild species
87 and two cultivated ones, *Oryza sativa* (Asian rice) and *Oryza glaberrima* (African rice).
88 *Oryza sativa* is the most commonly grown species throughout the world today. Rice is
89 rich in many nutrient components including carbohydrate, proteins, certain fatty acids
90 and micronutrients (vitamins and trace minerals). They are also sources of many
91 bioactive non-nutrient compounds, known as an antioxidant, including phenolic
92 compounds [7]. Adani rice is a local rice grown in Adani community. It is known for its
93 good nutritive, physical and cooking properties and needs to be supplemented with a
94 legume for higher nutrient-dense product. The average daily protein consumed by
95 Nigerians is well below the recommended value of protein intake[8]. In recent times,
96 food product developers have incorporated legumes into traditional cereal formulations
97 as a nutrient diversification strategy as well as an effort to reduce the incidence of
98 malnutrition among vulnerable groups. African yam bean is an under-utilized indigenous
99 African legume and one of the most important crops in the continent. There are seven
100 species of the genus *sphenostylis* [9]. African yam bean has attracted research
101 attention in recent times [10]. Protein content is up to 19% in the tubers and 29% in the
102 seed grain. The seeds form a valuable and prominent source of plant proteins in the diet
103 of Nigerians. The seeds may be boiled and eaten with local seasoning, starchy roots
104 and tubers. The seeds can also be roasted and eaten with coconut or palm kernels [11].
105 Orange fleshed sweet potato is a breed of sweet potato that is bio-fortified with A. It has
106 a great potential to be used in food-based intervention programs to address vitamin A
107 deficiency a major micronutrient required for health in both children and adults. The crop
108 is a promising solution to vitamin A deficiency because it is rich in β -carotene and
109 substantially better absorbed than leaves and vegetables. Sweet potato is generally
110 recognized as being an underutilized nutritious food [12]. Beyond 'boil' and 'eat', orange
111 fleshed sweet potato can be processed into various commercial products and can be
112 used to enrich indigenous foods. The study is useful in the improvement of the
113 nutritional quality of cereals by complementing their limiting amino acid with legumes.
114 This study would also provide avenue for the utilization of Adani rice, African yam bean
115 and orange fleshed sweet potato, which are presently underutilized as raw materials for
116 industrial production of breakfast cereals. Coupled with the recent economic recession,
117 the disposable income of most Nigerians has reduced, hence the increase in demand
118 for breakfast cereals produced via locally available cereals; this is cheaper than
119 imported ones as high cost of importation is evaded. The product from this study would
120 go a long way in addressing macro and micro-nutrient deficiencies among consumers
121 especially children. The data obtained from this study could play an important role as
122 reference material or baseline for researchers, health and nutrition policy makers,
123 dietary counselors as well as households [8].
124 Therefore, the broad objective of this study was to produce and evaluate ready-to-eat
125 breakfast cereal from blends of rice, malted African yam bean and orange-fleshed
126 sweet potato.

127 **2. MATERIALS AND METHODS**

128 **2.1 Raw Materials**

129 Parboiled seeds of Rice (*Oryza sativa*) were obtained from Adani Rice Mill in Uzouwani
130 Local Government Area, Enugu State. The seeds of African yam bean were obtained
131 from Orié Obá market in Udenú Local Government Area, Enugu State, while mature

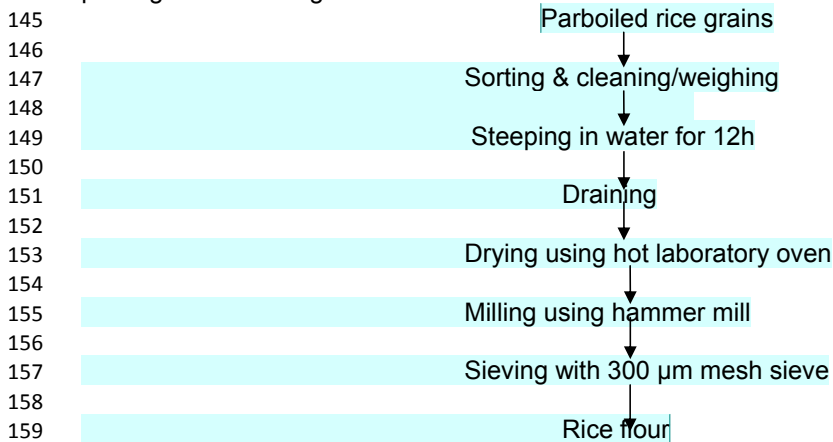
132 orange-fleshed sweet potato (*Ipomeo batatas* L.) (umusco/3) was obtained from
133 National Root Crop Research Institute, Umudike, Abia state. Other ingredients such as
134 sugar and salt were purchased from Ogige market, Nsukka.

135 2.2 Production of Raw Materials

136 Rice, African yam bean and orange-fleshed sweet potato were processed into flour
137 using different methods

138 2.2.1 Production of rice flour

139 Rice flour was processed by modifying the method [13] as shown in Fig. 1. Parboiled
140 rice grains were cleaned, sorted and washed, then steeped in water for 12h, drained
141 and dried in a hot air laboratory oven (LABE 1201, Divine International, Dehi. Milling of
142 the dried rice grain was done using hammer mill (I.G. Jurgens, Bremmer, Germany) and
143 the milled grains were sieved using a 300 µm mesh size sieve to obtain fine flour and
144 packaged in an air tight container.



145
146
147
148
149
150
151
152
153
154
155
156
157
158
159 Fig. 1 Production of rice flour

Comment [a8]: Figure is repetition. Either follow write up pattern or draw figure for all the processing methods

161 2.2 Production of malted African yam bean

162 Malted African yam bean flour was produced by modifying the method described by [14]
163 as shown in Fig.2. Healthy and clean seeds of African yam bean was weighed into
164 perforated polyvinyl chloride bag and steeped in water. The 2-step wet steep method for
165 African yam bean had 6 hours wet steep, 3 hours air rest and 6 hours wet steep (6-3-6)
166 as described by Anon, [14]. The grains were then germinated for 72 hours under dark
167 conditions. They were turned once in 24 hours. The seeds were moistened on alternate
168 days by dipping the jute bags containing the germinating grains in water for 30 seconds.
169 The germinated grains were removed after 72 hours and dried at 50°C for 12 hours in a
170 convectional Gallenkamp oven (Model IH-150, Gallenkamp, England). They were
171 cleaned by dehulling and winnowing before milling into flour using an attrition mill
172 (Bentall Plate Mill, Model 200L 090, E. H. Bentall, England).



173
174
175



176 2-step wet steep in water at room temperature (28±2°C) (African yam bean: 6-3-6)
 177 Germination for 72h (28±2°C)
 178 Drying (50°C)
 179 Cleaning
 180 Milling
 181 Malted African yam bean flour

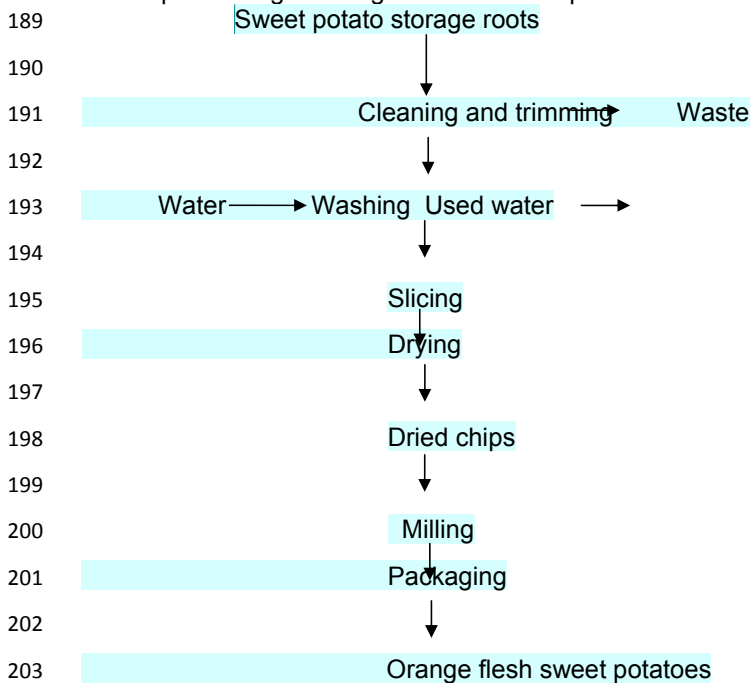


Comment [a9]: Figure is repetition. Either follow write up pattern or draw figure for all the processing methods

182 **Figure 2: Flow chart for the production of malted African yam bean flour.**

183 **2.2.3 Production of orange-fleshed sweet potato (*Ipomoea batatas* L.) flour**

184 Orange fleshed sweet potato was processed in to flour using the procedure described
 185 by [15]. Orange fleshed sweet potatoes were sorted, peeled, chipped and dried. The
 186 dried sweet potato chips were then milled in a hammer mill (Thomas Wiley mill Model
 187 ED-5) into flour and packaged in an air tight container for further use. The flow diagram
 188 for the processing of orange fleshed sweet potato to flour is shown in Figure 3.



204 **Figure 3: Flow chart for the production of orange fleshed sweet potato flour.**

205 Source: [15].

Comment [a10]: Figure is repetition. Either follow write up pattern or draw figure for all the processing methods

206 **2.3 Preparation of the Flour Blends**

207 Adani rice flour (RCF) and African yam bean flour (AYBF) were blended in the ratio
 208 100:0, 90:10, 80:20, 70:30, 60:40, 50:50 and breakfast cereals produced from the
 209 blend. The resultant breakfast cereals were subjected to sensory evaluation in order to
 210 obtain the best blend (90:10). Composite flour was formulated by mixing Adani rice flour
 211 (RCF) and African yam bean flour (AYBF) best blend (90:10) in different percentages.
 212 Samples of breakfast cereals were generated by mixing the composite flour (Adani rice
 213 and African yam bean flour) with graded levels of Orange fleshed sweet potato flour
 214 (OP) with 100% rice as the control as shown in Table 1 and 2.

Comment [a11]: It is better to give only in tabular form. No need to write in paragraph

215 **Table 1: Blending ratios of local rice and malted African yam bean flour**

Sample code	Local rice	Malted African yam bean
RCF+ AYBF (100:0)	100	0
RCF+ AYBF (90:10)	90	10
RCF+ AYBF (80:20)	80	20
RCF+AYBF(70:30)	70	30
RCF+ AYBF (60:40)	60	40
RCF+ AYBF (50:50)	50	50

Comment [a12]: Samples codes are not clear. Codes should be given in format of S1 or anything else

216 *Key: RCF + AYBF (100:0) = 100% Local rice flour and 0% African yam bean flour; RCF*
 217 *+ AYBF (90:10) = 90% of local rice flour and 10% malted African yam bean flour; RCF +*
 218 *AYBF (80:20) = 80% Local rice flour and 20% malted African yam bean flour; RCF +*
 219 *AYBF (70:30)*
 220 *= 70% Local rice flour and 30% malted African yam bean flour; RCF +AYBF (60:40) =*
 221 *60% Local rice flour and 40% malted African yam bean flour; while RCF + AYBF (50:50)*
 222 *= 50% Local rice flour and 50% malted African yam bean flour*

Comment [a13]: No need to write under tables. It must be mentioned in First row of Table 1 like local rice flour and Malted African yam bean flour

223

224 **Table 2: Blending ratios of local rice + African yam bean best blend and orange-**
 225 **fleshed sweet potato composite flour for the production of ready-to-eat breakfast**
 226 **cereals**

Sample code	Rice+ African yam bean best blend	Orange-fleshed sweet potato
RC (CONTROL 100% RICE)	100	0
RAYBF1+OPF1(90:10)	90	10
RAYBF2+OPF2(80:20)	80	20
RAYBF3+OPF3(70:30)	70	30
RAYBF4+OPF4(60:40)	60	40
RAYBF5+OPF5(50:50)	50	50

Comment [a14]: Samples codes are not clear. Codes should be given in format of S1 or anything else.

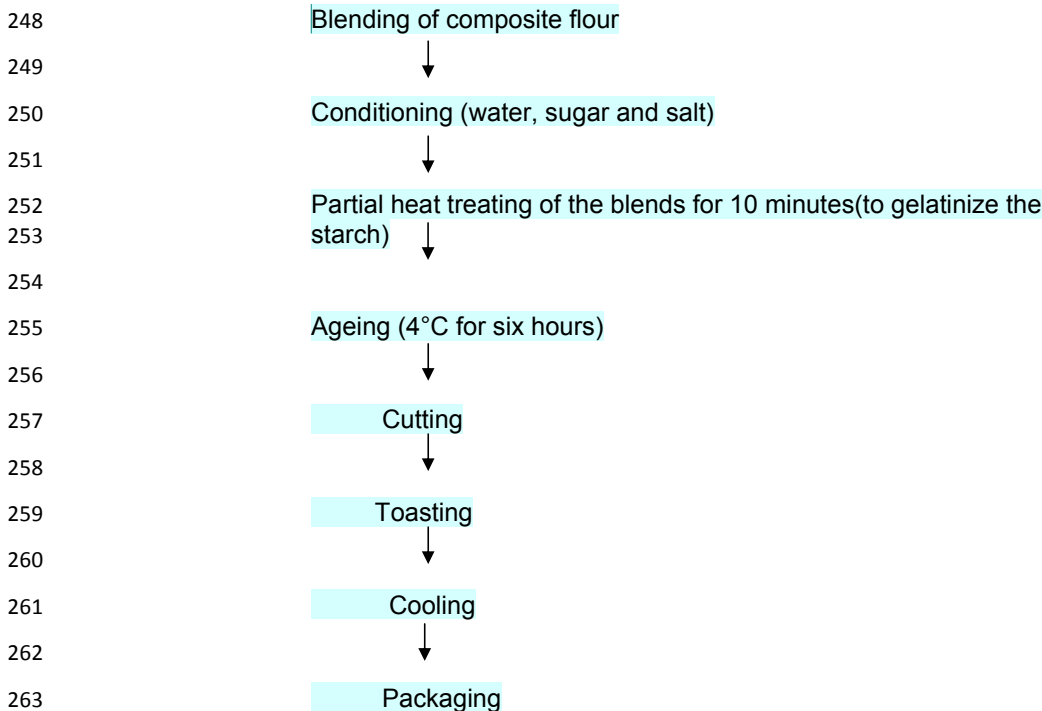
227 *Key: RC= Control 100% rice, RAYBF1+OPF1(90:10)= 90%rice/African yam bean best*
 228 *blend flour+ 10% orange-fleshed sweet potato flour,*
 229 *RAYBF2+OPF2(80:20)= 80%rice/African yam bean best blend flour+ 20% orange-*
 230 *fleshed sweet potato flour RAYBF3+OPF3(70:30) =*
 231 *70%rice/African yam bean best blend flour+ 30% orange-fleshed sweet potato flour,*
 232 *RAYBF4+OPF4(60:40)= 60%rice/African yam bean*
 233 *best blend flour+ 40% orange-fleshed sweet potato flour, while RAYBF5+OPF5(50:50)=*
 234 *50%rice/African yam bean best blend flour+ 50%*
 235 *orange-fleshed sweet potato flour*

Comment [a15]: Similarly as in case of Table 1. No need to write under tables. It already mentioned in mentioned in First row of Table 2.

236

237 2.3.1 Production of breakfast cereals

238 The stepwise process involved in the formulation of the ready-to-eat breakfast cereal is
239 explained thus; The Adani rice, malted African yam bean and orange flesh sweet potato
240 composite flour was mixed together. Small quantity of water was added to the flour
241 mixtures as to have a binding effect; sugar and salt was added to give it taste. The
242 mixtures was precooked(heat treated) by steaming for 10 minutes and then allowed to
243 age at a temperature of 4°C for about six hours. After ageing, the product was shaped
244 by cutting into flakes using stainless steel knives and put in baking pans and toasted in
245 an oven at a temperature of 120°C for 1 hour after which the ready-to-eat breakfast
246 cereal was allowed to cool under room temperature and packaged in packaging
247 materials for use.



264 Figure 4: Flow diagram for the production of ready-to-eat breakfast cereal.

265 2.4 Analysis of Raw Materials and Ready-to-eat Breakfast Cereals from Blends of 266 Local Rice, Malted African Yam Bean and Orange-Fleshed Sweet Potato

267 The flour blends were analyzed for their proximate composition, beta-carotene content
268 and functional properties, while the ready-to-eat breakfast cereals were analyzed for
269 their proximate composition, micronutrient content, sensory properties and microbial
270 content.

Comment [a16]: Similarly, In case of production of breakfast cereals, either draw flow chart or write in paragraph. There is a repetition of things.

271 **2.4.1 Determination of bulk density and water absorption capacity of flour**
272 **samples**

273 *2.4.4.1 Determination of water absorption capacities*

274 Water absorption capacity was determined by modifying the method [16]. One gram
275 (dry weight basis) of the sample was dispersed in 10 ml distilled water, vortexed
276 intermittently for 10 minutes and centrifuged at 4500 rpm for 20 minutes. The aqueous
277 supernatant obtained after centrifuging was decanted and the test tubes inserted and
278 allowed to drain for 5 minutes on a towel. By weighing the residue, water absorption
279 capacity was calculated as a percentage of a gram of water absorbed per gram of
280 sample.

281 *2.4.4.2 Determination of bulk density*

282 The bulk density was determined according to the method [17]. A graduated measuring
283 cylinder of 10 ml capacity was weighed and gently filled with the sample, followed by
284 gently tapping the bottom until there was no further diminution of the sample level after
285 filling to the 10 cm³ mark. The bulk density was calculated as:

286 Bulk density (g / cm³) = Weight of sample (g)/ The weight of sample after tapping (cm³)

287 **2.4.2 Proximate composition**

288 *2.4.2.1 Determination of moisture content*

289 Moisture content was determined according to the methods of Association of Official
290 Analytical Chemists [18]. The Samples were dried at 105°C for 3 h using the preset
291 oven mechanized convection air oven (Phoenix furnace, model 534, SN: 524-85,
292 Chapel town, Sheffield).

293 *2.4.2.2 Determination of crude protein*

294 The protein content (% nitrogen x 6.25) of the sample was determined using the
295 Kjeldahl method [18].

296 *2.4.2.3 Determination of crude ash*

297 The crucible containing the pre-weighed samples were placed in a heated furnace
298 mechanized convection air oven (Phoenix furnace, model 534, SN: 524-85, Chapel
299 town, Sheffield). At 600°C for 6 h after which they were cooled to room temperature in
300 desiccators and weighed.

301 *2.4.2.4 Determination of crude fiber content*

302 The crude fiber content of the samples was determined using the standard method [19].
303 N-Hexane was used to de-fat 2 g of sample, added in oiled 200 ml of 1.25% H₂SO₄ and
304 boiled for 30 minutes, filtered, washed with 1% HCl and boiling water. The residues
305 were returned into 200 ml boiling NaOH and allowed for 30 minutes. The final residues
306 were drained and transferred to the silica ash crucible (porcelain crucible), dried in an
307 oven at 100°C for 2 hours and cooled until a constant weight obtained. and incinerated
308 (ashed) in a muffle furnace at 600°C for 5 hours, cooled in a desiccator and weighed.

309 *2.4.2.5 Determination of fat content*

310 The fat content of the samples content (1g was extracted for ether extract determination
311 using petroleum ether as solvent) was determined using the standard Soxhlet method
312 [18].

313 *2.4.2.6 Determination of carbohydrate content*

314 The carbohydrate content of the sample was determined as nitrogen free extraction
315 calculation by difference [18].using the formula below:

316 % Carbohydrate = 100 – (% moisture + % protein + % ash + % crude fiber + % fat)

317 **2.4.3 Determination of micronutrient**

318 *2.4.3.1 Determination of β -carotene content*

319 The β – carotene content of the samples was determined using the method [20]. The
320 samples were weighed, W1 and homogenized in methanol in the ratio of 1:10 (%) using
321 a laboratory blender. The homogenate was filtered using a filter paper of measured
322 weight, W2 to obtain the initial crude extract, washed with 20 ml of distilled water in
323 separating funnel. The other layer was recovered and evaporated to dryness at a low
324 temperature (35 – 50°C) in vacuum desiccator. The dry extract was saponified with 20
325 ml of ethanoic potassium hydroxide and was left overnight in a dark cupboard. After a
326 day, the β – carotene was taken up in 20 ml of ether and then washed with two portions
327 of 20 ml distilled water. The β – carotene content extract (ether layer) was dried in a
328 desiccator and treated with petroleum (petroleum spurt) and allowed to stand overnight
329 in a freezer. The next day, the precipitated steroid was removed by centrifugation and β
330 – carotene extract was evaporated to dryness in a desiccator and
331 weighed, W3. The weight of the β – carotene was determined and expressed as a
332 percentage of the sample weight.

333 β – Carotene content (%) = $\frac{W3 - W2}{W1} \times 100$

334 W1 1

335 Where W1 = Weight of sample; W2 = Weight of empty filter paper and W3 = Weight of
336 filter paper + Weight of precipitate.

337 **2.4.4 Total Viable and Mould Count (TVC)**

338 The total viable count was determined according to the method [21]. The samples were
339 inoculated using nutrient agar after the serial dilution of the sample had been obtained.
340 Pour plate method was used. The colony count was done after 24 hours of incubation at
341 37 °C using a colony counter (Gallenkamp colony counter, CNW 330 – 010X) and the
342 number of colonies calculated using the following

343 formula:

344 $TVC (CFU / g) = \frac{\text{Number of colonies} \times \text{Original concentration}}{\text{Dilution factor} \times \text{Volume of inoculums}}$ CFU = Colony Forming Unit

346 For the mould count, after the serial dilution of the samples, they were inoculated using
347 Sabauroud dextrose agar (SDA). Pour plate method was used. The colony count was
348 done after 72 hours on incubation at 37 oC,using a colony counter (Gallenkamp colony
349 counter, CNW 330 – 010X) and the number of colonies calculated using the following
350 method:

351 $\text{Mould count } (CFU / g) = \frac{\text{Number of colonies} \times \text{Original concentration}}{\text{Dilution factor} \times \text{Volume of inoculums}}$ CFU = colony forming unit

353 **2.4.5 Sensory evaluation of the ready-to-eat breakfast cereals**

354 Sensory evaluation of the samples was evaluated by 20 semi-trained panelists from the
355 Department of Food Science and Technology for various sensory attributes
356 (appearance, taste, colour, texture, after taste and overall acceptability). A 9-point
357 Hedonic scale was used where “9” represents extremely like and “1” represents
358 extremely dislike [22]. The samples were presented in coded plastic plates. The order of
359 presentation of samples to the judges was randomised. Clean water was presented for
360 the panelists to rinse their mouth in between evaluation.

361 **2.5 Data Analysis and Experimental Design**

362 The experiment was conducted in a Completely Randomized Design (CRD). Data
363 obtained were subjected to one-way Analysis of Variance (ANOVA) and mean
364 separation was done by Duncan multiple range test, using Statistical Product for
365 Service Solution (SPSS) version 20 and significance difference was accepted at
366 ($p < 0.05$).

367 3. RESULTS AND DISCUSSION

368 Plates 1 to 3 shows the processed flours from rice (plate 1), malted African yam bean
369 (plate 2) and orange-fleshed sweet potato (Plate 3).



370

371 Plate 1: Adani rice flour

Plate 2: malted African yam bean flour

373 Plate 3: orange-fleshed sweet potato flour

374 3.1 Proximate Composition (%), β -carotene (mg/100g), Water Absorption Capacity 375 and Bulk Density(%) Content of Rice, African yam Bean and Orange Fleshed 376 Sweet Potato Flour

377 Table 3 shows the proximate composition (%), β -carotene (mg/100 g), water absorption
378 capacity (%) and bulk density (g/cm³) contents of rice, African yam bean and orange
379 fleshed sweet potato flour.

Comment [a17]: No need to write it again.
Already written under pictures

Comment [a18]: Nutritional and functional
composition of flours

380 The moisture content of the flour samples ranged from 6.60% (sample RCF) to 7.60%
381 (sample OPF). The moisture contents of local rice (6.60%), malted African yam bean
382 (7.00%) and orange-fleshed sweet potato(7.60%) flour was within the 10% stipulated
383 standard for storage stability of flours [23].The high moisture content of food is an index
384 of spoilage since the moisture enhances chemical and biochemical reactions that could
385 lead to spoilage. In general, the lower, the lower the moisture contents of a product, the
386 longer the storage life.

Comment [a19]: ????? RCF/RF

387 The protein content (%) of the malted African yam bean flour (26.92%) was higher than
388 that of local rice flour (7.88%) and orange-fleshed sweet potato flour (3.31%) which
389 makes it a good protein supplement. The protein content of the African yam bean was
390 higher than that reported by[13], who reported 18.63% as the protein content. This
391 could be as a result of the processing method used in processing the African yam bean
392 seeds into flour.

Comment [a20]: repetition

393 Malted African yam bean flour had the highest fat content (2.20%) which was higher
394 than that of local rice flour(0.70%) and orange-fleshed sweet potato flour(0.49%). [The
395 low fat content of the flour samples in particular, orange-fleshed sweet potato indicates
396 that it would not be easily susceptible to rancidity. Fat have been known to impart on the
397 sensory attributes of food products, however, high fat content of food may reduce its
398 keeping quality.

Comment [a21]: Is there any comparison between these three? May these belong to similar or different food groups?????

399 Orange-fleshed sweet potato flour has the highest ash content (4.60%) which is higher
400 than that of local rice flour (2.45%) and malted African yam bean flour (2.14%). [The
401 value of ash for African yam bean flour is in line with that reported by [13]. The presence
402 of the high ash content in orange-fleshed sweet potato flour shows that the mineral
403 content is higher than others which could be as a result of the bio-fortification of the
404 sweet potato. This would probably increase the mineral and vitamin content of the blend
405 since ash is an index of mineral content [24].The ash content of the orange-fleshed
406 sweet potato flour also conformed with that obtained by [24].

Comment [a22]: Is there any comparison between these three? May these belong to similar or different food groups?????

407 The crude fiber ranged from 1.86% (sample RCF) to 3.00% (sample OPF). It was
408 observed that orange-fleshed sweet potato flour had the highest crude fiber which was
409 higher than that of malted African yam bean flour (2.11%) and local rice (1.86%). The
410 crude fiber content was similar to 3.0% reported by [25]. There were significant ($p<0.05$)
411 differences among the samples. The fiber content would be effective in the delay of
412 gastric emptying [25] and a reduction in serum cholesterol [26].

Comment [a23]: Is there any comparison between these three? May these belong to similar or different food groups?????

413 The carbohydrate content of the flours was 80.51,59.63 and 81.00% for local rice,
414 African yam bean and orange-fleshed sweet potato flours respectively. Orange-fleshed
415 sweet potato flour had the highest carbohydrate content while African yam bean had the
416 lowest. The solar drying technique employed during the processing of the flour helped in
417 the retention of the nutrients present in the flour. .

Comment [a24]: Is there any comparison between these three? May these belong to similar or different food groups?????

418 The Vitamin A content of the flour samples are shown in Table 3. The pro-vitamin A
419 content (mg/100g) of the flour samples varied from 0.11 to 7.86 mg/100g with sample
420 AYBF having the least pro-vitamin A content while sample OPF had the highest pro-
421 vitamin A content. Sample RCF was found to contain no amount of pro-vitamin A. The
422 use of solar dryer in the drying of the orange-fleshed sweet potato flour prevented the
423 loss of the pro-vitamin A component of the flour. The values obtained for the pro-vitamin
424 A content compared favourably well with the values reported by [25]. using different
425 varieties of orange-fleshed sweet potato. The β -carotene in the orange-fleshed sweet

426 potato flour would help to solve the problem of poor sight in developing countries like
427 Nigeria.

428 Water absorption capacity of the flour samples varied from 134.20 to 24.52%. The water
429 absorption capacity is the ability of a product (such as flour) to absorb water. Orange-
430 fleshed sweet potato flour had the highest water absorption capacity (264.52%) and
431 was followed by malted Africa yam bean flour (213.20%). Local rice flour had the least
432 water absorption capacity (134.20%) among the flour samples. Water absorption
433 capacities of flours depend on several factors such as the size of granules,
434 amylose/amylopectin ratio, and intra and inter molecular forces [27]. Water absorption
435 capacity gives the indication of the amount of water available for gelatinization. The
436 relatively high water absorption capacity of orange-fleshed sweet potato flour could be
437 attributed to its high amylose to amylopectin ratio (21:79) which gives it a higher affinity
438 for water. The relatively low water absorption capacity of rice and African yam bean
439 flour could be attributed to the presence of low amount of hydrophilic constituents in
440 these flours [27].

441 The bulk density of the flour samples varied from 0.65 to 0.90 g/cm³. The bulk densities
442 of local rice, African yam bean and orange-fleshed sweet potato flours were 0.90, 0.81
443 and 0.65 g/cm³ respectively. Bulk density is the weight per unit volume of a material.
444 Bulk density is important for determining packaging food requirements, material
445 handling and application in the food industry [28]. The differences in the bulk densities
446 of the flours may probably be due to their different particle sizes. According to [29], bulk
447 density depends on the particle size and initial moisture content of the flours. It was
448 observed that the bulk density of local rice flour was the highest. The local rice may
449 require more packing space than the other flour samples. The more the bulk density,
450 the more the packing space and careful stacking required. There were significant
451 ($p < 0.05$) differences among the samples.

452 **Table 3: Proximate composition (%), functional properties and β -carotene (mg/100**
453 **g) content of rice, African yam bean and orange fleshed sweet potato flour.**

454

Parameters	Sample code		
	RF	AYBF	OPF
Moisture (%)	6.60 ^c ±0.01	7.00 ^b ±0.04	7.60 ^a ±0.01
Protein (%)	7.88 ^b ±0.01	26.92 ^a ±0.01	3.31 ^c ±0.01
Ash (%)	2.45 ^b ±0.01	2.14 ^c ±0.01	4.60 ^a ±0.01
Fat (%)	0.70 ^b ±0.01	2.20 ^a ±0.00	0.49 ^c ±0.01
Fiber (%)	1.86 ^c ±0.01	2.11 ^a ±0.01	3.00 ^b ±0.00

Comment [a25]: Check the values

Comment [a26]: Delete it

Comment [a27]: Nutritional and functional properties of flours used for development of breakfast cereals

CHO (%)	80.51 ^a ±0.01	59.63 ^c ±0.32	81.00 ^a ±0.01
β-carotene (mg/100g)	ND	0.11 ^b ±0.04	7.86 ^a ±0.05
WAC (%)	134.20 ^c ± 0.00	213.20 ^b ± 0.00	264.52 ^a ± 0.01
Bulk density (g/cm ³)	0.90 ^a ± 0.5	0.81 ^b ± 0.01	0.65 ^c ± 0.01

455 *Values are means ± Standard Deviation (SD) of duplicate determinations. Values*
 456 *having the same superscript (a,b and c) within the same column are not significantly*
 457 *(p<0.05) different. RF: Rice Flour; AYBF: African yam bean flour; OPF: Orange fleshed*
 458 *sweet potato flour; CHO: Carbohydrate; WAC:Water Absorption Capacity*

459 3.2 Sensory Scores of Breakfast Cereal Produced from Rice and African Yam 460 Bean Flour.

461 The sensory scores of breakfast cereal formulated from rice and African yam bean flour
 462 is shown in Table 4.

463 The scores for colour of the breakfast cereal ranged from 5.13 (RF+AYBF5) to 7.18
 464 (RF+AYBF1). There was no significant (p<0.05) difference between the samples and
 465 control (RF+AYBF0) except for sample RF+AYBF5. Sample RF+AYBF1 ranked highest
 466 followed by sample RF+AYBF0 (control). From Table 4, it was observed that the judges
 467 preferred the colour of sample RF+AYBF1 although it was not significantly(p<0.05)
 468 different from sample RF+AYBF0 (control). The scores for colour decreased with
 469 increased substitution with African yam bean flour. It was also observed that the
 470 preference for the samples in terms of colour decreased with increased addition of
 471 African yam bean flour. Taste of the formulated breakfast cereal ranged from 3.85
 472 (RF+AYBF5) to 7.55 (RF+AYBF1). Sample RF+AYBF1 was highly rated compared to
 473 other formulated samples. This showed that it was preferred to other samples and could
 474 be attributed to improvement in the taste of the breakfast cereal by the malted African
 475 yam bean flour. There was no significant (p<0.05) difference between the taste of
 476 sample RF+AYBF1 and RF+AYBF0 (control). This could imply that blending rice and
 477 African yam bean in the ratio of 90:10 (RF+AYBF1) for breakfast cereal production
 478 would not affect its acceptability in terms of taste. Table 4 shows that texture of the
 479 formulated breakfast cereal ranged from 4.50 (RF+AYBF5) to 7.25 (RF+AYBF1). There
 480 was no significant(p<0.05) difference between the texture of sample RF+AYBF1 and
 481 that of the control (RF+AYBF0). The scores for texture of sample (RF+AYBF1) was
 482 highest as shown in Table 4. This showed that it was highly preferred relative to other
 483 samples. Texture of a sample usually determine whether a food product could be
 484 swallowed or chewed . From Table 4, it was observed that the mean values for the
 485 texture decreased as the addition of African yam bean exceed 10% but its addition at
 486 this level improved the texture of the breakfast cereal. This is in agreement with the
 487 findings of [30] as well as [31]. The scores for the aftertaste of the breakfast cereals
 488 ranged from 4.16 (RF+AYBF5) to 7.55 (RF+AYBF1). Sample RF+AYBF1 was mostly
 489 preferred by the panelists although no significant (p>0.05) different exist between the
 490 aftertaste of the sample (RF+AYBF1) and sample RF+AYBF0 (control). The preference

Comment [a28]: Did not match with the text

Comment [a29]: Which samples? experimental????

491 for the breakfast cereal in terms of aftertaste decreased as the quantity of rice in the
 492 blend decreased. The sensory scores for the appearance of the breakfast cereal ranged
 493 from 4.78 (RF+AYBF5) to 7.30 (RF+AYBF1). The appearance of sample RF+AYBF1
 494 was highly preferred by the judges compared to other samples although no significant
 495 ($p < 0.05$) difference exist between the sample (RF+AYBF1) and sample RF+AYBF0
 496 (control). The appearance of the all the breakfast cereal were generally acceptable by
 497 the panelists.

498 The mean score for the overall acceptability of the formulated breakfast cereals ranged
 499 from 4.05 (sample RF+AYBF5) to 7.75 (sample RF+AYBF1). There was a general
 500 decrease in the overall acceptability of the breakfast cereal with a decrease in rice flour
 501 and increase in African yam bean flour. This is similar to the findings of [32] who has it
 502 that the overall acceptability of biscuit produced from acha flour, bambara groundnut
 503 flour and unripe plantain flour decreased with increased addition of bambara groundnut
 504 flour and unripe plantain. Sample RF+AYBF1 had the highest mean score (7.75) in
 505 overall acceptability which made the breakfast cereal most acceptable to the judges
 506 although it was not significantly ($p < 0.05$) different from the control (RF+AYBF0).

507 Generally, sample RF+AYBF1 (90% rice+10% African yam bean) had the highest mean
 508 score in all parameters assessed which indicates that the sample (RF+AYBF1) was
 509 most preferred by the judges and was selected as the best blend for further substitution
 510 with orange fleshed sweet potato.

511 **Table 4 : Sensory scores of breakfast cereal formulated from rice and African yam**
 512 **bean flour.**

Sample code	Colour	Taste	Texture	After taste	Appearance	Overall acceptability
RF+AYBF 0	6.70 ^a ± 0.40	7.15 ^a b ± 0.22	6.75 ^{ab} ±0.32	7.00 ^a ±0.3 2	6.15 ^{ab} ±0.43	6.90 ^{ab} ±0.32
RF+AYBF 1	7.18 ^a ± 0.31	7.55 ^a ± 0.31	7.25 ^a ±0.25	7.55 ^a ±0.2 9	7.30 ^a ±0.40	7.75 ^a ±0.29
RF+AYBF 2	6.60 ^a ± 0.26	6.15 ^b c ± 0.30	6.35 ^{abc} ±0.3	5.95 ^b ±0.3 3	5.80 ^{bc} ±0.35	6.35 ^{bc} ±0.32

RF+AYBF	6.40 ^a	5.75 ^c	5.90 ^{bc} ±0.45	5.95 ^b ±0.3	6.15 ^{ab} ±0.37	5.7 ^{cd} ±0.38
3	± 0.37	±		3		
		0.43				
RF+AYBF	6.10 ^{ab}	5.00 ^c	5.40 ^{cd} ±0.43	4.80 ^c ±0.3	5.30 ^{bc} ±0.44	5.05 ^{de} ±0.41
4	± 0.42	^d ±		5		
		0.40				
RF+AYBF	5.13 ^b	3.85 ^d	4.50 ^d ±0.51	4.16 ^c ±0.4	4.78 ^c ±0.47	4.05 ^e ±0.53
5	± 0.46	±		8		
		0.59				

513 Values are means ± Standard Error of Means (SEM) of 20 panelists. Values having the
514 same superscript within the same column are not significantly (p<0.05) different (a,b,c
515 and d) Key: RF+AYBF0=100% rice+0% African yam bean; RF+AYBF1=90%rice
516 flour+10% African yam bean flour; RF+AYBF2=80% ricea flour+20% African yam bean
517 flour; RF+AYBF3=70% rice flour+30% African yam bean flour; RF+AYBF4=60% rice
518 flour+ 40% African yam bean flour; RF+AYBF5=50 % rice flour+50% African yam bean
519 flour.

520

521 3.3 Proximate Composition and β-carotene Content of the Breakfast Cereal

522 Table 5 shows the proximate composition (%) and β-carotene (mg/100 g) content of
523 breakfast cereals formulated from rice, African yam bean and orange fleshed sweet
524 potato flour blends.

525 The moisture content of the formulated breakfast cereal ranged from 6.61% (sample
526 RF) to 10.92% (sample RAYBF5+OPF5). There was a significant (p<0.05) difference in
527 the moisture content of the samples. The moisture content of the formulated breakfast
528 cereal samples increased as blending level of OPF increased. This is in agreement
529 with [33] who stated that increased addition of orange fleshed sweet potato flour
530 increased the moisture content of the bread produced from wheat and orange fleshed
531 sweet potato flour. This could be attributed to the ability of the total high fiber in orange
532 fleshed sweet potato to interact with large amount of water through the hydroxyl group
533 existing in the fiber structure.

534 The protein content (%) of the samples ranged from 11.21% (sample RAYBF1+OPF1)
535 to 6.82% (sample RF). There was a significant (p<0.05) difference in the protein content
536 of the samples. The protein content of the sample decreased with increasing blend of
537 orange fleshed sweet potato flour. The samples that contain African yam bean had
538 higher protein contents than the control sample. Several researchers have reported
539 increase in protein contents of food supplemented with African yam bean [34,35,36].
540 However, the protein values obtained were much lower, this could be as a result of the

541 low protein ratio used in formulating the product which was gotten from the 90:10 best
542 blend ratio. The control (sample RF) had the lowest protein content while among the
543 blended samples, RAYBF1+OPF1 (11.21%) had the highest protein content with a
544 decrease through to sample RAYBF5+OPF5 (6.82%) which had the lowest. This was in
545 agreement with the findings of [33] who produced bread from orange fleshed sweet
546 potato and wheat and [37] who also produced bread from wheat, maize and orange
547 fleshed sweet potato. The decrease in protein content could be attributed to the low
548 protein content of the orange fleshed sweet potato flour [33].

549 The ash content (%) of the formulated breakfast cereal showed significant ($p < 0.05$)
550 differences with values ranging from 4.03% (sample RF) to 15.81% (sample
551 RAYBF5+OPF5). The ash content is an index of the mineral content of a food sample
552 which is necessary for growth and development [38]. Lower value of 5.29% to 7.36%
553 was reported by [39] who formulated breakfast cereal from African yam bean, maize
554 and defatted coconut. This variation could be attributed to the use of different raw
555 materials in formulation of the product. As the graded levels of orange fleshed sweet
556 potato increased in the composite flour, the ash content of the blend increased. This
557 was in agreement with the findings of [40] who blended orange fleshed sweet potato
558 and wheat flours for cookies production. This result showed that sample
559 RAYBF5+OPF5(50:50) contained highest mineral element than other samples including
560 the control (100% rice) due to the increase in the ratio of the orange-fleshed sweet
561 potato flour in the blend.

562 Table 5 shows that the fat content (%) of the breakfast cereal ranged from 0.20%
563 (sample RAYBF5+OPF5) to 1.21% (sample RAYBF1+OPF1). There were significant
564 ($p < 0.05$) differences among samples RF, RAYBF1+OPF1, RAYBF2+OPF2 and
565 RAYBF5+OPF5 but there was no significant ($p < 0.05$) difference between samples
566 RAYBF3+OPF3 and RAYBF4+OPF4. This result was not in agreement with the
567 findings of [41], using sorghum and pigeon pea blends flour blends. The results of the fat
568 content obtained by [41], showed relative high-fat content of the products (8.70-14.2%).
569 The fat contents of all the samples were found to be generally low. The relatively low-fat
570 content of the food blends could contribute to the extension of the shelf-life of ready-to-
571 eat breakfast cereals by retarding the onset of rancidity. The low-fat content of all the
572 blends could also make the product an excellent food for diabetic and obese patients
573 [38]. The presence of graded levels of orange fleshed sweet potato in the formulation
574 could be responsible for the generally low fat content of the resulting products.

575 Table 5 shows that the fiber content (%) of the breakfast cereal ranged from 1.31%
576 (sample RF) to 2.80% (sample RAYBF5+OPF5). There were significant ($p < 0.05$)
577 differences among the samples. The fiber contents of the blends were observed to be
578 higher than that of the control (100% rice). The crude fiber content increased with
579 increase addition of orange fleshed sweet potato in the blend. This was similar to the
580 findings of [40] who incorporated orange fleshed sweet potato in his blends. This could
581 be attributed to the increased fiber content of orange fleshed sweet potato in the blend.

582 The carbohydrate content ranged from 80.22% (RF) to 63.07% (RAYBF5+OPF5) where
583 sample RF (80.22%) being the control had highest value and the least RAYBF5+OPF5
584 (63.07%). The samples had higher values of carbohydrate due to the presence of rice
585 (cereal) and orange fleshed sweet potato.

586 Table 5 shows the β -carotene content of the formulated breakfast cereal. The β -
 587 carotene content of the breakfast cereals formulated with orange fleshed sweet potato
 588 ranged from 0.41 mg/100 g (sample RAYBF1+OPF1) to 2.55 mg/100 g (sample
 589 RAYBF5+OPF5) and in control sample RF it was relatively low 0.13mg/100 g . The β -
 590 carotene increased with increased addition of orange fleshed sweet potato flour to the
 591 blend. This could be attributed to the high β -carotene content of orange fleshed sweet
 592 potato[40].

593

594 **Table 5: Proximate (%) composition and β - carotene content of the breakfast**

595 **cereals**

Sample code	Moistur e (%)	Protein (%)	Ash (%)	Fat (%)	Fibre (%)	CHO (%)	β Carote ne (mg/10 0g)
RF	6.61 ^f ±0.1	6.82 ^f ±0.1	4.03 ^f ±0.1	1.01 ^b ±0.01	1.31 ^f ±0.0	80.22 ^a ±0.1	0.13 ^f ±0.01
RAYBF1+O PF1	8.73 ^e ±0.01	11.21 ^a ±0.02	5.80 ^e ±0.02	1.21 ^a ±0.01	1.70 ^d ±0.01	71.35 ^b ±0.05	0.41 ^e ±0.01
RAYBF2+O PF2	10.44 ^d ±0.01	9.53 ^b ±0.01	10.72 ^d ±0.01	0.72 ^c ±0.01	1.71 ^d ±0.01	66.88 ^c ±0.02	1.02 ^d ±0.01
RAYBF3+O PF3	10.60 ^c ±0.01	8.24 ^c ±0.1	11.71 ^c ±0.01	0.60 ^d ±0.01	2.72 ^{cd} ±0.01	66.13 ^d ±0.1	1.80 ^c ±0.03
RAYBF4+O	10.82 ^b ±0.0	7.56 ^d ±0.0	13.03 ^b ±0.0	0.60 ^d ±0.0	2.74 ^b ±0.0		2.50 ^b ±0.0

PF4	.02	01	.02	.01	01	65.25 ^e ±0	.01
						.01	
RAYBF5+O	10.92 ^a ±0	7.20 ^e ±0.	15.81 ^a ±0	0.20 ^e ±0	2.80 ^a ±0.	63.07 ^f ±0	2.55 ^a ±0
PF5	.10	01	.01	.01	01	.1	.01

596 *Values are means ± Standard Deviation (SD) of duplicate determinations. Values*
597 *having the same superscript (a,b and c) within the same column are not significantly*
598 *(p>0.05) different. Key: RF:100% Rice Flour , RAYBF1+OPF1(90:10) =90%rice/African*
599 *yam best blend flour + 10% orange-fleshed sweet potato flour; RAYBF2+OPF2(80:20) =*
600 *80%rice/African yam bean best blend flour + 20% orange-fleshed sweet potato flour;*
601 *RAYBF3+ OPF3(70:30) = 70% rice/African yam bean best blend flour + 30% orange-*
602 *fleshed sweet potato flour, RAYBF4+OPF4(60:40) = 60% rice/African yam bean best*
603 *blend flour+ 40% orange-fleshed sweet potato flour and RAYBF5+OPF5(50:50) = 50%*
604 *rice/African yam bean best blend flour + 50% orange-fleshed sweet potato flour. CHO:*
605 *Carbohydrate*

606

607 **3.4. Microbial Count (cfu/g) of the Breakfast Cereals Formulated from Rice,**
608 **African Yam Bean and Orange Fleshed Sweet Potato Flour**

609 Table 6 shows the total viable and mould count of the formulated breakfast cereal from
610 rice, African yam bean and orange fleshed potato flour.

611 The total viable count of the formulated samples ranged from 3.0x10³ (sample
612 RAYBF1+OPF1) to 6.7 x10³ (sample RAYBF5+OPF5) cfu/g. The microbial loads of the
613 sample were generally low. However, there were variations in the microbial load of the
614 samples, this may be attributed to handling of the product after processing. There was
615 no mould growth in all the formulated breakfast cereals which could be attributed to the
616 low moisture content of the formulated samples. This implies that product could be kept
617 for a very long time.

618

619 **Table 6: Microbial count (cfu/g) of the breakfast cereals**

Sample	TVC (cfu/g)	Mould (cfu/g)
RF	4.5×10^3	ND
RAYBF1+OPF1	3.0×10^3	ND
RAYBF2+OPF2	4.7×10^3	ND
RAYBF3+OPF3	4.5×10^3	ND
RAYBF4+OPF4	5.3×10^3	ND
RAYBF5+OPF5	6.7×10^3	ND

620 *Values are means of duplicate determinations. Key: R: Rice flour; AYB: African yam*
621 *bean flour; OPF: Orange fleshed sweet potato flour ;ND: Not detected; TVC: Total*
622 *viable count; RF: 100% Rice flour; RAYBF1+OPF1: 90% of best blend+10% orange*
623 *fleshed sweet potato; RAYBF2+OPF2: 80% best blend+20% orange fleshed sweet*
624 *potato; RAYBF3+OP3=70% best blend+30% orange fleshed sweet potato;*
625 *RAYBF4+OP4=60% best blend+40% orange fleshed sweet potato; AYBF5+OP5=50%*
626 *best blend+50% orange fleshed sweet potato.*

627 **3.5 Sensory Scores of Ready-to-eat Breakfast Cereals Formulated from Local** 628 **Rice, Malted African Yam Beans and Orange-fleshed Sweet Potato Flour Blends**

629 The sensory scores of the ready-to-eat breakfast cereals formulated from local rice,
630 malted African yam beans and orange-fleshed sweet potato flour blends are shown in
631 Table 7 and Plate 4, 5,6,7, 8 and 9.

632 From the Table, the mean scores for colour ranged from 7.60 to 5.95 with sample RF
633 (100 % Adani rice flour) having the highest value and sample RAYBF4+OPF4(60:40)
634 having the lowest value. Sample RF was preferred probably because of its unique
635 cream colour, however, there was only a slight significant difference ($p < 0.05$) between
636 the samples, there was no significant difference ($p > 0.05$) between samples RF,
637 RAYBF1+OPF1 and RAYBF2+OPF2, no significant difference ($p > 0.05$) between
638 samples RAYBF3+OPF3, RAYBF4+OPF4 and RAYBF5+OPF5 and no significant
639 difference ($p > 0.05$) between RAYBF1+OPF1, RAYBF2+OPF2 and RAYBF3+OPF3 and
640 this could be because the panelists liked the products in terms of colour. The colour of
641 the ready-to-eat breakfast cereals became darker (from light brown to dark brown) with
642 increasing level of orange-fleshed sweet potato in the blend. This could probably be
643 because potatoes are more apt to scotch or discolour during dehydration or darken
644 during product storage when they have high reducing sugar content. This discolouration

645 could be due to the reactions involving amino acids and reducing sugars [42]. The
 646 sensory score for flavour ranged from 6.20 to 7.70 with sample RF(100%) having the
 647 least score and sample RAYBF5+OPF5 (50:50) having the highest score. There were
 648 no significant ($p<0.05$) different in flavour among the samples. It was observed that
 649 malted African yam bean as well as the orange flesh sweet potato improved the flavor
 650 of the product. The sensory scores for taste ranged from 6.20 to 7.70 with sample
 651 RAYBF2+OPF2 (80:20) having the lowest score and sample RAYBF5+OPF5 having the
 652 highest score. There was no significant ($p<0.05$) difference in the taste of the blends
 653 and the control (100% rice). The samples were found to have a good taste which could
 654 be attributed to the sweetness of the orange-fleshed potato flour as a result of its high
 655 reducing sugar content. A similar result was obtained by [43]. The sensory scores for
 656 texture ranged from 5.95 to 7.20 with sample RAYBF5+OPF5 (50:50) having the least
 657 score and sample RF (100%) and RAYBF1+OPF1(90:10) having the highest scores.
 658 The low texture score of sample RAYBF5+OPF5(50:50) could be attributed to the
 659 increase in the amount of orange-fleshed sweet potato flour in the blend. This was
 660 because, the orange-fleshed sweet potato had a coarse particle size (300 μ m). There
 661 were no significant ($p<0.05$) difference among the samples and the control (100% rice)
 662 except for sample RAYBF4+OPF4 which showed significant ($p<0.05$) difference with the
 663 control. Based on the overall acceptability, sample RAYBF1+OPF1 and RAYBF5+OPF5
 664 had the highest score (7.30), followed by the control (100% rice) 7.10. Sample
 665 RAYBF4+OPF4 had the least score (6.60). There were no significant ($p<0.05$)
 666 difference among the samples and the control. All the samples had a good rating for all
 667 the sensory attributes since their scores were higher than the mean 4.5 for a 9 – point
 668 Hedonic scale used for the sensory. There was much acceptance of the newly
 669 formulated samples by the panelists. This shows that breakfast cereals formulated with
 670 local raw materials are highly acceptable in Nigeria.

671 **Table 7: Sensory scores for ready-to-eat breakfast cereals formulated from rice,**
 672 **African yam bean and orange-fleshed sweet potato flour blends .**

Sample	Colour	Appear ance	Flavor	Textur e	Mouth feel	Taste	Afterta ste	Overall accepta bility
RF	7.60 ^a ±	7.40 ^a ±1	6.20 ^b ±	7.20 ^a ±	6.95 ^{ab} ±	6.70 ^{ab} ±	6.60 ^{ab} ±	7.10 ^a ±1.
	0.94	.23	2.07	1.40	1.67	1.53	1.50	60
RAYBF1+		7.20 ^{ab} ±	7.20 ^{ab} ±	7.20 ^a ±		6.90 ^{ab} ±	6.60 ^{ab} ±	7.30 ^a ±1.
	7.30 ^{ab} ±				7.10 ^{ab} ±			

OPF1	1.40	1.43	1.01	1.80	1.60	1.80	1.50	60
RAYBF2+	7.10 ^{ab±}	6.95 ^{ab±}	6.70 ^{b±}	6.80 ^{ab±}	6.60 ^{b±}	6.20 ^{b±}	6.00 ^{b±}	6.60 ^{a±1.}
OPF2	1.21	0.82	1.04	1.61	1.40	1.74	1.30	20
RAYBF3+	6.30 ^{bc±}	6.80 ^{ab±}	7.10 ^{ab±}	7.10 ^{a±}	7.10 ^{ab±}	6.90 ^{ab±}	6.50 ^{ab±}	6.90 ^{a±1.}
OPF3	1.74	1.40	1.61	1.16	1.61	1.63	1.40	41
RAYBF4+	5.95 ^{c±}	6.50 ^{b±1}	6.80 ^{b±}	5.95 ^{b±}	6.10 ^{b±}	6.20 ^{b±}	6.10 ^{b±}	6.60 ^{a±1.}
OPF4	1.90	.43	1.62	1.70	2.13	1.70	1.83	85
RAYBF5+	6.90 ^{bc±}	7.20 ^{ab±}	7.70 ^{b±}	7.30 ^{a±}	7.50 ^{a±}	7.70 ^{b±}	7.20 ^{a±}	7.30 ^{a±1.}
OPF5	1.62	1.50	1.40	1.70	1.80	1.63	1.98	84

673 Values are means ± Standard Deviation (SD) of duplicate determinations. Values
674 having the same superscript (a,b and c) within the same column are not significantly
675 ($p>0.05$) different. Key: RF:100% Rice Flour , RAYBF1+OPF1(90:10) =90%rice/African
676 yam best blend flour + 10% orange-fleshed sweet potato flour; RAYBF2+OPF2(80:20) =
677 80%rice/African yam best blend flour + 20% orange-fleshed sweet potato flour;
678 RAYBF3+ OPF3 = 70%rice/African yam bean best blend flour + 30% orange-
679 fleshed sweet potato flour; RAYBF4+OPF4(60:40) = 60% rice/African yam bean best
680 blend flour+ 40% orange-fleshed sweet potato flour and RAYBF5+OPF5(50:50) = 50%
681 rice/African yam bean best blend flour + 50% orange-fleshed sweet potato flour. CHO:
682 Carbohydrate



683

684

685



Plate 4: 100% rice

686

687

688

Plate 5: 90%best blend + 10% Orange-flesh sweet potato flour

690

691

692

693

694

695

696



Plate 6: 80%best blend + 20% Orange-flesh sweet potato flour

697

698

699

Plate 7: 70%best blend + 30% Orange-flesh sweet potato flour

700

701

702

703

704

705

706

707

708

709

710

711



Plate 8: 60% best blend + 40% orange-flesh potato flour

Plate

9: 50% best blend + 50% orange-flesh sweet potato flour

712

713

714

715

4. CONCLUSION AND RECOMMENDATION

717

718

719

720

721

722

723

724

725

The study showed that ready-to-eat breakfast cereals could be formulated from rice, African yam bean and orange fleshed sweet potato which are presently underutilized. From the study, it was observed that among the breakfast cereals formulated from rice and African yam bean flour, the judges preferred sample RF +AYBF1 which was selected as the best blend. The breakfast cereals formulated from rice, African yam bean and orange fleshed sweet potato flour were highly rated and acceptable to the panelists in all the attributes assessed. Thus, blending of rice, African yam bean and orange fleshed sweet potato flour improved the acceptability and nutritional value of the resultant breakfast cereal. It was also observed that malting of the African yam bean

Comment [a30]: Mention that Which breakfast cereal product should be used for further feeding trials after the addition of orange flesh sweet potato flour.

726 increased the nutritional composition and functional properties and reduced the anti-
727 nutrients present in the legume during processing. The resulting product from the study
728 contained appreciable amount of carbohydrate which provides energy to the body when
729 consumed. The inclusion of orange fleshed sweet potato to the blend improved the
730 mineral (ash, fibre and β -carotene) content of the breakfast cereal. The formulated
731 breakfast cereals had very low microbial load while no mould was detected. The
732 production of breakfast cereal from the raw materials used in this study would contribute
733 to the nutritional needs of individuals who are protein and
734 vitamin A deficient. The high nutrient density and low bulk of the flours could serve as
735 good base ingredients to be used especially in breakfast cereals so as to enhance
736 dietary diversification.

737 It is recommended that further studies be carried out on the breakfast cereals to
738 determine their health benefits, further studies should also be carried out to determine
739 the storage life and stability of the product. Consumers should also be enlightened on
740 nutrient bioavailability of the genetically modified orange flesh sweet potato. The
741 production of breakfast cereal from the blends used in the study should be encouraged
742 as this would help alleviate to a reasonable extent protein and vitamin A deficiency and
743 promote diversification of their utilization.

744

745

746 **Reference**

747 1. MayoClinic, (2009). Why is breakfast the most important meal of the day
748 ?[.http://www.mayoclinic.com/health/food-and-nutrition/AN01119](http://www.mayoclinic.com/health/food-and-nutrition/AN01119). [Accessed 16
749 December 2010].

750 2. Sharma, Ji. Caralli, S. . A Dictionary of Food and Nutrition. CBS Pub. New Delhi.
751 2004

752 3. Jones, MP., Dingkuhn, M., Aluko, GK., Semon, M. Interspecific *oryza sativa* L. x *O.*
753 *glaberrimasteud* progenies in upland rice improvement. *Euphytica*, 1997 92, 237-
754 246.

755 4. Okaka, JC. Handling, Storage and Processing of Plant Foods. OJC Academic
756 Publishers, Enugu. 2005

757 5. Gernah, DI., Ariaahu, CC. and Ingbian, EK. (2011).Effect of malting and lactic
758 fermentation on some chemical and functional propertoos of maize. *American*
759 *Journal of Food Technology*,11:432-435.

760 6. Oko, AO. Ugwu, SI. The proximate and mineral compositions of five major rice
761 varieties in Abakaliki, South-Eastern Nigeria. *International Journal of Plant*
762 *Physiology and Boichemistry*,2011; 3(2) :25-27.

- 763 7. Frei M, Becker K. Agro-biodiversity in subsistence-oriented farming systems in a
764 Philippine upland region: Nutritional considerations. *Biodiversity and Conservation*.
765 2004;13:1591-1610.
766
- 767 8. Usman, GO. Production and evaluation of breakfast cereals from blends of African
768 yam bean (*Shenostylisstenocarpa*), maize (*Zea mays*) and defatted coconut
769 (*Cocosnucifera*). M.Sc. Dissertation, University of Nigeria, Nsukka. 2012
- 770 9. Porter, D. Economy Botany of *Sphenostylis* (Leguminosae). *Economic Botany*1992;
771 46: 262 -275.
- 772 10. Azeke, MA., Fretzdorf, B., Buening-pfane, H., Holzapfel, W. Betsche, T. Nutritional
773 Value of African yam bean (*Sphenostylisstenocapa L*): Improvement by Lactic
774 Acid Fermentation. *Journal of Food Science and Agriculture*, 2005;85(2): 963 –
775 970.
- 776 11. Enwere, JN. Foods of Plant Origin: Processing and Utilization with Recipes and
777 Technology Profiles. 1st Edition. Afro-orbis Publications Ltd,1998; pp: 50 – 60.
- 778 12. Bovell-Benjamin AC . Sweet Potato: A review of its past, present, and future role in
779 human nutrition. *Adv. Food. Nutr. Res.*2007; 52(1): 1 - 59.
780
- 781 13. Iwe MO, Onyeukwu U, Agiriga AN. Proximate, functional and pasting properties of
782 FARO44 rice, African yam bean and brown cowpea seeds composite flour. *Journal of*
783 *Food and Agriculture*; 2016.
784 Available:<http://dxdoi.org/10.1080/23311932.2016.1143409>.
785
- 786 14. Anon (2009). The free Encyclopedia. [http:// www.wikepedia.com](http://www.wikepedia.com). [Accessed on
787 September, 2010].
- 788 15. Laryea D. Formulation and characterization of sweet potato-based complimentary
789 food. Ph.D thesis. Department of Food Science and Technology, Kwame Nkrumah
790 University of Science and Technology, Ghana. 2016.
791
- 792 16. Philips RD, Chinnan MS, Branch AL, Miller J, Mcwatters KH.Effects of pre –
793 treatment on functional and nutritional properties of cowpea meal. *Journal of Food*
794 *Science*. 1998;53:805–809.
795
- 796 17. Onwuka GI. Food analysis and instrumentations theory and practice. 1st edition.
797 Lagos; Naphtali Prints. 2005;29–73.
798
- 799 18. AOAC. Association of official analytical chemist, official methods of analysis. 18th
800 edition, Washington DC, USA; 2010.
801

- 802 19. AACC. Approved methods of American association of cereal chemists (10th
803 edition). Minnesota: American Association of Cereal Chemists. St. Paul. 2000;276– 280.
804
- 805 20. Onyeka EU, Nwabekwu IO. Phytochemical profile of some leafy vegetables dried
806 using solar dryer. Nigeria Food Journal 2007;1:72-82.
807
- 808 21. Prescott LM, Harley JP, Kelein OA. Microbial nutrition: Types of media. In:
809 Microbiology, Sixth edition. New York; McGrawill. 2005;93–105.
810
- 811 22. Ihekoronye, Al. Ngoddy, PO. Integrated Food Science and Technology for the
812 Tropics. Macmillan publishers Ltd., London, 1985; pp 345 – 360.
- 813 23. SON Nigerian industrial standard for pastas. Standard organization of Nigeria. ICS :
814 2007;664.68. pp. 1-8.
- 815 24. Wardlaw, GM. Kessel, MW. Minerals: Dietary Needs Absorption, Transport and
816 Excretion. In: Perspective in Nutrition. (5th edition), McGraw-Hill Companies
817 Incorporation, New York, pp 2002;418-464.
- 818 25. Mohammad K, Ziaul H, Sheikh N. Comparison of the proximate composition, total
819 carotenoids and total polyphenol content of nine varieties of orange-fleshed sweet
820 potato grown in Bangladesh. Institute of Nutrition and Food Science, University of
821 Dhaka, Dhaka, Bangladesh; 2016.
822
- 823 26. Kure OA, Bahago EJ, Daniel EA. Studies on the proximate composition and effect of
824 flours particle size and susceptibility of biscuits produced from blends of soybeans and
825 plantain flours. Namado Technology Scope Journal. 1998;3(2):17-22.
826
- 827 27. Matil KF. Functional requirement of proteins for foods. Journal of American Oil
828 Chemistry Society. 2007;48: 477-480.
829
- 830 28. Taira H. Buckwheat introduction. Encyclopaedia of Food Technology. 2010;139.
831
- 832 29. Apata, DF. Ologhoba, AD. . Some Aspects of Biochemistry and Nutritive Value of
833 African yam bean Seed (*Sphenostylis stenocarpa*). Food Chemistry.,1990; 36:
834 271 – 280.
- 835 30. Chukwu O, Abdul-kadir JA . Proximate composition of acha (*Digitaria exilis* and
836 *Digitaria iburua*) grains. J. Food. Technol. 2008;6: 214-216.
837
- 838 31. Mbaeyi-Nwaoha IE, Uchendu NO . Production and Evaluation of Breakfast Cereals
839 from Blends of acha and Fermented Soybean Paste (Okara). J. Food. Sci.Technol.
840 2016;53(1): 50-70.
- 841 32. Agu HO, Eze GC, Jideani AIO (2008). Quality assessment of acha-based biscuit
842 improved with bambara nut and unripe plantain. Afr. J. Food. Sci. 8(5): 278-285.

- 843
844 33. Kidane G, Abegaz K, Mulugeta A, Singh P Nutritional analysis of vitamin A enriched
845 bread from orange flesh sweet potato and locally available wheat flours at Samre
846 Woreda, Northern Ethiopia. J. Current. Nutr. Food. Sci. 2013; 1(1): 49-57.
847
848 34. Uguru, MI. Madukaife, SO.. Studies on the variability in agronomic and nutritive
849 characteristics of African yam bean (*Sphenostylis stenocarpa*). Journal of Plant
850 Products and Resources,2001; 6:10-16.
851 35. Okoye, JI. Obi, CD. Chemical composition and sensory properties of wheat-African
852 yam bean composite flour cookies. Discourse Journal of Agriculture and Food Sciences,
853 2017;32(1):31-37.
854
855 36. Okoye, JI., Alugwu, SU. Obi, CD. Effect of processing methods on the proximate
856 composition and functional properties of African yam bean (*Sphenostylis stenocarpa*).
857 seed flours. Journal of Science, Agriculture, Food Technology and Environment, 2015;
858 14:1-6.
859
860 37. Igbabul B, Num G, Amove J . Quality evaluation of composite bread produced from
861 wheat, maize and orange fleshed sweet potato flours. Amer. J. Food. Sci.
862 Technol.2014; 2(4): 109-115.
863 38. Jeckins DJA. Dietary fibre, Lente carbohydrates and the insulin resistant diseases.
864 British Journal of Nutrition 2000; 83:157-163.
865 39. Usman GO. Production and evaluation of breakfast cereal made from blends of
866 sorghum, soybeans and defatted coconut. An M.Sc dissertation of the Department of
867 Food Science and Technology, University of Nigeria, Nsukka, 2009.
868 40. Temesgen L, Abebe H, Tigist F. Production and quality evaluation of cookies
869 enriched with β -carotene by blending orange-fleshed sweet potato and wheat flours for
870 alleviation of nutritional insecurity. Intern. J. Food. Sci. Nutr. Eng.2015; 5 (5): 209-217.
871 41. Mbaeyi IE . Production and evaluation of breakfast cereal using pigeon-pea
872 (*Cajanus cajan*) and sorghum (*Sorghum bicolor*), An M.Sc. dissertation of Department
873 of Food Science and Technology, University of Nigeria, Nsukka, 2005.
874 42. Tewe OO, Ojeniyi FE, Abu OA. Sweet potato production, utilization and marketing in
875 Nigeria. Department of Social Sciences, International Potato Centre (CIP), Lima, Peru;
876 2003.
877 43. Umego E. Chemical composition, physical and sensory properties of fried noodles
878 prepared from wheat, sweet potato and soybean flour blends. A B.Sc. Project,
879 Department of Food Science and Technology, University of Nigeria, Nsukka; 2012.