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Original Research Article

**Comparative Studies on the Effect of Drying
Methods on Proximate, Functional and
Pasting Properties of Fufu Flour
Fortified with Soybean**

ABSTRACT

Aims: Comparative studies on the effect of drying methods on proximate, functional and pasting properties of fufu and fufu flour fortified with soybean flour was investigated.

Study design: Randomized experimental design was employed in this work(How did you use randomize method to select method of drying?).

Place and Duration of Study: Department of Food Science and Technology, Osun State Polytechnic, Iree, Osun State, Nigeria, between January 2013 and August 2013.

Methodology: The peeled cassava (botanical name?)roots were steeped in water for two days. The roots were thereafter grated. The grated pulp was steeped in water for another two days for fermentation. The fermented pulp was sieved and packed in jute bags and dewatered using hydraulic press. The cassava cake was pulverized by hand and dried using oven, sun and solar drying methods. Soybean seeds were washed and boiled for 20 mins. The boiled seeds were drained and dehulled to remove seed coats. The dehulled soybeans seeds were dried, milled, sieved and packaged. Flour from cassava and soybean were mixed in the ratio of 80%:20%(How did you arrive at using this ratio?) for this research work.

Results:The protein contents of fufu fortified flours using different drying methods were higher than fufu flour. Bulk density, water absorption capacity, swelling capacity and gelation of fufu and fufu fortified flours were not affected by the drying methods. But there was improvement(How and to what extent?) in the proximate and functional properties due to soybean inclusion into the flours as the values were higher than that of fufu flours. Viscosities of fufu flour were higher than the fortified fufu flour.

Conclusion:There was increase in proximate constituents and functional properties of the fufu flours with addition of soybean flour. The functional properties were not significantly affected by the drying methods while the pasting parameters were significantly affected by the methods of drying coupled with addition of soybean flour(But some of the pasting properties are of the functional so how comes?).

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Keywords: Proximate, fufu, flour, soybeans, fortification, drying methods

1. INTRODUCTION

Fresh root of cassava (*Manihotesculentacrantz*) have over the years been used in the production of different types of food in Nigeria among which are fufu, lafun, and gari[1].

These products are processed from freshly harvested cassava roots [2]. Cassava root is highly perishable and therefore cannot be stored in fresh state after harvest for more than a few days [3]. Postharvest losses of the crop occur during storage due to high physiological and microorganism activities that infest the bruises received during harvesting [4]. Processing cassava roots into more shelf stable products like fufu flour reduces these postharvest problems. Fufu is a fermented wet paste made from cassava roots. It is ranked next to garri as an indigenous food of most Nigerians in the south(Ref?).

Fufu which is known as 'Akpu' is made by steeping whole or cut, peeled cassava roots in water to ferment for maximum of five days depending on the ambient temperature [5]. Fermentation process helps to detoxify the cassava pulp and enhance flavour development(Ref?). Fufu preparation varies from locality to locality [6]. During steeping, fermentation takes place leading to softening of the roots and reduction of potentially toxic cyanogenic compounds [7]. The keeping quality of fufu could be is greatly affected by the methods of processing. Fufu is traditionally sold in the wet form or cooked form which rendered it highly perishable. The poor or low shelf life is a serious limitation for large scale processors. A practical approach to improving the shelf life and marketability of fufu is drying the fufu paste to powder. Drying of fufu is aimed at getting re-constitutable fufu with peculiar physicochemical characteristics of cooked wet paste [8].

Nutritionally, fufu contains high percentage of carbohydrate which is needed for energy production and source of calories, other nutrients like vitamins, or minerals and protein are in negligible proportion or completely absent. The problems of malnutrition are therefore imminent. The problems of malnutrition in Nigeria although different in magnitude and severity among different areas are due to protein, vitamins, iron and other mineral deficiency [9]. There is the need to enrich or fortify fufu in order to improve its nutritional status. Fortification of food has become a means of ensuring nutritional adequacy of the diet. Example of appropriate food fortifier include soy flour, fish protein concentration etc. [10].

Akingboola *et. al.* [11] reported that drying, of fufu in the oven at 60°C for 48hrs reduces the repulsive odour of fufu but the product is sticky, bland and the quality was unacceptable when compared with wet fufu, this restricts the consumption of fufu to its traditional base. This study therefore investigates the effects of drying methods on proximate, functional and pasting properties of fufu flour fortified with soy bean flour.

2. MATERIALS AND METHODS

2.1 Materials

Matured cassava(botanical name and variety?) root and soya beans(botanical name and variety?) seeds were purchased from Ada market, Osun State, Nigeria.

2.1.1 Production of fufu flour

Matured cassava tubers were peeled manually(how?) washed and steeped in water for two days(temperature?). The tubers were thereafter grated, and the grated pulp was steeped in water(for another two days for fermentation). The fermented pulp was sieved with the aid of laboratory test sieve (Seive no 246209, aperture 2.0mm). Sieved pulp was packed in jute bags and dewatered using hydraulic press. Following dewatering, Tthe cassava cake was pulverized by hand and oven dried using oven (at 50 °C for 48 hrs), sun dried (for 48 hrs)

66 and solar drying methods (using fabricated solar drier). The dried flours were milled with
67 attrition mill(manufacturer?) and sieved manually(how?) to obtain fufu flour.

68 **2.2Production of soybeans flour**

69 Soybean seeds were sorted and washed with cold(temperature?) portable water. The seeds
70 were boiled in warm water for 20 mins. The boiled seeds were drained and dehulled to
71 remove seed coats. The dehulled soybeans seeds were dried (how?)and milled (with
72 attrition mill), to obtain soybean flour which was later sieved (how?)and packaged(how?) for
73 further analytical work. Flour from cassava and soybean were mixed in the ratio of 80%:20%
74 for this research work(how did you arrive at this ratio?).
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76 **2.3Analyses**

77 The proximate analyses of the flours were carried out using the method described by
78 Association of Official Analytical Chemist [12]. Carbohydrate determination was done by
79 difference. Bulk density was determined using the method of Okaka and Potter [13]. The
80 water absorption capacity and swelling capacity were determined using the procedure of Lin
81 *et. al.*, [14]. Foam capacity was determined using the method of Narayanaet. *al.*, [15]Pasting
82 properties were determined using Rapid Visco Analyzer (RVA) (Network scientific, Austria)
83 described by Adebowaleet. *al.*[16].

84 **2.4 Statistical Analyses**

85 Statistical analyses were performed using SPSS 17.0 for Windows (SPSS Inc., Chicago, IL).
86 All experiments were performed in triplicate and the mean values were reported.
87 Comparisons between means were performed with Turkeys test. Differences between
88 means were evaluated as significant at $P < 0.05$.
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90 **3. RESULTS AND DISCUSSION**

91 **3.1 Proximate Analysis Results of Fufu Fortified with Soybean Flour**

92 The proximate analysis results of fufu flour and fortified fufu flour dried using sun, solar and
93 oven drying methods is as presented in Tables 1 and 2. From the result table, it is revealed
94 that there is noticeable difference in the proximate constituent of raw fufu flour flour and
95 fortified flour. The crude protein content for raw flour ranged from 1.02-1.21% with the flour
96 dried using solar drying method having the highest value and sundried flour having the least
97 value while For the fortified flours has the value for protein value Of ranged from 6.90-
98 7.10%. There was no significant difference ($p < 0.05$) in the protein values of sundried and
99 solar dried fortified fufu flours. This showed that protein contents of fufu were more retained
100 using the two methods. The protein contents obtained were lower than the value (13.65%)
101 observed by Akoja and Mohammed [17] for fufu fortified with 20 % pigeon pea flour(why?).
102 There was significant increase in protein content of fortified fufu flour due to incorporation of
103 soybean flour, a rich and cheap source of protein. Legumes which include soybeans are
104 good examples some of the low priced source of protein rich foods that have been of
105 importance in alleviating protein malnutrition [18].
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113 Table 1: Proximate composition of fufu flour

Drying method	Crude protein (%)	Moisture content (%)	Crude fat (%)	Crude fibre (%)	Ash (%)	Carbohydrate (%)
Oven dried	1.17±0.32b	8.70±0.16a	0.72±0.11a	0.23±0.20a	0.35±0.21a	88.83±0.27a
Sun dried	1.02±0.41c	8.50±0.23b	0.62±0.09b	0.17±0.13b	0.30±0.17b	88.39±0.33c
Solar dried	1.21±0.27a	8.00±0.19c	0.70±0.10a	0.15±0.10b	0.32±0.11b	88.62±0.22b

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115 Table 2: Proximate composition of fortified fufu flour

Drying method	Crude protein (%)	Moisture content (%)	Crude fat (%)	Crude fibre (%)	Ash (%)	Carbohydrate (%)
Oven dried	6.90±0.35b	8.67±0.29a	1.24±0.08c	1.20±0.31b	0.41±0.27c	85.58±0.41a
Sun dried	7.10±0.61a	8.22±0.21b	1.30±0.10b	1.27±0.26a	0.81±0.19b	81.30±0.53b
Solar dried	7.10±0.50a	8.22±0.15b	1.37±0.19a	1.28±0.33a	0.87±0.20a	81.06±0.37c

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117 Proteins are needed in the body for repair and replacement of worn-out tissues, serve as
 118 antibodies, primary sources of amino acids and the building block of cellular protein [10]. The
 119 moisture content for raw flour ranged between 8.00 and 8.70% while the fortified flour
 120 recorded 8.22 and 8.67%. The moisture content of sundried and solar dried flour were the
 121 same (8.22%). There is variation in the moisture contents (water activity) of the raw and
 122 fortified flours based on the methods of drying employed. However, the moisture content of
 123 both flours were in the range of dried or powdered product (15%) [19]. The lower the
 124 moisture contents of food product, the longer the shelf life of the product.

125 The fat content for the raw flours ranged between 0.62 and 0.72% while the fortified flours
 126 had value ranging from 1.24 to 1.37%. The sundried flour recorded the lowest value of fat
 127 (0.62%) in the raw flour while the oven dried flour recorded the lowest value in the fortified
 128 flours. There was significant difference ($p < 0.05$) in the fat contents (value?) of the fortified
 129 fufu flours using different drying methods. Although, lower fat contents were observed in the
 130 flours but there was increase in the fat contents of the fortified fufu flour which could be due
 131 to incorporation of soybean flour. Cassava from which the flour were produced are generally
 132 not rich source of fat hence, the lower value recorded. The storage life of the flour may
 133 however be elongated owing to these low fat content since all fats and fat containing foods
 134 are potentially susceptible to oxidative rancidity [19].

135 The crude fibre contents of raw and fortified fufu flours ranged from 0.15-1.28%, while
 136 Equally the fortified flours has recorded higher values for crude fibre. Owing to the different
 137 methods of drying employed, there are variations in the value for both raw and fortified flour
 138 how did different methods of drying affect the values?. Flour dried using solar method
 139 recorded the highest value 1.28% crude fibre content for fortified flour while the oven dried
 140 flour recorded the highest values 0.23% for the raw flour. Crude fibre has been proved to
 141 through its water absorption capacity aids peristalsis movement of food through the digestive

tract [10]. Increase in fibre contributes to the bulk density which could help in the bowel movement, lower blood cholesterol and helps prevent cancer of the colon [20].

Ash contents for raw and fortified fufu flour flours ranged from (0.32-0.87%). Ash content of food product gives insight to the mineral content of food products [10]. The ash content of the fortified flour dried using the specified methods were relatively higher than their unfortified counterparts. This suggests that the inclusion of soybean flour has the potential of improving the mineral content of fufu flour when used as fortifier. In the same vein, there was variation in the value recorded for the flours dried using the specified drying, methods. Flour dried using solar method recorded the highest value for fortified flour 0.87%.

The carbohydrate content of the fortified flour decreased compared to the raw flours. The values ranged from (88.39-88.83%) for raw flours to (81.06-85.58%) for fortified flour. The decrease could be due to low carbohydrate level of the added soybean. These trends were obvious due to increase in other proximate constituents (protein, fat, ash and fibre) brought about by the inclusion of soybean flour as a fortifier. Iwe [21] reported similar results when higher levels of soybean flour were added to sweet potatoes and plantain flour.

3.2 Functional properties of Fufu Fortified with Soybean Flour

The results of functional properties of fufu flour fortified with soybean and dried using oven, sun and drying methods are as presented in Table 3 and 4. From the results, the bulk densities for flours from the three methods of drying were the same. They all had equal values of (0.59 and 0.62g/cm³ for fufu and fufu fortified flours respectively). This revealed that the methods of drying employed did not have any effect on the bulk density. The bulk densities increased with addition of soybean flour. Bulk density is the ratio of the mass per unit volume of substance [13]. This increases with increase in starch content [22] (but the starch content of soybean is relatively lower than the cassava flour, so how?). Bulk density is an indication of the porosity of a product which influences package design. It helps in determining suitable packaging material for food products [23]. It is also important in infant feeding, where less bulk is desirable [24]. The fermentation process undergone by the cassava reduced the bulk densities of the fufu flour. It has been reported that fermentation and germination are possible factors that cause decrease in bulk density [25].

Water absorption capacities of the fortified fufu flours were equally the same 1.43ml H₂O/g higher than fufu flours 1.20ml H₂O/g. There was no significant (p>0.05) difference in the values obtained for fufu and fufu fortified flours. Water absorption capacity is the ability of the flour to absorb or take in water during processing [14]. This is an indication of the extent to which protein can be incorporated into the food formulation increase in water absorption capacity implies high digestibility of starch. The water absorption characteristics represent the ability of a product to associate with water under condition where water is limiting in order to improve its handling characteristics [26] and dough making potentials [24].

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Table 3: Functional Properties of fufu Flour

Drying method	Bulk density (g/cm ³)	Water absorption (ml H ₂ O/g)	Swelling power	Foam capacity	Gelation
Oven dried	0.59±0.04a	1.20±0.01a	1.66±0.05a	9.25±0.10b	6.0±0.01a
Sun dried	0.59±0.01a	1.20±0.02a	1.67±0.02a	9.10±0.15c	6.0±0.01a

Solar dried	0.59±0.02a	1.20±0.01a	1.67±0.07a	9.50±0.10a	6.0±0.01a
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Table 4: Functional Properties of fufu Fortified with Soybeans Flour

Drying method	Bulk density (g/cm ³)	Water absorption (ml H ₂ O/g)	Swelling power	Foam capacity	Gelation
Oven dried	0.62±0.02a	1.43±0.02a	1.41±0.02a	12.30±0.06c	4.0±0.01a
Sun dried	0.62±0.02a	1.43±0.01a	1.41±0.04a	15.60±0.03a	4.0±0.01a
Solar dried	0.62±0.02a	1.43±0.02a	1.41±0.02a	14.80±0.02b	4.0±0.02a

Fermentation and germination has been reported to increase water absorption of flours. During fermentation, proteolytic activities takes place which cause increase in the number of polar group [27].The addition of soybeans flour helps in the water binding properties because of the presence of protein and the damage of starch as a result of milling process. Sanniet. al., [28] reported that high water absorption capacity is attributed to loose structure of the starch polymers while low value indicates the compactness of the molecular structure. Water absorption capacity has a linear relationship with swelling capacity, is a useful indication of whether protein can be incorporated.The swelling capacity for the three flours followed the same trend. For the fufu flour, the sun and solar drying methods had the same values of 1.67 while all the fortified fufu flours recorded the same value of 1.41. This showed that fufu flour swelled more than the fortified flours. High swelling capacity has been reported as part of the criteria for a good product [29]. The result for foam capacity revealed that flour dried using sun drying method recorded 15.60%, followed by solar drying method which recorded 14.80% and oven drying method with the value of 12.30% indicating that the drying methods had significant effect on this parameter. Foam capacity is known as aerating or whipping properties of food. It is the ability to incorporate air by it or a mixture with other ingredients and to hold the aerated structure long enough so that it can be set by heat or other means [15].The increase in the foaming capacity may be attributed to the increase in the addition of soybean flour [13].The gelation capacity was not affected by the drying methods employed as all the flours recorded the same values of 6.0 and 4.0% in fufu and fufu fortified flours.This is dependent on the starch contents of the flours. This showed that addition of soybean flour to fufu flour cause considerable reduction in the gelling ability of the flours. The rate of gelling and gel firmness depend on temperature, time of heating and protein concentration [30]. Gelatinization affects digestibility and texture of starch containing foods [31-32].

3.2Pasting properties of Fufu Fortified with Soybean Flour

The Results of fufu flour fortified with soybean and dried using oven, sun and solar drying methods are as presented in Table 3. Fufu flour is cooked into paste before consumption hence, the pasting characteristics of fufu flour are important quality index in predicting the behaviour of fufu paste during and after cooking [25]. The pasting characteristics of fufu flours were higher than the fortified fufu flours with significant difference ($p<0.05$) in the

220 **methods of drying.** The drying methods have significant effect on the pasting quality of the
 221 **composite flour** Higher peak viscosities were observed in both fufu and fortified fufu using
 222 solar drying method. The highest final viscosities for fufu and fortified fufu was obtained with
 223 solar and sun drying methods respectively.
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227 Table 5: Pasting properties of Fufu Flour.

Drying method	Peak viscosity (RVU)	Holding strength (RVU)	Breakdown (RVU)	Final viscosity (RVU)	Setback (RVU)	Pasting time (min)	Pasting Temp (°C)
Oven dried	355.82±0.94b	245.31±1.18b	110.51±0.81b	317.36±0.99b	72.05±0.46b	5.46±0.02a	76.23±0.05a
Sun dried	349.99±1.41c	234.47±1.10c	115.52±1.16a	309.43±0.86c	74.96±0.23a	5.46±0.02a	76.23±0.02a
Solar dried	357.58±1.26a	250.26±1.14a	107.32±1.12c	320.12±1.01a	69.86±0.33c	5.43±0.01c	76.20±0.02c

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230 Table 6: Pasting properties of Fufu Fortified with Soybeans Flour.

Drying method	Peak viscosity (RVU)	Holding strength (RVU)	Breakdown (RVU)	Final viscosity (RVU)	Setback (RVU)	Pasting time (min)	Pasting Temp (°C)
Oven dried	235.12±0.99b	131.75±1.21a	103.37±0.52b	204.42±0.61c	72.67±0.25c	5.60±0.10b	77.56±0.09a
Sun dried	231.87±0.86c	129.25±0.69b	102.62±0.49c	217.42±1.01a	88.17±0.41a	6.60±0.16a	76.55±0.06b
Solar dried	235.29±0.83a	128.75±0.71c	106.54±0.37a	212.33±0.90b	83.58±0.52b	5.07±0.11c	76.25±0.02c

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232 Viscosity is the parameter used to determine a particular starch based flour quality [28]. It
 233 **gives an idea of the ability of a material to foam gel after cooking** [25]. Fufu flour fortified with
 234 soybeans flour dried with oven had the lowest viscosity due to the denatured protein by heat
 235 processing [33] and low starch content in soybean [34]. The low viscosities showed that the
 236 associative forces between the starch molecules are relatively weak [25]. Setback viscosities
 237 showed variations in the fufu flours processed and dried with different methods. Values
 238 ranged from 72.05-88.17 RVU. The setback value for sun dried that high water absorption
 239 capacity is attributed to loose structure of the starch polymers while low value indicates the
 240 compactness of the molecular structure. The higher the setback value, the lower the
 241 retrogradation during cooling and the lower the staling rate of the products made from the
 242 flour [35]. Setback value is the difference between final viscosity and hot paste viscosity or
 243 trough [28]. It is a measure of the stability of the paste after cooking. It is a phase where
 244 during cooling of the mixture, a re-association of the starch granule occur which affects
 245 retrogradation or re-ordering of the starch molecules leading to syneresis or the release of
 246 water. The high values of setback indicate low stability after cooking.

247 The pasting time and temperature varied with the different drying methods. The pasting
 248 temperature ranged from 76.20-77.56^oc, pasting temperature is the temperature above the
 249 gelatinization temperature at which the viscosity begins to rise. It provides an indication of
 250 the minimum temperature required to cook flour, which can have implication on the stability
 251 of other components in a formulation and also indicates energy loss. Pasting temperature
 252 gives an indication of the gelatinization time during processing [36]. It is the temperature at

253 which the first detectable increase in viscosity is measured and it is an index characterized
254 by the initial change due to the swelling of starch [37]. Pasting temperature has been
255 reported to relate to water binding capacity. A higher pasting temperature implies higher
256 swelling properties of starch due to a high degree of association between starch granules
257 [37-38].

258 The pasting time ranged from 5.07-6.60mins. Pasting time decreased with the different
259 methods of drying. Sun drying method recorded highest value of 6.60mins followed by oven
260 drying method 5.60mins and solar drying method recorded the least value of 5.07mins. [How](#)
261 [does the drying methods affect the pasting time?](#) Pasting time is an indication that the
262 product is easy to cook. The pasting temperature ranged from 76.20-77.56°C. Pasting
263 temperature signifies the minimum temperature required to cook the flour samples.

264 **4. CONCLUSION**

266 This work showed that fortification of fufu flour with soybean flour resulted in improvement in
267 proximate constituents and functional properties of the flours. The functional properties
268 results revealed that except for foam capacity, all other properties like bulk density, water
269 absorption capacity and swelling capacity were not significantly affected by the drying
270 methods as all the flours recorded the same values for these parameters. The pasting
271 parameters were also significantly affected by the method of drying coupled with addition of
272 soybean flour.

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