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FUNCTIONAL PROPERTIES OF SOME VARIETIES OF NEW RICE FOR AFRICA (NERICA) RELEVANT TO ITS PROCESSING

FUNKCINALNA SVOJSTVA NOVIH SORTI PIRINČA U AFRICI (NERICA) RELEVANTNIH ZA NJEGOVU PRERADU

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ABSTRACT

Flour from rice can be applicable to several types of food or be used directly as a food substitute, and this can have an impact on the final quality of the product. This aimed to determine the functional properties of some selected NERICA varieties, namely, FARO 44, FARO 52, FARO 57, FARO 60 and FARO 61. Results obtained showed that the functional properties, such as the water absorption capacity (WAC), swelling power, water solubility index (WSI), bulk density, oil absorption capacity (OAC), and the foaming capacity, ranged from 251.74 to 298.51 (%); 7.42 to 8.41 (g/g); 10.01 to 12.27 (%); 0.92 to 1.00 (%); 0.45 to 1.36 (%); and 7.29 to 11.76 (%) respectively. All recorded samples were significantly different ($p < 0.05$). FARO 61 recorded the highest point of 298.51 (%), and 1.36 (%), in WAC and OAC respectively. While FARO 57 recorded the highest swelling power of 8.41 (g/g). These determined results of the functional properties of NERICA flour samples will be useful in determining their suitability in food and other relevant industries because the flour samples showed a high-quality range of functional properties that make them favourable for such activities.

Keywords: *NERICA, Functional properties, rice, food industry, rice centre.*

REZIME

Pirinčano brašno se može primeniti u više vrsta hrane, ili direktno koristiti kao prehrambena zamena, a to može uticati na konačni kvalitet proizvoda. Cilj u ovom istraživanju je da se utvrde funkcionalna svojstva nekih odabranih novih sorti za Afriku NERICA, odnosno FARO 44, FARO 52, FARO 57, FARO 60 i FARO 61. Dobijeni rezultati su pokazali da funkcionalna svojstva, kao što su kapacitet apsorpcije vode (VAC), moć bubrenja, indeks rastvorljivosti u vodi (VSI), nasipna gustina, kapacitet apsorpcije ulja (OAC) i kapacitet pene, kretali su se od 251,74 do 298,51 (%); 7,42 do 8,41 (g/g); 10,01 do 12,27 (%); 0,92 do 1,00 (%); 0,45 do 1,36 (%); i 7,29 do 11,76 (%) respektivno. Svi zabeleženi uzorci su se značajno razlikovali ($p < 0,05$). FARO 61 je zabeležio najvišu tačku od 298,51 (%) i 1,36 (%), u VAC i OAC respektivno. Dok je FARO 57 zabeležio najveću moć bubrenja od 8,41 (g/g). Ovi utvrđeni rezultati funkcionalnih svojstava uzoraka brašna NERICA, biće korisni u određivanju njihove pogodnosti u prehrambenoj i drugim relevantnim industrijama jer su uzorci brašna pokazali kvalitetan spektar funkcionalnih svojstava što ih čini pogodnim za takve aktivnosti.

Ključne reči: *NERICA, funkcionalna svojstva, pirinač, prehrambena industrija, centar za pirinač.*

INTRODUCTION

Rice is a very common foodstuff in Nigeria, and indeed, the world. It is scientifically known as “Oryza”, and it is one of the most popular grains eaten by human beings. Apart from eating rice as a normal meal, it is regarded as one of the best foods for ceremonies in the sub-Saharan part of Africa. Naturally, rice cultivated in this part of Africa has been called “Oryza Glaberrima Steud” before the introduction of NERICA. NERICA is referred to as “New Rice for Africa”, according to the West Africa Rice Development Center, (WARDA, 2008). This is used to characterize the genetic products or species samples from the successful hybridization of two rice cultivars, the African rice, often referred to as *O. Glaberrima Steud*, and the Asian rice species, usually called O. Sativa L., to create progenies that together bring the high-class qualities of the parentages, (WARDA, 2008; *Eze et al., 2020*). These attributes include high-quality characteristics from the Asian species and the capabilities of the African species to be grown dynamically in a difficult and unpleasant environment. NERICA varieties were developed through normal hybridization, which is crossbreeding, and it should be noted, these species are not hereditarily improved rice, (WARDA, 2008). NERICA varieties are regarded as rice of highland varieties, which in common sense, encompass the rainfed high land environment in sub-Sahara Africa, where very poor farmers do not have access to chemical fertilizers, irrigation, or pesticides. Reports from African Rice Center, (WARDA, 2008), indicated that NERICA varieties correspondingly respond positively to exceptional input more than the locally sourced varieties. Nevertheless, the high demand for rice, both in quality and quantity, far overclouded local production. Hence the needfulness to increase production and improve on the locally produced rice to make it more competing with that of foreign rice, led to the breakthrough on NERICA, (*Udemezue, 2018*).

The amplified cost-effective essentiality of agricultural food materials, in combination with the complexity of present-day technologies for their handling, processing, preservation and storage, quality evaluation, distribution, marketing and consumption, entails substantial knowledge of the engineering properties of these agricultural products suitable to their handling, processing, storage and preservation, (*Eze, 2020*).

The functional properties of agricultural products involve classifying the quality, shape, nutritional value and acceptability of the food material, and the general arrangement of properties that influence the food characteristics and procedural effectiveness, (*Jideani, 2011*). The functional properties of these food materials are determined through their physiochemical and organoleptic properties, (*Kraithong et al., 2018*). Example parameters of food functional properties include water retention index, solubility, water absorption capacity, oil absorption capacity, frothing ability, elasticity and absorptive capacity for fats and foreign particles. These properties vary significantly for various agricultural products and processes, and this may be calculated by a chemical process or evaluation testing, (Jideani, 2011).

The rice flour from rice grain is extensively used as ingredients in various food products, such as food thickeners, baby food cereals, beverages, bakeries, and so on, and in such case, the functional properties of NERICA need to be determined to help the food engineers on the quality properties of the food product. There are various studies on the qualities of several rice flour varieties as reported by researchers, but not much has been reported on NERICA flour varieties. Therefore, this study centres on the need to determine the various functional properties of NERICA flour varieties relevant to its processing, handling, and storage.

MATERIALS AND METHODS

Research Materials and Sample Preparation

The sample materials that were used during this study include five varieties of NERICA, and are, FARO 44, FARO 52, FARO 57, FARO 60 and FARO 61. These NERICA varieties were collected from Ebonyi State Agricultural Development Programme (EBADEP), Abakaliki, Ebonyi State, Nigeria, at moisture content storage of 12.5% (db). Some samples of the NERICA paddy from each variety were carefully parboiled and dehulled with a rice dehulling machine to obtain parboiled-milled samples of the NERICA varieties. The methods applied in parboiling and dehulling the samples were in line with the rice parboiling and dehulling process standard, and these include cleanings, soaking, drying, and milling *(Ituen and Ukpakha, 2011*). The flour samples were prepared by having the sample grains ground into a powdered form using a hammer mill. The powdered samples were sieved through a mesh sieve of 250 µm, packed in airtight polyethylene bags for further analysis.

Determination of the functional properties of nerica flour

Determination of Water Absorption Capacity (WAC).

The water absorption capacity (WAC) was determined using the method reported by *Abbey and Ibeh* (1998), and *Nishad et al.* (2017). In the process, one gram of each of the flour samples was weighed separately and is concurrent with a neat and dry centrifuge tube, on which it was deposited. The sample flour was then mixed with distilled water to integrate it up 10 ml of distribution and centrifuged at 3500 rpm for 16 minutes. The supernatant was then removed and the tube, together with its substance, was reweighed. The increase in mass after reweighing was the water absorption capacity of the sample flour. Thus, water absorption capacity (WAC), as reported by *Nishad et al.* (2017), is calculated using equation 1.

$$WAC\ (\%) = \frac{\text{Amount of Water Absorbed}}{\text{Mass of Sample before absorption}} \quad (1)$$

Determination of Swelling Index or Power

The swelling indexes of the NERICA flour samples were determined using an approach as reported by *Ukpabi and Ndimele* (1990). During the experiment, three grams of each of the NERICA flour samples were sprayed in a 50 ml calibrated canister that contains 30 ml purified cold water. The mixed contents were then kept at room temperature for one hour to absorb water, while the change in swelling volume is being recorded every fifteen minutes. The swelling index of each of the NERICA sample flour was determined as multiples of the original volume using equation 2.

$$\text{Swel. Index or Power} = \frac{\text{vol. after soaking-volume before soaking}}{\text{mass of sample before soaking}} \quad (2)$$

Determination of the Water Solubility Index.

The water solubility index of the NERICA flour samples was determined using a method as reported by *Malomo et al*. (2012). During the experiment, the vessels and centrifuge tubes were oven-dried at 105^{o}C for 20 minutes and allowed to be cooled in a desiccator, and after that, the vessels and the centrifuge tubes were then weighed. One gram of the NERICA sample flour was then measured into the tube and 10 milliliters of purified water were added and stirred gently with a stirring rod for 30 minutes. The tube containing the paste is centrifuged at 4000 rpm for 15 minutes on completion of the 15 minutes the supernatants were poured into vessels and dried in the oven at 105°C until the supernatant is dried off. The residue that remained in the tubes was weighed and the crucible after drying with the supernatant. Equation (3) as reported by *Malomo et al.* (2012) was used as thus.

$$\text{Water solubility index } (\%) = \frac{WOCAD\text{-}WOEC \times 100}{WOS} \quad (3)$$

where: *WOCAD* = mass (“weight”) of the crucible after drying; *WOEC* = mass (“weight”) of the empty crucible; *WOS* = mass of the sample.

Determination of the Bulk Density

Bulk density was determined using the method as reported by *Falade and Christopher*, (2015). 50g of flour of each NERICA flour sample were weighed into a 100ml of a granulated cylinder. The samples were tapped 30 times after that. The volumes of the samples were recorded. The bulk density was calculated by using the following formula:

$$\text{Bulk Density } (g/cm^3) = \frac{Mass\ of\ Sample\ (g)}{Volume\ of\ Sample\ after\ tapping\ \ (g/cm3)} \quad (4)$$

Determination of the Oil Absorption Capability

Determination of the oil absorption capability of the NERICA flour sample was carried out using an approach as reported by *Malomo et al*. (2012). In the process, 10 ml of soybean oil was mixed with one gram of NERICA flour sample. The mixtures were then centrifuged at 4000 rpm for 20 minutes, after which the excess oil was decanted while the remains (weight of absorbed oil) were reweighed. Equation 5 was used to calculate the oil absorption capacity (OAC) as reported by *Malomo et al.* (2012), thus,

$$OAC\ (g/g) = \frac{\boldsymbol{mass\ of\ oil\ absorbed\ (g)}}{\boldsymbol{mass\ of\ sample\ (g)}} \quad (5)$$

Determination of the Foaming Capacity

The standard method as described in AOAC (2005), was used to determine the foaming capacity of NERICA flour samples, where the samples’ one % concentration was prepared in ionized water and adjusted to pH value of 7.4 with 1.0 N NaOH and 1.0 N HCl. 100 ml volume (V_1) of the concentrate suspension was then blended with a high-speed blender for 3 minutes, before being poured into a 250 ml graduated cylinder, and the volume of the foam (V_F), was recorded immediately and calculated using equation (6) as reported by AOAC (2005).

$$FC=\left(\frac{V_F}{V_1}\right) \text{ x } 100 \qquad (6)$$

Statistical analysis

The obtained results were analysed statistically using Analysis of Variance (ANOVA), with the averages evaluated by Duncan's test at a 5% confidence significance level ($p < 0.05$). All the calculated results were stated as the average values standard error (SE) of triplicate observations.

RESULTS AND DISCUSSION

Water absorption capability refers to the ability by which agricultural materials, most especially flour consociates with water molecules (*Kraithong et al., 2018*). It also refers to the capacity of food to absorb water and swell thickness improvement in food. The water absorption capacity values of NERICA sample flours were 289.14%, 257.36%, 270.98%, 251.74%, and 298.51% for FAROs 44, 52, 57, 60, and 61 varieties respectively, Table 1 and Figure 1. Accordingly, the obtained results agree as reported by Kraithong et al. (2018) for Thai organic rice flour, *Jamal et al.* (2016) for Pakistani rice, and *Malomo et al.* (2012) for *Fakhr-e-Malakand and Basmati*. FARO 61 had the highest value of water absorption capacity of 298.51% ($p<0.05$), followed by 289.14 % for FARO 44 ($p<0.05$). These effects are because of a high number of hydrophilic groups in the starch molecules, that provide softness, viscosity, and smoothness in food materials (*Kraithong et al., 2018; and Aprianita et al., 2014*). Also, as reported by *Wang et al*. (2016), was an increase in water binding capacity is produced from low charges of groups of phosphate within the amylopectin. On the other side, low absorption of water in rice flour is due to a high amount of lipid and is caused by interrupting starch granule hydration with parts of hydrophobic (*Alcaza-Alay and Meireles, 2015*). More so high particle sizes in rice flour reduce the amount of water absorption capacity (Otegbayo et al., 2013). However, water absorption capacity lowest value of 51.74% was recorded in FARO 60 ($p<0.05$), which results in an increase in gelatinization temperature in the flour variety and roughness in texture in its products. Furthermore, the water-binding blockage in the flour variety may be because of the aspect of amylose/protein or amylose/lipid complexes, that reduce values of bulk density of 1.00 g/cm^3 ($p<0.05$). But in comparison, Tharise et al. (2014) reported that high compactness and lower porosity of starch granules decrease the bulk density value of agricultural materials. It was reported that an increase in bulk density of flour is essential for lowering pasting thickness due to its low viscosity and for food materials' rough textures. And rice flour with low bulk density is well served for food with smooth and dense textures (*Kraithong et al., 2018; and Jamal et al., 2016*). The little changes in bulk density recorded could be because of the variations in starch content (*Iwe and Onuh, 1992*). Also, bulk density functions on some factors such as the size of materials, geometry, method of measurement, solid density, and surface properties of materials and these could be enhanced more especially when the particles are compactible, small, or properly tapped or vibrated using an appropriate packaging material (*Iwe et al., 2016*). Bulk density also looks at how suitable packaging volume of material is needed. The more the bulk density increases, the more compacted the packaging material becomes. *Iwe et al.* (2016) also reported that bulk density is used to determine the porosity of a material that affects the packaging design, and this could then be used to determine the kind of packaging material needed during the processing, handling, and packaging of agricultural products.

Oil absorption capacity (OAC) is another essential functional property of agricultural products that helps to enhance the feel of the mouth and the same time, keeps the flavour of the food products (*Iwe et al., 2016; Adebowale and Lawal, 2004)*. The obtained results of oil absorption capacity for the NERICA flour samples include 0.45 g/g for FARO 44; 1.24 g/g for FARO 52; 1.32 g/g for FARO 57; 0.50 g/g for FARO 60; and 1.36 g/g for FARO 61, Table 1 and Figure 1. The recorded values show that the starch granules can retain oil. There was a significant difference ($p<0.05$) in the oil absorption capacities of the flour samples as statistically analysed. These recorded values are pointily in line with *Sarangapani et al.* (2016), *Iwe et al.* (2016), and *Kraithong et al.* (2018). *Tharise et al.* (2014) reported that an increase in numbers for hydrophobic groups from inside the molecules of the starch products leads to an increase in the oil absorption capacity of the product samples. High oil absorption capacity contributes to improvement in mouthfeel, food product palatability and retention of flavour in food materials. More so, rancidity in food (that is distasteful flavours and odours in food products because of decaying of the fat and oil parts of the food) that occurs in food materials is also stimulated by high values of oil absorption capacity (*Falade and Christopher, 2015).*

The foaming capacity of NERICA flour samples was also determined and recorded in Table 1, and Figure 1, and the values include 10.24% for FARO 44, 8.32% for FARO 52; 11.76% for FARO 57; 9.98% for FARO 60 and 7.29% for FARO 61. There was a significant difference between the foaming capacity values of the sample flours ($p<0.05$). Iwe et al. (2016) reported that good foaming capacity and stability are essential for product flours that are to be used to produce varieties of bakery food like biscuits, cakes, bean cakes, cookies, etcetera, and even as functional determinants in various food product formulations. El-Adawy (2001) had also reported that foaming capacity acts as an enhancer of either between flours or with other food cereals

Table 1. Functional Properties of NERICA flour.

NERICA Varieties	Water Absorption Capacity (%)	Swelling Power (g/g)	Water Solubility Index (%)	Bulk Density (g/cm^3)	Oil Absorption Capacity (g/g)	Foaming Capacity (%)
FARO 44	289.14 (3.41)	7.42 (0.34)	11.37 (2.01)	1.00 (0.02)	0.45 (0.02)	10.24 (1.99)
FARO 52	257.36 (3.11)	8.07 (1.33)	10.62 (0.99)	1.00 (0.12)	1.24 (0.21)	8.32 (0.55)
FARO 57	270.98 (2.71)	8.41 (0.77)	10.01 (1.33)	1.00 (0.41)	1.32 (0.67)	11.76 (1.87)
FARO 60	251.74 (2.01)	7.96 (1.76)	12.27 (1.21)	0.92 (0.31)	0.58 (0.45)	9.98 (1.89)
FARO 61	298.51 (1.32)	7.51 (1.56)	10.91 (2.01)	0.96 (0.11)	1.36 (0.43)	7.29 (0.89)
Average	273.55 (2.51)	7.87 (1.15)	11.04 (1.51)	0.97 (0.19)	0.99 (0.36)	9.52 (1.44)

N.B: Numbers in Parenthesis represent the Standard Deviation.

to produce a food product with an improved texture, firmness, and a good look.

the adverse and dynamic molecules (*Falade and Christopher, 2015*). In summary, water absorption capacity is a very essential functional property that is highly needed in food formulations mainly in those areas that requires dough handling (*Iwe et al., 2016*). The recorded variations in the water absorption capacity data between the NERICA flour varieties may be due to different protein formulations, because of the level of mixing with water and their design characteristics (*McWaters et al., 2003*). This impact could be because of the loose bond of amylose and amylopectin in the starch granules and weaker bond forces that maintains the granular structure. Water absorption capacity is very essential in the bulkiness and viscidity of agricultural materials and even bakery applications (*Iwe et al., 2016*). Consequently, the NERICA sample with the highest absorption capacity is best accepted in baking applications.

The swelling power of the NERICA samples, FAROs 44, 52, 57, 60 and 61, were determined and recorded as 7.42 g/g, 8.07 g/g, 8.41 g/g, 7.96 g/g, and 7.51 g/g respectively. The recorded values of the flour samples differed significantly ($p<0.05$). These results may be because of the nature of the samples and the processing methods used. Swelling capacity is seen as a very important tool in some food formulations as in bakeries (*Iwe et al., 2016*). It is evidence of non-covalent bonding relating to the molecules within the starch granules and factors of the ratio of amylose and amylopectin (Iwe et al., 2016). Recorded results showed that FARO 57 has the highest swelling capability of 8.41 g/g, seconded by FARO 52 with 8.04 g/g, while FARO 44 recorded the lowest swelling power with 7.42 g/g, Table 1 and Figure 1.

The water solubility index (WSI) of NERICA sample flours was recorded in Table 1 and Figure 1. These values are 11.37%, 10.62%, 10.01%, 12.27%, and 10.91% for FAROs 44, 52, 57, 60 and 61, respectively. These results are in accordance with what was reported by *Kraithong et al.* (2018), *Jamal et al.* (2016), and *Iwe et al.* (2016). FARO 60 recorded the highest water solubility index of 12.27%, and this indicates a very high number of water-soluble components that dissolve in water during cooking (Shafi et al., 2016b). According to Kraithong et al., (2018), a higher water solubility capacity in rice flour shows a very high value of adhesiveness and gumminess in food particles and represents the capacity of the food product to gain a preserving food structure. Normally, the connecting point formation by the amylose yields a food structure of starch granules, that provides a low water solubility index (*Chung et al., 2011*). Also, the complicacy of starch with proteins or lipids can reduce the water solubility index value in the flour of rice due to a decrease in the soluble parts within starch molecules (*Keawpeng and Meenune, 2012*). Thus, the lowest water solubility index as recorded in FARO 57 as 10.01 % ($p<0.05$), shows a high ability to keep food structures intact during the process of cooking.

Bulk density is regarded as an important parameter that is used in determining the flour expansion and porosity of agricultural products and is also used to indicate the volume of the packaging material (*Shafi et al., 2016b*). The recorded values of bulk density of the flour samples ranged from 0.92 to 1.00 g/cm^3. The results obtained are in accordance with *Kraithong et al.* (2018) for Thai Organic rice and Iwe et al. (2016) for composite flour of African yam bean, Faro 44, and brown cowpea seeds. Thus, FAROs 44, 52, and 57 recorded the highest

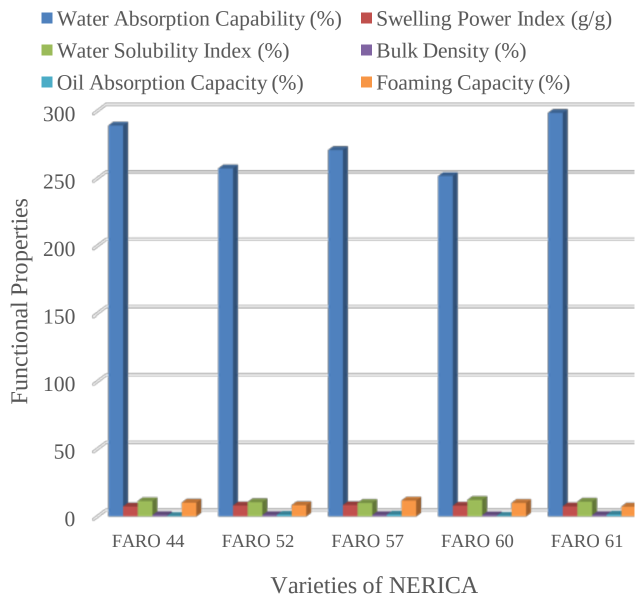

Fig. 1. Functional properties of NERICA flour

CONCLUSION

Differences were observed in the functional properties of NERICA sample flours. The recorded results for water absorption capacities of NERICA sample flour varieties were high and ranged from 251.74 to 298.51 %, and this indicates that NERICA varieties will be very good for cooking and the flours will also be good for baking and doughy practices. Swelling power is seen as an important key in bakery products formulations and the values ranged from 7.42 g/g to 8.41 g/g. An increase in swelling power results in a high swelling of the flour. Results obtained showed that NERICA has a good range of swelling power that makes them good bioproduct for baking and doughy activities. Recorded values for the water solubility index of NERICA varieties ranged from 10.01 to 12.27 %. The water solubility index determines the quantity of water-soluble particles that dissolve in water while cooking. The higher water solubility index in NERICA varieties shows their higher value of stickiness and adhesiveness. The bulk density of NERICA flour varieties was also determined, and the results ranged from 0.92 to 1.00 g/cm^3. Flour with high bulk density is very essential in minimising the paste thickness of flour because of its low viscosity and for food materials that have high textures, and at the same time, flour with low bulk density is suitably served with food and thick textures. Results for oil absorption capacity ranged from 0.45 to 1.36 g/g. Oil absorption capacity is an essential functional property of food material that enhances the feel of the mouth and at the same time keeps the flavour of the food products and results obtained indicated such characteristics in NERICA flour samples. The foaming capacity of NERICA flour samples was also determined, and the recorded results ranged from 7.29 to 11.76 %. Good foaming capacity and stability are profitable characteristics for flour materials intended to produce a variety of baked and dough products. The results indicated that NERICA flour has a good range of foaming capacity that makes them favourable for baking and doughy activities. Thus, the results of functional properties of NERICA will be needed by the baking and doughy industries for bakery, pasta, and noodle production. This is because NERICA flour showed a high-quality range of functional properties that make them favourable for such activities.

Declaration of Competing Interest

There are no conflicts to declare.

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