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Full Length Research Paper

Physicochemical and functional properties of bean flours of three cowpea (*Vigna unguiculata* L. Walp) varieties in Ghana

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Cowpea, an important protein food, is used for its nutritional and functional properties. A study was carried out to determine the physicochemical and functional properties of seeds of 3 local cowpea varieties ('Nhyira', 'Adom' and 'Tona') in Ghana to assess their potential use in the food industry. Seed length, minor diameter, major diameter, and 100-grain weight were in the range of 7.73-7.67 mm, 4.51-4.86, 5.75-6.30 mm, and 13.16-15.16 g, respectively. Moisture, crude protein, crude fat, crude fibre, ash, carbohydrate and dry matter were in the range of 9.15-9.83, 26.53-29.00, 2.50-3.99, 2.95-3.22, 4.24-4.80, 50.95-53.98 and 90.17-90.85% respectively. Bulk density ranged between 0.69 and 0.80 g/dm^3. Water and oil absorption capacities ranged between 1.89 and 2.15, and 1.95 and 2.31 ml/g, respectively. Swelling power had values varying from 265 to 268% while foam capacity varied from 10.00 to 21.00 ml. The results indicate that the three varieties of cowpea have great potential as functional agents in the food industry.

Key words: Cowpea, proximate composition, functional properties.

INTRODUCTION

Cowpea (*Vigna unguiculata L. Walp.*), is a leguminous plant belonging to the *fabaceae* family. It originated from Africa and is now widely grown in Africa, Latin America, and Southeast Asia and in the Southern United States (Davis et al., 1991). Cowpea, like other grain legumes is an important foodstuff in tropical and subtropical countries (Chinma et al., 2008) because of its use mainly, as a grain crop, a vegetable or fodder for animals. Cowpea is highly valued for its ability to tolerate drought and the high protein content of about 25% (IITA, 2007). These qualities make it a choice crop forcatering for the food security needs of societies. Nutrients provided by cowpea make it extremely valuable where many people cannot afford proteins from animal sources such as meat and fish (Akpapunam and Sefa-Dedeh, 1997). In Ghana, cowpea is mainly prepared and eaten as a whole or part of a meal.

It is used in foods such as koose (cowpea fritters), garri and beans (roasted grated fermented cassava and cooked beans) and tugbani (steamed bean cake). It is also used in stews and soups. To ascertain other potential food uses of these varieties and expand their uses, it is important to know the physico-functional properties of their flours.

Even though extensive works have been done by Sefa-Dedeh and Stanley (1979) and Sefa-Dedeh and Yiadom-Farkye (1988) on several varieties of cowpea there is insufficient information on Tona, Adom and Nhyira which are newly developed varieties in Ghana. To ascertain other potential food uses of these varieties and expand their uses, it is important to know the physico-functional properties of their flours. Therefore, the object of this study was to determine the physico-chemical properties of these newly developed cowpea varieties and ascertain their potential uses in food.

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MATERIALS AND METHODS

Materials

Three newly developed local varieties of cowpea (Nhyira, Adom and Tona) were obtained from the Crops Research Institute of the Centre for Scientific and Industrial Research (CSIR) at Fumesua, Kumasi, Ghana.

Cowpea flour preparation

The acquired samples were cleaned of extraneous matter (unhealthy insect infested seeds and chaff) before processing. The beans were dried in an oven (Wagtech oven Model GP120SSE300HYD) for 24 h at 60°C and milled with an attrition mill and sieved through a net with mesh size of 75 µm. Flour samples were packaged in sealed low density polyethylene bags and stored in refrigerators prior to analysis.

Physical properties determination

The colour of beans was determined according to the method of Gomez et al. (1997). Using micro-meter-screw-gauge the major diameter of seeds was determined by the measuring the longest dimension (along the split of the cotyledon) of cowpea beans while minor diameter was measured at the dorsal side as described by Dela and Khush (2000). 100-seed weight was determined by weighing 100 randomly selected raw seeds of each variety as recommended by AOAC (2000). Cooking time of each cowpea variety was determined according to the method of Akinyele et al. (1986) with slight modifications in terms of quantity of water and seeds used. A undred- gram dry beans was cooked in water in a ratio of 4:1 v/w. Cooking was adjudged complete when the beans crushed when gently pressed between the thumb and forefinger, and no hard material found in the cotyledon. Cooking time was reported in minutes.

Functional properties determination

Bulk density

Using the procedure of Okaka and Potter (1979), 50 g of cowpea flour was put into a 100 ml measuring cylinder and tapped to a constant volume and the bulk density (gcm^{-3}) calculated using the formula:

Bulk density = weight of flour (g) / flour volume (cm^3).

Water and oil absorption capacities

One gram of cowpea flour was mixed with 10 ml distilled water or refined palm oil (frytol) in a pre-weighed 20 ml centrifuge tube. The slurry was agitated for 2 min, allowed to stand at 28°C for 30 min and then centrifuged at 500 rpm for 20 min. The clear supernatant was decanted and discarded. The adhering drops of water or oil in the centrifuge tube were removed with cotton wool and the tube was weighed, the weight of water or oil absorbed by 1 g of flour or protein was calculated and expressed as water or fat absorption capacity (Beuchat, 1977).

Foam capacity and stability

One gram of cowpea flour was whipped with 100 ml distilled water for 5 min in a Kenwood blender at 500 rpm and poured into a 250 ml graduated cylinder. The volume of foam at 30 sec after whipping was expressed as the foam capacity and the volume of the foam after 60 min as the stability for the respective time periods. Foam stability was determined at 0, 30, 60 and 90 min after whipping as described by Chinma et al. (2008).

Swelling power

This was determined as described by Leach et al. (1959). One gram of the cowpea flour was mixed with 10 ml distilled water in a centrifuge tube and heated in a hot water bath at 80°C for 30 min while continuously shaking the tube. After heating, the suspension was centrifuged at 1000 g for 15 min. The supernatant was decanted and the weight of the paste taken. The swelling power was calculated as:

Swelling power = weight of the paste / weight of dry flour.

RESULTS

Physical properties of the cowpea varieties

The physical properties of the cowpea varieties are presented in Table 1. The length of the cowpea varieties ranged between 7.73 and 7.67 mm. The differences between the lengths of the cowpea varieties were not significant (P>0.05). Adom was marginally longer than Tona and Nhyira. Similarly, no significant differences were found among the major diameters, even though Adom (6.30 mm) was marginally bigger than Nhyira (5.90 mm) and Tona (5.75 mm). The minor diameters of the three cowpea varieties ranged between 4.51 and 4.86 mm. There were no significantly different among them (P>0.05).

There were, also, no significant difference among the 100-seed weight of the cowpea varieties which ranged between 13.16 and 15.16 g.

In contrast, significant differences (P<0.05) were observed in cooking time. Nhyira had the shortest cooking time of 57 min, followed by Tona (65 min) and Adom (84 min).

Proximate composition of cowpea varieties

The moisture content of the cowpea varieties varied significantly between 9.15 and 9.83% with Tona having the least and Adom the highest (Table 2). The Nhyira variety had the highest crude protein content (29.00%) and was significantly different (P<0.05) from both Tona (26.55%) and Adom (26.53%) which were not signify-cantly different from each other. The crude fat content was highest in the Adom variety (3.99%) and was signify-cantly different (P<0.05) from Nhyira (2.50%) and Tona (2.50%). The crude fibre content of Nhyira, Tona and Adom, were 4.80, 4.77 and 4.24, respectively. The differences between them were significant (P<0.05). With respect to the ash content of the varieties it ranged from 2.95 to 3.22% with Adom having the highest ash content

Table 1. Physical properties of cowpea varieties.

Varieties	Length (mm)	Major diameter (mm)	Minor diameter (mm)	100 grain weight (g)	Cooking time (min)
Nhyira	7.57±0.04	5.90±0.01	4.51±0.08	13.17±0.07	57±0.50
Tona	7.67±0.05	5.75±0.05	4.56±0.03	14.18±0.06	65±0.50
Adom	7.73±0.04	6.30±0.06	4.86±0.05	15.16±0.03	84±0.5
Lsd (P=0.05)	1.13	0.98	1.12	5.53	2.90

Table 2. Proximate composition (%) of cowpea varieties.

Varieties	Moisture	Protein	Fat	Crude fibre	Ash	Carbohydrate
Nhyira	9.79±0.03	29.00±0.13	2.50±0.03	4.80±0.05	2.95±0.03	50.95±0.12
Tona	9.15±0.05	26.55±0.12	2.50±0.07	4.77±0.07	3.00±0.02	52.22±0.10
Adom	9.83±0.02	26.53±0.08	3.99±0.06	4.24±0.03	3.22±0.04	53.98±0.09
Lsd (P=0.05)	0.23	1.70	0.26	0.45	0.66	2.14

Table 3. Functional properties of three local varieties of cowpea.

Varieties	Bulk density (g/ml)	*WAC(g/g)	*OAC (g/g)	Foam capacity (ml)	Foam stability in 30 min (ml)	Foam stability in 60 min (ml)	Swelling power
Nhyira	0.69±0.05	1.89±0.02	1.95±0.03	21.00±0.06	16.00±0.03	10.00±0.01	2.66±0.03
Tona	0.80±0.05	2.15±0.03	2.14±0.04	10.00±0.07	6.00±0.00	4.00±0.03	2.65±0.06
Adom	0.79±0.02	2.13±0.02	2.31±0.06	17.00±0.06	12.00±0.00	4.00±0.05	2.68±0.04
Lsd(P=0.05)	0.07	0.16	0.33	3.41	6.05	2.54	0.09

*WAC – Water absorption capacity. *OAC – Oil absorption capacity.

while Nhyira had the least. The differences observed among them were, however, not significant. The carbohydrate content of the flours ranged between 50.95 and 53.98%.

The highest carbohydrate content (53.98%) was observed in Adom and was significantly different (P<0.05) from Nhyira which had the least (50.95) but was not significantly different from Tona (50.22%). There was, however, no significant difference between Nhyira and Tona, even though, Tona's was higher.

Functional properties of the cowpea varieties

The functional properties the cowpea flours are shown in Table 3. Bulk densities of 0.80 0.79 and 0.69 g/cm^3 were recorded for Tona, Adom and Nhyira respectively. Whereas the difference between Tona and Adom was not significant (P>0.05) those between Tona and Nhyira as well as Nhyira and Adom were significant.

Water absorption capacity was between 1.89 and 2.15 g/g. While the difference between Tona and Adom was not significant (P>0.05) those between Tona and Nhyira as well as Adom and Nhyira were significant. The oil absorption capacity of the flours of the cowpea varieties ranged between 1.95 and 2.31 g/g. The differences between Tona and Nhyira as well as between Tona and Adom were not significant (P>0.05). However, there was significant difference between Adom and Nhyira. The foam capacity of each of the 3 varieties varied signify-cantly (P>0.05) from each other. While Nhyira foamed most (21 ml/g), the foaming ability of Tona (10 ml/g) was the least. Concerning foam stability, the stability at 30 min for Tona and Nhyira were significantly different (P<0.05) from each other, while the differences between Tona and Adom, as well as, Nhyira and Adom were not significant (P>0.05). At 60 min, however, differences between Tona and Nhyira and also Nhyira and Adom were significant. The swelling power of the cowpea flours significantly differed from each other and ranged between 2.65 and 2.68 with Adom having the greatest swelling power (2.68) and Tona having the least.

DISCUSSION

Physical properties of cowpea flours

The dimensions of cowpea beans and their 100-seed weight give indication of the space the flour would occupy as well as their bulkiness. Since the dimensions of the cowpea beans were similar it suggests that equal quantity of each variety could occupy equal space and the cost of packaging and transportation could be similar if based on space occupied. Short cooking time is desirable as it reduces duration, energy used in cooking as well as save labour cost. Modern trend towards convenience foods with reduced cooking time makes Nhyira superior to the Adom and Tona and, therefore, could be more acceptable to consumers and processors with limited time and resources.

Proximate composition of cowpea varieties

According to Chinma et al. (2008), compositional differences in cowpea could be attributable to soil type, cultural practices, environmental condition and genetic factors.

Since the cowpea varieties were grown under similar conditions, their differences could be mainly genetic. Generally, higher protein content in cowpea is desirable for improved nutrition. The higher protein content of Nhyira, therefore, suggests it could be a superior source of protein to Tona and Adom. The high protein content of the varieties is indicative that its use could help reduce protein-deficiency conditions such as Kwashiorkor. As regards crude fibre content, Nhyira again would be a better source than either Adom or Tona since it had significantly higher crude fibre content and could be useful in providing bulk to foods to relieve constipation. Although the crude fat content of the flours were low Adom, being richer in fat, could be useful in improving palatability of foods in which it is incorporated. The high ash and carbohydrate contents indicate that the cowpea varieties could be important sources of minerals and energy for consumers (Brown, 1991).

Functional properties of cowpea flours

The high bulk densities observed in the cowpea varieties used in this study indicate that their flours are heavy. The bulk densities were similar to other cowpea varieties (0.71 g/cm^3) but higher than pegeon pea (0.68±0.04 g/cm^3; (Butt and Batool, 2010). Tona and Adom being the heavier would occupy less space per unit weight compared to Nhyira.

However, Nhyira would be easier to transport as it was lighter. On the other hand, since Nhyira was the least dense it would occupy greater space and, therefore, would require more packaging material per unit weight and so could have high packaging cost (Oluwatooyin et al., 2002; Padmashree et al., 1987) compared to Adom and Tona. The high bulk densities of the flours suggest their suitability for use in various food preparations.

According to Padmasshree et al. (1987), higher bulk density is desirable for greater ease of dispersibility of flours. In contrast, however, low bulk density would be an advantage in the formulation of complementary foods (Akpata and Akubor, 1999). Since Nhyira had the least bulk density it could be the most suitable for production of complementary foods.

The water absorption capacity was highest for Tona than Nhyira. The water absorption capacities were higher than the 1.60 and 1.94 g/g reported by Chinma et al. in 2008, for some cowpea varieties in Nigeria. According to Butt and Batool (2010), protein has both hydrophilic and hydrophobic properties, and so can interact with water in foods.

Carbohydrates have also been reported to influence water absorption capacity of foods (Adejuyitan, 2009). The ability of protein to bind water is indicative of its water absorption capacity. The observed variation in water absorption among the cowpea flours may be due to different protein concentration, their degree of interaction with water and their conformational characteristics (Butt and Batool, 2010). On the other hand, Kuntz (1971) reported that lower water absorption capacity is due to less availability of polar amino acids in flours. The observed high water absorption capacity of the cowpea flours could be attributable to the presence of hydrophilic proteins. The water absorption capacity of the cowpea flours is comparable to the 220% (2.2 g/cm^3; cowpea) and 110% (1.10 g/cm^3; pigeon pea) reported by Ragab et al. (2004). The high water absorption capacity of the flours suggests that they would be useful functional ingredients in bakery products.

The oil absorption capacities of the flours of the 3 varieties studied were higher than the 0.39 to 0.53 g/g reported for some Nigerian cowpeas (Chinma et al., 2008). The ability of the proteins of these cowpea varieties to bind oil makes them useful in food systems where oil imbibition is desired. The flours could, therefore, have functional uses in foods such as sausage production. The high oil absorption capacity also makes the flours suitable in facilitating enhancement in flavor and mouth feel when used in food preparations. Adom could, therefore, be superior to Nhyira and Tona as flavor retainer since it had significantly higher oil absorption capacity.

The foam capacity and stability of the cowpea flours were comparable to those reported by Chinma et al. (2008) for some Nigerian cowpea varieties. Kinsella et al. (1985) attributed low foaming capacity to inadequate electrostatic repulsions, lesser solubility and hence, excessive protein-protein interactions. On the other hand, higher foaming capacity may be due to highly hydrated foams but decrease in foaming stability due to protein denaturation (Mwasaru et al., 1999; Butt and Batool, 2010). Since the Nhyira produced significantly more foam and had the highest stability than both Tona and Adom, it would be most useful as foam enhancer in food systems. This implies that the flours of these varieties may be useful as aerating agents in food such as koose (cowpea fritters) which require the production of stable foam volumes when whipped. The swelling powers of the flours of the varieties studied were higher to that of tigernut flour (2.47; Oladele and Aina, 2007) but lower than for cereal starches (24 to 42; Tester and Morrison, 1990). The high swelling power suggests the cowpea flours could be useful in food systems where swelling is required.

Conclusion

The findings of this study show that the cowpea varieties (Nhyira, Tona and Adom) are rich in proteins and have good physicochemical properties which could be exploited for nutrition and food formulation. The good functional properties make them useful in foods such as koose, sauces and stews where they could play functional roles. The cowpea flours could be used to fortify conventional flours which are low in protein. Consumption of foods based on these cowpea varieties would be important step towards alleviating protein malnutrition. Nonetheless, the Nhyira variety could be most suitable among the 3, for food uses since it had the best functional properties.

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