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Effect of processing methods on the functional and proximate composition of melon seed (*Colocynthis citrullus*) flour

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Abstract
Melon seed (*Colocynthis citrullus*) locally referred to as locally referred to as 'bara' was processed into flour by subjecting to four different processing methods which were raw processing, roasting, raw and defatting, roasting and defatting to determine the effect of these on the functional and proximate properties using standard methods. The functional properties determined include, bulk density, dispersibility, emulsification capacity, water and fat absorption capacity, foaming capacity and stability and nitrogen solubility. The roasted flour had the highest value for bulk density and dispersibility, 0.50 g/cm^3 and 75.03% respectively. The roasted defatted flour had maximum values for fat and water absorption capacity, emulsification capacity, foam capacity and stability and gelation capacity, 206%, 92.48%, 16.67%, 6%, 3%, and 13.33% respectively. Processing methods involving roasting and roasting coupled with defatting tends to enhance the functional properties of melon seed flour.

Keywords: melon, roasted, defatted, functional, formulation

1. Introduction

The significance of plant protein in the diets of developing countries cannot be over-emphasized, as one of the pressing problems in this part of the world is the challenge of augmenting the shortage of protein in the diets of majority of the populace which leads to malnutrition, kwashiorkor and beriberi associated with inadequate protein intake.(Fasasi *et al*., 2005) [5] Production of high protein rich foods from locally under-utilized substrates within the reach of low income earners can be advantageous in improving the protein intake of the less privileged and melon is one of such promising foods.

Melon belongs to the large family of cucurbitaceae and is generally grown in the tropical and some temperate region of the world such as Asia as it demands a lot of heat and sunshine (Mabalaha *et al.,* 2007) [8]. The seed is highly nutritious, rich in vegetable protein, fat and vitamins **(**Peter-Ikechukwu *et al*. 2016) [16]. The application of the raw meal in several delicacies and dietary preparations vary with the culture and habits of the people. The dried seeds of melon can be peeled and ground into fine flour to make the popular 'egusi' soup or incorporated as soup thickeners into some other soups (Enujiugha and Ayodele-Oni 2003) [4]. To further increase its utility and versatility in food formulations, melon seed meal can be partially defatted and made into parties to serve as meat substitute or roasted and made into snack balls of 'robo'. In the confectionary industries melon seeds are used as dressing for breads, sweet, cake and other snack foods **(**Oluwole and Adedeji, 2012) [12].

Functional properties of a food refer to those characteristics that affect the behaviour of the food during processing, storage and the end utilization of such food and food components (Ogundele and Oshodi, 2010) [10]. More work is still required on the functional and technological utilization of melon seeds as such extended use of melon will depend on the knowledge of its chemical, nutritional and functional properties. Therefore, the objective of this research is to evaluate the functional and proximate properties of melon seed flour processed under different conditions in order to enhance its extended use.

2. Materials and Method

2.1 Sample Preparation

Matured *Colocynthis citrullus* seeds locally referred to as 'bara' was obtained from 'Kuto' market in Abeokuta, Ogun State, Nigeria. The unshelled *Colocynthis citrullus* seeds were sorted to remove the unwholesome and extraneous materials and peeled to remove the seed coat. The seeds were processed into flour by subjecting to four different processing techniques of raw processing, roasting, raw defatting, roasting coupled with defatting. The method of Oniyeike *et al*. (1994) was adopted with slight modification. Briefly, the dried seeds were milled to obtain the full fat raw sample. Roasting of dried seeds was done by frying in a microwave oven at 85 ºC for 5 min. defatting of raw and roasted meal was done using solvent extraction apparatus for eight hours refluxing with n–hexane.

2.2 Proximate Analysis

Moisture, crude fat, total ash and crude fibre contents were determined using the standard methods of Association of Official Analytical Chemists (AOAC, 2005) [1]. The crude protein content was determined by the micro Kjeldahl nitrogen method and the nitrogen content was converted to protein using a 6.25 conversion factor. Carbohydrate content was calculated by difference.

2.3 Functional properties

Bulk Density

A 10 ml-graduated cylinder was carefully filled to mark with melon seed flour. The filled cylinder was gently tapped on a laboratory bench about 10 times until there was no further diminution of the sample level after filling to the 10 ml mark. The bulk density was calculated using Equation 1 below:

Bulk density (g/ml) =

$$\frac{mass\ of\ sample}{volume\ of\ sample\ aftter\ tapping} \quad \text{(Eqn. 1)}$$

Water and oil absorption capacity

The water and oil absorption capacity (WAC, OAC) of the flours were determined as described by Fagbemi *et al*. (2012). Distilled water (ρ=1 g/ml) and Executive Chef® vegetable oil (ρ=0.92 g/ml) were used for WAC and OAC determinations, respectively. Briefly, 10 ml of water was added to 1.0 g of the flour sample (for WAC) and 10 ml of oil (for OAC) in a beaker and stirred using magnetic stirrer for 5 min. The resulting suspension was centrifuged for 30 min at 2,500 × g. The supernatant was decanted and the volume measured. The water or oil absorbed was calculated as the difference between the initial volume of water or oil used and the final volume of the decanted supernatant. The result was expressed in percentages.

Foam capacity and stability

Two gram of melon seed flour was dissolved with 100 ml of distilled water in a warring Blender at 1600 rpm for 5 min. The suspension was poured into a 250 ml measuring cylinder and the volume after 30 sec was recorded. Foam capacity was expressed as percent increase in volume and calculated thus:

Foam capacity =

$$\frac{vol\ after\ whipping - vol\ before\ whipping}{vol\ after\ whipping} \times 100 \quad \text{(Eqn. 2)}$$

The foam stability was measured as a decrease in foam volume with time and an average of 4 replicates expressed as mean values.

Gelation properties

Gelation properties were determined using the method described by Coffman and Garcia (1977). Sample suspensions of 2-10% w/v were prepared in 5 ml distilled water. The tubes containing suspensions were heated in a boiling water bath for 1 h, cooled rapidly under running tap water, and further cooled for 2 h in a refrigerator at 4 °C. The tubes were inverted and the least gelation concentration was taken as the concentration at which the sample did not fall from the inverted test tube.

Protein solubility

The effect of pH on the protein solubility of the flour samples were carried out according to the method described by Ige *et al*. (1984) [6]. Mixture of 0.5 g of the flour and 10 ml of distilled water was homogenised and left to solubilise at room temperature for about 5 min. The pH of the mixture was adjusted to pH 2-10 with the aid of 0.1 M HCl and 0.1 M NaOH. The samples were then centrifuged at 3,500 rpm for 30 min. The supernatant was decanted and the soluble protein determined using Kjeldahl's method. The values were expressed as the percentage of the protein content of each flour sample.

2.4 Statistical analysis

All determinations were carried out in triplicates for each test and analysis of variance (ANOVA) was used to analyze the result and means were separated by Duncan's method. The statistical package SPSS version 17.0 (SPSS Inc., Chicago, Illinois USA) computer program was used and significant differences was noted at 95% confidence limit.

3. Results and Discussion

Table 1: Proximate Composition% (g 100 g^{-1} DM) of melon seed flour

	MC	CP	CFAT	CF	ASH	CHO
RAS	$5.49^a±0.18$	$32.66^c±o.15$	$38.4^a±0.15$	$5.96^b±0.26$	$3.12^b±0.02$	$12.90^c±0.05$
ROS	$5.20^a±0.13$	$38.12^b±0.02$	$6.90^c±0.18$	$6.85^b±0.85$	$4.96^a±0.2$	$37.97^a±0.17$
RAD	$5.52^a±0.18$	$40.21^a±0.43$	$7.92^b±0.18$	$5.42^b±0.26$	$4.41^a±0.18$	$36.52^a±0.12$
RDS	$4.55^b±0.05$	$27.31^d±0.01$	$41.20^a±0.15$	$9.2^a±0.21$	$3.20^b±0.85$	$14.54^b±0.01$

RAS=Raw sample, ROS=Roasted sample RAD=Raw defatted sample, RDS=Roasted defatted sample

The chemical proximate composition of full fat (raw and roasted) and defatted (raw and roasted) melon seed flour samples are presented in table 1. Moisture content of different flour samples showed that full fat raw melon seed flour is significantly higher (5.49%) as compared to the other three categories of melon seed flours. Omosuli *et al*. (2009) [13] also reported close results for moisture content of defatted cashew nuts. It was observed that defatting significantly improved the crude protein content of melon seed flour. The crude fat content of the full fat raw melon seed flour (38.40%) and full fat roasted melon seed flour (41.20%) were high and not-significantly different as a result of microwave roasting**.** Similar results reported by Sanni and Jaji (2003) [17] for fufu (wet paste from cassava) which revealed that processing methods of drying and roasting had no effect on the protein and fat content of the samples. Ash content of the raw defatted and roasted defatted melon seed flours is significantly higher (4.96% and 4.41%, respectively) as compared to the full fat raw (3.12%) and full fat roasted (3.20%). The crude fat content of the defatted samples was higher than 2.86% for gourd seed reported by Ogungbenle (2006) [11] and favourably compared with 2.57% - 48.57% reported by Omowaye-Taiwo *et al*. (2015) [14].

Table 2: Functional properties of melon seed flour

Functional properties	RAS	ROS	RAD	RDS
Bulk density(g/cm^3)	0.50^a±0.002	0.50^a±0.150	0.46^b±0.026	0.47^b±0.153
Emulsion capacity(m/g)	9.09^d±0.015	13.79^b±0.015	10.71^c±0.015	16.67^a±0.015
Oil absorption capacity (%)	105.33^c±1.527	80.33^d±1.527	156.33^b±1.527	206.33^a±1.527
Water absorption capacity (%)	52.09^d±0.015	84.70^b±0.015	54.67^c±0.015	92.48^a±0.015
Foam capacity (%)	4.00^b±0.000	4.00^b±0.015	4.00^b±0.000	6.00^a±1.000
Foam stability (%)	2.00^a±0.000	2.00^a±0.000	2.00^a±0.000	3.00^b±1.000
Dispersibility (%)	70.03^b±0.153	75.03^a±0.153	64.03^c±0.153	63.33^c±1.528
Gelation (%)	12.01^{ab}±0.012	11.00^b±0.000	12.00^{ab}±1.000	13.33^a±1.528

Values are means of triplicate determinations α= ($p<0.05$)
RAS=Raw sample, ROS=Roasted sample RAD=Raw defatted sample, RDS=Roasted defatted sample

Foam capacity and stability
There was no significant difference in the foam capacity and stability of all the flours. Good foam capacity is related to the amount of native protein which can help reduce surface tension of air-water interface as a result of the protein molecule absorption. The low foam capacity obtained in all the samples may be undesirable in food formulations requiring aeration when whipped such as ice cream (Mempha *et al*., 2007) [9]. Hence the samples when processed individually or in a mixture with other ingredient or substrate may not have the potential to retain air and hold aerated matrix such that it can be set by the application of heat or other processing methods (Balami *et al*., 2004) [2].

Bulk density
The bulk density of a substance is important in relation to its packaging. The results obtained indicates that bulk density decreased following defatting of flours. The values of defatted samples ranged from 0.47 g/cm^3 to 0.46 g/cm^3. The high bulk density of the undefatted samples 0.50 g/cm^3 is an indication that they are denser than the defatted samples. High bulk density is a plus in food processing as it brings about a decrease in paste thickness and aid the ease of dispersibility of food powders (Udensi and Iwe, 2009) [18]. Bulk density refers to the weight of a mass of an intact individual unit of the material packed by a specific method. The low bulk density value of the defatted samples could be desirable in the formulation of weaning foods as it can help increase the calorie and nutrient intake per serving of the infant, thus resulting in healthy growth

Water and oil absorption
There was significant difference ($p<0.05$) in the water absorption of the flours and the result is presented in table 2. The values obtained were high and ranged from (RDS, 92.48%) to (RAS, 52.09%). These values were lower than results obtained by Peter-Ikechukwu *et al*. (2016) [16] which ranged from (340% -179%) for five members of cucurbitaceae family. Generally, the moderate water absorption capacity of the flours is an indication that they would be useful as functional ingredients in food systems such as bakery products where high hydration is required to improve handling characteristics. Water absorption capacity indicates the ability of a product to associate with water in situations of limited water for example dough and paste
There was no significant difference in the fat absorption capacity of the flours and the results were comparable with that obtained by Peter-Ikechukwu *et al*. (2016) [16] for different species of melon seed which also reported low fat absorption. The result showed that melon seeds may possess a high flavour retention potential which could be due to the high hydrophobic protein of the seeds. When applied as a functional agent in food preparations such as meat substitute and extenders it can serve to increase mouth feel (Omosuli *et al*., 2009) [13].

Dispersibility
At a level of α= ($p<0.05$) there was significant difference in the dispersibility of melon seed flour. The dispersibility index of raw flour was 70%, roasting enhanced the dispersibility of melon flour (75%). The dispersibility of the undefatted samples was significantly lower with values of 63 and 64%. This result suggests that the roasted samples could be utilized find utilization as functional ingredients in food systems that require reconstitution such as weaning foods and other breakfast cereal (Kulkarni *et al*., 1991) [7]

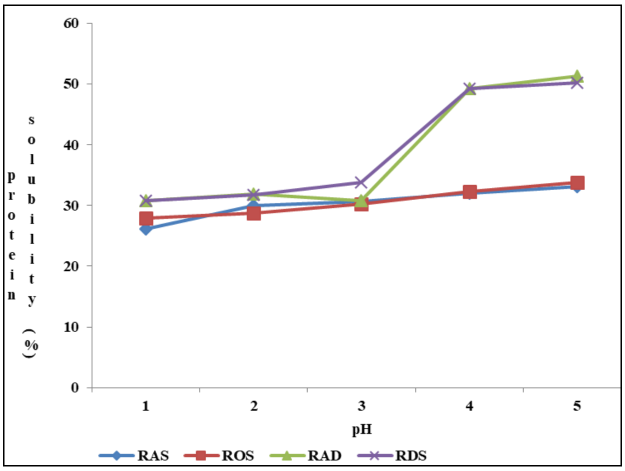

Fig 1: pH effect on the protein solubility (%) of melon seed flour

The protein solubility is presented in fig.1 and was observed to be pH dependent, increase in pH resulted in a simultaneous increase in protein solubility and the main difference was studied in solubility of protein between pH 2.0 and pH 10.0 and minimum solubility was observed at pH 2.0 (26.12%). Similar trend observed in the solubility of the flour showed that the defatted samples had higher solubility than the undefatted samples. The results were comparable with the protein solubility of full-fat and defatted *Cucumeropsis mannii* seed flours reported by Omowaye-Taiwo *et al.* (2015) [14]. The findings of this work also revealed that the flour were more soluble in the basic region than the acidic medium suggesting that protein of the melon flour, especially the defatted flour can be used in basic food formulation such as biscuit and meat product. Protein as function of pH offers a good index of the possibility or reservation of protein as a functional ingredient (Ogundele and Oshodi, 2010) [10]. Similar results on pH dependent protein solubility of melon seed are available Wanni *et al*. (2011a, b) [19, 20].

4. Conclusion

The findings of this study showed that processing methods of roasting and defatting appreciably improved the selected functional properties of *Colocynthis citrullus* seed flour and as such will be suitable for innovative applications in the food industry. The high protein and fat profile of this underutilized seed flour could also be utilized as a functional ingredient in soups, frozen desert and as an emulsifier in vegetable milk production.

Conflict of interests. The author(s) did not declare any conflict of interest.

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