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Effect of Watermelon (*Citrullus lantus)* Rind Flour Supplementation on the Quality of Wheat Based Cookies.

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ABSTRACT
Watermelon (Citrullus lantus) rind is the greenish outer covering of the fleshy, succulent sweet pulp and is usually wasted after consumption of the pulp. The functional, proximate, mineral, vitamin, physical and sensory properties of the cookies from the blends of wheat flour and watermelon rind flour at 0% (A), 2.5% (B), 5% (C) and 7.5% (D) were evaluated. The results of the functional properties showed that the water absorption capacity (83.66 %) and reconstitution index (81. 65%) had a higher percentage than the foaming capacity (28.48%), solubility (52.78%) and swelling index (8.43%) which makes the watermelon rind flour a good functional material in food formulations. The results of the proximate composition showed a significant ($p< 0.05$) increase in moisture, protein, crude fibre, ash, fat content and a decrease in carbohydrate and dry matter content with the gradual increase in the watermelon rind flour. The results of the mineral and vitamin content showed a significant ($p< 0.05$) increase in iron, magnesium, potassium, phosphorus, calcium and vitamins A, B_1, B_2 and C content with the gradual increase in the watermelon rind flour. The result of the sensory attributes showed no significant ($p<0.05$) difference in appearance, crispness, texture, and flavour but sample B was the most acceptable among the blends of wheat and watermelon rind flour cookies. Cookies supplemented with watermelon rind flour would enhance the nutritional status of consumers of cookies as snacks.
Key words: *Wheat flour, Watermelon rind, Cookies, Supplementation, Nutritional status*

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I. INTRODUCTION

Watermelon (*Citrullus lantus*), a tropical fruit,belongs to the family *Cucurbitaceae* and grows in almost all parts of Africa and South East Asia (1). It's center of origin has been traced to both the Kalahari and Sahara deserts (2). It is large oval, round or oblong in shape. The skin is smooth, with dark green rind and some stripes that turn yellowish green when ripe. It is an annual herb with long (up to 10metres) stems lying or creeping on the ground, with curly tendrils. The fruits vary considerably in morphology, size range from about 7cm to over 20cm in diameter (3). Watermelon (*Citrullus lantus*) produces a fruit that is about 93% water, hence the name 'water'melon. The 'melon' part came from the fact that the fruit is large and round and had a sweet, pulpy flesh. The scientific name of the watermelon is derived from both Greek and Latin roots. The *citrullus* part comes from a Greek word 'citrus' which is a reference to the fruit. The *Lanatus* part is Latin and has the meaning of being wooly, referring to the small hairs on the stems and leaves of the plant (4). Watermelon (*Citrullus lantus*) fruit is generally eaten raw, however, most times only the fleshy pulp of the fruit is consumed leaving the seeds and rind.

The fruit is a good source of amino acid, citrulline, vitamin C, Beta carotene a precursor of vitamin A, potassium and the anti-oxidant such as lycopene. Lycopene and citrulline have been shown to be helpful in preventing some chronic diseases. The seeds of the fruit are flat and smooth, varying in size and may be white, tan and brown, red, green or mottled (5). Watermelon (*Citrullus lantus*) seeds contain cucurbocitrin to aid the lowering of the blood pressure and improve kidney function (1). In Africa, the seeds may be ground into coarse flour or oil may be extracted from them (6). The seeds may also be used in the treatment of urinary tract infection, renal stones, hypertension, diabetes, diarrhea and gonorrhea (7).

Watermelon rind is the area of white flesh between the coloured flesh (usually red or yellow) and the outer skin (8). Rind thickness varies between varieties. Most often watermelon rind are usually discarded, applied to feeds or fertilizer, but they are edible and sometimes used as a vegetable (9). As watermelon rind flour possesses significant amount of ash, fat, protein crude fibre and carbohydrate and contribute 30% of the total weight, it is essential to find out ways of using watermelon rinds (so-called 'waste') for the formulation of different food products (10). Cookies are small, flat dessert treats commonly formed into a circular shape and are one of the most popular bakery products widely consumed due to it's ready-to-eat nature, low cost and longer shelf life

(11). Dietary fiber in human diet lowers serum cholesterol, reduces the risk of obesity, blood pressure and many other diseases (12). Cookies are convenient snacks products dried to a very low moisture content taken among young people and adults to provide energy.

II. MATERIALS AND METHODS

Watermelon (*Citrullus lanatus*) fruits were purchased from railway market while wheat flour and the other baking ingredients (salt, sugar, fat and eggs) were purchased from High level market all in Makurdi, Benue State, Nigeria. The watermelon rind were processed into flour using modified method as described by (13). The watermelon fruits were split and the pulp separated from the rind. The rinds were cleansed and sliced into smaller size for easy drying. The sliced rinds were sun dried, milled using attrition mill and sieved into flour using a 0.5mm pore sieve

Formulation of Blends: The blend ratio for the cookies were formulated using the modified methods as described by (14). The wheat flour and the watermelon rind flour were blended in the ratio of 100:0% (sample A [control]), 97.5:2.5% (sample B), 95:5% (sample C), 92.5:7.5% (sample D).

Preparation of the cookies: Four batches of cookies were produced at University of Agriculture Makurdi, Benue State Nigeria, in the Bakery Laboratory of Food Science and Technology Department. The cookies were prepared according to (15) method with the dry ingredients (wheat flour with the various proportion of the melon rind flour), sugar(30g), salt (1g), baking powder (0.5g) weighed accurately and thoroughly mixed in a bowl for 3mins. The creaming of fat (45g) was done and eggs (56g) mixed in a mixer till foaming occurred. The flour was added to the creamy mass and mixed for 3mins manually. The dough was then rested for 15mins followed by cutting the dough to a desired shape of uniform thickness and baked at 180^{o}C for 20mins in a baking oven. The baked cookies were cooled to ambient temperature, packed in low density polyethylene bags and kept in airtight containers prior to subsequent analysis and sensory evaluation.

Determination of the functional properties:

Foaming Capacity (FC) determination: The foaming capacity of the four blends was determined as described by (16). Two grams (2g) of flour sample was blended with 100ml distilled water in a blender and the suspension was whipped at 1600rpm for 5 minutes. The mixture was poured into a 250ml measuring cylinder and the volume was recorded after 30seconds. Foaming capacity is expressed as percentage increase in volume using the formula of (17).

$$\text{Foaming Capacity} = \frac{\text{volume after whipping} - \text{volume before whipping}}{\text{Volume before whipping}}$$

Solubility determination: The method as described by (16) was adopted. One hundred gram (100g) of flour sample was placed in 100ml measuring cylinder and distilled water was added to reach the graduated volume 100ml. The mixture was stirred vigorously and allowed to settle for 3hrs. The volume of the settled particles was deducted from 100 and the difference reported.

Water Absorption Capacity (WAC) determination: The method as described by (16) was adopted. One gram (1g) of the flour sample was weighed into conical graduated centrifuge tube of known weight and mixed with 10ml of distilled water and allowed to stand for one minute. The tube was centrifuged at 5000rpm for 30min. The volume of free water (the supernatant) was discarded and the tube with it's content was reweighed as water absorbed per gram of sample. The gain in mass was the water absorption capacity of the flour sample. Absorption capacity is expressed in grams of water absorbed per gram of sample.

$$\text{WAC} = \frac{\text{Density of water} \times \text{Volume absorbed}}{\text{Weight of sample}}$$

Swelling Index (SI) determination: The method as described by (17) was used in the determination of the swelling index. One gram (1g) of the flour sample was weighed into 10ml graduate cylinder. Five milliliters (5ml) of distilled water was carefully added and the volume occupied by the sample was recorded. The sample was allowed stand undisturbed in water for one hour (1hr) and the volume occupied after swelling was recorded and calculated as:

$$\text{Swelling Index} = \frac{\text{Change in volume of sample}}{\text{Original volume of sample}}$$

Reconstitution Index (RI): The reconstitution index of the flour sample was determined according to method described by (16). Five grams (5g) of the flour sample was dissolved in 50ml of boiling water. The mixture was agitated for 90 seconds and was transferred into a 50ml graduated cylinder and the volume of the sediment was recorded after settling for 30minutes.

$$RI\ (g/ml) = \frac{\text{Volume of sediment}}{\text{Weight of sample}}$$

Determination of Chemical composition of the wheat - watermelon (*Citrullus lanatus*) rind blend cookie samples: Standard methods of Association of Official Analytical Chemists (15) were used to determine the crude protein, crude fiber, ash, fat, moisture content of the samples. The crude protein content was determined by kjeldahl method, fat by solvent extraction using n-hexane as the extractor. Ash was determined by incineration of 2g sample in a Muffle furnace maintained at 550^{o}C for 5hrs. Moisture content was determined by heating 2g of sample to constant weight in a crucible placed in an oven maintained at 105^{o}C. The carbohydrate content was obtained by difference according to (18) method. Dry matter (total solids) was determined by subtracting % moisture content from the mass (100) as described by (19).All the chemical analysis were carried out in duplicate and reported in percentage.

The concentration of some selected minerals, iron, magnesium, potassium and calcium was determined using atomic absorption spectrophotometer (AAS model; Perkin Elmer2380, USA 1976) and phosphorus was determined using Vanadomolybdate reagent using colorimetric method (Colorimeter SP20, Bausch and Lamb) according to (19).

Vitamin content was determined by High Performance Liquid Chromatography (HPLC) method as described by (15). The vitamin C content was determined using the titration method as described by (16) while vitamin A content was determined by Spectrophotometric method as by (20).

Determination of Physical Characteristics: The physical characteristics (diameter, height, weight and spread ratio) of cookies were evaluated the method of (16). For the diameter, six cookies were placed edge to edge and total diameter (D) was measured in cm by using a rule. The cookies were rotated at an angle of 90^{o} for duplicate reading. This act was repeated twice and average D was reported in cm. For the height (H), the cookies height were taken at different points (lowest and highest) and average height was then recorded. For their weight (W), the cookies weights were taken 30mins after they were removed from the oven using a weighing balance. The spread factor (SF) was determined from the diameter (D) and height (H) by employing subsequent formula: SF = (D/H × CF) ×10, where CF is a correction factor at constant atmospheric pressure (it's value is 1.0) at present study.

Sensory Evaluation of Cookies Sample: A sensory attributes of the cookies was determined using a fifteen member panelist. The panelists scored the appearance, crispness, texture, after taste , flavor, and overall acceptability of the cookies using a nine point hedonic scale, where 9 indicates extremely like and 1 extremely dislike (18).

Statistical Analysis: All analysis were carried out in duplicate Data were subjected to analysis of variance (ANOVA), (21) where significant difference existed and Turkey's test was used in separating the means as described by (18).

III. RESULTS AND DISCUSSION

The results of the functional properties in Table1 showed that the water absorption capacity and reconstitution index have very high concentration. The ability of flour to absorb and retain water suggests better performance in texture and baked product as reported by (22). Foam capacity requires rapid absorption of protein at an air-water interface during whipping or bubbling, ability to undergo rapid conformational change and rearrangement at the interface. Conversely, foam stability requires a thick, elastic cohesive, continuous, air permeable protein film around each gas bubble (23).

The proximate composition of the samples is as shown on Table 2. The result showed that the moisture content increased from 9.57% (sample A) to 11.64% (sample D). The increase in moisture content of samples could be attributed to the increase in fiber content (0.87 to 1.66%) as dietary fiber bind water molecules and promote retention of water but prevent evaporation during baking (24). The fiber from fruits and vegetables have been reported to serve important functions in lowering blood cholesterol concentrations, slowing glucose absorption, weight control and reducing the risk of colon cancer (25, 26). The higher the moisture content the lower the amount of dry solids in flour (19). The result also showed a decrease in dry matter from 90.43% (sample A) to 88.37% (sample D).

There was an increase in crude protein (9.79 to 15.35%) which helps to improve the nutritional quality of the cookies, crude fiber (0.86 to 1.66%), fat (8.38 to 13.12%), Ash (1.43 to 3.16%) and a decrease in carbohydrate (69.96 to 55.07%) showing the watermelon rind flour has low carbohydrate content. Ash is the mineral material in flour. However, the ash does not affect baking performance of flour (19).

The results in Table 3 showed that the mineral content of the samples were significantly ($p<0.05$) higher than the control (Sample A).The samples had significant increase in iron (31.56mg/g to 48.22mg/g), magnesium (17.36mg/g to 61.73mg/g), potassium (104.20mg/g to 344.60mg/g), phosphorus (175.40mg/g to 341.50mg/g) and calcium (42.63mg/g to 172.70mg/g). High mineral content makes for ideal dietary source of electrolytes. Several clinical studies have shown potassium, magnesium and calcium to be effective pressure lowering agent (27). Potassium aids in transmitting nerve impulse and also has a catalytic role in energy metabolism that results in making energy available from carbohydrate, fat and protein; phosphorus, like calcium serve as a structural component of bones and teeth and also is concerned with the release and transfer of energy inside the cells (28). Iron in the body aid the transport of energy for the red blood cell formation. It is also a component of the enzymes that catalyze oxidation-reduction reaction in the glucose and fatty acid metabolism. Deficiency of iron over a period of time is characterized by poor growth, decreased pigmentation in the interior of the mouth, increases heart and respiration rate (28). Magnesium is required for energy production. It contributes to the structural development of bones and also plays a role in active transport of calcium and potassium ions across cell membrane, a process that is important to nerve impulse conduction, muscle contraction and normal rhythm (29).

The results from Table 4 showed that there was significant ($p<0.05$) increase in vitamins A (1.23iu/g to 8.08iu/g), B1 (0.12mg/g to 0.22mg/g), B2 (0.17mg/g to 0.21mg/g) and C (2.72mg/g to 7.23mg/g) as watermelon rind flour was gradually supplemented in the cookies. Vitamin A is an essential nutrient required for maintaining immune function, playing an important role in the regulation of cell-mediated immunity and in hormonal antibody responses,it helps in the maintenance of healthy teeth, skeletal and soft tissue, mucos membranes and skin and It is also known as retinol because it produces the pigment in the retina of the eye(30). Consumption of food rich in vitamin C helps the body develop resistance against infective agents and scavenge harmful oxygen free radicals.

The results from Table 5 showed that in the sensory evaluation, there was a decrease in the appearance and overall acceptability of the cookies with the gradual increase in the watermelon rind flour. Specimen B with 2.5% supplementation of watermelon rind flour is the most acceptable.

IV. CONCLUSIONS

The major findings from this study was that the watermelon rind flour which is usually a waste after the consumption of the pulp had a high functional properties and thus can be used for food formulations. There was a significant increase in crude protein, ash, crude fibre and a decrease in carbohydrate values. The cookies blended with the watermelon rind flour had significant increase in mineral and vitamin contents thus making the cookies a good vehicle for micronutrient for consumers of the cookies

From the study, the most acceptable blend was 97.5: 2.5% level of incorporation of the watermelon rind flour.

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Table 1. Functional Properties of Watermelon Rind Flour

Parameters	Watermelon Rind Flour
Foaming Capacity (%)	28.48±0.05
Solubility (%)	52.78±0.02
Water Absorption Capacity (g/cm^3)	83.66±0.06
Swelling Index	8.43±0.07
Reconstitution Index	81.65±0.01

Values are Triplicate Determination ± Standard Deviation

Table 2. Effect of Watermelon Rind Flour Supplementation on the Chemical Properties of Wheat Cookies (%).

	Sample codes				
Parameter	A	B	C	D	LSD
Moisture	9.57±0.01^d	10.71±0.01^c	11.35±0.00^b	11.64±0.01^a	0.03
Crude protein	9.79±0.02^d	13.57±0.01^c	14.22±0.01^b	15.35±0.01^a	0.04
Crude fiber	0.87±0.01^d	1.13±0.01^c	1.44±0.07^b	1.66±0.03^a	0.05
Fat	8.38±0	9.59±0.02^c	12.47±0.01^b	13.12±0.01^a	0.04
Ash	1.43±0.01^d	2.18±0.01^c	2.84±0.03^b	3.17±0.01^a	0.05
Carbohydrate	69.96±0.04^a	62.79±0.01^b	57.68±0.00^c	55.07±0.06^d	0.10
Dry matter	90.43±0.01^a	89.29±0.01^b	88.65±0.01^c	88.37±0.01^d	0.03

Values are means of ± deviation of triplicate determination.
Values in the same row with different superscripts are significantly different ($p<0.05$)

Key:
A = 100% wheat flour (control)
B = 97.5% wheat : 2.5% watermelon rind flour
C= 95% wheat : 5% watermelon rind flour
D = 95.5% wheat : 7.5% watermelon rind flour
LSD = Least Significant Difference

Table 3. Effect of Watermelon Rind Flour Supplementation on the Mineral Content of Wheat Cookies (mg/g)

Parameter	Sample codes				LSD
	A	B	C	D	
Iron	31.56±0.01^{d}	35.84±0.01^{c}	41.06±0.02^{b}	48.22±0.01^{a}	0.03
Magnesium	17.36±0.01^{d}	20.81±0.01^{c}	27.52±0.01^{b}	61.73±0.01^{a}	0.04
Potassium	104.20±0.01^{d}	187.30±0.01^{c}	241.50±0.01^{b}	344.60±0.01^{a}	0.03
Phosphorus	175.40±0.02^{d}	214.50±0.04^{c}	271.30±0.01^{b}	341.50±0.01^{a}	0.04
Calcium	42.63±0.01^{d}	79.39±0.01^{c}	137.30±0.01^{b}	172.70±0.01^{a}	0.02

Values are means of ± deviation of triplicate determination
Values in the same row with different superscripts are significantly different ($p<0.05$)

Key:
A = 100% wheat flour (control)
B = 97.5% wheat : 2.5% watermelon rind flour.
C = 95% wheat : 5% watermelon rind flour
D = 95.5% wheat : 7.5% watermelon rind flour
LSD = Least Significant Difference

Table 4. Effect of Watermelon Rind Flour Supplementation on the Vitamin Content of Wheat Cookies.

Parameter	Sample codes				LSD
	A	B	C	D	
Vitamin A (iu/g)	1.23±0.02^{d}	2.77±0.01^{c}	4.77±0.01^{b}	8.08±0.01^{a}	0.01
Vitamin B_1 (mg/g)	0.12±0,00^{c}	0.14±0.01^{cb}	0.16±0.01^{b}	0.22±0.01^{a}	0.02
Vitamin B_2 (mg/g)	0.17±0.01^{c}	0.18±0.01^{c}	0.19±0.01^{b}	0.21±0.01^{a}	0.02
Vitamin C (mg/g)	2.72±0.01^{d}	3.87±0.01^{c}	5.28±0.01^{b}	7.23±0.01^{a}	0.03

Values are means of ± deviation of triplicate determination
Values in the same row with different superscripts are significantly different ($p<0.05$)

Key:
A = 100% wheat flour (control)
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C = 95% wheat : 5% watermelon rind flour
D = 95.5% wheat : 7.5% watermelon rind flour
LSD = Least Significant Difference

Table 5. Effect of Watermelon Rind Flour Supplementation on the Sensory Attributes of Wheat Cookies.

Parameter	Sample codes				LSD
	A	B	C	D	
Appearance	7.87^{a}	7.53^{a}	6.60^{b}	6.47^{b}	0.834
Crispness	6.60^{a}	6.60^{a}	5.87^{a}	6.27^{a}	0.916
Texture	7.00^{a}	7.27^{a}	6.80^{a}	6.80^{a}	0.996
After taste	7.93^{a}	7.80^{a}	7.27^{a}	6.93^{a}	0.923
Flavors	7.73^{ab}	7.80^{a}	6.80^{c}	7.00^{b}	0.743
Overall Acceptability	8.00^{a}	7.87^{a}	7.13^{ab}	6.67^{b}	1.001

Values are means of ± deviation of triplicate determination.

Values in the same row with different superscripts are significantly different ($p<0.05$)
Key:
A = 100% wheat flour (control)
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