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Drying of Watermelon Rind and Development of Cakes from Rind Powder

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Abstract: **This study reports on the possibility of value addition to watermelon rinds by processing of cakes using watermelon rind flour with wheat flour. Good quality fresh watermelon rinds were collected from local market. Chemical analysis of watermelon rind flour revealed that it contains 10.72% moisture, 11.21% protein, 73.18% carbohydrates, 12.61% ash and 2.38% fat. Three samples of watermelon rind flour cakes containing 10.0%, 20.0% and 30.0% watermelon rind flour in combination with wheat flour were processed. The properties of the cakes were evaluated in terms of volume, moisture content, crumb and crust characteristics etc. The cake supplemented with low level of watermelon rind flour had significantly improved the cake volume than those with high level of watermelon rind flour. Moisture content of cakes affected with the substitution levels of wheat flour with watermelon rind flour. Crumb and crust quality, symmetry and bloom of the cake containing 10.0% watermelon rind flour was significantly better than those of cakes containing 20.0% and 30.0% flour. The overall acceptability of the cake sample incorporating 10.0% watermelon rinds flour was more acceptable and significantly better from other cake samples prepared with watermelon rinds flour.**

I. INTRODUCTION

Watermelon (*Citrullus lanatus* var. *lanatus*, family Cucurbitaceae) is a vine-like (scrambler and trailer) flowering plant originally from southern Africa to Bangladesh. Watermelon contains about 6% sugar and 91% water by weight. As with many other fruits, it is a source of vitamin C. Watermelons contain a significant amount of amino acid citrulline. The watermelon skin is smooth, with dark green rind or sometimes pale green stripes that turn yellowish green when ripe. It is a very rich source of vitamins and also serves as a good source of phytochemicals (Perkins-Veazie and Collins, 2004). Watermelon rinds are edible and contain many hidden nutrients, but most people avoid eating them due to their unappealing flavor. They are sometimes used as a vegetable. In China, they are stir-fried, stewed or more often pickled. Pickled watermelon rind is commonly consumed in the Southern US (Rattray and Diana, 2012).

During the growing season water melon grows in plenty in Bangladesh. People eat watermelon pink portion and throw away the rind to the dustbin. But the watermelon rind is nutritive (Koocheki et al., 2007) Watermelon biomass can be categorized as three main components which are the flesh, seed, and rind. The flesh constitutes approximately 68%of the total weight, the rind approximately 30%, and the seeds approximately 2% (Kumar, 1985). It has protein, fat, carbohydrates, crude fiber and ash contends decently (Koocheki et al., 2007). As Watermelon rind powder possess significant amount of moisture, ash, fat, protein and carbohydrates 10.61%, 13.09%, 2.44%, 11.17% and 56.00% (Al-Sayed and Ahmed, 2013) and rind contribute 30% of the total weight, it is essential to find out the way of using watermelon rinds (so-called ‘wastes’) for the formulation of different food products. Water melon rind can be converted into value added product by drying and can be used for the preparation of bakery products with the supplementation of rind powder very easily.

The bakery industries are one of the largest organized food industries all over the world and particularly cakes are one of the most popular products (Sindhuja et al., 2005). Bakery products are generally used as a source for incorporation of different nutritionally rich ingredients for their diversification (Sudha et at., 2007). Cake is one of the relished and palatable baked products prepared from flour, sugar, shortening, baking powder, egg, essence as principal ingredients.

The variation in these constituents causes the changes in textural properties of cakes. Cakes are highly popular among the large segment of population in urban and rural places and its demand and consumption are increasing by day by day. For this reason, the overall aim of this research is to process and preserve watermelon rind by drying and development of cake with the watermelon rind powder. The specific objectives of the research are:

i. To observe the dehydration characteristics of watermelon rind.

ii. To observe the possibility of making cake with the incorporation of watermelon rind powder.

II. MATERIALS AND METHODS

The research has been conducted in the laboratory of the Department of Food Technology and Rural Industries, Bangladesh Agricultural University, Mymensingh. Locally available fresh watermelon free from physical disorder was procured from the market and the rinds were collected after the flesh has been consumed. Other necessary materials and chemicals were used from the laboratory stock.

Chemical analysis:

The fresh rinds and dried rind powder were analyzed for their moisture, total solids, ash, protein and fat using standard method (AOAC, 2005; Ranganna, 2004) while carbohydrate content was calculated by difference. All the determinations were done in triplicate and the results were expressed as average value.

Drying of watermelon rinds and preparation of powder:

Watermelon rinds were dried using mechanical dryer. Cabinet dryer (Model OV-165, Gallen Kamp Company) was used for drying of watermelon rinds. The dryer consists of a chamber in which trays of product were placed. Air was blown by a fan past a heater and then across the trays of product being dried. The velocity of air was recorded (0.6m/sec) by an anemometer. For determining the effect of temperature and loading density on the rate of drying, rinds were sliced by stainless steel knives and slices were taken for determination of initial moisture content. Fresh watermelon rinds of 8 mm thickness were placed in trays and drying commenced in the drier at a constant air velocity (0.6m/sec) and at a specific air dry bulb temperature (°C). Weight loss was used as a measure of the extent of drying. Again, to determine the effect of temperature on the rate of drying the rinds were dried at different temperature such as 55^0C, 60^0C and 65^0C. The dried rinds were then converted into powder by grinding in a grinder.

Preparation of cakes incorporation with watermelon rind flour:

Cakes were prepared as per the standard method but replacing only wheat flour with different levels of watermelon rind powder in the basic formulation of cake. The replacement of wheat flour by watermelon rind powder was 10%, 20% and 30%. Oil, sugar, egg, baking powder and NaCl were taken as 84%, 84%, and 84%, 3.5% and 2% of flour, respectively. The wheat flour, watermelon rind powder and other ingredients for each cake were weighed accurately and the sugar and oil were mixed in a mixing machine for 20 minutes to produce a cream. In later stages, half of the egg and other ingredients and finally the flour were mixed using a mixer at low speed (145 rpm) for 10 minutes to ensure even distribution of the components. The bowl was scrapped and batter was mixed for an additional two minutes at medium speed (250 rpm). The mixed cream then put into small rectangular boxes. All cakes were baked in an oven for 40 minutes at 160°C.

Objective evaluation of cake:

The weight, volume (was measured by rapeseed displacement) and specific volumes of cake samples were measured after 40 minutes of baking (Randez-Gil et al., 1995). The ratio of volume to weight was also calculated to obtain the specific volume.

Sensory evaluation of cake:

The symmetry and the characteristics of crust and crumb of the cakes supplemented with watermelon rind flour were evaluated and recorded. Cakes were evaluated organoleptically for color, flavor, texture and overall acceptability. One slice of cake from each formulation was presented to 10 panelists as randomly coded samples. The taste panelists were asked to rate the sample for color, flavor, texture and overall acceptability on a 1 to 9 point scale. The results were analyzed using the software package STATISTICA 8.0 (StatSoft, USA).

III. RESULTS AND DISCUSSION

Chemical composition of fresh watermelon rind and its powder:

The Chemical Composition of the fresh rind and its powder was determined and the results are given in Table 1.

Table 1 Chemical composition of fresh watermelon rind and its powder

Chemical composition	Watermelon rind	Watermelon rind powder
Moisture (%)	94.62	10.72
TS (%)	5.39	89.28
Protein (%)	0.63	11.21
Ash (%)	0.46	12.61
Fat (%)	0.08	2.38
Carbohydrate (%)	4.2	73.18

The moisture content of powder was 10.72% while the moisture content of watermelon rind was 94.62%. The moisture content of rind found in this study indicating that the moisture content is higher than Bawa and Bains (1977), which was 93.8%. The moisture content of rind powder was found higher than Al-Sayed and Ahmed, (2013) who reported 10.61%. The ash contents in watermelon rind and rind powder were 0.46 % and 12.61%, respectively. The rind ash content was lower than found by Bawa and Bains (1977). The rind powder ash was lower than Al-Sayed and Ahmed, (2013), which was 13.09%.

The protein contents in watermelon rind and rind powder were o.63% and 11.21%, respectively. The observed rinds protein was similar to found by Bawa and Bains (1977). The rind powder protein was slightly higher than Al-Sayed and Ahmed, (2013), which was 73.30%. The total carbohydrate contents in watermelon rind and rind powder were 4.2% and 73.18% respectively. The observed rind total carbohydrate was lower than found by Olaofe (1994). The rind powder total carbohydrate was similar to Al-Sayed and Ahmed, (2013), which was 73.30%.

Effect of temperature on drying of watermelon rind:

To observe the effect of temperature on drying, watermelon rinds were dried in the same dryer at different dry bulb temperature (55^0 C, 60^0 C and 65^0 C) using samples of constant thickness (8 mm). The experimental data were analyzed by using Fick's 2^{nd} law of diffusion. Moisture ratio (MR) versus drying time (hr) was plotted on a semi-log scale as shown in Figure 1 and the following regression lines (1 to 3) were obtained.

$MR = 1.021e^{-0.16t}$ (for 50^0 C)…………………………………………………..(1)

$MR = 1.054e^{-0.29t}$ (for 55^0 C)…………………………………………………...(2)

$MR = 1.0213e^{-0.36t}$ (for 60^0 C)…………………………………………………..(3)

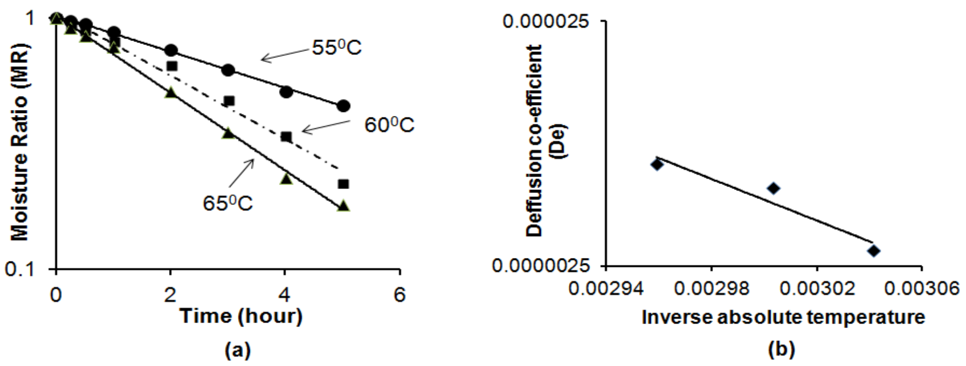

Figure 1. Effect of temperature on (a) drying rate and (b) diffusion coefficient of watermelon rind

From the Figure 1(a) and also from the above equations, it is seen that the moisture ratio (MR) decreases with time and time to dry to a specific moisture ratio decreases with increasing time. From the Figure 1(a) it is obvious that when the temperature of dryer increased, drying rate constants also increased (equations 1 to 3). This indicates higher temperature would give faster drying rate. At very high temperature and low humidity drying rate may initially increase, but, resulted case hardening would reduce drying rate and deteriorate the product quality due to cooking instead of drying (Islam, 1980).

To develop the Arrhenius type relationship, from the drying rate constants that are determined by regression equations, the diffusion co-efficient were calculated. Diffusion co-efficient (D_e) versus inverse absolute temperatures (T_{abs}^{-1}) were plotted on a semi-log scale (Figure 1(b)) and regression line (4) were drawn as follows:

$D_e = 6E+07e^{-9768T_{abs}^{-1}}$ ………………………………………………………………… (4)

From which, E_a =19.41 kcal/g-mol is obtained.

From the slope of the resultant straight line, activation energy (E_a) for diffusion of water was calculated and the value was obtained 19.95 kcal/ g mole. These calculated activation energy was lower than that obtained by Afzal Babu et al. (1997) for onion (26.83 kcal/g-mole) and higher than the result reported by Poppy et al. (2013) for parboiled paddy (15.719 kcal/g-mole).

The effect of watermelon rind powder on cake properties:

Cakes prepared by incorporating 10.0%, 20.0% and 30.0% of watermelon rind powder were evaluated for physical properties, external and internal characteristics and the results are presented in Table 2 .

Physical properties of cake:

The **loaf Volume** is the most important individual quality parameter used for the evaluation of cake. It is a quantitative measurement and correlates well with dough handling properties, crumb, texture, freshness and technological versatility (Pomeranz, 1980).

Table 2. Effect of watermelon rind powder on volume, weight, specific volume and moisture content of plain cake

Cake sample	Volume (cc)	Weight (g)	Specific volume (cc/g)	Moisture content (%)
S_1	100	50.00	2	18.50
S_2	110	50.18	2.2	18.85
S_3	95	51.10	1.9	20.70
S_4	96.25	52.02	1.925	22.45

S_1 = Plain or control cake (without watermelon rind powder)

S_2 = 10% watermelon rind powder containing cake

S_3 = 20% watermelon rind powder containing cake

S_4 = 30% watermelon rind powder containing cake

It is seen from Table 2 that 10.0% rind powder in cake formulations gave higher cake volume than those of 20.0% and 30.0% of rind powder incorporation. This is due to presence of water absorbing matrix (oil, cellulose, hemicelluloses, lignin and other dietary fiber components) in rind powder which increased water holding capacity leading to enhancement of cake volume. A significant impact of fibre is to reduce dough gas retention and of fat is to increase dough gas retention (Williams and Pullen, 1998).

The **weights of cake** prepared from watermelon flour samples were higher than those of control cake. Cakes at 10.0%, 20.0% and 30.0% replacement level gave a higher weight due to increased water holding capacity of the rind powder. This variation in cake weight may result from the increased water absorption by the watermelon rind powder. The physical nature of the product might have affected the cake weight gain. The fibre holds the water which contributes to the higher weight of the composite flour cake (Cauvain, 1996).

The cake specific volume attained by watermelon flour at 10.0%, 20.0 %and 30.0% levels were higher than that of control cake. The cake sample S_2 (containing 10% rind powder) gave highest specific volume. It was also observed that the specific volume of cake samples (from S_1 to S_3) was increased with increasing the levels of rind powder in the formulation of cakes and there after decreased. The weight increased while volume decreased of the composite flour cakes (Williams and Pullen, 1998).

The moisture content of cakes prepared with 10.0%, 20.0% and 30.0% substitution level of rind powder had higher than that of control and the moisture content increased with increasing substitution level (Table 2). The effect of increased water holding capacity by rind powder dough might be due to the presence of high concentration of fiber components (cellulose, hemi cellulose or pentosans, lignins and other dietary fiber components) the high concentration of oil might have significance for water holding capacity in the rind powder dough. The fibre may hold high may contribute to the higher moisture content of the composite flour cake (Cauvain and Young, 2006).

Effects of flour on external and internal characteristics:

The cakes prepared by incorporating 10.0%, 20.0% and 30.0% of watermelon rind powder in the formulation of plain cakes were evaluated by a panel of 10 taster for its external and internal characteristics.

External characteristics of cake:

Symmetry and bloom characteristics of cake containing rind powder are presented in Table 3. The term "Symmetry" is self-explanatory. The most common faults for while points are deducted are: low edges, high edges, low centres, high centres and unevenness. From Table 3, it is seen that the control cakes and cakes with 10.0% watermelon rind powder had better symmetry compared to other cakes. The term bloom refers to luster or sheen. It describes the brilliance of the colour. The control and watermelon rind powder samples possess better bloom at different substitution level.

The crust colour of the cake Containing watermelon rind powder at 30.0% substitution level were deeper than those of control cake sample. The term Consistency of crust applies to the condition of the crust and varies with the types of cakes. As shown in Table 3, the tender crust has been obtained in control and 10.0% watermelon rind powder samples. The cake sample S_2 had medium tough crust compared to both the control and the sample S_3. The overall crust characteristics of 10.0% watermelon rind powder cake seemed to be better than the other samples (S_3 and S_4).

Internal (crumb) characteristics of cakes:

Colour evaluation was made with interior slices. As shown in Table 3, the crumb colour of the cakes watermelon rind powder was generally more brownish than the control. The increase in the levels of flour substitution changed the crumb colour of the watermelon rind powder cakes from yellowish to deep gray yellow.

From Table 3 it is seen that the differences in **crumb texture** were observed in plain cake and rind powdered cakes. 10% rind powder substitution cake gave better texture than the others.

Crumb grain of cakes indicates to the shape, size and character of the cell wall structure of crumb. The crumb grain of cake containing watermelon rind powder at 10.0%, 20.0% and 30.0% levels of substitution are presented In Table 3. Uniformity of size with thin walled cell is most desirable for crumb grain. Coarseness, thick walled cells, uneven cell size and large holes are indicative of poor grain. As shown in Table 3, the cakes containing watermelon rind powder samples at 30.0% substitution levels had coarser grain and the size and shape of those cakes were non-uniform while compared with cake containing 10.0% rind powder. The crumb grain of cake supplied with 10% rind powder was equally acceptable while compared with the control cake. This acceptability decreased for higher substitution levels.

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Table 3. Effect of water melon rind powder on symmetry, crust and crumb characteristics of plain cake

Cake type	Symmetry			bloom	Crust characteristics		Crumb characteristic					
								Texture		Grain		
	Evenness	Edges	center		colour	Consistency	Colour	Lumps and hardness	Surface	Close or airy	Shape and size
S_1	Even	Medium	Medium	Luster	Light brown	Tender	White yellow	Free	Smooth	Close	Uniform
S_2	Even	Medium	Medium	Shining	Brownish	Tender	yellowish	Free	Smooth	Close	Uniform
S_3	Even	Low	Low	Shining	Brown	Medium Tender	Slightly yellow	Slightly free	Light Smooth	Close	Uniform
S_4	Medium even	Too low	Low	Slightly dull	Deep brown	Medium tough	Deep yellow	Present	Rough	Less airy	Less uniform

S_1 = Plain or control cake (without watermelon rind powder)

S_2 = 10% watermelon rind powder containing cake

S_3 = 20% watermelon rind powder containing cake

S_4 = 30% watermelon rind powder containing cake

Sensory evaluation of the cakes containing different level of flour:

Cake samples S_1 (control), S_2 (containing 10.0% watermelon rind powder), s_3 (containing 20.0% watermelon rind powder) and S_4 (containing 30.0% watermelon rind powder) were subjected to sensory evaluation. The color, flavor, texture and overall acceptability of cake samples were evaluated by a panel of 10 tasters. The mean score for colors flavor, texture and overall acceptability preference are presented in Table 4.

Table 4. Mean sensory scores of control cake and the cakes containing rind powder

Cake sample	Sensory attributes			
	Color	Flavor	texture	Overall acceptability
S_1	7.40^b	7.30^b	7.70^a	7.50^b
S_2	8.30^a	8.10^a	7.80^a	8.20^a
S_3	7.00^b	7.40^b	6.50^b	6.80^c
S_4	6.00^c	7.30^b	5.60^c	6.20^d

Mean with same superscript within a column are not significantly different at 5% (P<0.05) level of significance.

S_1 = Plain or control cake (without watermelon rind powder)

S_2 = 10% watermelon rind powder containing cake

S_3 = 20% watermelon rind powder containing cake

S_4 = 30% watermelon rind powder containing cake

Analysis of variance has been carried out for color, flavor, texture and overall acceptability and result revealed that there are significance difference ($P<0.05$) exists among the samples. From the mean score of overall acceptability (Table 4) it is obvious that the samples S_2 is the best product securing score 8.20 (out of 9.0) and was ranked “liked very much”. It is thus may be concluded that watermelon rind powder can be supplemented (up to 10%) during preparation of cakes.

IV. CONCLUSION

During peak season a vast amount of watermelon is grown and sold but people eat only the pink portion and throw away the rind. But watermelon rind can be utilized for the preparation of cake. On the basis of physic-chemical properties and organoleptic evaluation of the processed cakes, it may be concluded that good quality watermelon rind powder cake (sample S_2) may be processed incorporating 10.0% watermelon rind powder into the formulation of plain cake for improved nutritional value and other aspects. Further studies may include detailed analysis of nutritional constituents and the shelf life of watermelon rind powder cakes.

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