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Processing of Watermelon Rind Dehydrated Candy

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Abstract *-Watermelon rind (Citrullus lanatus) dehydrated candy was prepared by using osmotic dehydration process that involves slow impregnation of syrup before drying at 50°C for 8, 14 and 20 hours. From the study, it can be seen that drying time significantly affected the moisture content of the watermelon rind dehydrated candy. The moisture content was significantly decreased with drying time. For colour evaluation, the L* value of watermelon rind dehydrated candy was slightly decreased with drying time while the a* value was slightly increased. Watermelon rind dehydrated candy that dried for 14 hours was the most preferred sample by the panelists as it received the highest score for texture, taste and overall acceptability attributes. So, it can be concluded that 14 hours of drying time is the most appropriate time to dry the candied watermelon rind.*

Keywords *—Watermelon rind, dehydrated candy, osmotic dehydration, drying*

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I. INTRODUCTION

Watermelon, *Citrullus lanatus* (Thunb.) is a tropical fruit which grows in almost all parts of Africa and South East Asia (Koocheki et al., 2007). The skin is smooth, with dark green rind or sometimes pale green stripes that turn yellowish green when ripe. It belongs to the family of cucumber (*Cucurbitacea*) with large, oval, round or oblong shape. Watermelon can be categorized into three main components i.e. the flesh, seed and rind. According to Kumar (1985), watermelon flesh represents approximately 68%, the rind approximately 30%, and the seeds approximately 2% of the total weight. Generally, the rind is discarded, applied to feeds or used as fertilizer. Utilization of the rind as an ingredient has been studied in products including pickle, candy, vadiyam and cheese. (Kumar, 1985; Simonne et al., 2002; Madhuri and Devi, 2003). According to Athmaselvi et al. (2011), watermelon rind has 95% of water content that making it susceptible to deterioration. Thus, it is important to reduce the moisture content in order to produce shelf stable products from watermelon rind. Air drying is a primeval method used to preserve food in which the solid to be dried is exposed to a continuously flowing hot air stream where moisture evaporates. According to Ratti (2001), although air drying offers dehydrated products that can have longer shelf life but the conventional dried products usually have low quality products compared to the original food stuffs. Therefore, pre-drying treatment such as osmotic dehydration is commonly used in order to minimize adverse changes occurring during drying. Osmotic dehydration is a method for partial dehydration of water-rich foods, such as fruits and vegetables, by immersing them in a concentrated solution of sugar. According to Rastogi and Raghavarao (1997), osmo-air drying is the combined approach of drying method in which osmotic dehydration and hot air drying is carried out simultaneously one after another. This drying process is an economical method of drying for fruits or vegetables containing more than 70% moisture content (Vishal et al., 2012). Candied products were predicted to have a longer shelf life with no microbial growth as they contain 65–70% of sugar with water activity values at 0.6–0.8 (Chen, 1989).

The objective of this research is to investigate the potential of watermelon by-products which is watermelon rind as dehydrated candy as well as to determine the suitable drying time for the watermelon rind dehydrated candy.

II. MATERIALS AND METHODS

Processing of watermelon rind dehydrated candy

The watermelons *(C. lanatus)* were purchased from a local supplier at Larkin market in Johor Bahru, Johor, Malaysia. Processing of the dehydrated watermelon rind candies was carried out using the method described by Zainun (2007) with some modifications. The watermelons were washed thoroughly and peeled. Only the rinds were used to develop the dehydrated candies while the flesh was discarded. The green layers of the rinds were removed and the remaining white flesh was cut into 3cm long and 1cm wide pieces. The rinds were blanched in boiling water for 1 min and then submerged in sugar syrup which slowly impregnated the rind tissues with sugar until the sugar concentration was high enough to prevent microbial spoilage. Initial sugar concentration of 40 °Brix was employed and the concentration was increased everyday by 5 °Brix until a final concentration of 55 °Brix was reached. Every time an increase in the sugar concentration was made, the syrup was drained, heated and sugar was added to bring the total soluble solids up to the desired level. The hot syrup was cooled to 60 °C before adding to the rinds. At the final syrup concentration, the rinds were kept for three days and drained. 650 g rind samples were then weighed and arranged on stainless steel perforated tray (57 cm x 57 cm) before drying in a cabinet dryer at 50°C for 8, 14 and 20 h respectively. The dehydrated candies then underwent a sweating process at room temperature for 24 h to stabilize the moisture content with the relative moisture of the environment (Hasimah, 1988). The candies were then coated with a mixture of icing sugar and corn flour (1:1) and packed in high density polyethylene bags until the evaluation process.

Determination of moisture content

The moisture content was determined using the air oven method (AOAC, 2000). The candy samples were dried in the oven at 105 °C for 24 h. The moisture content was calculated from the weight difference between the original and dried sample and expressed in percentage. For each sample, the observation was done in duplicates and the average was reported.

Determination of water activity

The water activity (a_w) of dehydrated watermelon rind candies was determined using Labswift-a_w hygrometer (Novasina, Switzerland). The dehydrated candies were cut into small pieces then loaded into a sample dish and put in the measurement chamber. The equilibrium of the air humidity over a sample (water-vapour pressure), which is proportional to the a_w value, was measured. For each sample, duplicates were obtained and the mean was reported.

Determination of colour intensity

The colour index of the dehydrated watermelon rind candies was measured using a chroma meter CR400 (Minolta Camera Co.) based on the L* a* b* colour system. L* denotes the lightness on a 0–100 scale from black to white while a* and b* denote the hues which represented two colour axes with a* denoting redness (+) or greenness (–) and b* denoting yellowness (+) or blueness (–). The equipment was calibrated using a white tile for the Y, x, y values of 92.5, 0.3134 and 0.3194 respectively. Each of the samples was measured in five replicates and the average was reported.

Sensory evaluation

The sensory evaluation was carried out at MARDI Johor Bahru, Johor, Malaysia with 14 experienced panellists according to Stone and Sidel (1985). Sensory attributes evaluated were according to the degree of liking (DOL) in the aspects of taste, colour, texture and overall acceptability. All samples was served and coded with three digits chosen at random. All panellists evaluated the samples using a 7-point category hedonic scale (1 = dislike very much; 4 = neither like nor dislike; 7 = like very much) as described by Meilgaard et al. (1999).

Statistical analysis

Experimental data were analysed using the analysis of variance (ANOVA) and the significant differences among means were determined by the Duncan Multiple Range Test (DMRT) at $p \leq 0.05$ using the Statistical Analysis System (SAS 9.0) computing program.

III. RESULTS AND DISCUSSION

Moisture content, water activity and colour of the dehydrated watermelon rind candies

There was no significant difference in the moisture content between fresh and blanched watermelon rinds as shown in Table 1. However, the increase in moisture content of blanched watermelon rind maybe due to the migration of water molecules from the boiling water used for blanching into the rind cells. Osmotic dehydration and drying significantly affected the samples. The subsequent processes following blanching such as osmotic dehydration, hot air drying and coating caused significant losses in moisture content of the dehydrated watermelon rind candies. Osmotic dehydration is an important pre-treatment used prior to air-drying for water removal in cellular solids (Rahman and Perera, 1996). The results showed that watermelon rind candies dried for longer time had significantly lower moisture contents. The result also showed that the moisture content during the air-drying process decrease with time which was in compliance with the nature of drying characteristics of various fruit, vegetables and cereals (Lyderson, 1983; Gabriela et al., 2004).

Table 1. Moisture content of fresh, blanched and dehydrated candy of watermelon rind

Sample	Moisture content (%)
Fresh	94.60 ± 0.07a
blanched	96.18 ± 0.04a
50°C, 8 hours	22.82 ± 0.02b
50°C, 14 hours	16.68 ± 0.11c
50°C, 20 hours	15.07 ± 0.23d

Mean with the same letter are not significantly different at $p < 0.05$

Drying is a critical process in developing a dehydrated candy product. The standard moisture content for dehydrated fruit candy should be in the range of 12- 21% as described by Zainun (1995), so that the candy to be stored for longer period of time without any deterioration caused by microorganisms. The drying time of 14 and 20 hours (Table 1) were adequate to produce good quality dehydrated watermelon rind candies compared to the 8 hours drying time at 50°C which contained higher moisture content (22.82 %). According to Fellows and Hampton (1992), higher moisture content resulted in products that are highly vulnerable to damage especially mould growth which can endanger the health of consumers due to food poisoning. The stability and safety of food is improved when water activity (a_w) of the product is decreased. The a_w of foods influences the metabolic activity, multiplication, resistance and survival of the microorganisms present (Leistner et al. 1981). The a_w for dehydrated candy samples dried for 8, 14 and 20 hours were 0.656, 0.671 and 0.658 respectively (Table 2). According to Jangam et al. (2008), food with water activity between 0.4 and 0.6 is considered as a dry product, while food with water activity between 0.65 and 0.75 is considered to be an intermediate moisture content product.

Table 2. Water activity (a_w) of dehydrated watermelon rind candies dried at 50°C

Sample	Drying time (hours)	Water activity (a_w)
A	8	0.656 ± 0.004ab
B	14	0.671 ± 0.009a
C	20	0.658 ± 0.005ab

Mean with the same letter are not significantly different at $p < 0.05$

Table 3 showed that there was no significant difference in colour measurement between samples dried for 8, 14 and 20 hours. The L* value for dehydrated watermelon rind candy samples were decrease slightly with increased drying time. It showed that longer drying time darkened the colour of the dehydrated candy compared to samples dried with shorter drying time. Conversely, b* values for dried samples were slightly increased with increasing drying temperature and time. The changes of colour may be due to non-enzymatic browning and formation of brown pigments (Lopez et al., 1997; Maskan, 2001; Diamante et al., 2010). According to McBean et al. (1971) and Kresic et al. (2004), non-enyzmic browning is liable for tissue darkening during drying due to both condensation of reducing sugars with amino acids and pigment conversion.

Table 3. Colour of dehydrated watermelon rind candies dried at 50°C

Sample	L* (lightness)	a* (chromaticity coordinate)	b* (chromaticity coordinate)
A	66.86 ± 6.63a	1.86 ± 0.46a	6.45 ± 0.54a
B	60.63 ± 8.86ab	0.59 ± 0.63a	7.83 ± 0.62a
C	53.56 ± 2.11b	1.21 ± 0.63a	8.10 ± 0.75a

Mean in the same column with the same letter are not significantly different at $p < 0.05$

Sensory evaluation of dehydrated watermelon rind candies

The mean scores given by the panellists for sensory attributes of dehydrated watermelon rind candies are presented in Table 4. The results showed that there were no significant differences for colour and texture attributes among all the samples. For taste attribute, there were significant differences in sample B (dried at 50°C for 14 hours) and sample C (dried at 50°C for 20 hours). However, the panellists preferred the taste of sample B by giving it the highest score compared to the others. For overall acceptability (OA), sample B received the highest score (5.6) compared to sample A (4.9) and sample C (4.9) Sample B also received the highest score for texture (5.6), taste (5.67) and overall acceptability (5.67). This indicated that sample B was the most acceptable dehydrated watermelon candies. This result was in accordance with Morita et al. (2005) whose finding showed good acceptability in crystallized melon products processed through the slow method of sugar impregnation and further drying at 50°C.

Table 4. Average scores for colour, texture, taste and overall acceptability of dehydrated watermelon rind candies dried at 50°C

Sample	Texture	Taste	OA
A	5.20 ± 1.15a	4.70 ± 1.22ab	4.90 ± 1.03ab
B	5.60 ± 0.83a	5.67 ± 0.98a	5.60 ± 1.05a
C	5.00 ± 1.13a	4.60 ± 1.12b	4.90 ± 1.06ab

Mean in the same column with the same letter are not significantly different at $p < 0.05$

IV. CONCLUSION

The physical characteristics and sensory acceptance of the dehydrated watermelon rind candies as influenced by the drying time have been conducted. The drying time significantly affected the moisture content of the dehydrated watermelon rind candies. These results showed that longer drying time will result in a significant decrease in the moisture content of the dehydrated candies. For colour, the L* value of the dehydrated candies slightly decreased with lower drying time while the a* value slightly increased with longer drying time. Sample B (dried at 50 ^{o}C for 14 hours) was the most acceptable dehydrated watermelon rind candies as the sample received the highest score for overall acceptability compared to the other samples. This showed that drying time affect the sensorial characteristics of the dehydrated watermelon rind candies. Therefore, it can be concluded that the drying temperature of 50 °C and 14 hours of drying time is the most appropriate time to dry the candied watermelon rind.

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