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INVESTIGATION THE DRYING CHARACTERISTICS OF SOME CITRUS PEELS TO UTILIZE IN PREPRATION OF CAKES

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ABSTRACT

This work was carried out to investigate the effect of drying temperature and residual moisture content on the quality of orange and mandarin peels. The changes in moisture content of citrus peels (CP), drying rate and specific energy consumption at various drying temperature was examined. The test samples were dried in a laboratory scale hot air dryer at a constant air velocity of 1m/s and air temperature in the range of 40–70^{o}C. The effect of drying temperature and residual moisture content on gross chemical composition, vitamin C, carotenoids and essential oils of citrus peels was studied. Cakes prepared from blendes containing different proportions (0, 10, 15 and 20%) of dried orange and mandarin peels were also evaluated for chemical composition and sensory attributes. The results indicated that, the drying temperature was very effective in removing moisture from citrus peels. The orange peels had the highest drying rate than that of mandarin peels. The time required for drying citrus peels was considerably decreased with the increment in the drying air temperature. The simple exponential equation satisfactorily described the drying behavior of citrus peels as indicated by the higher correlation coefficients. The drying time was decreased by 50% and specific energy consumption decreased by about 28.5% with increasing drying temperature from 40 to70^{o}C for drying citrus peels. Meanwhile, the optimal drying temperature was 60°C to reach 10±0.2%, w.b, moisture level, which saved energy consumption and reduced drying time as well as decreased the losses of vitamin C, carotenoids and essential oils of citrus peels. In addition, overdrying to reach final moisture level of 5.4±0.2% with drying air temperature of 70^{o}C increased the losses of vitamin C, carotenoids and essential oils of orange peels by 80.5, 13.5 and 62.5%, while for mandarin peels the losses increased by 77.9, 14.2 and 64.3, respectively compared to fresh samples. Incorporation 15% of dried orange and mandarin peels in cakes increased dietary fiber by 33.5 and 29.6%, ether extract by 2.9 and 4.6% and ash by 30.6 and 29.0%, respectively, while protein and total carbohydrates contents were slightly decreased. Highly acceptable cakes could be obtained by incorporating 15% of orange and mandarin peels dried to about 10% moisture content and they can be used as value-added food ingredients.

Keywords: Drying temperature, citrus peels, orange peels, mandarin peels, cake, energy consumption, chemical analysis, sensory attributes.

INTRODUCTION

Most food processing residues in developing nations are disposed without being recycled and their utilization is sometimes limited as a result of their poor understanding of their nutritional and economical values. A disposal of these materials usually represents a problem that is further aggravated by legal restrictions. Usually, these by-products are used in animal feeding. By-products derived from food processing are attractive source for their valuable bioactive components and color pigments (*Kong et al., 2010*) and their high amount of dietary fiber could permit the use of them in developing new natural ingredients for the food industry. Citrus fruits are mainly used for juice, oil and pectin production and are underutilized source for dietary fiber and antioxidants. The peel which represents almost one half of the fruit mass includes valuable compounds and an important source of bioactive compounds including antioxidants such as terpenoid, ascorbic acid (vitamin C), flavonoids, phenolic compounds that are important to human nutrition *(Jayaprakasha and Patil, 2007).* Dietary fiber of citrus peels (CP) is found in albedo which is a white, spongy and cellulosic tissue which is the principle components of the citrus peel and could be considered as a potential source of fiber. Epidemiological studies on dietary citrus flavonoids improved a reduction in risk of coronary heart disease (*Di Majo et al., 2005*) and is attracting more and more attention not only due to their antioxidant properties, anti-cancer, anti-viral, effects on capillary fragility, and an observed inhibition of human platelet aggregation but as anti-carcinogenic and anti-inflammatory agents because of their lipid anti-peroxidation effects (*Marin et al., 2007*). Carotenoids have received a tremendous amount of attention as potential anti-cancer and anti-ageing compounds. Also, they play an important role as food ingredients due to their pro-vitamin A and antioxidant activity. Citrus peels (CP) contains a high amount of carotenoids *(Mortensen, 2006)*, thus, new aspects concerning the use of these wastes as by-products for further exploitation on the production of food additives or supplements with high nutritional value have gained increasing interest because these are high-value products and their recovery may be economically attractive (*Djilas and Gordara, 2009).* Due to the high moisture content of such residuals after processing, there is a need to rapidly drying for reduce the moisture content down to safe level before further process. Hot air drying is the most widely used method to produce dried foods and agricultural products due to the low investment and operating cost (*Inchuen et al., 2010).* Air drying is the most frequently used dehydration operation in the food industry, where the temperature of this operation is limited by the heat sensitivity of the material and expected quality of the final product *(Lewicki, 2006).* Therefore, there is a need to optimize the conditions to produce high-quality dried products. The specific objectives of this research were to study the effects of drying air temperatures on the drying behavior of CP and specific energy consumption for drying. The effects of drying temperatures and residual moisture content on the quality of CP after drying and incorporation in cakes formula were also evaluated.

MATERIALS AND METHODS

Materials:

Fresh citrus peels of Egyptian mandarin and sour orange were collected during 2012 season from household residuals and stored in refrigerator at

5±1^{o}C until used. Wheat flour, eggs, sunflower oil, baking powder, sugar powder and vanillin were purchased from local market at Kafrelsheikh city. All chemicals used in alalytical methods were obtained from El-Gomhouria Company for chemicals and Drugs at Tanta city, Eygpt.

Methods:

1. Moisture content

The initial moisture content was determined using hot air oven method at 60°C for 72h *(Wiriyaumpaiwong and Wiset, 2008)*. The moisture content of the sample on a wet weight basis (%w.b.) was then calculated. The initial moisture content of mandarin peels was 79.6%, w.b., and for orange peels of 76.4%, w.b. The experimental moisture ratio was obtained by using the exponential model for the hot air drying process as described by *Doymaz (2006)*. To obtain the save storage moisture content of about 10% (w.b.), 773.3kg water per 1000kg fresh mass of mandarin peels and 737.8kg water per 1000kg fresh mass of orange peels had to be evaporated.

2. Drying conditions:

The collected peels were washed and minced to pieces and dried at the temperatures of 40, 50, 60 and 70^{o}C. To eliminate the other factors affecting drying behaviors, the samples were dried in a single layer in a standard precision oven model (*RKJ*) as shown in Fig. 1. Heat was generated by the heater integrated into the side walls of the oven and the hot air flowed by the fan through the samples. The exhaust air escaped through four ventilation holes (1cm diameter of each) at the top of the oven. Because of velocity of drying air has no significant impact on drying behavior of thin layers, *Doymaz (2006),* a constant air velocity of 1m/s is used. The oven drying temperature was controlled by a temperature-control dial and air velocity of the drying chamber was measured by using thermal anemometer, model (*Sato Sk-73D*). A1000g from orange and mandarin peels was placed on the trays (100g each) and put in a drying chamber after the drying temperature reach to the setting point. Then, liable sample was taken to weight and moisture losses of samples were recorded hourly for determination of drying curves. The drying was continued until the samples reached 10%, w.b., ideal for medicinal plants storage, since the recommended moisture content is 8-12%, w.b., for medicinal plants, *(Muller and Heindl, 2006).* Another samples remained in the dryer until it reached the final moisture content. The experiments were replicated three times. The dried samples was cooled in a desicator and then packed in low density polyethylene bags that were heat-sealed until used. The data between moisture content and drying rate at various drying temperatures versus drying time was plotted. The final or equilibrium moisture content of each condition was obtained by static method to calculate the moisture ratio (MR) as reported by *(Wiriyaumpaiwong and Wiset, 2008)*.

$$MR=(M-M_f)/(M_o-M_f) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where: MR = moisture ratio, dec.; M = CP moisture content at any time, w.b, %;

M_f= final moisture content, w.b., %; and M_o= initial moisture content, w.b., %.

The final (equilibrium) moisture content was determined according to *Tanko et al., (2005)* taking consideration that, the change in mass during drying the sample between two successive readings was within 0.01g or eliminated.

3. Specific energy consumption:

To evaluate specific energy consumption, the electric power consumption for each test was measured by using an electrical multi-meter, model *(GG 150E)* which connected at the source of power supply as reported by *Shoughy et al., (2011) as follows:*

$$P,\ kW = N_L .\ I_L .\ \eta\ .\ \cos\varphi\ /1000 \ldots\ldots\ldots\ldots (2)$$

Where: N_L= electric potential, volt, being equal to 220 volt I_L= electric current, ampere,

η = fan efficiency (95%), and Cos φ = power factor (0.85).

4. Analytical methods:

After drying at various drying temperatures, three replicated samples of 100g for dried mandarin and orange peels were grounded by using a laboratory hammer milling machine with screening sieve containing pores 1mm in size to obtain powder before analysis. The prepared CP powder was sealed in polyethylene bags to prevent moisture absorption and stored at 5±1°C for further studies.

a. Gross chemical composition:

Moisture content, crude protein (N x 6.25), ash content, crude fibers content and ether extract of fresh and dried CP samples at various drying air temperatures were determined according to the methods of A.O.A.C., (2005).Total carbohydrates were calculated by difference.

b. Vitamin C, carotenoids and essential oils extraction and determination:

Samples of fresh CP were taken for vitamin C, carotenoids and essential oils determination before the beginning of drying as a control sample to compare with the samples dried to 9.8 and 5.2% for orange peels and for mandarin peels, the moisture levels of 10.2 and 5.6%,w.b., at 60-70^{o}C drying air temperatures. The extraction of vitamin C (Ascorbic acid) from the CP was carried out as the method described by *Javed et al., (2010).* The essential oils of fresh and dried CP were extracted using water distillation method and calculated in g of oil/100g of samples according to the procedure described in A.O.A.C., (2005). Losses of essential oils were calculated based on the difference in essential oils content of fresh and dried samples. Carotenoids were extracted from fresh and dried CP by acetone according to the procedure of Megahed (1985). The carotenoids extracted from fresh and dried CP were determined using spectrophotometer at 450nm according to the method described by *Heinonen (1990)*. The following equation was used for calculation:

$$X=(E_y/E_{1Cm}) \qquad (3)$$

Where: X = g of carotene, y = ml of solution, E = Absorbance at 450 nm and

E_{1cm} = Specific extinction coefficient (2500).

5. Preparation of cakes from blendes with dried CP:

The cakes were prepared by using the method of ***Hanneman, (1984)***. Preparation of cake was carried out using wheat flour samples replaced separately with 0, 10, 15 and 20% of dried citrus by-products (orange and mandarin peels) powders. Wheat flour and other ingredients used in cake were obtained from local markets.

6. Sensory evaluation:

Organoleptic evaluation of prepared cake was done by 10panelists from students and staff members in Food Technology Dept., Fac. of Agric., Kafrelsheikh Univ. using ten point hedonic-scale ratings for color, taste, aroma, texture, and overall acceptability according to the procedure described by *Watts et al. (1989)*.

7. Statistical Analysis:

The regression analysis was employed in this experimental work to examine and assess the effect of drying air temperatures on the drying behavior of CP. The quality data of CP were analyzed by an analysis of variance ($p<0.05$) and the means separated by Duncan's multiple range tests (*Duncan, 1995)*.

RESULTS AND DISCUSSION

1. Moisture contents of CP:

The effect of drying temperatures on moisture content of orange and mandarin peels was studied and the results show that, the drying temperature was very effective in removing moisture from fresh CP as shown in Fig. 2. Rapid moisture removed from peels was obvious in all experiments particularly at higher drying temperature. While, the moisture removed from orange peels was faster than that of mandarin peels. This result may be due to the mandarin peels have higher oil glands in the skin than orange peels. The higher temperature accelerated the moisture migration in biomaterial as its structure sensible to heat. Decreasing moisture content of mandarin peels from 79.6 to about 10.2%, w.b. needed 12, 10, 8 and 6h at drying air temperature of 40, 50, 60 and 70^{o}C respectively. While for orange peels, decreasing moisture content from 76.4 to about 9.8%, w.b. needed 10, 7, 6 and 5h at the same drying air temperature maintained above as shown in Fig. 2. Although the initial moisture content of the samples was quite high (76.4%, w.b., for orange peels and 79.6%, w.b., for mandarin peels), a constant drying rate period was not observed under the experimental conditions employed, and the overall drying process totally took place in the falling rate period until reach the final moisture content. The during rate decreases continuously with decreasing moisture content and increasing drying time. Similar result was found by many researchers *(Doymaz, 2006, Doymaz et al., 2006* and *Vengaiah and Pandey, 2007).*

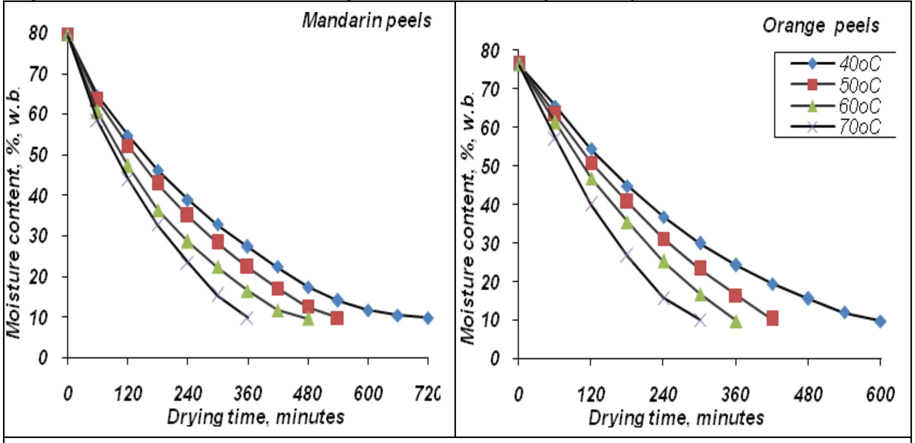

Fig. 2: Effect of drying temperatures on the moisture content of mandarin and orange peels.

2. Drying rates of CP at various drying air temperatures:

As expected, the drying rate of the Citrus peels was increased with increasing drying air temperatures as shown in Fig. 3. CP has a natural wax coat on their surfaces, which prevents most of the migration of moisture from the inside into the drying air. Faster evaporation rates were observed at higher temperatures due to the melting of the natural wax on the skin, thus, the drying time needed to reach specified moisture content was decreased. Also, the drying rate at the beginning of drying time was higher than that at the entre drying period. This was attributed to the fact that the product, which had high moisture content, dried faster than that of low moisture content at the same drying conditions. The average values of drying rates of mandarin peels were 5.5, 7.6, 9.6 and 12.7%/h with drying temperatures of 40, 50, 60 and 70^{o}C, respectively. While, the average values of drying rates of orange peels were 7.9, 9.9, 13.3 and 15.9%/h with the same drying air temperature maintained above. This may be because when the temperature is increased, some water molecules are activated to energy levels that allow them to break away from their sorption sites, thus decreasing the final or equilibrium moisture content (*Kouhila et al., 2002*). The reduction of drying time with increasing drying air temperature is desired in practice, because capacity of a dryer will be increased and allow for a considerable reduction of drying costs. While it has been documented that air temperatures above this range cause degradation of heat sensitive properties, air temperatures falling below this range will be unsuccessful in dehydrating herbs in time before spoilage occurs.

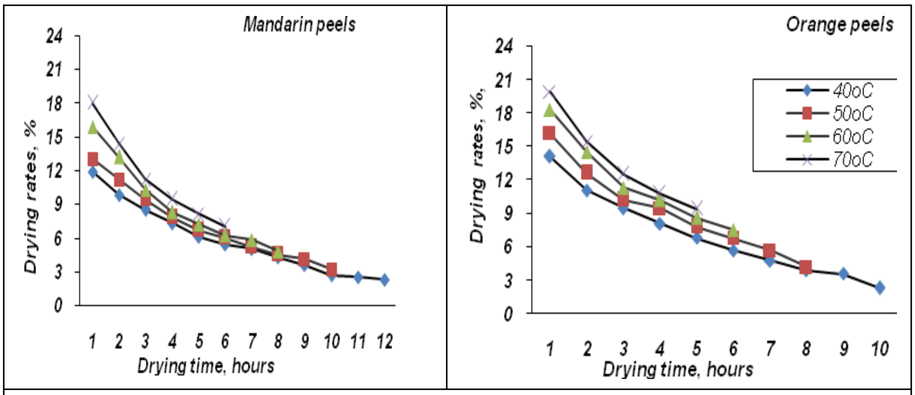

Fig. 3: Effect of drying temperatures on the drying rates of mandarin and orange peels.

3. The Moisture ratios (MR) and required time (t) for drying citrus peels:

Effect of drying air temperatures on the moisture ratios of mandarin and orange peels was evacuated. The results showed that, the simple exponential equation satisfactorily described the drying behavior of CP as indicated by the higher correlation coefficients as shown in Fig. 4. The moisture ratios of citrus peels were decreased with increasing drying air temperatures and extended drying time and the values of moisture ratios of mandarin peels was higher than that of the orange peels. The rate of evaporation tends to fall as the moisture content decreases and the drying curve decays exponentially towards the final moisture content. Similar results have been reported in the literature for various fruits and vegetables such as *Sacilik et al., (2005)* for organic tomato, *Doymaz (2006)* for tomato and *Sharma et al., (2005)* for onion slices. The time required for drying CP to the recommended moisture for storage and the final moisture content was considerably decreased with the increase in the drying air temperature as tabulated in Table 1. Similar results have been reported by *Tanko et al., (2005)*. Also, *Muller and Heindl (2006)* reported that, by increasing air temperature, drying time decreased exponentially. It is also obviously that the final moisture content decreases with increasing of the drying air temperature (*Kaya et al., 2007*) as well the time needed to reach this final moisture level was decreased.

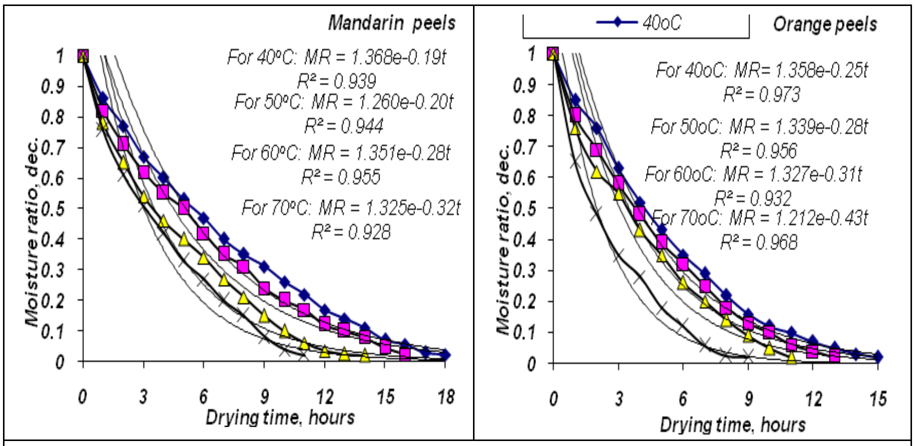

Fig.4: Effect of drying temperatures on the moisture ratio of mandarin and orange peels.

Table 1: The required time to drying citrus peels at various drying temperatures.

Drying time, h	**Mandarin peels**				**Orange peels**			
	Drying temperature, (°C)							
	40	**50**	**60**	**70**	**40**	**50**	**60**	**70**
To moisture of 10±0.2%, w.b.	12	10	8	6	10	7	6	5
To final moisture level%, w.b.	18	15	12	10	15	13	10	8

4. Specific energy consumption, kJ/kg:

Currently, energy demand of drying represents a significant cost factor, especially with the increased price of fossil fuels. This is largely due to the high moisture content of the agriculture materials to be dried. Fig. 5 shows the specific energy consumption for drying CP with various drying air temperatures to save storage moisture level of about 10±0.2%, w.b. The results showed that the power consumption increased with increasing drying air temperature. While, the specific energy consumption was decreased from 5808 to 4170kJ/kg (by 28.2% decreasing rate) with increasing drying temperature from 40^{o}C to 70^{o}C for mandarin peels. Also, for orange peels, the specific energy consumption was decreased from 4840 to 3450kJ/kg (by 28.7% decreasing rate). This result was confirmed with the result obtained by *Soysal and Oztekin (2001)*. This result may be due to the shorter drying time and higher drying rate was obtained with increasing drying temperature. Timesaving is an important management factor in drying and marketing of the dried products. It may be necessary to dry product as fast as possible to prevent product spoilage, minimize capital investment by rotating the drying equipment from one product to the other to meet market demand. The use of high temperature (60 and 70^{o}C) to reduce drying time with quality preservation may be economical if the electrical power is at low prices and feasible in the farms.

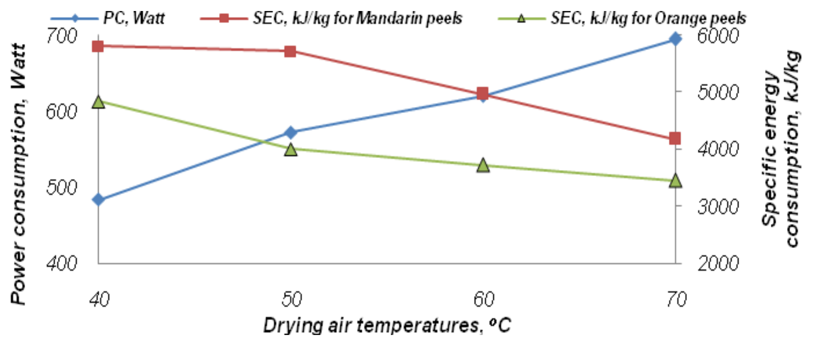

Fig. 5: The power consumption (PC) and specific energy consumption (SEC) of citrus peels at various drying air temperatures.

5. Gross chemical composition of dried CP:

The purpose of the second part of the experiment was to evaluate the effect of drying temperature on the quality of dried citrus peels and to select the range of residual moisture content after drying which provide the highest quality. Obtained results reveal that the chemical composition of CP after drying at 40, 50 and 60°C to the residual moisture content of about 10±0.2% w.b., were not significantly different. However, the drying time for CP at 60 and 70°C was the shortest. Considering the time and energy consumption, the temperature of 60 and 70°C were, therefore, selected to use in the further experiment. Chemical composition of CP powder dried at 60 and 70°C to reach the desired moisture of 10.2 and 9.8% and final moisture content of 5.6 and 5.2% for mandarin and orange peels, respectively, as compared to fresh peels are presented in Table 2. Dried mandarin and orange peels had very low content of ether extract as compared with fresh peels. The decrease of ether extract increased with the increasing of drying temperature. This result related to the fact that CP contains high level of volatile compounds such as essential oils which was evaporated during the drying process. Also, there is no significantly deference in protein content of dried CP at high moisture content of 9.8-10.2%, w.b., and fresh samples. While, the decreasing of protein content and ether extract of samples dried to final moisture level of 5.4±0.2%, w.b was higher than that of the samples dried to high moisture level of 10±0.2%, w.b., for mandarin and orange peels, respectively. The decrease in protein and ether extract contents of samples dried to low moisture level due to exposure the samples to heat for long time that leads to evaporate some volatile compounds such as nitrogen volatile compounds and essential oils. The ether extract content of dried CP markedly decreased, while protein and crude fiber contents slightly decreased with increasing drying air temperature from 60 to 70°C.

Table 2: Chemical composition of fresh and dried CP powder (g/100g DW).

Samples	Moisture ,%	Protein	Ash	Ether extract	Crude fiber	Total Carbohydrates
Orange peels						
Fresh	**76.4**	5.3±0.12a	3.5±1.32a	6.0±0.10a	8.2±0.15b	85.2±1.3c
Dried at 60^{o}C	**9.8**	5.2±0.02a	3.5±0.15a	3.6±0.12b	8.5±0.18a	87.7±1.2b
60^{o}C	**5.2**	5.0±0.15b	3.5±0.12a	2.5±0.14c	8.6±0.28a	89.0±1.4a
70^{o}C	**9.8**	4.9±0.18b	3.5±0.15a	3.1±0.22b	8.1±0.12b	88.5±1.5a
70^{o}C	**5.2**	4.7±0.13c	3.5±0.15a	2.0±0.10d	7.8±0.12c	89.8±1.5a
Mandarin						
peels	**79.6**	6.2±0.15a	3.5±0.20a	8.5±0.23a	7.9±0.35a	81.8±1.1c
Fresh	**10.2**	6.0±0.13b	3.4±0.12b	5.8±0.02b	7.8±0.25a	85.0±1.2b
Dried at 60^{o}C	**5.4**	5.8±0.18c	3.5±0.02a	3.0±0.02c	7.9±0.20a	87.7±1.6a
60^{o}C	**10.2**	5.9±0.12c	3.4±0.15b	5.1±0.22b	7.3±0.15b	85.6±1.3b
70^{o}C	**5.4**	5.7±0.13d	3.5±0.10a	2.2±0.18d	7.0±0.12c	88.6± 1.8a
70^{o}C						

The results are expressed as means ±SD (n=3). In each column different letters mean significant differences (*p*<0.05).

6. Losses of vitamin C, carotenoids and essential oils:

Increased intake of vitamin C, an important antioxidant found in fruits and vegetables, is strongly linked to reduced risk of many types of cancers, ***Block (1991)***. Also, **Javed *et al., (2010)*** reported that the vitamin C level of sour orange peels was 55.5mg/100g and in the sweet orange peels it was 65.0mg/100g. Table 3 shows that fresh orange and mandarin peels contained high amounts of vitamin C, carotenoids and essential oils. The losses of vitamin C, carotenoids and essential oils of mandarin and orange peels were significantly increased with increasing drying air temperatures from 60 to 70^{o}C and reduced dried moisture content from about 9.8-10.2% to 5.4-5.2%, w.b, respectively. At the same drying temperature (60^{o}C), the loss of vitamin C, carotenoids and essential oils was increased by 22.7, 2.8 and 33.4% for orange peels and by 22.9, 3.1 and 34.2% for mandarin peels dried to 10.2% moisture content. While, when drying to lower moisture level, the losses were increased by 44.9, 8.4 and 47.8% for orange peels and increased by 47.7, 9.0 and 50.1% for dried mandarin peels as compared to fresh peels.

Also, increasing drying temperatures from 60 to 70^{o}C tends to increase the losses of vitamin C, carotenoids and essential oils from 22.7 to 43.7%, from 2.8 to 6.1% and from 33.4 to 41.0% for orange peels, while, for mandarin peels, the losses increased from 22.9 to 46.2%, from 3.1 to 4.9% and from 34.2 to 52.7%, when dried to 10±0.2%, moisture level. Moreover, the losses of vitamin C, carotenoids and essential oils increased by 80.5, 13.5 and 62.5% for orange peels dried to 5.2% moisture level, while, for mandarin peels dried to 5.6% moisture level, the losses of vitamin C, carotenoids and essential oils increased by 77.9, 14.2 and 64.3%, respectively, as compared to fresh CP, with increasing drying temperature from 60 to 70^{o}C,. The increase of nutritive value at lower temperature than that at higher temperature may be attributed to the increased availability of the compounds when exposed to moderate temperature (60^{o}C) at higher moisture content. This result was agreed with the results obtained by *Garau et al., (2007).* They found that hot air drying of orange peels around 50-60°C apparently promoted the minor disruption of cell wall polymers. The intense heat generated from the drying process creates a high vapor pressure and temperature inside plant tissue, resulting in the disruption of plant cell wall polymers.

Moreover, *Jeong et al., (2004)* indicated that the antioxidant activity of CP extracts was significantly affected by heating temperature and duration of treatment on CP and that the heating process can be used as a tool for increasing the antioxidant activity of CP. They also found that appreciable decomposition of carotenoids was observed at high temperature between 70-90°C but at 105°C natural carotenoids were completely decomposed. *Abdel-Hady (2013)* found that the degradation of carrot pomace carotenoids heated at 60°C for 30min was 1.4%, while it reached to 3.9% at 70°C. She also found that the duration of exposure to heat had a great effect on carotenoids. While, *Müller (2004)* has clearly documented that the influence of high temperature on essential oils losses is high in the final phase, especially if material is over dried.

Table 3: Losses of vitamin C, carotenoids and essential oil of dried CP.

Samples	Moisture, %, w.b.	Vitamin C (mg/100g)	Carotenoids (mg/100g)	Essential oils, %
Orange peels:				
Fresh	**76.4**	55.4±0.15a	21.5±0.08a	3.68±0.01a
Dried at 60°C	**9.8**	42.8±0.22b	20.9±0.02a	2.45±0.02b
60°C	**5.2**	30.5±0.12c	19.7±0.05b	1.92±0.03c
70°C	**9.8**	31.2±0.02c	20.2±0.03a	2.17±0.02b
70°C	**5.2**	10.8±0.25d	18.6±0.16c	1.38±0.02d
Mandarin peels:				
Fresh	**79.6**	62.5±0.10a	32.4±0.03a	4.71±0.02a
Dried at 60°C	**10.2**	48.2±0.03b	31.4±0.02a	3.10±0.02b
60°C	**5.6**	32.7±0.02c	29.5±0.10b	2.35±0.03c
70°C	**10.2**	33.6±0.10c	30.8±0.15ab	2.23±0.01c
70°C	**5.6**	13.8±0.22d	27.8±0.25c	1.68±0.02d

The results are expressed as means ±SD (n=3). In each column different letters mean significant differences (*p*<0.05). The values are expressed as a dry weight basis.

7. Sensory evaluation of substituted cakes:

Cakes prepared from blendes containing different proportions (0, 10, 15 and 20%) orange and mandarin peels dried at 60°C to 10±0.2%, w.b., moisture content as recommended samples, were evaluated for sensory characteristics and the results are recorded in Table 4. The results show that dried orange and mandarin peels powder enhanced all sensory characteristics of cake comparing with the control. The enhancement increased with increasing the level of dried orange and mandarin peels powder up to 15%. *Mortensen, (2006)* also reported that, carotenoids, specifically beta-carotene, are believed to enhance the function of the immune system and are the precursors of many important chemicals responsible for the flavor of foods.

On the other hand, the sensory characteristics of the samples contained the highest level of orange and mandarin peels (20%) has lower scores compared to control and the samples contained the lower levels of orange and mandarin peels. This may be attributed to the CP have high content of pigments which changed during baking resulted undesirable color especially at higher substitution level. In addition, CP contains high content of essential oils which contain some bitter compounds and give (at higher level) a bitter taste in the final product.

Table 4: Sensory evaluation of cakes prepared using dried orange and mandarin peels powder.

Samples	Percent,%	Color	Taste	Aroma	Texture	Overall acceptability	LSD (P 0.05)
Orange peels	**0**	7.8	8.1	7.5	8.6	8.0	0.86
	10	8.2	8.3	8.6	8.6	8.2	0.75
	15	8.6	9.1	9.2	8.4	9.1	0.62
	20	6.4	7.5	7.8	7.5	7.3	0.91
Mandarin peels	**0**	7.8	8.1	7.5	8.8	8.1	0.86
	10	8.5	9.0	8.5	8.9	8.7	0.76
	15	9.4	9.4	9.2	8.7	9.2	0.65
	20	7.2	7.5	7.3	8.0	7.5	0.92

8. Chemical composition of substituted cakes:

Cakes prepared from blendes containing 0, 10, and 15% orange and mandarin peels dried at 60^{o}C to 10±0.2%, w.b., moisture content as recommended samples, were evaluated for chemical composition. Table 5 shows that, the ash, ether extract and crude fiber contents increased with increasing the percent of citrus powders in cakes, while protein and total carbohydrates decreased. Incorporation of 15% orange and mandarin peels in cakes formula significantly increased ash content by 30.6 and 29.0% and crude fiber content by 33.5 and 29.6%, respectively, as compared to the control sample. This may be due to higher contents of ash and crude fiber constituents in CP. This result was in harmony with the results obtained by *Bilgicli et al., (2007)* and *Nassar et al., (2008*).

Table 5: Chemical composition of CP substituted cakes g/100g dry weight basis.

Sample	Protein	Ash	Ether extract	Crude fiber	Total Carbohydrates
Orange peels:					
0%	9.64±0.15a	1.24±0.01c	18.31±0.18b	3.82±0.20c	70.81±2.12a
10%	9.44±0.12b	1.54±0.11b	18.63±0.16a	4.62±0.25b	70.39±1.8a
15%	9.32±0.15c	1.62±0.22a	18.84±0.22a	5.10±0.35a	70.22±1.5b
Mandarin peels:					
0%	9.64±0.15a	1.24±0.02c	18.31±0.18b	3.82±0.21c	70.81±1.5a
10%	9.48±0.22b	1.50±0.04b	18.83±0.20a	4.53±0.35b	70.19±1.4a
15%	9.40±0.01b	1.60±0.02a	19.15±0.30a	4.95±0.25a	69.85±1.2b

The results are expressed as means ±SD (n=3). In each column different letters mean significant differences (*p*<0.05).

CONCLUSIONS

1. The drying air temperature was effective in removing moisture exponentially from citrus peels.
2. The mandarin peels had higher moisture ratios and slower drying rate for all drying temperatures than that of orange peels due to its high oil content.
3. The drying time was decreased by 50% and specific energy consumption decreased by about 28.5% with increasing drying temperature from 40 to 70^{o}C for drying citrus peels.
4. The optimal drying temperature was 60°C and CP dried to moisture content of about 10%, w.b., to decrease drying time, save energy consumption and reduce the quality losses.
5. Overdrying to moisture levels of 5.4±0.2% with drying air temperature of 70^{o}C for orange peels increased the losses of vitamin C, carotenoids and essential oils by 80.5, 13.5 and 62.5%, while for mandarin peels, the losses increased by 77.9, 14.2 and 64.3%.
6. Incorporation of orange and mandarin peels dried at 60^{o}C to 10±0.2% moisture level in cakes formula increased ash, ether extract and crude fiber contents, while protein and total carbohydrates contents slightly decreased.
7. Highly acceptable cakes could be obtained by incorporating 15% orange and mandarin peel powders in the formulation.

It will further endorse CP as an important functional food which may prevent cancer in humans. This study will act as first line information to the researchers who are exploring the possibilities of converting waste to wealth, the concept which is currently evolving rapidly in the applied science branches from all possible dimensions.

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دراسة خصائص التجفيف لقشور الموالح للإستفادة منها في تحضير الكيك

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هدف هذا البحث هو دراسة خصائص التجفيف لقشور البرتقال واليوسفي بإستخدام الهواء الساخن للإستفادة منها في تدعيم بعض منتجات المخابز وتقليل المشاكل البيئية التي تنجم عن هذه المخلفات وزيادة الدخل القومي من الإنتاج الزراعي. لذلك تم دراسة تأثير درجات حرارة التجفيف بإستخدام الهواء الساخن علي القيمة الغذائية وجودة القشور وكذلك تأثيرها علي التغير فى خصائص التجفيف مثل معدل التجفيف والزمن اللازم للتجفيف ونسبة الرطوبة وثابت التجفيف. بالإضافة إلي حساب الطاقة اللازمة للتجفيف ودراسة تأثير إضافة نسب مختلفة من القشور المجففة علي الخواص الحسية والتركيب الكيماوي للكيك.

ومن أهم النتائج المتحصل عليها ما يلي:

إنخفض المحتوى الرطوبى من 79.6% لقشور اليوسفي ومن 76.4 % لقشور البرتقال إلى حوالى 10% (على أساس رطب) فى زمن قدرة 12، 10 ساعات عند درجة الحرارة 40 م^o علي الترتيب. وبزيادة درجة الحرارة من 40 إلي 70 درجة مئوية أنخفض الزمن اللازم للتجفيف بنسبة 50%. زاد معدل التجفيف بمقدار 2.3 ضعف تقريبا مع قشور اليوسفي ، 2.0 ضعف مع قشور البرتقال مع زيادة درجة حرارة من 40 الي 70 م^o. وعند نفس درجة الحرارة كان معدل التجفيف لقشور البرتقال أعلي من قشور اليوسفي. إنخفضت الطاقة النوعية اللازمة للتجفيف بمقدار 28.2% ، 28.7 % عند تجفيف قشور اليوسفي والبرتقال

علي الترتيب مع زيادة درجة الحرارة من 40 الي 70م°. تعتبر درجة الحرارة 60م° هي الدرجة المثلي لتجفيف قشور الموالح إلي محتوي رطوبي حوالي 10% حيث إنخفض الزمن والطاقة اللازمه للتجفيف مع المحافظة علي جودة المنتج النهائي.

تحتوي قشور الموالح المجففة علي نسبة عالية من الكربوهيدرات والألياف الكلية وفيتامين C والكاروتينات والزيوت العطرية مما يجعلها ذات قيمة مضافة تعمل علي رفع القيمة الغذائية وتحسين الخواص الحسية للمنتجات. التجفيف الزائد لقشور الموالح بحيث تصل نسبة الرطوبة إلي حوالي 5.4% أدي إلي فقد في فيتامين ج والكاروتينات والزيوت العطرية بمقدار 80.5 ، 13.5 ، 62.5% في قشور البرتقال وبمقدار 77.9 ، 14.2 ، 64.3% في قشور اليوسفي علي التوالي بالإضافة إلي زيادة الطاقة المستهلكة في التجفيف.

الإختبار الحسي للكيك المصنع من مسحوق الموالح المجفف حتي نسبة إستبدال بدقيق القمح 15 % لاقي قبولا بدرجة ممتازة مقارنة بالكيك المصنع بدون مسحوق قشور الموالح ولكن بزيادة نسبة الإستبدال إلي 20% أدي ذلك إلي إنخفاض درجات التقييم الحسي. خلط مسحوق الموالح المجففه (عند درجة حرارة 60م° ومحتوي رطوبي 10 %) حتي 15% نسبة إستبدال مع دقيق القمح لصناعة الكيك أدي الي زيادة نسبة الألياف الكلية و الرماد بدرجة ملحوظة مما يجعلها غذاء صحي.

لذا توصي الدراسة بتجفيف قشور الموالح علي درجة حرارة 60 درجة مئوية بدلا من 70 درجة مئوية ونسبة رطوبة 10% لتقليل الطاقة المستهلكة في التجفيف وتقليل الفقد في القيمة الغذائية. كذلك توصي الدراسة بالإستفادة من هذه القشور المجففة بإضافتها إلي بعض الأغذية مثل منتجات المخابز لتحسين خواصها الحسية ورفع قيمتها الغذائية.

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