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Effect of Drying Methods on Nutrient Content and Sensory Acceptability of Processed Products from *Benincasa hispida*

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Abstract *Benincasa hispida* is a seasonal fruit widely grown in Tanzania mostly in Dodoma region. Assessing effect of drying methods on nutrient content of *Benincasa hispida* varieties in Tanzania is valuable for preserving the fruit's availability throughout the year. Additionally, evaluating sensory acceptability of processed product will provide insights into consumer preferences. Three varieties such as *Maule*, *Mbwagale* and *Iyungumapele* were collected and subjected to direct sun and solar drying followed by laboratory analysis to determine the effect of drying methods on nutrient content. Also, prepared porridge and '*chinchin*' from sun and solar dried flour were subjected to sensory evaluation using 9-point hedonic scale as described by Lawless and Heymann (2010) [14], where by a trained panel of 70 people with age raging 15-45 years was used. The results showed that there was a significant difference ($p \leq 0.05$) between direct sun and solar drying methods on nutrient content. Drying methods in all varieties reduced the nutrient content with exception of potassium. Some nutrients varied significantly ($p \leq 0.05$) between varieties. Higher amount of nutrient content was observed in Maule variety compared to *Mbwagale* and *Iyungumapele* varieties. There was significant difference ($p \leq 0.05$) in all attributes except texture in *chinchin* while there was no significant difference ($p \leq 0.05$) in all attributes except colour in porridge. Farmers in Dodoma should be encouraged to dry *Benincasa hispida* particularly *Maule* variety and develop other value added product for diversification.

Keywords: *Benincasa hispida, Direct sun drying, Nutrient Content, Sensory Acceptability, Solar drying*

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1. Introduction

Benincasa hispida is a member of the family *Cucurbitaceae.* Primaly, this crop is grown and used as vegetable and later recognized for its nutritional and medicinal properties especially in Asian countries [1,2,3].

Benincasa hispida is a fruit but it is referred to as a vegetable because it is cooked and eaten as a vegetable. It is an excellent source of carbohydrates, vitamin B1 (thiamine) and vitamin B3 (niacin), vitamin C, calcium, zinc and potassium [4,5]. *Benincasa hispida* has got different names include ash pumkin, winter melon, ash gourd, white pumkin and wax gourd. [6]. The names depend on the place where it is cultivated, for example, in China it is called Chinese or winter melon while in Malawi it is called "*Mphonda*" and in Tanzania it is called "*Mamung'unya*" [7].

In Tanzania, most farmers in central zone, including Dodoma, cultivate and consume *Benincasa hispida* during the rainy seasons. Farmers in this region like to grow *Benincasa hispida* because it is the crop that matures early compared to other crops like maize, sorghum and millet. Therefore, *Benincasa hispida* help the farmers in food security in this region as they tend to utilize this crop during the rainy seasons before the next harvest.

Also, this region has only one rainy season per year that mostly commences from December to April each year and *Benincasa hispida* is mainly available during this season. Since the crop is seasonal, the study aims to test drying methods for *Benincasa hispida* fruit in Tanzania to extend its availability. In developing countries, drying of the fruit can play important role to increase fruit production, reduce post harvest losses, improve nutrition and develop new value added products [8].

Moreover, people in this region believe that, *Benincasa hispida* is a good food for children as it has been noted that there is increase in weight for the children who consume this food hence, this could provide alternative means of reducing child malnutrition [9]. Lack of processing technology has made the fruit underutilized, and the documented information on value addition and processing of *Benincasa hispida* is limited [7]. Therefore, the objective of this study was to evaluate the effect of drying methods on nutritional quality and to evaluate sensory acceptability of product developed from *Benincasa hispida* fruits

2. Materials and Methods

Sample collection and preparation

Fresh matured *Benincasa hispida* fruits of three varieties were collected from farmers in Dodoma Region. These three varieties were selected out of five varieties such as *Mbwagale, Iyungumapele, Maule, Mbuyane* and *Mhokolo* because they are the varieties mainly cultivated by the farmers in Dodoma. The fruit samples were packed in polyethylene sacks and transported to Sokoine University of Agriculture (SUA) for nutritional analysis.

Fresh matured *Benincasa hispida* fruit samples were washed peeled using a knife and sliced into thin uniform slices (3-5 mm). The slices were soaked in citric acid solution (5g citric acid: 1l cold water) for about 10 minutes before drying to avoid vitamin losses and discoloration due to action of oxygen. Some of the treated slices were spread on a mat and dried under sun in a day for three to six days, while the other lot of treated slices were arranged on trays (single layer) and then loaded into solar tunnel dryer and dried at temperature of 65 ± 5^{o}C for two to three days. The dried samples (direct sun and solar) were ground by using 8"LAB MILL machine to get flour. The obtained flour was stored in air-tight plastic containers prior to chemical analysis and product development.

Determination of crude protein

Crude protein content of fresh and dried *Benincasa hispida* fruits was determined by (AOAC, 1995) [10] procedure using micro Kjeldahl method number 920.87. About 0.25 g of each sample was weighed onto tarred filter papers. The samples were wrapped securely and dropped into 100 ml Kjeldahl digestion tube. Blanks were prepared by dropping pieces of filter papers without samples into separate 100 ml digestion tubes. To each tube, 2.0 g of Kjeldahl catalyst and 5.0 ml of concentrated sulphuric acid were added. Samples were digested until a clear, blue solution was obtained and digestion continued further as per instructions. The digest was cooled and then 20 ml of distilled water was added to dissolve the content. The dilute digest was distilled using micro-distillation apparatus (Kjeltec^{TM} 8200 Auto distillation Unit 2012). Twenty ml of 45 % sodium hydroxide was added to the digest to facilitate the release of ammonia. Ammonia was extracted by steam distillation and collected in a 50 ml flask containing 4 % boric acid. The distillate was titrated with 0.02N HCl standard solution using bromocresol green methyl red mixture as indicator. Nitrogen content was calculated from the following formula

$$\%\ N = (Titre\ blank)\ in\ ml\ \times\ 0.014077 \times\ 100 \qquad (3)$$

Weight of samples (g)

Percent protein was calculated from the percent nitrogen using the factor 6.25 as follows:

% CP= % N x Factor (6.25)

Determination of moisture content

Moisture content was determined based on oven drying method, where 5 grams of fresh and dried *Benincasa hispida* fruits was placed in an oven at 105 °C for 24 h [11]. Samples were cooled to room temperature in a desiccator before weighing again. Moisture content was expressed as percentage.

Moisture content (% MC) = $(W1 - W2) W1 \times 100$

Where, W1=Weight of fresh and dried *Benincasa hispida* fruits before oven drying,

W2=Weight of fresh and dried *Benincasa hispida* fruits after oven drying.

Determination of Niacin

Niacin content of fresh and dried samples was determined by colorimetric method as described by George [12]. About 20 g samples were defatted for six hours using n-Hexane in Soxhlet extraction apparatus. The excess n-Hexane was evaporated and 80 mg of defatted sample was measured into 15 ml test tubes, 3 ml of 4 mg/ml papain were added and incubated for 16 h at 65^{o}C with two hours shaking intervals. The incubated samples were centrifuged at 3600 g/minute for 10 minutes. Standard tryptophan with concentration of 0, 10, 20 and 30 µg/ml was prepared into 0.165 mM Sodium acetate. Then 1ml of the samples and the prepared standards were transferred into another clean 10 ml test tubes and 3 ml of 1:1 of mixed reagent (1.8 mM $FeCl_3.6H_2O$ and 30N H_2SO_4) added followed by 1 ml of freshly prepared glyoxylic acid added and incubated at 65^{o}C for 30 minutes . Absorbances were read at 560 nm and standard plot constructed according to Nurit et al. [13]. The obtained tryptophan was converted to Niacin by dividing with 60 mg since; 1mg of niacin is equivalent to 60 mg of tryptophan

$$\text{Niacin content}(\text{mg}/100\text{g}) = (\text{B560} - \text{A560})\,\text{xVx100}/(\text{Slope x Swt x60}) \qquad (10)$$

Where;

B560 =Blank absorbance as read at 560 nm

A560 =Sample absorbance as read at 560 nm

V =Total extraction volume (ml)

Slope =Obtained from the linear regression equation of the standard plot

Swt =Weight of the sample assayed

60 =Conversion factor of tryptophan to niacin content

Determination of mineral content

Mineral content (Ca, Fe, and K) of fresh and dried samples were determined by Atomic Absorption Spectrophotometer by method described in AOAC [10], using method no. 968.08. Mineral content were determined using Absorbencies at various wavelength as follows: - iron (Fe) 248.8 nm, potassium (K) 766.5 nm and calcium (Ca) 422.7 nm. The mineral content (mg/100g) was calculated as follows:

$$\text{Mineral content}\left(\frac{\text{mg}}{100\text{g}}\right) = \frac{\text{Reading value in ppm} \times \text{dilution factor} \times 100}{\text{Sample weight}(\text{g})} \qquad (12)$$

Where;

R = absorbance reading in ppm

100 = Volume of sample made

D.F = Dilution Factor

1000 = conversion factor to mg/100g
S = sample weight.

Product Development

The products that developed from the dried *Benincasa hispida* fruits were *chinchin* and porridge. *Chichin* (is a Nigerian word) is a type of snack. These products were developed from dried "*Maule"* variety (sun and solar dried) because of its higher amount of nutrient content compared to "*Mbwagale*" and "*Iyungumapele*" varieties.

Porridge

About two litres of water was poured in a cooking pan and placed on a cooker and 250 g of *Benincasa hispida* flour was added slowly while stirring vigorously using wooden spoon until the mixture became thick. The mixture was allowed to boil for about 30 minutes while stirring frequently. A teaspoonful of salt and two tablespoon of sugar were added to the mixture according while stirring vigorously. Then the porridge was poured in thermos flask ready for sensory evaluation.

Chinchin

About 250 g of *Benincasa hispida* flour was mixed with one teaspoon of salt and one teaspoon of baking powder in a mixing bowl followed by addition of 250 ml of water. Then the mixture was poured into the frying pan containing boiling oil by using the '*chinchin'* machine and deep fried until the colour changed into desired yellow colour. Afterwhich they were removed from the frying pan and cooled at room temperature for 30 minutes before package in plastics bags ready for sensory evaluation.

Sensory Evaluation

The prepared porridge and '*chinchin'* from sun and solar dried flour were subjected to sensory evaluation using 9-point hedonic scale as described by Lawless and Heymann [14]. Sensory evaluation was conducted using a trained panel of 70 people with age raging 15-45 years. The samples were coded with 3-digit random number using statistical tables. The porridge was poured in disposable cups while the '*chinchin*' was served in cake cups and presented to the panelists at around 9.00 up to 11.45 a.m in two different days. All the panelists were given distilled water for rinsing the mouth between the taste. The panelists were asked to rate the attributes such as color, aroma, taste, texture/mouth feel, and overall acceptability indicating their degree of liking or disliking by putting a number as provided in the hedonic scale according to their preference.

Statistical Data Analysis

R statistical package (R Development Core Team, Version 3.0.3 Vienna Austria) was used to analyse the data. The significance difference between treatment and interaction between the factors at $p \leq 0.05$ was determined by two way analysis of variances. Means were separated by Turkey test at $p \leq 0.05$ for laboratory analysis and t-test at $p \leq 0.05$ for sensory evaluation to compare products from two drying methods.

3. Results and Discussion

Effect of drying methods on each variety of *Benincasa hispida* fruit in nutrient content

The results from Table 1 show that, there was a significant difference ($p \leq 0.05$) in protein content among the three varieties. *"Maule"* variety had higher protein content 5.78 g/100g followed by "*Iyungmapele"* (5.54 g/100g) and "*Mbwagale"* (4.53 g/100g). Difference in protein content could be due to variety difference. Chang et al (2005) reported that, variety with physiological character of having large seed size have higher amount of protein content than the grapes having small seed size. These observations could be applied in this study as it was observed that *Maule* variety has physiological character of having large seed size.

Also, there was significance variation ($p \leq 0.05$) in niacin and mineral content between "*Mbwagale"*, and *"Maule"* varieties. "*Maule"* variety having significantly higher value of niacin of 0.29 mg/100g than *"Mbwagale"* with value of 0.13 mg/100g.

Table 1. Effect of drying methods on each variety of *Benincasa hispida* fruit in nutrient content (DMB)

Variety	Treatment	g/100g CP	Niacin	mg/100g Ca	Fe	K
Mbwagale	Fresh	5.53 ± 0.02^{g}	0.13 ± 0.00^{b}	5.65 ± 0.81^{b}	0.29 ± 0.00^{a}	97.21 ± 0.19^{b}
	Solar drying	0.17 ± 0.02^{a}	0.12 ± 00^{ab}	3.66 ± 0.06^{a}	0.28 ± 0.00^{a}	97.65 ± 2.11^{c}
	DirectSun drying	0.49 ± 0.00^{d}	0.12 ± 0.00^{ab}	3.64 ± 0.02^{a}	0.28 ± 0.00^{a}	97.36 ± 0.95^{b}
Iyungumapele	Fresh	5.44 ± 0.01^{f}	0.12 ± 0.00^{ab}	5.30 ± 0.00^{b}	0.40 ± 0.10^{b}	85.61 ± 13.70^{a}
	Solar drying	0.25 ± 0.02^{b}	0.11 ± 0.00^{a}	3.68 ± 0.02^{a}	0.28 ± 0.00^{a}	97.23 ± 1.49^{b}
	Direct Sun drying	0.59 ± 0.01^{e}	0.12 ± 0.00^{ab}	3.63 ± 0.06^{a}	0.28 ± 0.01^{a}	94.50 ± 0.99^{bc}
Maule	Fresh	5.78 ± 0.00^{g}	0.29 ± 0.01^{c}	4.55 ± 0.21^{ab}	0.31 ± 0.01^{ab}	$97\ 70\pm13.70^{c}$
	Solar drying	0.33 ± 0.12^{c}	0.13 ± 0.00^{b}	3.66 ± 0.01^{a}	0.28 ± 0.00^{a}	97.84 ± 2.72^{c}
	Direct Sun drying	0.60 ± 0.11^{e}	0.13 ± 0.00^{b}	3.64 ± 0.06^{a}	0.28 ± 0.00^{a}	97.94 ± 4.48^{b}

Data presented as arithmetic means ± SD (Standard Deviation)
Means in column with different superscript letters are significantly different at $p \leq 0.05$ based on Turkey Test
Key: CP = Crude Protein, Ca= Calcium, Fe = Iron, K = Potassium

The effect of drying methods on each variety of *Benincasa hispida* fruit in nutrient content is shown in Table 1. There was significant difference ($p \leq 0.05$) on nutrient content between fresh and dried samples in all varieties with exception of *Mbwagale* variety on iron content and *Iyungumapele* on niacin content. However, there was no significant difference ($p \leq 0.05$) between direct sun and solar dying methods in all varieties with exception of crude protein. Drying methods (direct sun and solar) in all varieties reduced the nutrient content with exception of potassium.

Higher changes in nutrient content were observed in protein compared to niacin, calcium, iron and potassium. This might be due to the fact that protein undergoes denaturation with increase in temperature and tend to interact with other food components, which may cause changes in solubility, texture and nutrient values [15]. The findings of this study agree with those reported by Mongi [16] that nutritional losses during drying occur to great extent due to application of heat hence, decreasing the concentration of some nutrients especially protein.

The results in Table 1 also showed that drying methods (direct sun and solar) had an effect on mineral content. Calcium and iron decreased with drying methods while potassium increased with the drying methods in all varieties. These observations are similar with those reported by Senem et al. [17] who observed significant variation in mineral content with drying methods in fruits.

4. Sensory Evaluation

chinchin

The mean hedonic scores for the *chinchin* products from sun and solar dried flour of the "*Maule*" variety are shown in Table 2. The panelists showed significant difference ($p<0.05$) in all attributes except texture between *chinchin* products from sun and solar dried flour. However, *chinchin* from direct sun dried flour had low scores compared to *chinchin* from solar dried flour in all attributes. These results suggest that dried *Benincasa hispida* flour could be utilized in baking industry to produce acceptable snacks which can be consumed by both adults and children

Porridge

Table 3 shows the mean hedonic scores for the porridge made from solar and direct sun dried flour of the *Maule* variety. There was no significant difference ($p \leq 0.05$) in all attributes except colour between porridge from direct sun and solar dried flour. Mean hedonic scores for colour of direct sun dried porridge was significantly lower ($p \leq 0.05$) (5.02) than that of solar dried porridge (6.81). The lower scores for colour of the porridge from direct sun dried flour might be attributed to the unattractive dark brown colour caused by prolonged drying of fruits for several days, as colour tend to deteriorate with oxidation and browning reaction in the presence of temperature and prolonged drying period. According to Coultate [18] colour is an important parameter in food processing as it may provide information on nutrients, the freshness of the food, and the type and intensity of processing. Colour is also important for the sensory perception of food by consumer [19]. These observations suggest that *Benincasa hispida* flour could be used to prepare acceptable porridge just as cereal flour. Although the scores for the sensory attributes were not significantly different ($p<0.05$) except for colour, the values of porridge from solar dried flour were higher, suggesting that solar drying method could be superior to direct sun drying and could be recommended for drying *Benincasa hispida* fruits for large scale processing.

5. Conclusion

The study found that both direct sun and solar drying methods significantly reduced the protein, niacin, iron, and calcium content of *Benincasa hispida* fruit. However, the resulting flour from *Benincasa hispida* could be used to prepare acceptable products similar to cereal flour. Therefore, farmers should be encouraged to dry the fruit to distribute its availability throughout the year and reduce post-harvest losses. The porridge made from solar-dried flour had higher nutritional values compared to that made from sun-dried flour, suggesting that solar drying may be a superior method for large-scale processing of *Benincasa hispida* fruits.

Table 2. Mean hedonic scores of *chinchin* product from solar and sun dried flour

Sample name	Aroma	Colour	Texture	Taste	General acceptability
Solar dried *chinchin*	$6.56{\pm}1.31^b$	$7.38{\pm}1.03^b$	$6.01{\pm}1.45^a$	$6.59{\pm}1.42^b$	$6.81{\pm}1.24^b$
Direct Sun dried *chinchin*	$5.84{\pm}1.58^a$	$6.01{\pm}1.63^a$	$5.91{\pm}1.67^a$	$5.94{\pm}1.61^a$	$6.07{\pm}1.32^a$

Data presented as arithmetic means ± SD (Standard Deviation)
Means in column with different superscript letters are significantly different at $p \leq 0.05$ based on t- Test

Table 3. Mean hedonic scores of porridge products made from solar and sun dried flour

Sample name	Aroma	Colour	Mouthfeel	Taste	General acceptability
Solar dried porridge	$6.14{\pm}1.42^a$	$6.81{\pm}1.46^b$	$5.90{\pm}1.61^a$	$6.20{\pm}1.51^a$	$6.18{\pm}1.48^a$
Direct Sun dried porridge	$5.94{\pm}1.51^a$	$5.02{\pm}1.53^a$	$5.51{\pm}2.02^a$	$5.80{\pm}1.61^a$	$5.74{\pm}1.75^a$

Data presented as arithmetic means ± SD (Standard Deviation)
Means in column with different superscript letters are significantly different at $p \leq 0.05$ based on t- Test

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