EFFECT OF VARIETIES AND DRYING METHODS ON NUTRIENT CONTENT AND SENSORY ACCEPTABILITY OF PROCCESSED PRODUCTS FROM "*Mamung'unya*" (*Benincasa hispida*)

SADA OMARI SHOSY

A DISSERTATION SUBMITTED IN PARTIALFULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN FOOD SCIENCE OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

2015

ABSTRACT

"Mamung'unya" (*Benincasa hispida*) is a seasonal fruit widely grown in Dodoma region. To distribute its availability throughout the year, there is a need to test different drying methods for preservation. The present study was carried out to assess the effect of drying methods on nutrient content and sensory acceptability of processed products from selected *Benincasa hispida* varieties available in Dodoma region. A total of 120 farmers were interviewed using a structured questionnaire with open ended questions to collect information on available varieties, utilization and methods of preservation currently used by farmers. Three varieties were collected and subjected to sun and solar drying followed by laboratory analysis to determine the effect of drying methods on nutrient content. Sensory evaluation was carried out to evaluate the acceptability of the products developed from dried *Benincasa hispida* flour. The results showed that five varieties of *Benincasa hispida* commonly cultivated by farmers were *Mbwagale* (43.3 %), *Iyungumapele* (27.5 %), *Maule* (17.5 %), *Mbuyane* (10.0 %) and *Mhokolo* (1.7 %). All the respondents (100 %) eat *Benincasa hispida* fruits. Majority (54.2 %) eat the fruits daily, 22.5 % weekly while 21.7 % after two days. The results showed that there was a significant difference ($p<0.05$) between sun and solar drying methods on nutrient content. Crude protein, vitamin C and phenol were significantly reduced ($p<0.05$) after drying. However, niacin, iron, sodium and flavonoid were not significantly affected ($p<0.05$) by either sun or solar drying. Some nutrients and phytochemicals compounds varied significantly ($p<0.05$) between varieties. Higher amount of nutrient content was observed in *Maule* variety compared to *Mbwagale* and *Iyungumapele* varieties. There was significant difference ($p<0.05$) in all attributes except texture in *chinchin* while there was no significant difference ($p<0.05$) 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.

DECLARATION

I, Sada Omari Shosy do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution for a degree award.

Sada Omari Shosy **Date**

(MSc. Candidate)

The above declaration is confirmed;

Professor M. Lyimo **Date**

(Supervisor)

COPYRIGHT

ACKNOWLEDGEMENTS

All prayers go to Allah Almighty who has given me chance, courage and confidence to complete this noble task. But with passion of hard work, nothing remains difficult.

I wish to thank the Tanzania Commission for Science and Technology (COSTECH) for awarding me the scholarship which enabled undertake this study. I am deeply indebted to my supervisor Prof. M. Lyimo from the Sokoine University of Agriculture, Department of Food Science and Technology whose help, stimulating suggestions and encouragement helped me during all the time of research.

I am also grateful to my friends, classmates and College mates for their valuable support. I wish also to extend my thanks to the Mr. Mufui and Mr. S. Mwanyika for technical assistance in laboratory analysis.

Last but not the least; I take this chance to thank my family for the patience, love and perseverance they have shown during the whole period of the study. I cannot find any good words to express my feelings except saying “thank you so much”.

DEDICATION

This dissertation is dedicated to the memory of my late mother and father Rukia J. Akida and Omary Shosy, may God rest their soul in Peace, Ameen. Also I dedicate this dissertation to my beloved husband Aziz Gendo, my sons Abdulwarith, Umar and Ayman, my daughter Sadyah and My sister Hamida Omary Shosy for their support and encouragement.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

LIST OF ABBREVIATION

CHO	Carbohydrates
COSTECH	Commission of Science and Technology
CRD	Completely Randomized Design
DMB	Dry matter basis
g	Gram
h	Hour
ITDG	International Technology Development Group
L	Litre
mg/100g	Milligram per hundred gram
ml	Milliliter
NGO	Non-Government Organization
SD	Standard deviation
SPSS	Statistical Package for Social Science
SUA	Sokoine University of Agriculture
USDA	United State Database Association

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

"Mamungunya" (*Benincasa hispida*) a member of the family *Cucurbitaceae* is one of the familiar crops that is grown primarily for its use as a vegetable and usually recognized for its nutritional and medicinal properties especially in Asian countries (Hui *et al*., 2004). The crop is also a rich source of functionally important bioactives and therapeutics such as triterpenes, phenolics, sterols, glycosides and soluble dietary fibre, hence the vegetable has widely been used for therapeutic treatments (Gupta and Premavalli, 2010). *Benincasa hispida* was used medicinally in the cure of various complains such as gastrointestinal problems, respiratory disease, heart diseases, diabetes mellitus and urinary diseases (Al-Snafi, 2013).

Benincasa hispida is actually 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 (Chidan *et al.,* 2012). Other names of *Benincasa hispida* include ash gourd, wax gourd, winter melon, white gourd, white pumpkin and ash pumpkin (Patel *et al*., 2012). 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"* (Geeta, 2010).

Benincasa hispida is increasingly grown as food crop in Dodoma region during rainy season. 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.

1.2 Problem Statement and Justification

In Tanzania, most farmers in central zone, including Dodoma, cultivate and consume *Benincasa hispida* during the rainy seasons. Famers utilize the leaves of *Benincasa hispida* as vegetables while the fruits are harvested when green matured, boiled in water with salt or coconut with salt. This region has only one rainy season per year which is during December to April and *Benincasa hispida* is mainly available during this season. Since the crop is seasonal and perishable there is a need to find means of extending its shelf-life so as to distribute its availability throughout the year. Lack of processing technology has made the fruit underutilized, and the documented information on value addition and processing of *Benincasa hispida* is limited (Geeta, 2010).

The basic principle of drying is removal of moisture through simultaneous heat and mass transfer, which provide more shelf-life, reduce weight and volume. Fruit drying can play a significant role in developing countries to diversify the economy, stimulate fruit production, reduce post-harvest losses, improve nutrition and develop new value added products (Parshant *et al*., 2013). By exploiting various value added products from the fruit will give it more remunerable returns to the growers and benefiting consumers with respect to nutrition and its therapeutic value. Moreover, people in this region also 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 (George, 2008).Therefore, the objective of this study was to evaluate the effect of drying methods on nutritional quality of *Benincasa hispida* fruits and potentials for developing different products from the dried

fruits. Information from this study will create awareness to famers on how best to preserve *Benincasa hispida* to be used after the rainy season, and this will alleviate food insecurity, contribute to food diversity and overall improvement in livelihoods of the rural poor where *Benincasa hispida* is grown.

1.3 Objectives

1.3.1 General objective

To evaluate the effect of drying methods on nutritional quality of *Benincasa hispida* and its potential for developing products.

1.3.2 Specific objective

1. To assess the existing utilization and processing/preservation methods of the available varieties of *Benincasa hispida* in Dodoma region.
2. To determine nutrient composition of selected common varieties of *Benincasa hispida* available in Dodoma.
3. To evaluate the effects of sun and solar drying on nutrient content of *Benincasa hispida* fruits.
4. To evaluate sensory acceptability of sun and solar dried *Benincasa hispida* products.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Origin of *Benincasa hispida*

According to Al-Snafi (2013), the crop originated in Asia specifically in Java and Japan. Now a days it is grown throughout the tropics. Chinese literature praises its medicinal value in texts from 5 to 6th century AD. In India, the crop is widely grown in Delhi for preparation of 'Agra petha' and in southern states for use as vegetable (Geeta, 2010). Today, *Benincasa hispida* remains an important vegetable crop in India, Southern China, Bangladesh, and other parts of South East Asia (Nimbal *et al.,* 2011).

2.2 Nutrient Composition of *Benincasa hispida*

Benincasa hispida fruit has been valued as a nutritious vegetable as it provides a good source for natural sugars, amino acids, organic acids, mineral elements and vitamins (Zaini *et al*., 2011). Nutritionally, this fruit contain mainly water with minor amounts of protein, fat and ash. Edible portion of *Benincasa hispida* fruit recorded the highest vitamin C content (Fatariah *et al*., 2015).

Previous study showed the presence of phytochamicals such as phenols, glycosides, alkaloids, flavonoids, carotenes and tannins in *Benincasa hispida* extracts (Gill *et al.*, 2010). The extracted *Benincasa hispida* seed oil mainly consisted of linoleic acid (C18:2), accounting to 80.07 % of the total fatty acids. Other important fatty acid detected were palmitic (C16:0) (11.71 %), oleic (C18:1) (4.19 %) and stearic (C18:0) (3.7 %) acids. The fatty acids profile of the tested ash gourd seed oil was quite comparable to those of previously reported *cucurbitaceae* seed oils and some other wholesome oils, revealing that it can be used as a potential seed oil crop (Chang *et al*., 2010).

Table 1: Nutritional value of *Benincasa hispida* per 100g of edible portion in DMB

Nutrient	Amount
Energy, Kcal	13.0
Protein, g	4.0
Fat, g	0.2
Carbohydrates, g	79.9
Fibre, g	12.9
Ash, g	3.0
Vitamin C, mg	13.0
Thiamine, mg	0.04
Niacin, mg	0.4
Riboflavin, mg	0.11
Calcium, mg	19.0
Iron, mg	0.4
Phosphorus, mg	20.0

Source: USDA (2014)

2.3 Medicinal Benefits of *Benincasa hispida*

Benincasa hispida is inexpensive and versatile, healthful vegetable that should definitely be a part of any nutritious diet. It has been part of human diet for ages due to its nutritional and medicinal values, as it is a good vegetable for maintaining a healthy blood pressure (Chidan *et al*., 2012). Al-Snafi (2013) reported that the *Benincasa hispida* fruit and seed possess a number of pharmalogical properties mainly as laxatives, diuretics and used during epilepsy, internal hemorrhages and nervous disorders. Seed extract of *Benincasa hispida* is known to facilitate mucus secretion and thus has an expectorant effect (Grover *et al*., 2000; 2001). *Benincasa hispida* is alkaline in nature and hence has a cooling and neutralizing effect on stomach acids and as such is used effectively for treating digestive ailments like hyperacidity, dyspepsia, and ulcers (Rachch and Jain, 2008).

According to Geeta (2010) the *Benincasa hispida* is effective against diabetes, diseases related to liver and leucorrhea. It is also good for the detoxification of minerals, removal of fever and strengthening the functions of bladder and intestine (Choi *et al.*, 2001). The methenolic extract of fruit of *Benincasa hispida* was evaluated for its anti-diarrheal potential by Mathad *et al*. (2005) against castor oil induced diarrhea in rats. Results showed that there was significant reduction in incident as well as severity of diarrhea in experimental models. An *in vitro* study conducted by Lee *et al*. (2005) revealed that the seed extract of *Benincasa hispida* decreased endothelial cell proliferation and tube formation in a dose-dependent manner with no cytotoxicity and showed potent inhibitory effect on angiogenesis *in vivo*. Seed extract of *Benincasa hispida* supports its anti-angiogenic property through inhibition of endothelial cell proliferation.

Every part of this fruit is useful. *Benincasa hispida* leaves are rubbed on bruises to heal them, while the seeds are used for expelling intestinal worms. The ash made from burning the rind and seeds are mixed with coconut oil and used to promote hair growth and to treat dandruff (Chidan *et al.,* 2012). For improving sperm count and its movement, often the seeds of this vegetable are cooked with milk and consumed (Rayees *et al.,* 2013). An effective remedy for tapeworms and intestinal infections can be offered by the winter melon's seeds. It can be blended in coconut milk and consumed as a remedy (Sharma *et al*., 2014).

2.4 Utilization of *Benincasa hispida*

It is commonly eaten throughout the winter in countries of deciduous vegetation such as China, as one of the few vegetables available during winter; hence its Chinese name literally means 'winter melon'. And they use the melons in stir fry or usually combined with pork or pork/beef bones to make winter melon soup, often served in the scooped

out melon, carved by scraping off the waxy coating. It has also been used as the base filling in Chinese and Taiwanese moon cakes for the Moon Festival (Marr *et al*., 2007).

*Benincasa hispida*is called, "*kondol"* or "*gondola"* in the Philippines. It is candied (referred to plainly as *kundol*) and is used as a pastry. It is also an ingredient in some savory soups (sabaw) and stir-fries (guisado) (Zaini *et al.,* 2011).

Benincasa hispida is cut into pieces, peeled and boiled in sugar syrup to make "*Petha"*, a sweet dish which is very famous as Agra *petha* in the southern part of India, also, the matured ash gourd fruit and seeds are used to prepare a dehydrated product "*Sandige"*, along with the other spices. The fruit is also used as a vegetable in curry as well as in the "*sambar"* (Geeta, 2010). In African countries including Malawi and Tanzania, *Benincasa hispida* fruit is cut into pieces then boiled with water or coconut and salt and usually eaten as breakfast or dinner.

2.5 Drying Method

Drying is one of the oldest and easiest methods of food preservation known to man and ranges from open sun drying to industrial drying. It is a process that involves the removal of water from food products in order to avoid or to slow down food spoilage by microorganism and deteriorative enzymes (Mongi *et al.,* 2011). There are wide array of drying methods, each better suited for a particular situation and are commercially used to remove moisture from fruits (Pangavhane, 2002). There are three basic types of drying process namely open sun drying, solar drying and mechanized drying (Fadhel *et al*., 2005). Open sun and solar drying rely on solar energy for drying, whereas the oven method utilizes electricity (Intermediate Technology Development Group (ITDG), 2004). Therefore, the choice of drying method depends on the type of the product, availability,

cost of the dryer, energy source and consumption, cost of dehydration and the final quality of the dried product (Sagar and Kumar, 2010). Simple drying techniques are often the most appropriate for application in small-scale households in rural areas which are limited in their technical, financial and managerial resources (Christensen and Peacock, 2000).

2.5.1 Open sun drying

Sun drying is the traditional method of drying in developing countries and it denotes the spreading of foodstuff in the sun on a suitable surface such as mat, roof, or drying floors (Mongi *et al.,* 2011). According to Visavale (2012) sun drying is the evaporation of water from products by sun assisted by movement of surrounding air. To be successful, it demands a rainless season of bright sunshine and temperatures above 98^{o} F coinciding with the period of product maturity. The main problems of sun drying are dust, rain and cloudy weather (Al-Juamily *et al.*, 2007). It needs a continuous follow up throughout the drying period to protect the product from domestic animals and remove the produce when the weather becomes too windy, dusty, or rainy. The dried product is often of poor quality as a result of dirt (Bala and Janjai, 2009), and microbial contamination and insects such as flies (Mnkeni *et al.,* 2004). Although it is the cheapest method, the dried products are of poor quality due to contamination by insects, birds and dust. Moreover, the direct exposure to sunlight, or more precisely ultraviolet radiation, can greatly reduce the level of nutrients such as vitamins in the dried product (Sharma *et al*., 2008).

2.5.2 Solar drying

Improvements of sun drying have led to the development of solar drying technology (Krokida *et al*., 2001). Solar drying is said to be an elaboration of sun drying and is an efficient system of utilizing solar energy (Bala and Janjai, 2009). Similar to sun drying,

solar drying refers to methods of using the sun's energy for drying, but excludes open air "sun drying" (Mnkeni *et al.,* 2004).

Solar drying technology is a more efficient method of drying that produces better quality products and is considered to be an alternative for drying agricultural products in developing countries. It is often differentiated from 'sun drying' by having and using designed structure to collect and enhance the solar radiation in order to harness the radiative energy for drying applications (Mongi *et al.,* 2011). Solar drying has more advantages over sun dying. Generation of higher air temperature and consequently lower relative humidities in solar dyer are both conducive to improve drying rates and lower final moisture content of the dried crops, energy and labour saving and environmental protection. Also, solar dying method tend to make the products to be less spoiled and less infestation from organisms, thus leading to improve quality of the product (Sharma *et al*., 2008).

2.5.3 Effects of drying

Drying is used to remove water from foods so as to prevent or inhibit micro-organisms, preserve the food, reduce the weight and bulk of the food hence, facilitating for storage (Elizabeth and Judy, 1999; Danso-Boating, 2013). The quality of dried foods is greatly influenced by the drying operation and is judged by the amount of physical, chemical and biochemical changes occurring during the drying process (Jokic *et al.,* 2009). However, the extent of drying depends on product end-use. Cereals and oilseeds are dried after harvest to the moisture content that allows microbial stability during storage (Dirk and Fred, 2002). Vegetables are blanched before drying to avoid rapid darkening, and drying is not only carried out to inhibit microbial growth, but also to avoid browning during storage. In dried fruits, the reduction of moisture acts in combination with its acid and

sugar contents to provide protection against microbial growth (Ife and Bas, 2003). Products such as milk powder must be dried to very low moisture contents (2 – 4 %) in order to ensure flowability and avoid caking. Other products as crackers are dried beyond the microbial growth threshold to confer a crispy texture, which is liked by consumers (Genskow *et al*., 2007).

The drying methods (sun, oven and solar drying) utilize heat to remove water from food by evaporation. The removal of water by heat has been reported to affect the nutrient contents of food in various ways. It can either increase or decrease the concentration of some nutrients by making them more available or unavailable (Ladan *et al*., 1997; Morris *et al*., 2004; Hassan *et al*., 2007).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Description of the Study Area

The study was conducted at Sokoine University of Agriculture in Morogoro and Dodoma region. Laboratory work was conducted at SUA while field survey and sample collection were done in Dodoma region. This is because most farmers in Dodoma region cultivate and consume *Benincasa hispida*. Dodoma region is located at 6°10′23″S 35°44′31″E Coordinates in the center of Tanzania. The town is located at 486 kilometres West of the former capital of Dar es Salaam and 441 kilometres South of Arusha. It covers an area of 2,669 square kilometres of which 625 square kilometres are urbanized. The region is divided into seven districts namely Chamwino, Bahi, Chemba, Dodoma municipal, Kondoa, Kongwa and Mpwapwa.

3.2 Research Design

The study involved field survey and laboratory experiments where by qualitative and quantitative data were collected. Completely Randomized Design (CRD) in factorial arrangement with three replicates were used in experimental part where factor A=varieties and factor B=drying method. Three varieties of *Benincasa hispida* fruits were subjected to two types of drying methods (sun and solar drying). The effect of these factors on nutrient content and sensory parameters was assessed and compared. The expression for this design is shown in equation 1.

$$Y_{ij} = \mu + \tau_i + \varepsilon_{ij} \quad \ldots\ldots (1)$$

Where Y_{ij} is the j^{th} observation of the i^{th} treatment

μ is the population mean

τ_i is the treatment effect of the i^{th} treatment

ε_{ij} is the random error

3.3 Sampling Procedures and Sample Size

Two districts namely Bahi and Dodoma municipal were selected randomly out of seven districts found in Dodoma region. Then, four wards (Zuzu, Ng'hong'honha, Chibelela, Mtitaa) were selected randomly from the two districts then four villages (Zuzu, Ng'hong'honha, Isangha, Nhyinila) were selected randomly from the four selected wards. The interviewed farmers were selected randomly from those four villages, following a formula described by Glenn (2009). A sample size was obtained as follows:-

$$n = \frac{Z^2 pq}{e^2} \quad \text{.......(2)}$$

Where;

n = sample size

Z= critical value

p = estimated to the proportion of farmers expected to cultivate *Benincasa hispida*

q = 1-p

e = the desired level of precision

Therefore 95 % confidence level, p =.5 (maximum variability) and ± 5 % precision was used to calculate the sample size as demonstrated below:-.

$$n = \frac{(1.96)^2 (0.5) (0.5)}{(0.05)^2} = 385 \text{ respondents}$$

It was very difficult to take a sample size of 385 respondents due to financial and time constraints. However, according to Bailey (1994), a sample of 30 respondents is minimum to allow statistical analysis. Therefore, 30 households were sampled from each village, making a total of 120 households. The sample size was found to be convenient for statistical analysis.

3.4 Data Collection

3.4.1 Field survey

Structured questionnaire with open and closed ended questions was administered to the selected farmers so as to collect information on how many varieties of *Benincasa hispida* are available in Dodoma region and their names, utilization of *Benincasa hispida* in terms of food, medicine, feed for animals or fertilizer, and preservation methods used by farmers.

3.4.2 Sample collection and preparation

3.4.2.1 Sample collection

Three fruits from each of the selected three varieties of matured fruits were collected from interviewed farmers during field survey (3 fruit x 3 varieties x 120 households) making a total of 1080 fruits. These three varieties were selected out of five varieties because they are the varieties mainly cultivated by the farmers. The fruit samples were packed in polyethylene sacks and transported to SUA for chemical analysis.

3.4.2.2 Sample preparation

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 (five grams of citric acid into one liter of 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 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 (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. The drying procedure is shown in Figure 1.

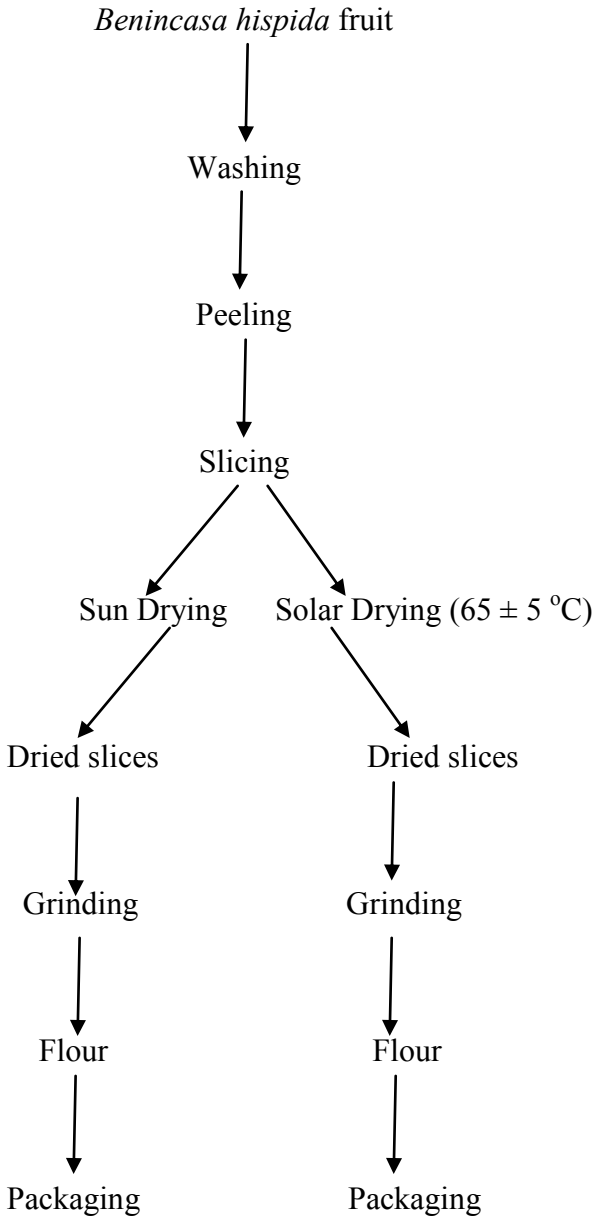


Figure 1: Drying Procedure of *Benincasa hispida* fruit

3.5 Chemical Analysis

3.5.1 Proximate analysis

Proximate analysis of fresh and dried *Benincasa hispida* fruits was determined according to the official methods of the Association of Analytical Chemists (AOAC, 1995). The

samples were analyzed in duplicate for crude protein, crude fiber, dietary fat, moisture, ash and carbohydrate content. The average value of two measurements was used.

3.5.1.1 Determination of crude protein

Crude protein content of fresh and dried *Benincasa hispida* fruits was determined by (AOAC, 1995) 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:

$$\% N = \frac{(\text{Titre blank}) \text{ in ml} \times 0.014077}{\text{Weight of samples (g)}} \times 100 \quad \ldots\ldots (3)$$

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

$$\% CP = \% N \times \text{Factor } (6.25)$$

3.5.1.2 Determination of moisture content

Moisture content of fresh and dried *Benincasa hispida* fruits were determined by procedure described by AOAC (1995) method number 925.09. The dishes were dried in

an oven at 105^{o}C for three hours and cooled in desiccators. Then sample was first weighed (W_1) transferred into a pre-weighed dried crucibles (W_2) and oven dried at 110^{o}C for overnight. The crucibles with dried sample were cooled in desiccator for half an hour and re-weighed (W_3).The amount of moisture in percent was calculated as follows:

$$\% \text{ Moisture content} = \frac{W1-(W3-W2)}{W1} \times 100 \quad \ldots\ldots (4)$$

3.5.1.3 Determination of crude fiber

Crude fiber of fresh and dried *Benincasa hispida* fruits was determined by AOAC (1995) procedure, method number 920.86. About one gram of each sample was taken for crude fibre determination. The samples were digested first by dilute acid (0.125 M H_2SO4) for 30 minutes and washed three times with hot water. The residue was then digested by dilute alkali (0.125 M KOH) for another 30 minutes and then washed by hot water three times. Digested residue was dried in an oven for five hours, cooled and weighed. The residue was then placed in muffle furnace and incinerated for two hours, cooled and weighed again. Total fibre content was calculated by using the formula below:

$$\% \text{ Crude fibre} = \frac{W_1\,(g) - W_2\,(g)}{W\,(g)} \times 100 \quad \ldots\ldots (5)$$

Where :

W_1 = weight of sample residue before incineration (g)

W_2 = weight of sample residue after incineration (g)

W = weight of dry sample taken for determination (g)

3.5.1.4 Determination of crude fat

Crude fat of fresh and dried *Benincasa hispida* fruits was determined by AOAC (1995) method number 920.65 by ether extraction using the Soxtec System (Soxtec TM 2055 Fat

analyser 2012). About ten grams of fresh samples and three grams of dry samples were weighed and then transferred into extraction thimble and covered with defatted cotton wool. The thimble support holder was used to insert the thimbles into the extraction unit, then the cup holder was used to insert the extraction cup containing 70 ml of solvent (40-60^{o}C petroleum ether) and extraction proceeded for about two hours. The extraction process involved three stages boiling (15 minutes), rinsing (45 minutes) and recovery (10 minutes). The cups containing extracted fat were dried in an oven at 105^{o}C for 30 min, cooled in desiccator and weighed. The percent fat was calculated as follows:

$$\% \text{ Crude fat} = \frac{\text{Weight of crude fat (g)}}{\text{Weight of dry samples (g)}} \times 100 \quad (6)$$

3.5.1.5 Determination of ash content

Ash content of fresh and dried samples was determined by using a muffle furnace as described in standard method (AOAC, 1995), method number 923.03. One gram of each sample in duplicate were placed in a pre-weighed crucible and dried in an oven at 105^{o}C for 12 h. The dried samples were weighed and then placed in muffle furnace at 550^{o}C for 12 h until white or grey ash was obtained. The samples were cooled in a desiccator at room temperature and weighed. Percent ash was calculated using the formula below:-

$$\% \text{ Ash} = \frac{\text{weight of ash (g)}}{\text{Weight of sample (g)}} \times 100 \quad (7)$$

3.5.1.6 Determination of carbohydrate

Carbohydrate content of fresh and dried *Benincasa hispida* fruits were calculated as difference (AOAC, 1995). The following formula was used:-

% carbohydrate = 100 – (% Protein + % Crude fibre +% Crude fat +% Ash content+% Moisture). ……. (8)

3.5.2 Determination of vitamins

3.5.2.1 Vitamin C

Vitamin C for fresh and fried *Benincasa hispida* fruit was determined by 2, 6-Dichlorophenol indophenols (DCIP) sodium salt method (AOAC, 2000) method number 967.21. Under this method, titration was performed in the presence of phosphoric acid/acetic acid solution to maintain proper acidity (pH 1 - 3) for titration and to inhibit oxidation of the acid. About five grams of fresh sample as well as dried sample were taken into 250 ml erlenmeyer flask followed by 50 ml of orthophosphoric acid to extract, to lower pH as well as to de-proteinize the sample. The extracted samples were then filtered using No. 1 whatman filter papers and titrated against standardized dichlorophenol indophenols the end point of the reduction process was observed (pink colour). The volume of dichlorophenol indophenols used was recorded and vitamin C content in samples was calculated using the following equation:-

Mg of ascorbic acid = (X-B) x (F/E) x (V/Y) ……...……. (9)

Where: X = titre value

B = blank

F = mg of ascorbic acid equivalent to 1.0 ml indophenol

E = number of ml assayed

V = initial assay solution volume

Y = volume of sample aliquot titrated

3.5.2.2 Niacin

Niacin content of fresh and dried samples was determined by colorimetric method as described by George (2006). 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.* (2009). The obtained tryptophan was converted to Niacin by dividing with 60 mg since; 1mg of niacin is equivalent to 60 mg of tryptophan.

$$\text{Niacin content (mg/100g)} = (\text{B560} - \text{A560})\text{xVx100}/(\text{Slope x Swt x 60}) \quad \ldots\ldots\ldots (10)$$

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

3.5.2.3 Thiamine

Thiamine content of fresh and dried samples was determined by the method described by Tee and Khor (1996) and Alaa *et al.* (2010). About one gram of fresh and dried samples were taken into 150ml erlenmeyer flask and 32.5 ml of 0.1 N sulphuric acid added, then heated for 30 minutes in a boiling water bath while stirring occasionally. The samples were left to cool in the ice cold water bath and the pH was adjusted to 4.5 with sodium acetate using the pH meter (JENWAY, Model 3305). The contents were transferred into 50 ml volumetric flask and the volume adjusted to 50 ml mark with distilled water. The

samples were diluted into 1:1 ratio with 0.01 N sodium hydroxide solution and filtered using no. 42 whatman filter papers. Standard thiamine hydrochloride (Sigma-Aldrich, analytical standards Merck No 149295) with the concentration of 1mg/ml was prepared by taking 0.1 g into 100 ml distilled water. Serial dilution (0.2 – 14 µg/ml) of standard thiamine hydrochloride into 10 ml volumetric flask. One milliliter of the diluted standards and the clear sample extract were measured into 25 ml clean and dry volumetric flask followed by 0.19 ml of $Fe(NO_3)3.9H_2O$ and 0.6 ml of 0.1 M, $K_3[Fe(CN)_6]$, the mixture was shaken and diluted to the 25 ml mark with distilled water. The mixtures were allowed to stand for 20 minutes in the water bath at 40 ± 2^oC. Absorbances were read at 747 nm. The Thiamine content in the samples was calculated using the linear regression equation from the standard plot as follows:

$$\text{Thiamine content } (\frac{\text{mg}}{100\text{g}}) = (\text{A} + 0.062)\text{x E x}100/(0.606 \text{ x S x V}) \quad \ldots\ldots\ldots\ldots\ldots (11)$$

Where;

A = Sample absorbance were read into UV-Visible spectrophotometer at 747 nm

0.062 = Y-intercept in the standard plot

E = Total extraction volume (50 ml)

0.606 = Slope of the standard plot

S = Weight of sample taken for analysis

V = Sample extract taken for analysis (10 ml)

3.5.3 Determination of mineral content

Mineral content (Ca, Na, Fe, P and K) of fresh and dried samples were determined by Atomic Absorption Spectrophotometer by method described in AOAC (1995), 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, calcium (Ca) 422.7

nm, sodium (Na) 587.0 nm and phosphorus (P) 840 nm. The mineral content (mg/100g) was calculated as follows:

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

Where;

R = absorbance reading in ppm

100 = Volume of sample made

D.F = Dilution Factor

1000 = conversion factor to mg/100g

S = sample weight.

3.5.4 Determination of phytochemical compounds

3.5.4.1 Total phenol content

Total phenol content of fresh and dried samples was determined spectrophotometrically using Folin-Ciocalteu method as described by Kujala *et al*. (2000). About 0.5 g of fresh and dried samples were weighed into 100 ml erlenmeyer flask. Then 50 ml of 95 % ethanol was added. The mixtures were incubated at room temperature 26 ± 2^{o}C for 30 minutes followed by filtration through no. 1 whatman filter paper. Standard garlic acid (10 mg) was dissolved in 100 ml distilled water in a volumetric flask to make 100 µg/ml of stock solution. Serial dilution of standard garlic solution (100 µg/ml) were prepared by taking 0 ml, 0.5 ml, 1.0 ml, 1.5 ml, 2 ml and 2.5 ml and diluted to obtain 25 ml of diluted solution. Then 0.5 ml of sample extracts as well as diluted garlic standard solution were transferred into 25 ml volumetric flask followed by addition of 10 ml of distilled water and 1.5 ml of Folin-Ciocalteu reagent. After five minutes, 4 ml of 1 M sodium carbonate was added in each volumetric flask and the volume was adjusted to 25 ml with distilled water.

After 30 min, absorbance at 765 nm was recorded and calibration curve for standard was plotted as absorbance against concentration. From this graph the amount of phenol content was determined.

$$\text{Total phenolic compounds } (\frac{\text{mg}}{100\text{g}}) = (\text{A} - 0.024)\text{x E x } 100/(0.01 \text{ x V x S}) \ldots\ldots (13)$$

Where;

A = Sample Absorbance as read at 765 nm

E = Total volume of sample extract

V = Volume extract assayed (ml)

S = Sample weight taken for analysis (g)

0.024 = Y-Intercept as obtained from the standard plot

0.01 = Slope from the standard plot

3.5.4.2 Total alkaloid content

Total alkaloid content of fresh and dried samples was determined by the method described by Kumar and Bhardwaj (2012). About two grams of fresh and dried samples were weighed into 250 ml beaker and 120 ml of 10 % acetic acid in ethanol was added in each beaker. Then the beakers were covered by parafilm to prevent evaporation and allowed to stand for four hours followed by filtration through no. 1 whatman filter paper. The extracts were concentrated on a water bath set at 40 ± 5^{o}C down to 40 ml of the total extract. The filter papers containing residues were dried in the oven at 110^{o}C. The dried filter papers containing residues were cooled in the desiccator and reweighed. The alkaloid content was calculated as follows:

$$\% \text{ Alkaloids} = \frac{W2-W1}{W} x\ 100 \ldots\ldots (14)$$

Where;

W= Weight of samples taken (g)

W2= Weight of filter + residue (g)

W1= weight of the filter

3.5.4.3 Total flavonoid content

Total flavonoid content of fresh and dried samples was determined by using a colorimetric method described by Shiva *et al*. (2007). About two grams of fresh and dried samples were taken into 250 ml erlernmeyer flasks followed by the addition of 20 ml of 80 % Methanol. The mixtures were left to stand for one hour at room temperature 26 ± 2^{o}C and filtered through no 42 whatman filter paper into pre-weighed beakers. The resulting filtrates were transferred into crucibles and evaporated to dryness until constant weight was obtained.

$$\%\text{Flavonoids} = \frac{W2-W1}{W} x\ 100 \ldots\ldots (15)$$

Where;

W= Weight of sample taken (g)

W1= weight of the beaker (g)

W2= Weight of the beaker + residue (g)

3.5.4.4 Cardiac glycosides

Cardiac glycoside was determine by Buljet’s reagent as described by El-Olemy *et al.* (1994) and Omalara and Samuel (2007). About one gram fresh and dried samples were soaked in 10 ml of 70 % Methanol for two hours and filtered through no. 1 whatman filter

paper. Then 0.5 ml of saturated lead acetate solution and 0.5 ml of saturated sodium phosphate solution were added to purify the filtrate. About 5 ml of samples filtrate were taken into 10 ml test tube. About 1 ml of Buljet's reagent (containing 95 ml aqueous picric acid + 5 ml 10 % sodium hydroxide) was added to the filtrates and the absorbance was read at 495 nm using UV-Visible spectrophotometer. The differences in colors of blank and test sample gave absorbance that was proportional to the cardiac glycosides (Soladoye and Chukwuma, 2012).

3.5.4.5 Cyanogenic glycosides

Cynogenic glycoside content of fresh and dried samples was determined by the method described by Omalara and Samuel (2007). About five grams of fresh and dried samples were weighed into 250 ml erlenmeyer flask, incubated at 38^{o}C for 16 h and extracted with 100 ml 95 % methanol. The extracted samples were filtered through double layers of whatman filter paper no. 1. Then the resulting filtrates were transferred into the tow-necked flask and connected to the steam generator and distilled for one hour and each distillate was collected into 250 ml erlenmeyer flask containing 50 ml of saturated sodium bicarbonate solution. About one milliliter of 1 % starch indicator was added into each 20 ml of distillate collected and then titrated against 0.2 N iodine solution until blue black color (end point) was obtained. The percent cyanogenic glycoside was calculated as follows:-

$$\% \text{ Cyanogenic glycoside } \left(\frac{\text{mg}}{100\text{g}}\right) = (\text{A} - \text{B})\text{xN x } 0.00027 \text{ x } 100/\text{S x V1}). \ldots\ldots\ldots (16)$$

Where;

A = Volume iodine solution used for sample

B = Volume of iodine solution used for blank

N = Concentration of iodine solution used

S = Amount of sample taken for analysis (g)

V_1 = Volume of distillate assayed (ml)

0.00027 = mg equivalent of Cyanogenic glycoside per ml of 0.2 N iodine solution

3.6 Product Development

The products that were 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 "*Iyungumapel*e" varieties.

3.6.1 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.

3.6.2 *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.

3.7 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 (2010). Sensory evaluation was conducted using a panel of 70 people (students with age raging 15-45 years) from Sokoine University of Agriculture. 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 (Appendix 2).

3.8 Statistical Data Analysis

Statistical Package for Social Science (SPSS) version 20 was used to analyse the data collected from survey. Data from laboratory and sensory evaluation were analysed by R statistical package (R Development Core Team, Version 3.0.3 Vienna Austria). The significance difference between treatment and interaction between the factors at $p<0.05$ was determined by two way analysis of variances. Means were separated by Turkey test at $p<0.05$ for laboratory analysis and t-test at $p<0.05$ for sensory evaluation to compare products from two drying methods.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Utilization and Processing/preservation Methods

4.1.1 Characteristics of respondent

In this study, out of 120 farmers interviewed, 63 were males (52.5 %) and 57 were females (47.5 %) with group age ranged between of 15 to 25 years described as youth-lower level (11.7 %), 26 to 40 years as youth upper level (32.5 %), 41-60 years as old (30.8 %) and 61 to 100 years described as very old (25.5 %).

Table 2: Distribution of respondents according to their age and sex (n = 120)

Age group	Description	Sex of respondent		Total
		Male	Female	
15-25years	Youth-lower level	8 (6.7 %)	6 (5 %)	14 (11.7 %)
26-40years	Youth-upper level	14 (11.7 %)	25 (20.83 %)	39 (32.5 %)
41-60years	Old	23 (19.17 %)	14 (11.7 %)	37 (30.8 %)
61-100years	Very old	18 (15 %)	12 (10 %)	30 (25.5 %)
Total		**63 (52.5 %)**	**57 (47.5 %)**	**120 (100 %)**

4.1.2 Varieties of *Benincasa hispida* available in Dodoma region

The results in Table 3 show that, 116 (96.7 %) of respondents indicate the range of 1 to 5 available varieties of *Benincasa hispida* in Dodoma region while only 4 (3.3 %) of respondents indicate the range of 6 to 10 varieties. This implies that many farmers cultivate less than five varieties of *Benincasa hispida* and each farmer only knew the varieties that he/she cultivate. It was observed that each farmer plant the seeds that he/she preserve during the last rainy seasons, with no tendency of getting seeds from their colleagues.

"*Mbwagale*" variety is the most popular variety cultivated by many farmers (43.3 %), followed by "*Iyungumapele*" (27.5 %), "*Maule*" (17.5 %) and "*Mbuyane*" (10.0 %) while "*Mhokolo*" (1.7 %) is the least variety cultivated by farmers in Dodoma region. According to these observations, the first three varieties were selected for the laboratory analysis and based on its higher nutrient content *Maule* was used for product development and sensory evaluation.

Table 3: Distribution of respondents according to their responses on varieties of *Benincasa hispida* available in Dodoma region (n = 120)

Category	Frequency	Percent (%)
Availability of varieties		
1-5	116	96.7
6-10	4	3.3
Total	120	100
Names of varieties		
Mbwagale	52	43.3
Iyungumapele	33	27.5
Maule	21	17.5
Mbuyane	12	10.0
Mhokolo	2	1.7
Total	120	100

The names of varieties of *Benincasa hispida* that were mentioned by respondents are local names (tribe's names) such as "*Mbuyane", "Mbwagale", "Iyungumapele", "Maule*" and "*Mhokolo*". These observations were similar to those reported by Marr *et al*. (2007) that in China, they call it Chinese or winter melon, Zain *et al.* (2011) reported that in Philippine, they call it *"kundol"* or "*gondol",* Chang *et al*. (2010) reported that in Malaysia, they call it "*Kundur"* and in Indonesia, they call it "*beligo".*

"Mbwagale"

"Iyungumapele"

"Maule"

"Mbuyane"

"Mhokolo"

Plate 1: Varieties of *Benincasa hispida* fruit

4.1.3 Utilization of *Benincasa hispida*

4.1.3.1 Uses of *Benincasa hispida* as food

Results shown in Table 4 indicate that *Benincasa hispida* was commonly utilized by respondents in different forms. Some respondents 68 (56.7 %) reported to use the fruits only, 52 (43.3 %) use both fruits and leaves while none of respondents use leaves only. It was observed that some prefer to use the matured fruits 5 (4.2 %) while 44 (36.7 %) to use the immature fruits, however most respondents 71 (59.2 %) reported to use both mature and immature fruits. These findings are different from the findings reported by Geeta (2010) in India who observed that all respondents in that study use only matured *Benincasa hispida* fruits.

As for consumption, it was observed that most of respondents (54.2 %) consume *Benincasa hispida* fruit daily, 22.5 % weekly while, 21.7 % after two days and only 1.7 % monthly. Most of the respondents who consume the fruits daily reported that, the crop mature early compared to other crops like sorghum, maize and millet during the rainy season. These observations suggest that, this crop is important for food security.

The results of this study revealed that only 1.7 % of respondents consume *Benincasa hispida* leaves daily, 10.8 % consume weekly, 10 % consume monthly while 20.8 % of respondents consume if there is a shortage of vegetables (i.e. they have no choice). About 56.7 % of respondents do not consume *Benincasa hispida* leaves at all (Table 4). Generally it was observed that, most of the farmers in Dodoma region do not prefer to consume *Benincasa hispida* leaves but use it when there is a shortage of vegetables due to the fact that, they do not like it very much compared to other available vegetables like "*mlenda*", pumpkin leaves and cowpeas leaves.

Table 4: Distribution of respondents according to their utilization of *Benincasa hispida* in Dodoma region (n = 120)

Category	Frequency (N)	Percent (%)
Type used		
Mature Fruit	5	4.2
Immature Fruit	44	36.7
Both Mature and Immature	71	59.2
Total	**120**	**100.0**
Part used		
Fruits only	68	56.7
Both fruits and leaves	52	43.3
Leaves only	0	0.0
Total	**120**	**100.0**
Frequency of fruit consumption		
Daily	65	54.2
Weekly	27	22.5
Monthly	2	1.7
After two days	26	21.7
Total	**120**	**100.0**
Frequency of leaves Consumption		
Daily	2	1.7
Weekly	13	10.8
Monthly	12	10.0
If there is a shortage of veg.	25	20.8
None	68	56.7
Total	**120**	**100.0**
Other uses		
Feed of Animal	23	19.2
Medicine	4	3.3
Fertilizer	2	1.7
None	91	75.8
Total	**120**	**100.0**

4.1.3.2 Uses of *Benincasa hispida* apart from food for human consumption

Other uses of *Benincasa hipida* apart from food for human consumption are shown in Table 4. It was observed that 19.2 % respondents use *Benincasa hispida* to feed their animals, 3.3 % as medicine while 1.7 % as fertilizer and 75.8 % of respondents have no other uses. It was reported that, one of the reasons that limited the uses of *Benincasa hispida* apart from food for human consumption is lack of knowledge for alternative uses. This could be due to the fact that, no research has been done in Tanzania on *Benincasa hispida* on pharmaceutical uses like in Asian countries where a several studies have been reported (Vrushabendra, 2005; Geeta, 2010; Ghosh and Bhaghel, 2011; Nimbal *et al*., 2011; Ashish and Siddhant, 2012).

4.1.4 Preservation methods

Results shown on Table 5 indicate that 100 % of respondents do not preserve *Benincasa hispida* fruits. The observation suggests that all farmers have no idea on how to preserve the fruits. According to Ife and Bas (2003), during the harvest season, fresh produces are available in abundance, but at other times they are scarce and most fruits and vegetables are only edible for a very short time, unless they are promptly and properly preserved. However, farmers in Dodoma were not aware on preservation of fruits hence, most of the fruits are lost during harvest season. Also it was observed that 85.8 % of respondents do not preserve *Benincasa hispida* leaves while only 14.2 % of respondents preserve *Benincasa hispida* leaves by sun drying method. Most of the respondents were familiar with sun drying as a method of preserving cereals such as millet and sorghum and other grains. However, majority of the households were not aware that vegetables and fruits could be preserved by drying. These findings are similar to that reported on various vegetables by Kiremire (2010). These results of the present study suggest that farmers

should be sensitized on the importance of preserving the fruits as well as leaves for use when they are off season.

Table 5: Distribution of respondents according to their preservation of *Benincasa hispida* fruits and leaves (n =120)

Category	Frequency	Percent (%)
Preservation of fruit		
Yes	0	0.0
No	120	100.0
Total	**120**	**100.0**
Preservation of leaves		
Yes	17	14.2
No	103	85.8
Total	**120**	**100.0**

4.2 Nutrient Composition of Selected Common Varieties of *Benincasa hispida* Fruits

4.2.1 Effect of varieties of *Benincasa hispida* fruit on proximate composition

The effect of variety on protein content is shown in Table 6. The results show that, there was a significant difference ($p<0.05$) 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. Mrosso (2005) reported that, grape 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.

The ash content was significantly different ($p< 0.05$) between varieties (Table 8). *"Maule"* had the highest ash content (3.87 g/100g) followed by *Iyungumapele* (3.47 g/100g) and

"Mbwagale" (3.46 g/100g). Variation in the ash content might be attributed to the soil variation and maturity level of the vegetables (Ukegbu and Okereke, 2013).

Table 6: Effect of varieties of *Benincasa hipida* fruit on proximate composition (DMB)

	g/100g				
Variety	**CP**	**Ash**	**F**	**FB**	**CHO**
Mbwagale	4.53±0.02[a]	3.46±0.04[a]	4.74±0.00[b]	13.80±0.15[b]	73.46±37.26[a]
Iyungumapele	5.44±0.01[b]	3.47±0.01[a]	4.44±0.01[a]	12.94±0.21[a]	73.75±38.34[a]
Maule	5.78±0.00[c]	3.87±0.08[b]	4.75±0.02[b]	13.85±0.42[b]	74.57±0.11[b]

Data presented as arithmetic means ± SD

Means in column with different superscript letters are significantly different at $p<0.05$ based on Turkey Test

Key: CP= Crude Protein, F= Fat, FB= Fibre, CHO= Carbohydrate.

The effect of varieties on fat content is shown in Table 6. There was significant difference ($p<0.05$) in fat content within the three varieties. "*Maule*" variety had higher fat content (4.75 g/100g) followed by "*Iyungumapele"* (4.44 g/100g) and *"Mbwagale"* (4.74 g/100g). This variation of fat content within the three varieties could be due to the degree of maturity of the *Benincasa hispida* fruit and the size of the seeds they contain.

There was a significant difference ($p<0.05$) in fibre content within the *Benincasa hispida* varieties (Table 6). *"Mbwagale"* variety had higher value of fibre content (13.85 g/100g) followed by *"Maule"* (13.80 g/100g) and *"Iyungumapele*" (12.94 g/100g). The differences could be due to difference in degree of maturity between the varieties of the *Benincasa hispida* fruits. Fiber content increases bulk and reduce food transit time in the alimentary canal and the incidence of constipation and other related diseases (Ifon *et al*., 2009).

The results of this study show that, there was significant variation ($p<0.05$) in carbohydrate content within the three varieties (Table 6). *"Maule"* had higher value of carbohydrate content (74.57 %) followed by "*Iyungumapele"* (73.75 %) and "*Mbwagale"*(73.46 %). Low carbohydrate content of vegetables show that they supply little or no energy when consumed except when supplemented with other foods (Rossello *et al*., 2000). Therefore, according to these results of the present study it was observed that all three varieties contain high amount of carbohydrates suggesting that they might supply enough energy when people consume them without supplement of other foods.

4.2.2 Effect of varieties of *Benincasa hispida* fruit on vitamins.

The effect of varieties on Vitamin C content is showed in Table 7. There was a significant difference ($p<0.05$) in vitamin C content among the three varieties ranging from 6.29 mg/100g to 6.87 mg/100g. "*Maule"* variety had higher Vitamin C content than "*Mbwagale"* and "*Iyungumapele"* varieties. These results suggest that farmers should be encouraged to cultivate and consume "*Maule*" variety than "*Mbwagale*" and *"Iyungumapele*" due to its high vitamin C content. Vitamin C is an anti-scurvy vitamin, it deficiency causes fragile capillary walls, easy bleeding of gums, loosening of teeth and bone joint disease. Like vitamin E, vitamin C favours the absorption of iron (Adejumo, 2012).

Table 7: Effect of varieties of *Benincasa hipida* fruit on vitamins (DMB)

	mg/100g		
Variety	**Niacin**	**Thiamine**	**Vitamin C**
Mbwagale	0.13 ± 0.00^{a}	0.03 ± 0.04^{a}	6.29 ± 0.28^{a}
Iyungumapele	0.16 ± 0.00^{ab}	0.03 ± 0.01^{a}	6.40 ± 0.02^{a}
Maule	0.29 ± 0.01^{b}	0.04 ± 0.02^{b}	6.87 ± 0.06^{b}

Data presented as arithmetic means ± SD

Means in column with different superscript letters are significantly different at $p<0.05$ based on Turkey Test.

Thiamine content within the selected *Benincasa hispida* varieties studied is presented in Table 8. The results showed that, *"Maule"* variety had the highest value (0.04 mg/100g) compared to *"Mbwagale"* and *"Iyungumapele"* (0.03 mg/100g). Deficiency of thiamine in the diet is manifested in the initial stages by anorexia, malaise, and weakness of the legs, frequently with paraesthesia, slight oedema and palpitations (Adejumo, 2012).

The results from Table 7 show that, there was significance variation ($p<0.05$) in niacin content between "*Mbwagale",* and *"Maule"* varieties. "*Maule"* variety having significantly higher value of 0.29 mg/100g than *"Mbwagale"* with value of 0.13 mg/100g. According to Burgeois (2006), clinical evidence of niacin deficiency includes fatigue, poor appetite, diarrhea, irritability, headache, emotional instability and possible memory loss. These may lead to changes in the skin, mucosa of the mouth, stomach and intestinal tract and the nervous system. These changes are called "pellagra", which means "raw skin" and are most pronounced in the parts of the skin exposed to sunlight.

4.2.3 Effect of varieties of *Benincasa hispida* fruit on minerals

Table 8 show the effect of selected varieties of *Benincasa hispida* fruits on mineral composition. There was significant difference ($p<0.05$) in mineral composition for the selected varieties. "*Maule"* had higher values in minerals composition analysed compared to "*Mbwagale*" and "*Iyungumapele"* varieties with exception of iron and sodium. Also the results showed the three varieties are rich in potassium content and poor in iron. These results are comparable to the findings obtained in other studies for various fruits (Lowor and Agyente-Badu, 2009). Also, it was reported by Mongi (2013) that fruits and vegetables are generally poor source of iron which suggest that consumption of large quantities of fruits and vegetables to meet the recommended daily allowance (RDA) of 45 mg/day. Generally, fruits and vegetables are important sources of minerals in human diet

which are vital for body functions such as maintaining the pH balance within the body and acting as co-factors for enzyme reactions. All cells in the body require enzymes to work and function and the enzymes do not work without minerals (Lydia, 2012).

Table 8: Effect of varieties of *Benincasa hispida* fruit on minerals (DMB)

	mg/100g				
Variety	**Ca**	**Fe**	**P**	**K**	**Na**
Mbwagale	4.55±0.21[a]	0.29±0.00[a]	19.20±0.85[a]	97.21±0.19[b]	4.98±0.21[b]
Iyungumapele	5.30±0.00[ab]	0.40±0.10[b]	19.45±2.23[a]	85.61±13.70[a]	5.10±0.03[b]
Maule	5.65±0.81[b]	0.31±0.01[ab]	20.91±1.12[b]	97.70±7.35[c]	3.73±0.77[a]

Data presented as arithmetic means ± SD

Means in column with different superscript letters are significantly different at $p<0.05$ based on Turkey Test

Key : Ca= Calsium, Fe = Iron, P = Phosphorus, K = Potassium, Na = Sodium

4.2.4 Effect of varieties of *Benincasa hispida* phytochemical compounds

The results in Table 9 showed that there was significant difference ($p<0.05$) in phytochemical compounds among the varieties tested with exception of alkaloids. The three varieties were rich in phenol and flavonoid content while cardiac glycoside was the least phytochemical. However, "*Maule*" variety had higher values in all phytochemical compounds analysed with exception of cynogenic glycoside compared to "*Mbwagale*" and "*Iyungumapele*" varieties. These results suggest that, farmers should be encouraged or advised to increase production as well as consumption of "*Maule*" variety as it contain higher values of phytochemical compounds which have a number of medicinal properties such as anti-diarrheal, anti-obesity, anti-ulcer, antioxidant and diuretic (Zain *et al*., 2011).

Table 9: Effect of varieties of *Benincasa hispida* fruit on photochemical compounds (DMB)

	mg/100g				
Variety	**Alkaloid**	**Flavonoid**	**Phenol**	**Car. gly**	**Cyn. gly**
Mbwagale	0.64±0.25[a]	67.55±137[a]	81.45±7.03[b]	0.42±0.02[a]	1.61±0.05[b]
Iyungumapele	0.98±0.23[a]	66.75±0.23[a]	71.38±0.69[a]	0.69±0.01[b]	1.00±0.00[a]
Maule	1.29±0.16[a]	70.65±0.06[b]	82.51±0.26[b]	0.90±0.00[b]	1.22±0.01[a]

Data presented as arithmetic means ± SD

Means in column with different superscript letters are significantly different at $p<0.05$ based on Turkey Test

Key : Car. Gly = Cardiac glycoside, Cyn. Gly=Cynogenic glycoside

4.3 Effect of Drying Methods on Nutritional Composition of the *Benincasa hispida* Fruits

4.3.1 Proximate composition

Results in Table 10 showed that, there was significant effect ($p<0.05$) on crude protein content between fresh and dried samples and between the dried samples. Fresh sample had significant higher values of 5.3 g/100g than dried samples with the values ranged from 0.3 g/100g to 0.6 g/100g. These observations may occur as the results of denaturation of protein cells caused by heating during drying process leading to loss of protein due to weakening of the three-dimensional conformation of the protein cells (Danso-Boating, 2013). Furthermore results showed that solar drying had greater effect on protein content compared to sun drying. Similar observations were reported by Hassan *et al*. (2007); Ukegbu and Okereke (2013) on effect of drying method on protein content of vegetables. Elegbede (1998) observed higher protein content in sun dried vegetables than in solar dried samples may occur as a result of higher denaturation action of protein cell due to

high temperature of solar drying (65 ± 5^{o}C) than sun drying. This phenomenon was also supported by Idah *et al*. (2010) who found a higher amount of protein content in vegetables after drying in open sun as compared to solar dried samples. More drying time leads to higher concentration of protein. In the present study sun drying took longer time (3-6 days) to dry *Benincasa hispida* fruit compared to 2-3 days in solar drying hence, high protein content.

Table 10: Effect of drying methods on proximate composition in *Benincasa hispida* fruits (DMB)

	g/100g				
Drying Method	**CP**	**Ash**	**F**	**FB**	**CHO**
Fresh	5.3±0.1^{c}	3.7±0.7^{a}	4.4±0.1^{a}	13.2±0.5^{a}	73.4±0.7^{a}
Solar drying	0.3±0.1^{a}	4.8±0.8^{b}	6.5±0.1^{c}	15.5±0.8^{c}	74.9±1.2^{b}
Sun drying	0.6±0.1^{b}	4.6±1.4^{b}	5.0±0.1^{b}	14.3±1.5^{b}	75.5±0.7^{c}

Data presented as arithmetic means ± SD

Means in column with different superscript letters are significantly different at $p<0.05$ based on Turkey Test

Key: CP= Crude Protein, F= Fat, FB= Fibre, CHO= Carbohydrate,

The results in Table 10 show that, there was a significant difference ($p< 0.05$) in ash content between fresh and dried samples. Dried samples had higher value of ash content than fresh samples due to the removal of moisture content and increased nutrient density. However solar and sun drying methods had no significant ($p<0.05$) effect on ash content. Similar finding were reported by Agoreyo *et al*. (2011) who observed that solar and sun drying methods had an equal effect on fruits.

Results of the present study showed that solar and sun drying methods had significant difference ($p<0.05$) on fat content (Table 10). The results of the present study showed that

fat content increased during drying contrary with the results reported by Omojola and Olusola (2009) who observed that fat content of selected vegetables increased with drying methods. Sun dried samples had lower value of fat content than solar dried samples. Similar observations were reported by Ukegbu and Okereke (2013) where the solar dried samples had higher values of fat content than sun dried samples of various vegetables including African spinach, fluted pumpkin and okra.

The results from Table 10 showed that, the drying methods had significant difference ($p<0.05$) on fibre content. Fiber content was significantly higher ($p<0.05$) in solar dried samples than sun dried samples because of low amount of moisture content in solar dried samples than sun dried samples. This suggests that solar dried *Benincasa hispida* fruit had more fiber than the sun dried and fresh. Drying methods have been reported to increase the level of fibre content in the food crops (Agoreyo *et al.,* 2011; Ukegbu and Okereke, 2013).

Table 10 showed that the effect of solar drying on carbohydrate content was significant difference ($p<0.05$) from that of sun drying. The fresh sample had lower value of carbohydrate content (73.4 %) while the dried samples had higher values (74.9 % and 75.5 %) for solar and sun dried samples respectively. According to Ukegbu and Okereke (2013) various vegetables like African spinach, fluted pumpkin and okra in their fresh state have been noted to be poor sources of carbohydrates. However, after drying, the carbohydrate content of vegetables increased due to removal of moisture content (Kolawole *et al*., 2011).

4.3.2 Vitamins

The results of this study showed that the two drying methods had significant different ($p<0.05$) in the level of vitamin C (Table 11). Vitamin C content for the fresh sample was higher than sun and solar dried samples. Hossain *et al.* (2010) reported that water loss may

also induce vitamin C losses. Vitamin C was higher in sun dried samples compared to solar dying probably due to low temperature in sun drying (atmospheric temperature) compared to high temperature of solar drying (about 65 ± 5^{o}C) as the Vitamin C is very sensitive to high temperature. Similar observations were reported by Adejumo (2012) that vitamin C is easily destroyed by oxidation, especially at high temperatures. Exposing fruits to high temperatures could cause decrease in Vitamin C (Isack and Lyimo, 2013).

Table 11: Effect of drying methods on vitamins in *Benincasa hispida* fruits (DMB)

	mg/100g		
Drying Method	**Niacin**	**Thiamine**	**Vit C**
Fresh	0.2± 0.1^{a}	0.4± 0.1^{b}	6.5± 0.3^{c}
Solar drying	0.1± 0.0^{a}	0.2± 0.0^{a}	3.1± 0.5^{a}
Sun drying	0.1 ± 0.0^{a}	0.2± 0.0^{a}	4.3± 0.2^{b}

Data presented as arithmetic means ± SD

Means in column with different superscript letters are significantly different at $p<0.05$ based on Turkey Test

Key: Vit. C= Vitamin C

There was significant difference ($p<0.05$) on thiamine content between fresh and dried samples (Table 11). However, there was no significant difference ($p<0.05$) between the drying methods. According to Mehdizadah and Zomorodian (2009), thiamine is one of the B vitamins that are very sensitive to temperatures. According to the results of the present study, it is suggested that farmers should be very careful on choosing drying methods as the method of preservation of *Benincasa hispida* fruits with low temperature like shade drying so as to prevent losses of thiamine content.

The results shown in Table 11 indicate that there was insignificant ($p<0.05$) variation in niacin content between fresh and dried samples. These results suggest that, niacin content was equally affected by the two drying methods. These observations are similar to those

reported by Adejumo (2012) in tomato, who observed that niacin was very stable to heat, light and oxidation.

4.3.3 Minerals

The results in Table 12 show that the drying methods had significant difference ($p<0.05$) on calcium, phosphorus and potassium with exception of iron and sodium. It was observed that potassium content increased during drying. This could be due to concentration effect which is as a result of the reduction in the moisture content compared to fresh *Benincasa hispida*. Ukegbu and Okereke (2013) reported that, the dried vegetables had higher potassium content than fresh vegetables. The higher potassium content of the dried vegetables may be an advantage since it can be used for therapy (Okoli, 2009). Dietary potassium may play a role in decreasing blood pressure. Potassium is involved in nerve function muscle control and blood pressure.

Table 12: Effect of drying method on minerals in *Benincasa hispida* fruit (DMB)

	mg/100g				
Drying method	**Ca**	**Fe**	**P**	**K**	**Na**
Fresh	5.1 ± 0.6^{b}	0.3 ± 0.1^{a}	20.0 ± 1.4^{b}	87.5 ± 10.6^{a}	4.6 ± 0.8^{a}
Solar drying	3.7 ± 0.0^{a}	0.3 ± 0.0^{a}	16.3 ± 2.1^{a}	94.9 ± 4.7^{b}	4.1 ± 0.4^{a}
Sun drying	3.6 ± 0.0^{a}	0.3 ± 0.0^{a}	18.0 ± 1.5^{ab}	94.1 ± 3.6^{b}	4.2 ± 0.3^{a}

Data presented as arithmetic means ± SD

Means in column with different superscript letters are significantly different at $p<0.05$ based on Turkey Test

Key : Ca= Calcium, Fe = Iron, P = Phosphorus, K = Potassium, Na = Sodium

Calcium and phosphorus content decreased during drying similar to the observations reported by Oguche (2011) in various vegetables such as spinach and pumpkin leaves. Calcium is mainly associated with the pectic substance of the cell wall and more than 99% of calcium in the body is used as a structural component of bones and teeth (Wardlaw and

Kessel, 2002). However, it has been noted earlier on that its mere presence does not guarantee its availability as its absorption depends on the presence of vitamin D, oxalic and phytic acid (White and Broadly, 2005).

4.3.4 Phytochemical compounds

Results in Table 13 represent the effect of drying method on phytochemical compounds of *Benincasa hispida* fruit. There was a significant difference ($p<0.05$) in phytochemical compounds such as alkaloids, cardiac glycoside, cynogenic glycoside and phenol between fresh and dried samples with exception of flavonoid. However, solar and sun drying methods had no significant effect ($p<0.05$) on all the phytochemical compounds studied except phenols.

It was observed that, flavonoids compound was not significantly affected ($p<0.05$) by the drying methods. Flavonoids content is very useful in the body as it possess anti-inflammatory, antioxidant, antiallergic, hepatoprotective, anti-thrombic, antiviral and anti-carcinogenic activity (Middleton *et al*., 2000; Mithraja *et al.,* 2012). Flavonoids, on the other hand, are water soluble antioxidants and free radical scavengers, which prevent oxidative cell damage and have strong anticancer activity (Havsten, 2012; Johnson *et al*., 2012).

The results of the present study show that fresh samples had lower alkaloids content (1.0 mg/100g) compared to dried samples (4.5 mg/100g). These observations are similar to the findings reported by Beier (1990) who observed that exposure of potatoes to light in the field or market place led to increased synthesis of the alkaloids. Similarly, Irondi *et al.* (2013) reported that sun drying was necessary to ensure that non-volatile alkaloids were retained within dried pawpaw seeds. Alkaloids are the most efficient therapeutic plant substances. Plant-derived alkaloids have such clinical uses as anticancer agents, gout

suppressant, muscle relaxant, antiarrythmic, antibiotic, and sedative agents (Facchini, 2001). Sharma *et al.* (2012) also reported that alkaloids are preventive or therapeutic agents against human free radical associated diseases.

Table 13: Effect of drying method on phytochemical compounds of *Benincasa hispida* fruit (DMB)

	mg/100g				
Drying method	**Alkaloids**	**Car. gly**	**Cyn. Gly**	**Flavonoid**	**Phenol**
Fresh	1.0±0.3[a]	0.7±0.2[a]	1.3±0.3[b]	68.3±1.9[a]	78.4±6.3[c]
Solar drying	4.5±0.6[b]	0.9±0.1[b]	0.2±0.2[a]	67.3±3.6[a]	37.6±12.3[b]
Sun drying	4.5±0.4[b]	1.0±0.0[b]	0.3±0.2[a]	67.7±2.2[a]	24.3±4.0[a]

Data presented as arithmetic means ± SD

Means in column with different superscript letters are significantly different at $p<0.05$ based on Turkey Test

Key : Car. Gly = Cardiac glycoside, Cyn. Gly=Cynogenic glycoside

The results of the present study showed that, solar and sun drying methods had a significant difference ($p< 0.05$) on phenol content. After the drying process, the total phenolic content of *Benincasa hispida* fruit decreased significantly from 78.4 mg/100g to 24.3 mg/100g and 37.6 mg/100g for solar and sun dried samples respectively. Similar observations were reported by Orak *et al*. (2011) in strawberry fruits. Mongi (2013) reported that the phenolic content of fresh samples was higher than dried samples for various fruits and vegetables. High temperatures in solar dryer lead to oxidation of bioactive compounds that are associated with antioxidant capacity (Irondi *et al.,* 2013). Reduction in total phenol levels resulting from sun drying could be attributed to enzymatic degradation due to the longer period it took (3-6 days) to dry at open sun drying (Chan *et al.,* 2009). Phenols are very important plant constituents because of their hydroxyl groups and may contribute directly to antioxidative action (Nadhiya and Vijayalakshmi, 2014). According to Merinal and Stela (2012) phenolics have

antioxidative, antidiabetic, anticarcinogenic, antimicrobial, antiallergic, antimutagenic and antiinflammatory activities.

Effect of drying methods on cardiac glycocide in *Benincasa hispida* fruit is shown in Table 13. After drying cardiac glycoside content increased significantly ($p<0.05$) ranging from 0.7 mg/100g in fresh sample to 1.0 mg/100g sun dried sample. Glycosides have beneficial effect in reducing inflammation, protecting against endotoxemia and may be used in cardiac treatment of congestive heart failure since glycosides possess such properties (Sood *et al*., 2012).

Results of present study in Table 13 show the effect of drying methods on cynogenic glycoside. The results showed that cynogenic glycoside decreased significantly ($p< 0.05$) from 1.3 mg/100g in fresh sample to 0.2 mg/100g in solar dried sample. According to Agbor-Egbe and Lape (2006) cyanogenic glycosides account for approximately 90 % of the wider group of plant toxins known as cyanogens which have key characteristic of formation of free hydrogen cyanide and symptoms of this acute cyanide poisoning include rapid respiration, drop in blood pressure, rapid pulse, headache, dizziness, vomiting, diarrhea and mental confusion. Therefore, the results of the present study suggest that farmers should be encouraged preserve *Benincasa hispida* fruits by drying methods since the level of cynogenic glycoside is reduced.

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

The effect of drying methods on each variety of *Benincasa hispida* fruit in nutrient content is shown in Table 14. There was significant difference ($p < 0.05$) 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 ($p < 0.05$) between sun and solar dying methods in all varieties with exception of crude protein. Drying methods (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 (Damodaran, 2008). The findings of this study agree with those reported by Mongi (2013) 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 14 also showed that drying methods (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.* (2014) who observed significant variation in mineral content with drying methods in fruits.

Table 14*:* Effect of drying methods on each variety of *Benincasa hispida* fruit in nutrient content (DMB)

		g/100g	mg/100g			
Variety	**Treatment**	**CP**	**Niacin**	**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}
	Sun 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}
	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±13.70^{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}
	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

Means in column with different superscript letters are significantly different at $p<0.05$ based on Turkey Test

Key: CP = Crude Protein, Ca= Calcium, Fe = Iron, K = Potassium

4.4 Sensory Evaluation

4.4.1 *chinchin*

The mean hedonic scores for the *chinchin* products from sun and solar dried flour of the "*Maule"* variety are shown in Table 11. 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 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

Table 15: 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±1.31[b]	7.38±1.03[b]	6.01±1,45[a]	6.59±1.42[b]	6.81±1.24[b]
Sun dried *chinchin*	5.84±1.58[a]	6.01±1.63[a]	5.91±1.67[a]	5.94±1.61[a]	6.07±1.32[a]

Data presented as arithmetic means ± SD

Means in column with different superscript letters are significantly different at $p<0.05$ based on t- Test

Plate 2: *Chinchin* products packed

4.4.2 Porridge

Table 16 shows the mean hedonic scores for the porridge made from solar and sun dried flour of the *Maule* variety. There was no significant difference ($p<0.05$) in all attributes except colour between porridge from sun and solar dried flour. Mean hedonic scores for colour of sun dried porridge was significantly lower ($p<0.05$) (5.02) than that of solar dried porridge (6.81). The lower scores for colour of the porridge from 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 (2009) 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 (Igbabul *et al*., 2014). 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 sun drying and could be recommended for drying *Benincasa hispida* fruits for large scale processing.

Table 16: 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±1.42[a]	6.81±1.46[b]	5.90±1.61[a]	6.20±1.51[a]	6.18±1.48[a]
Sun dried porridge	5.94±1.51[a]	5.02±1.53[a]	5.51±2.02[a]	5.80±1.61[a]	5.74±1.75[a]

Data presented as arithmetic means ± SD

Means in column with different superscript letters are significantly different at $p<0.05$ based on t- Test.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The findings of this study have shown that most of the farmers in Dodoma region were not aware that *Benincasa hispida* fruit could be preserved by drying methods. Also, most farmers are not aware of other uses of *Benincasa hispida* fruits, like medicine, fertilizer and feed for animals, apart from food for human consumption. Laboratory studies revealed that both drying methods (sun and solar) significantly reduced ($p<0.05$) some of nutrients and phytochemicals. The nutrients and phytochemical compounds that were significantly reduced ($p<0.05$) include protein, vitamin C, calcium, cynogenic glycoside and phenol. However, fibre, fat, carbohydrate, potassium, alkaloids, cardiac glycoside increased with drying methods. Drying method, tend to increase synthesis of alkaloids which are the most efficient therapeutic plant substance, while reduce the level of cynogenic glycoside which account for approximately 90% of the wider group of plant toxins. Also results of this study showed that the drying methods did not cause total loss of any nutrient hence, farmers should be encouraged to dry *Benincasa hispida* in order to distribute its availability throughout the year and also to reduce post-harvest losses. Sensory evaluation results showed that the products (*chinchin* and porridge) from sun and solar dried flour were generally accepted by panelists suggesting that it is possible to develop other value added food products from flour of dried *Benincasa hispida* fruits.

5.2 Recommendations

The results of this study showed that *Benincasa hispida* fruits could be preserved successfully by drying hence, there is a need to try other improved drying methods such as air drying, freeze drying and oven drying to produce more quality products.

To improve nutritional status of the rural people, the use of dried *Benincasa hispida* fruit especially in Dodoma (semi-arid) could be a substitute when the fresh forms are unavailable. Government, Non-Government Organisation and research Institutions should find a way of promoting consumption of dried fruit products and vegetables especially during the off-season period.

The products that have been developed using flour derived from dried *Benincasa hispida* fruits were generally accepted by panelists because all the scores were above average which is 4.5. However, some improvement is needed especially on colour attribute so as to make them more attractive to panelists. Also, farmers should be encouraged to produce and consume more *Benincasa hispida* fruit as well as to preserve and develop other value added products from *Benincasa hispida* fruits for diversification.

During survey, a lot of varieties of *Benincasa hispida* were observed. However, this study focused on only three varieties therefore, there is a need to conduct more research on the remaining varieties. It was observed that most farmers use *Benincasa hispida* seeds to extract oil and use it. Therefore, more research on the characterization of *Benincasa hispida* seed oil need to be done so as to establish suitability of the oil for human consumption. More research on chemical analysis of *Benincasa hispida* leaves is necessary to explore their composition. Green leafy vegetables are good source of minerals like iron and vitamin C, so farmers should be encouraged to increase consumption of the *Benincasa hispida* leaves in order to solve the problem of anemia.

REFERENCES

Adejumo, B. A. (2012). *The Effect of Pretreatment and Drying On Some Vitamin Contents of Tomato Powder.* Department of Agricultural and Bioresources Engineering, Federal University of Technology, Minna, Nigeria. [www.Afst.Valahia.Ro/Docs/Issues/.../S01_W06_Full.Pdf] site visited on 12/04/2015.

Agbor-Egbe, T. and Lape, M. I. (2006). The effects of processing techniques in reducing cyanogen levels during the production of some Cameroonian cassava foods. *Journal of Food Composition and Analysis* 19: 354-363.

Agoreyo, B. O., Akpiroroh, O., Orukpe, O. A., Osaweren, O. A. and Owabor, C. N.(2011). The Effects of various drying methods on the nutritional composition of *Musa paradisiaca*, *Dioscorea rotundata* and *Colocasia esculenta*. *Asian Journal of Biochemistry* 6: 458-464.

.

Alaa, F. H. Muneer, A. A. and Abd-almutalb, B. A. (2010). *Spectrophotometric Determination of Thiamine. HCl in Pharmaceutical Preparations using Prussian blue reaction.* Department of Chemistry, Science College, Karbala University.

Al-Juamily, K.E.J., Khalifa, A.J.N. and Yaseen, T.A. (2007). Testing of the of fruits and vegetables solar drying system performancein Iraq. *Journal of Desalination* 209: 163-170.

Al-Snaf, A. E. (2013). The pharmacological importance of *Benincasa hispida*. *International Journal of Pharma Sciences and Research* 4(12): 112-128

AOAC (1995). *Official Methods of Analysis. Association of Official Analytical Chemists.* 16th edition, Washington, D.C.

AOAC (2000). *Official Methods of Analysis, Association of Official Analytical Chemists.* 17th edition, Washington, D.C.

Ashish, S and Siddhant, R. (2012). Phytochemical investigation and evaluation of free radical scavenging potential of *Benincasa hispida* peel extracts. *International Journal of Current Pharmaceutical Review and Research* 3(3): 43-46.

Bailey, K. D. (1994). *Methods of Social Research.* Free Press, Toronto. 588pp.

Bala, B. K. and Janjai, S. (2009). Solar drying of fruits, vegetables, spices, medicinal plants and fish developments and potentials. *In: International Solar Food Processing Conference*. Held 21st March 2009, London.

Beier, R.C. (1990). Natural pesticides and bioactive components in foods. *Review of Environmental Contaminant and Toxicology* 113:47-137.

Burgeois, C., Cervantes-Laurean, D. and Moss, J. (2006). Niacin. In: *Modern Nutrition in Health and Disease* (Edited by Shils, M. E. and Shike, M.) 10th ed. Lippincott, Williams and Wilkins. Philadelphia 442 - 487.

Chan, E.W.C., Lim, Y.Y., Wong, S.K., Lim, K. K., Tan, S.P., Lianto, F.S.and Yong, M.Y. (2009). Effects of different drying methods on the antioxidant properties of leaves and tea of ginger species. *Food Chemistry*113:166-172.

Chang, C. S., Nurul, A. Mohd, Z. Farooq, A. Azizah, A. and Nazamid, S. (2010). Nutritional composition and oil fatty acids of Kundur [*Benincasa hispida* (Thunb.) Cogn.] seed. *Pakistan Journal of Botany* 42(5): 3247-3255.

Chidan, M., Kumar, C. S., Mythily, R. and Chandraju, S. (2012). Extraction and mass characterization of sugars from ash gourd peels (*Benincasa Hispida*). *Rasayan Journal of Chemistry* 5(3): 280-285.

Choi, H.Y., Park, Y.K., Kim, Y.H., Yoon, G.B., Noh, Y.G., Lee, E.S., Heo, H.R., Park, J.K., Han, S.M. and Kang, R.S. (2001). *Denguibogam*. Yeogang Press, Seoul. pp. 374-380.

Christensen, L.P. and Peacock, W.L. (2000). The raisin drying process. Effects of variety, fruit maturity, cultural practices, and drying temperatures on raisin sugaring. Raisin Research Reports.[http://www.pubmedcentral.nih.gov/articlerender] site visited on 17/03/2014.

Coultate, T.P. (2009). *Food: The Chemistry of its Components.* 5th Edition, Royal Society of Chemistry. pp 99.

Damodaran, S. (2008). Amino Acids, Peptides and Proteins. In: *Fennema's Food Chemistry*, (Edited by Damodaran S. Parkin K. L. & Fennema O.R.). 4th ed. CRC Press Taylor & Francis Group, Boca Raton, Florida, USA. p.1144

Danso-Boating, E. (2013). Effect of drying methods on nutrient quality of basil (Ocimum viride) leaves Cultivated in Ghana. *International Food Research Journal* 20(4): 1569-1573.

Dirk, E. M. and Fred, W. B. (2002). *Grain Drying System*, Illinois, USA. [www.uwex.edu/energy/pubs/graindryingsystem_GEAPS2002pdf] site visited on 02/08/2015.

Elegbede, J. A. (1998). Legumes: Nutritional quality of plant foods. *Nigeriaa Journal of Food Science* 1: 55.

Elizabeth, L. and Judy, A. H. (1999). So Easy to Preserve. Cooperative Extension Service, University of Georgia. Athens, Georgia. [http://extension.usu.edu/files/foodpubs/cangui0.pdf] site visited on 12/5/2014.

El-Olemy, M. M., Al-Muhtadi, F. J. and Afifi, A. A. (1994). Experimental Phytochemistry. A Laboratory Manual. Saudi Arabia: King Saud University Press Riyadh, pp.3-137.

Facchini, P. J. (2001). Alkaloid biosynthesis in plants: Biochemistry, cell biology, molecular regulation, and metabolic engineering applications. *Annual Review of Plant Physiology and Plant Molecular Biology* 52: 29–66.

Fadhel, A., Kooli, S., Farhat, A. and Bellghith, A. (2005). Study of the solar drying of grapes by three different processes. *Journal of Food Science and Technology* 34(3): 223-224.

Fatariah, Z., Zulkhairuazha, T. Y. and Wan Rosli, W. (2015). Ascorbic acid quantification in *Benincasa hispida* fruit extracted using different solvents. *International Food Research Journal* 22(1): 208-212.

Geeta, K. (2010). Standardization and Characterization of Value Added Ash Gourd (*Benincasa hispida*) Ready-To-Serve Beverage. Dissertation for Award of Msc Degree at University of Agricultural Sciences, Dharwad, India, 61pp.

Genskow, L.R., Beimesch, W.E., Hecht, J.P., Kemp, I.C., Langrish, T., Schwartzbach, C. and Smith, F. L. (2007). *Chemical Engineers' Handbook*. Mc Graw Hill, New York. 374 pp.

George, F. M. (2006). *Vitamins in Foods: Analysis, Bioavailability and Stability*. Taylor and Francis Group, USA. 785pp

George, T. E. (2008). Ash gourd: High Nutritional. [www.old.kerala.gov.in/keralacal_sept08/pg37.pdf] site visited on 15/06/2014.

Ghosh, K. and Baghel, M. S. (2011). A pharmacognostical and physiochemical study of *Benicasa hispida* with ayurvedic review. *International Journalof Research in Ayurveda and Pharmacy* 2 (6): 1664-1668.

Gill, N. S., Dhiman, K., Bajwa, J., Sharma, P. and Sood, S. (2010). Evaluation of free radical scavenging, antiimflammatory and analgesic potential of *Benincasa hispida* seed extract. *International Journal of Pharmacology* 6: 652-657.

Glenn, D. I. (2009). Determination of Sample, University of Florida. [http://edis.ifas.ufl.edu/pdffiles/pd/pd00600.pdf] site visited on 23/ 7/2014.

Grover, J.K., Rathi, S.S. and Vats, V. (2000). Preliminary study of fresh juice of *Benincasa hispida* on morphine addiction in mice. *Fitoterapia* 71: 707-709.

Grover, J.K., Adiga, G., Vats, V. and Rathi, S.S. (2001). Extracts of *Benincasa hispida* prevent development of experimental ulcers. *Journal of Ethnopharmacology* 78:159-164.

Gupta, H. and Premavalli, K. (2010). Effect of ash gourd (*Benincasa hispida*) and radish (*Raphanus sativus*) fibres. *International Journal of Food Science and Nutrition* 61(1):18-28.

Hassan, S.W., Umar, R.A., Maishanu, H.M., Matazu, I.K., Faruk, U.Z. and Sani, A.A. (2007). The effect of drying method on the nutrients and non-nutrients composition of leaves of *Gynandropsis gynandra* (*Capparaceae*). *Asian Journal Biochemistry* 2: 349-353.

Havsteen, B.H. (2012). The biochemistry and medical significance of flavonoids. *Pharmacol Therapeutics* 96: 67-202.

Hossain, M.E., Alam, M. J, Hakim, M. A., Amanullah, A.S.M. and Ahsanullah, A.S.M. (2010). An assessment of physico-chemical properties of some tomato genotypes and varieties grown at Rangpur. *Bangladesh Research Publication Journal* 4(3): 135-243.

Hui, Y.H., Ju, K.T., Tim, C.T., Ying, and Chen, K.C. (2004). Antioxidant and angiotension-converting enzyme inhibition capacities of various parts of *Benincasa hispida* (wax gourd). *Nahrung/Food*, 3: 230-233.

Idah, P.A., Musa, J.J. and Olaleye, S.T. (2010). Effect of temperature and drying time on some nutritional quality parameters of dried tomatoes. *African Journal of Technology* 14(1): 25-32.

Ife, F. J. and Bas, K. (2003). Preservation of Fruits and Vegetables, Agromisa Foundation, Wageningen. [http://www.solarfood.org/solarfood/pages/solarfood2009/3] site visited on 11/12/2014.

Ifon, E. T., Bassir, O. and Latunde-Dada, G. O. (2009). The nutritive value of some Nigeria leafy vegetables. Part 1, Vitamin and mineral content. *Food Chemistry* 3: 267-350.

Igbabul, B. D., Amove, J. and Okoh, A. (2014). Quality evaluation of composite bread produced from wheat, defatted soy and banana flours. *International Journal of Nutrition and Food Science* 3(5): 471-476.

Irondi, A.E., Anokam, K.K. and Ndidi, U.S. (2013). Effect of drying methods on the phytochemicals composition and antioxidant activities of *Carica papaya* seed. *International Journal of Biosciences* 3(11): 154-163.

Isack, M. E. and Lyimo, M. (2013). Post-harvest handling practices on physico-chemical composition of tomato. *International Journal of Vegetable* 22(54):

ITDG (2004). Solar drying. Intermediate technology development group. [http://www.itdg.org] site visited on 02/08/2014.

Johnson, M. A., Aparna, J. S., Jeeva, S., Sukumaran, S. and Anantham, B. (2012). Preliminary phytochemical studies on the methanolic flower extracts of some selected medicinal plants from India. *Asian Pac J. Trop Biomed* 2:579-582.

Jokic, S., Velic, D., Bilic, C., Lukinac, J., Planinic, M. and Bucic-Kojic, A. (2009). Influence of process parameter and pre-treatments on quality and drying kinetics of apple samples Czechoslovakia. *Journal of Food Science* 27: 88-94.

Kiremire, B. T., Musingusi, E., Kikafunda, J.K. and Lukwago, F. B. (2010). Effect of vegetable drying techniques on nutrient content: A case study of South-Western Uganda. *African Journal of Food Agriculture Nutrition and Development.* [www.ajfand.net/Volume10/No5/Kiremire3180.pdf] site visited on 04/05/2015.

Kolawole, O.M., Ayiboye, A.E., Aturu, E.E. and Anibijuwun, I.I. (2011). Effect of solar drying on the proximate and microbial composition of *Abelmoschus esculentus*. *Journal of Microbial Biotechnology* 1: 71 – 81.

Krokida, M., Maroulis, Z. B. and Saravacos, G. D. (2001). The effect of method of drying on colour of dehydrated product. *International Journal of Food Science and Technology* 36: 53-59.

Kujala, T. S., Loponen, J. M., Klika, K. D. and Pihlaja, K. (2000). Phenolics and betacyaninsin red beetroot (*Beta vulgaris*) root: distribution and effect of cold storage on the content of total phenolics and three individual compounds. *Journal of Agricultural Food Chemistry* 48: 5338-5342.

Kumar, A. and Bhardwaj, A. (2012). Comparative, qualitative and quantitative chemotypic characterization among North Indian *Tribulus Terrstris*. *International Research Journal of Pharmacy* 3(6).

Ladan, M.J., Abubakar, M.G. and Lawal, M. (1997). Effect of solar drying on the nutrient composition of tomatoes. *Nigeria Journal of Renewable Energy* 5: 67-69.

Lawless, T.H. and Heyman, H. (2010). *Sensory Evaluation of Food. Principles and Practices*, Second edition. Springer Science + Business media, LLC, Spring Street, New York. 233pp.

Lee, KH., Choi, H.R. and Kim, C. H. (2005). Anti-angiogenic effect of the seed extract of *Benincasa hispida* Cogniaux. *Journal of Ethnopharmacol* 97:509-513

Lowor S. T. and Agyente-Badu, C. K. (2009). Mineral and proximate composition of cashew Apple (*Anarcadium occidentale L*.) from Northen Savannah, forest and Coastal Savannah regions in Ghana. *American Journal of Food Technology* 4(4): 154-161.

Lydia (2012). The role of minerals in the body. [http://divinehealthfromtheinsideout.com/2012/05/the-role-of-minerals-in-the-body/] site visited on 11/12/2015.

Marr, K. L., Xia, Y. and Bhattaria, N. (2007). Allozymic, morphological, phonological, linguistic plant use and nutritional data of *Benincasa hispida* (Cucurbitacaea). *Economic Botany* 61(1): 44-59.

Mathad, V.S.B., S. Chandanam, S.R.T. Setty, D. Ramaiyan, B., Veerannaand, A. and Lakshminarayanasettry, V. (2005). Antidiarrhoeal evaluation of *Benincasa hispida* (Thunb.) Cogn. Fruit extract. *Iranian Journal of Pharmacology Therapeutics* 4(1): 24-27.

Mehdizadeh, Z. and Zomorodian, A. (2009). A study of the effect of solar drying system on rice quality. *Journal of Agricultural Science Technology* 11:527-537.

Merinal, S. and Stella, V. G. (2012). In Vitroantioxidant Activity and total phenolic content of leaf extracts of *Limonia crenulata* (Roxb). *Journal of Natiinal Production Plant Resource* 2:209-214.

Middleton, E., Kandaswami, C. and Theoharides, T. C. (2000). The effect of plant flavonoids on mammalian cells; Implications for inflammation, heart disease and cancer. *Pharmcology Review* 52(4): 673-751.

Mithraja, M. J., Irudayaraj, V., Kiruba, S. and Jeeva, S. (2012). Antibacterial efficacy of *Drynaria quercifolia* (L.)(Polypodiaceae) against clinically isolated urinary tract pathogens. *Asian Pac J. Trop Biomed.* 2:1-5.

Mnkeni, A.P., Soundy, P. and Brutsch, M.O. (2004). Solar drying of fruit and vegetables. *Journal of food Engineering* 5 (12): 65-68.

Mong, R., Ndabikunze, B., Tiisekwa, B.,. and Tiisekwa, A. (2011). Solar Drying of Fruits Vegetables Training Manual; principles, GMPs/GHPs and HACCP plan development.

Mongi, R. J. (2013). Solar Drying of Fruits and Vegetable Studies on Dryers Thermal Performance Quality and Shelflife of Dried Mango, Banana, Pineapple and Tomato. Thesis for Award of PhD Degree at Sokoine University of Agriculture, Morogoro, Tanzania. 241pp.

Morris, A., A. Barnett and Burrows, O. (2004). Effect of processing on nutrient content of foods. *Cajarticles* 37: 160-164.

Mrosso, L. (2005). Grapes production and management.In: Monitoring and evaluation report. Ministry of Agriculture, Food Security and Cooperatives. Dodoma, Tanzania. pp.23-24.

Nadhiya, K.and Vijayalakshmi, K. (2014). Evaluation of total phenol, flavonoid contents and *Invitro* antioxidant activity of *Benincasa hispida* fruit extracts. *International Journal of Pharmaceutical, Chemical and Biological Sciences* 4(2):332-338.

Nimbal, S.K., Venkatrao, N., Ladde, S. and Pujar, B. (2011). Anxiolytic evaluation of *Benincasa hispida* (Thunb) Cogn. fruit extracts. *International Journal of Pharmacy and Pharmaceutical Science Research* 1 (3): 93-97.

Nurit, E., Axel, T., Kevin, V., Pixley, Y. and Natalia, P. (2009). Reliable and inexpensive colorimetric method for determining protein-bound tryptophan in Maize kernels [www.ira.cinvestav.mx/LinkClick.aspx?fileticket] site visited on 12/04/2014.

Oguche, H. E. (2011). Effect of drying methods on chemical composition of spinach "*Aieifo*" (*Amaranthus aquatica*) and pumkin leaf (*Telfairia occidentalis*) and their soup meals. *Pakistan Journal of Nutrition* 10(11): 1061-1065.

Okoli, J. N. (2009). *Basic nutrition and diet therapy*. University of Nigeria press Ltd, Nigeria. 74pp.

Omalara, O. O. and Samuel, A. I. (2007). Extractability of *Thevetia peruviana* glycosides with alcohol mixture. *African Journal of Biotechnology* 6 (18): 2166-2170.

Omojola, A. and Olusola, O.I. (2009). Effect of drying on the qualities of some selected vegetables. *International Journal of Engineering and Technology*1 (5): 409-414.

Orak, H., Türkan, A, Hülya, Y., Selen, I., Neslihan, E., Fusun, H. S. and Namik, K. (2011). Antioxidant activity, some nutritional and colour properties of vacuum dried strawberry tree (*Arbutus Unedo* L.) fruit. *Acta Scientiarum Polonorum Alimentary* 10(3):327-338.

Pangavhane, D.R. (2002). Review of research and development work on solar driers for grape drying. *Journal of Energy Conservation Management* 43: 45-61.

Parshant, B., Bharat, B., Wali, V. K., Manish, B., Akash, S. and Deep, J. (2013). Standardization of drying method and organoleptic evaluation of wild pomegranate (Anardane) seeds. *Wild Journal of Agricultural Science* 9(5): 397-400.

Patel, R. K., Patel, S. B. and Shah, J. G. (2012). Acute and subacute oral toxicity evaluation of *Benincasa hispida* extract in rodents. *Journal of Applied Pharmaceutical Science* 02 (08): 250-253. [http://www.japsonline.com] site visited on 10/09/2014.

Rachch, M. A. and Jain, S.M. (2008). Gastroprotective effect of *Benincasa hispida* fruit extract. *Indian Journal of Pharmacology*. 40:271–275.

Reyees, B., Dorcus, M. and Chitra, S. (2013). Nutritional composition and oil fatty acids of Indian winter Melon *Benincasa hispida* (Thumb.) seeds. *International Food Research Journal* 20 (3): 1151-1155.

Rossello C., Berna A. and Mulet A. (2000). Solar drying of fruits in a mediterranean climate. *Drying Technology*. 8 (2):305 – 321.

Sagar, V.R. and Kumar, S.P. (2010). Recent advances in drying and dehydration of fruits and vegetables. *Journal of Food Science and Technology* 47(1): 15-26.

Senem, S., Canan, E., Bige, I., Glusah, O. and Omer, U. (2014). Impact of drying methods on physicochemical and sensory properties of *Apricort pestil*. *Indian Journal of Traditional Knowledge* 13 (1): 47-55.

Sharma, A., Chen, C. R. and Nguyen, V. L. (2008). Solar-energy drying system. *A renewable and Sustainable Energy Review* 13: 1185-1210.

Sharma, G. C., Sharma, A., Singh, S.K., Tonpay, S.D. (2012). Ethanomedicinal trends in Indian tradition for treatment of *vitiligo*. *Journal of Medicinal Plants Research* 6(10): 1827-1833.

Sharma, R. K., Singh, R., Jha, K. K. and Abhishek, B. (2014). Antibacterial and antioxidant activity of *Benincasa hispida* using hydrogen peroxide scavenging model. *Indian Journal of Pharmaceutical and Biological Research* 2 (1): 86-94.

Shiva, M., Mohamed, S., Manoochehr, H., Yaghoub, A. and Seyed, S. (2007). Antioxidant power of Iranian propolis extract. *Food Chemistry* 103:729-733.

Soladoye, M. O. and Chukwuma, E. C. (2012). Quantutative phytochemical profile of leaves of *Cissus populnea* Guill. and Perr. (Vitaceae) – an important plant in central Nigeria. *Archives of Applied Science Research* 4 (1): 200-206.

Sood, A., Kaur, P. and Gupta, R. (2012). Phytochemical screening and antimicrobial assay of various seeds extract of *Cucurbitaceae* family. *International Journal of Applied Biological, Pharmacology Technology* 3(3): 401-409.

Tee, E. and Khor, S. (1996). Simultenous Determination of B-vitamins and Ascorbic Acid in Multi-vitamin Preparations by Reverse-phase HPLC. Division of Human Nutrition, Institute of Medical Research, Kuala Lumpur.

Ukegbu, P. O. and Okereke, C. J. (2013). Effect of solar and sun drying methods of the nutrient composition and microbial load in selected vegetables, African spinach (*Amaranthus hybridus*), fluted pumpkin (*Telferia occidentalis*), and Okra (*Hibiscus esculentus*), *Sky Journal of Food Science Vol.* 2(5): 35 – 40.

USDA (2014). National Nutritional Database for Standard Reference.US Department of Agriculture, Agriculture Research Services. Nutrient Data Laboratory. [http://ndb.nal.usda.gov/ndb/foods/show/3295?fgcd] site visited on 3/07/2014.

Visavale, G. L. (2012). Principles, Classification and Selection of Solar Dryers. In: *Solar dryin: Fundamentals, Applications and Innovations*. (Edited by Hii, C.L., Ong, S.P., Jangam, S.V. and Mujumdar, A.S.), Computational Fluid Dynamics Division, Centre for Computational Technologies Pvt. Ltd, Singapore. pp. 1-50.

Vrushabendra, S. B. M., Sridhar C., Sreeniva, R. T. S., Dhanapal, R., Balamuralidhar, V. and Ashoka, B. V. L. (2005). Antidiarrheal evaluation of *Benincasa hispida* (Thumb.) Congn. fruit extracts. *Iranian Journal of Pharmacology and Therapeutics* 4:24-27.

Wardlaw, M. G. and Kessel, W. M. (2002). *Perspectives in Nutrition.* Mc. Graw Hill, New York. 822pp.

White, P. J. and Broadley, M. R. (2005). Bio- fortifying crops with essential mineral elements. *Trends Plant Science* 10: 586–593.

Zaini, N. A. M., Anwar, F., Hamid, A. A. and Saari, N. (2011). Kundur [*Benincasa hispida* (Thunb.) Cogn.]: A potential source for valuable nutrients and functional foods. *Food Research International* 44(7): 2368–23.

APPENDACES

Appendix 1: Questionnaire

Questionnaire to elicit information on availability and utility of *Benincasa hispida* among selected farmers

I General information

	Questionnaire number	
1.	District	
2.	Village	
3.	Name of the respondent:	
4.	Age of the respondent :	
5.	Relationship with Household Head:	1. HH Head ( ) 2. Wife ( ) 3. Son ( ) 4. Daughter ( ) 5. Other relation ( ) Specify …….
6.	Sex	1. Male ( ) b. Female ( )

II Specific information

1. Do you know *Benincasa hispida*? Yes/No
2. If yes, do you cultivate it? Yes/No
3. If yes, how many acres?
   1. 1-5
   2. 6-10
   3. 10-15
   4. 0ther, specify……

5. How many varieties of *Benincasa hispida* available in Dodoma?

1. 1-5
2. 6-10
3. 11-15
4. 16-20
5. More than 20

6. a) Do they have different names for each variety available in Dodoma? Yes/No

b) If yes mention them

…….

…….

…….

7. a) Are these varieties available on the same season? Yes/No

b) If yes, in which season?

1. December-February
2. March-May
3. June-August
4. September-November

c) If no, Describe

..……

……

……

……

……

5. Do you use *Benincasa hispida* as food? Yes/No

6. If yes,

1. Matured
2. Immature
3. both

4. Do you use both fruits and leaves of *Benincasa hispida?*

1. Fruit only
2. Leaves only
3. Both fruit and leaves
4. Others

5. Do you use all available varieties found in Dodoma? Yes/No

6. If no, how many varieties do you use?

1. 1-4
2. 4-8
3. 9-12
4. Others, Specify …….

5. Which group of people use most the available *Benincasa hispida* fruit

1. 1-10years
2. 11-20years
3. 21-30years
4. Others, Specify……..

6. Which varieties are good for which group of people?

……

……

……

……

13. Which group of people uses most the *Benincasa hispida* leaves?

1. 1-10years
2. 11-20years
3. 21-30years
4. Others, specify……

5. Frequency of consumption of *Benincasa hispida* fruits

1. Daily
2. Weekly
3. Monthly
4. Others, specify…….

5. Frequency of consumption of *Benincasa hispida* leaves

1. Daily
2. Weekly
3. Monthly
4. Others, specify……..

16. How do you prepare *Benincasa hispida* fruits for consumption?

……

……

……

……

17. How do you prepare *Benincasa hispida* leaves for consumption?

……

……

……

……

18. Do you utilize other parts of *Benincasa hispida*? Yes/No

19. .If yes,

1. Seed
2. Pith
3. Peel
4. Other, specify …….

20. a)Do you preserve the *Benincasa hispida* fruits? Yes/ No

b). If yes. How?

1. Drying methods only
2. Boiling method only
3. Fermentation method only
4. Others. Specify…….

21.a) Do you preserve the *Benincasa hispida leaves* ? Yes/ No

b). If yes. How?

1. Drying methods only
2. Boiling method only
3. Fermentation method only
4. Others. Specify…….

22. a) Can all available varieties can be preserved? Yes/ No

b)If no, how many varieties are good for preservation

1. 1-10
2. 11-20
3. 21-30
4. Above 30

23 .a)Are there any other uses *Benincasa hispida* of apart from food for human consumption?

1. Feed of animals
2. Medicine
3. Other. Specify ……..

b) Which part of *Benincasa hispida* is used for medicine?

1.Seeds only

2.Fruit only

3.Leaves only

4.Both

5.Others. Specify……

24. a) Do all available varieties used as medicine? Yes/No

b) If no, mention the used varieties

1. 1-10
2. 11-20
3. 21-30
4. Above 30

25. Which ill complaint can be cured by *Benincasa hispida?*

1. gastrointestinal problems,
2. respiratory disease,
3. heart diseases,
4. diabetes mellitus and
5. urinary diseases
6. both
7. Others. Specify ……

Appendix 2: Sensory Evaluation form

Sensory Evaluation Form

Panelist no**.**……..Sex……..

Time ……. Date……..

Age group (a) 10-20 yrs (b)21-30 yrs (c)31-40 yrs (d)above 40yrs

Education level (a) Bachelor degree (b) Master's degree (c) other specify……

Please look and taste each of the (2) coded samples. Indicate how much you like or dislike each sample by checking the appropriate sample attribute and indicate your preference (1-9) in the column against each attribute. Put the appropriate number against each attribute.

9 – Like extremely

8 – Like very much

7- Like moderately

6- Like

5- Neither like nor dislike

4- Dislike

3- Dislike moderately

2- Dislike very much

1- Dislike extremely

Table of attributes of the products

Attributes	Sample	Sample
Appearance/ colour		
Taste		
Aroma		
Texture		
General acceptability		

Comments

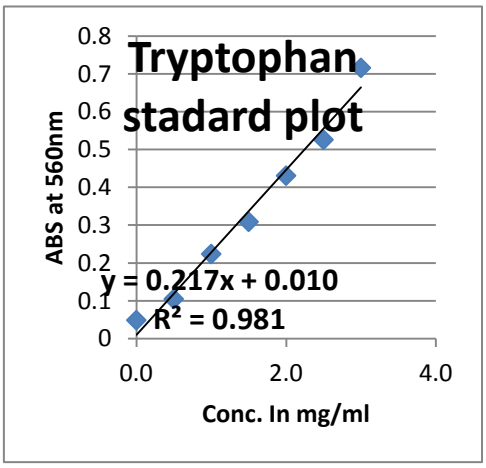
……

……

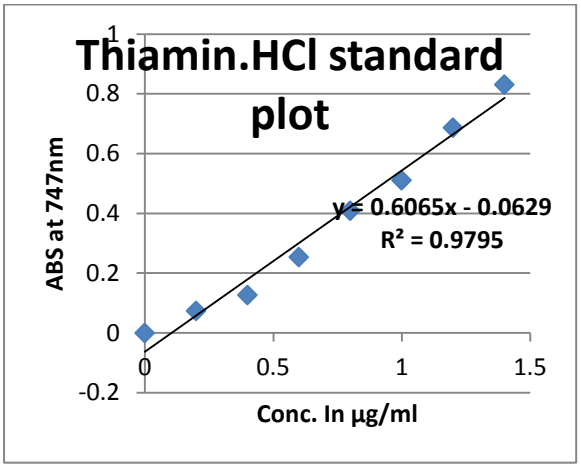
……

……

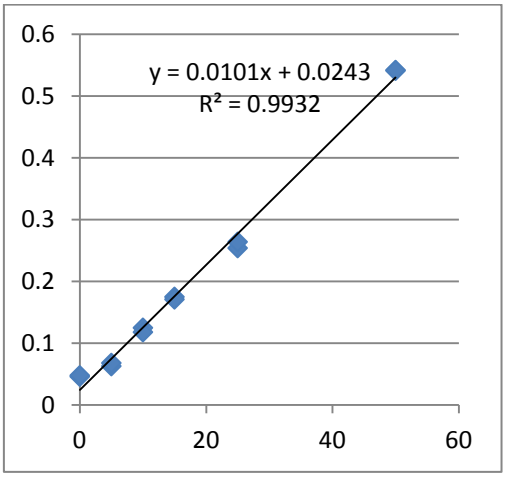
Appendix 3: Various Standard Plots Used in Calculation



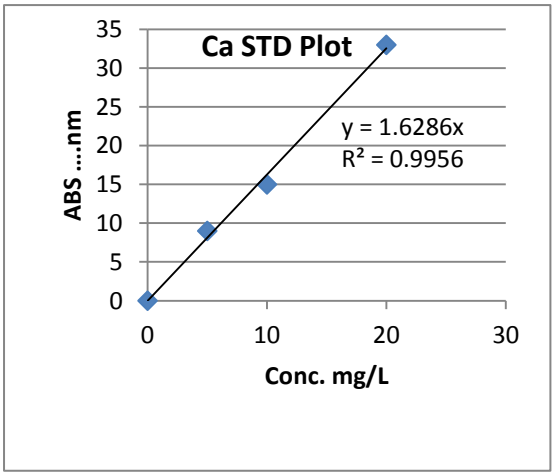
Standard plot for Niacin



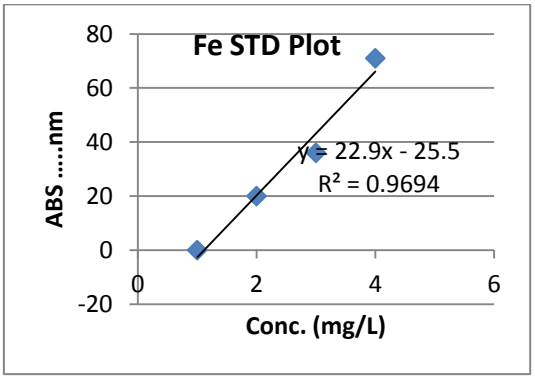
Standard plot for Thiamine



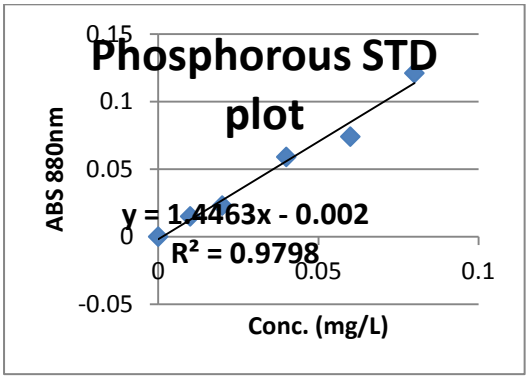
Standard plot for Phenol



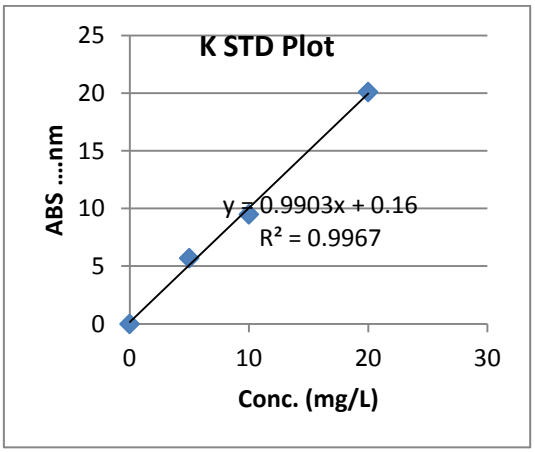
Standard plot for Calcium



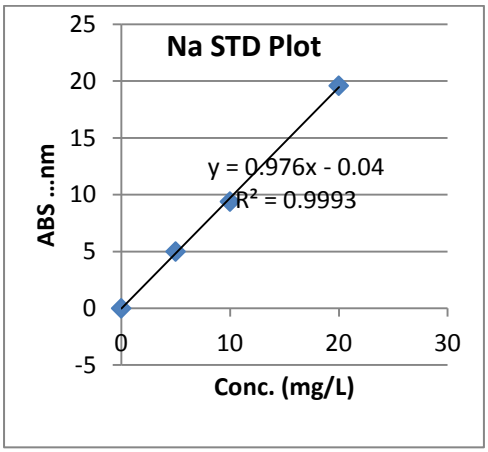
Standard plot for Iron



Standard plot for Phosphorus



Standard plot for Potassium



Standard plot for Sodium