

**DEVELOPMENT AND ASSESSMENT OF NUTRITIONAL COMPOSITION,  
SENSORY PROFILE AND CONSUMER ACCEPTABILITY OF JACKFRUIT  
SEED FLOUR BUNS FROM LOCALLY GROWN JACKFRUIT**

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**A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE  
REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN FOOD  
QUALITY AND SAFETY ASSURANCE OF SOKOINE UNIVERSITY OF  
AGRICULTURE. MOROGORO, TANZANIA.**

**2018**

**EXTENDED ABSTRACT**

The purpose of this study was to develop buns (*Mandazi*) based on wheat and jackfruit seeds flour and assess their chemical composition, sensory profile and consumer acceptability. Samples of jackfruit seeds were obtained from Tanga, Morogoro, Coast region and Zanzibar. Seeds were sorted, washed, pre-dried, seed coat peeled, sliced, dried and milled to flour. The developed jackfruit seed j flour from each location was blended with wheat flour at different levels of substitution (10%, 20%, and 30%) to form composite flour which was developed into buns. Factorial experimental design was used to determine variability of the response variables. Jackfruit seed flour, composite flour and the buns were chemically analysed for proximate and mineral composition. The buns were subjected to sensory evaluation both Qualitative Descriptive Analysis (QDA) and consumer acceptability using 1 – 9 Hedonic scale method. Results showed that jackfruit seed flour had higher amount of protein, ash and fibre contents of 12.6 – 15, 3.3 – 3.0 and 3.7 – 5.1 respectively than their respective lower value of 8.5, 0.4 and 1.4 g/100g in wheat flour. Potassium was found to be the most abundant in jackfruit seed flour followed by phosphorus, magnesium and calcium. Substitution of wheat flour with jackfruit seed flour enhanced the nutrients content in the composite products. Sensory evaluation showed no significant differences in all attributes between control and 10% composite bun (WJB 10%). Therefore, the findings suggest that jackfruit seed flour can be in cooperated into wheat flour up to 10% to enhance nutrient contents and to improve the quality of its final products without compromising its sensory attributes.

**DECLARATION**

I, Ngwere, Sarah Sudi, do hereby declare to neither the Senate of Sokoine University of Agriculture that this dissertation is the result of my own original work done within the registration period and has neither been submitted nor being concurrently submitted in any other institution.

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## ACKNOWLEDGEMENTS

First I would like to thank Allah (God) the Creator for everything that goes through in my life without him nothing is possible. I sincerely like to thank my supervisors Prof B. K. Ndabikunze and Dr. R. J Mongi for their good guidance, support and advice they have given me, their knowledge and tireless cooperation have made this work complete. Many thanks goes to Mr. S. Amour and Mr. Mdoe the technicians from soil department, Mr. Mosses from department of Animal Sciences and to Mr. S Mwanyika and Mr. M. Nkanwa from the department of Food Technology, Nutrition and Consumer sciences for their cooperation on chemical analysis of this work. My sincere appreciation goes to my supervisor Dr. R.J. Mongi for his technical and great assistance in statistical data analysis of this work.

Many thanks go to The Cereals and Other Produce Board of Tanzania (CPB) for permitting me to undertake this course and for the financial sponsorship in school fees and research.

My heartfelt thanks and appreciation go to my dear husband Mr. M. Tarimo for his kind heart, courage, his caring and support in many ways throughout my studying period. In a very unique way I would like to thank my lovely parents Mr. S. Ngwere and Mrs. Hamida Momboka for taking care of me since they have brought me to this world and for taking a good care of my children throughout my studying period. They are the best of all the people I have ever known in my life. They did nothing except the best throughout my life time. Lastly, I would like to thank my entire classmates and all those whom I can't mention here for their good cooperation. May God almighty pay you the best of everything in your life time.

## **DEDICATION**

With lot of love I dedicate this dissertation to my dear husband Mr. Mustapha Tarimo, to my lovely parents my father Mr. Sudi S. Ngwere and my mother Mrs. Hamida F. Momboka and to my lovely children.

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## LIST OF ABBREVIATIONS

|        |                                                               |
|--------|---------------------------------------------------------------|
| CJF    | Coast region Jackfruit Flour                                  |
| CWJC   | Coast region Wheat Jackfruit Composite                        |
| DAS    | Department of Animal Sciences                                 |
| DFNS   | Department of Food Nutrition and Consumer Science             |
| DFTNCS | Department of Food Technology Nutrition and Consumer Sciences |
| DM     | Dry Matter                                                    |
| DSS    | Department of Soil Sciences                                   |
| J S F  | Jackfruit Seed Flour                                          |
| KG     | Kilogram                                                      |
| MJF    | Morogoro Jackfruit Flour                                      |
| MWJC   | Morogoro Wheat Jackfruit Composite                            |
| PC     | Principal Component                                           |
| PCA    | Principal Component Analysis                                  |
| PPF    | Pure Patent Flour                                             |
| QDA    | Quantitative Descriptive Analysis                             |
| SD     | Standard Deviation                                            |
| TJF    | Tanga Jackfruit Flour                                         |
| TWJC   | Tanga Wheat Flour Jackfruit Composite                         |
| TWJC   | Tanga Wheat Jackfruit Composite                               |
| UNECA  | United Nations Commission for Africa                          |
| USDA   | United State Department of Agriculture                        |
| WF     | Wheat Flour                                                   |
| WFB    | Wheat Flour Bun                                               |

|      |                                    |
|------|------------------------------------|
| WJB  | Wheat Jackfruit Bun                |
| ZWJB | Zanzibar Wheat Jackfruit Bun       |
| ZWJC | Zanzibar Wheat Jackfruit Composite |

## CHAPTER ONE

### 1.0 INTRODUCTION

#### 1.1 Background Information

Jackfruit (*Artocarpus heterophyllus* Lam.) trees belong to the family *Moraceae*. The word *Artocarpus* is derived from the Greek words *artos* (bread) and *carpos* (fruit (Sindhu, 2012)). It is the highest yielding tree than any other tree species yielding 20 to 250 fruits per tree per annum. Jackfruit is the largest known edible fruit in the world weighing approximately 0.5 to 50 kg per individual fruit (Shyamamma *et al.*, 2008; Haq, 2006). Jackfruit is reportedly originated in the rainforests of the Western Ghats of India and in Malaysia. It was then spread to Sri Lanka, southern China, Southeast Asia and farther to tropical Africa, including Kenya, Uganda, Zanzibar, Mauritius, and Madagascar. From the mid-seventeenth century to the late nineteenth century, it spread further to tropical and subtropical America (Brazil, Suriname, Jamaica, and Florida) and Australia (Sindhu 2012).

Worldwide, Bangladesh, India, Myanmar, Nepal, Thailand, Vietnam, China, The Philippines, Indonesia, Malaysia and Srilanka are the largest known producer of the fruit (Sidhu, 2012). In Africa jackfruit is found in South Coastal party of Nigeria (Odoemelam, 2005) in Volta region in Ghana (Ocloo *et al.*, 2010), Kenya and Uganda (Abraham and Jayamuthunagai , 2014). In Tanzania jackfruit is locally grown in limited areas of Zanzibar, Tanga, Coast region and Morogoro (Mushumbusi, 2015).

Jackfruit contains vitamin A, vitamin c, thiamine, riboflavin, calcium, potassium, iron, sodium, zinc, and niacin (Mukprasirt *et al.*, 2004). The seeds are rich in starch and protein (Singh *et al.*, 1991) and good source of many minerals like nitrogen, potassium,

phosphorus, calcium, magnesium, zinc and copper (Abedin *et al.*, 2012). Two main varieties of jackfruits are known, one is small, fibrous, soft, and mushy having sweet carpels with similar texture of raw oyster while the other one is crisp and crunchy, but not very sweet, (Swami *et al.*, 2012).

Jackfruit pulp/bulb can be eaten fresh, or processed into jam, jellies, beverage, squash and syrup as well as candies, sweeties and frozen pulps. The seed can be consumed as cooked, baked or used in culinary to develop several menus, its flour can be used to prepare different baked products such as bread, and cake (Santos *et al.*, 2011; Noor *et al.*, 2014).

## **1.2 Problem Statement and Justification**

Jackfruits is reported to contain potential nutrients like protein, calcium, iron, vitamins and other essential nutrients but is still underutilized (Vazhacharickal *et al.*, 2015) and regarded as poor man's food (Rahman *et al.*, 1995). It is highly a seasonal fruit with shorter shelf life (Arpit *et al.*, 2015). The high postharvest losses are mainly due to ignorance, lack of postharvest technology and gaps in supply chain systems (Vazhacharickal *et al.*, 2015). Availability of processed products in the market is scarce due to lack of interest shown by the producers (Sindhu, 2012). In Tanzania people consume pulp/bulb and discard the seeds which lead to food wastage. Few studies have been done on locally grown jackfruit such as production and characterization of jackfruit jam (Mushumbuzi, 2015) leading to limited information on nutritional and sensory properties of jackfruit seeds and its products.

Therefore this study aims at analysing nutritional composition of the seeds from the locally grown tree, converting seed into flour and utilizing the flour to develop food products. It is expected that, the results that will be obtained from this study will provide

information on nutritional composition of the seed from locally grown jackfruit and methods for processing and preservation that will help to reduce postharvest losses. Moreover, positive findings will serve as basis for production, promotion and consumption of jackfruit by community so that population can enjoy the nutritional and health benefit as well as to capture business opportunities available from jackfruit. This in turn will help to fight against food insecurity in the country and improving well being of people in jackfruit value chain.

### **1.3 Study objectives**

#### **1.3.1 General objective**

The objective of this study was to develop and analyse nutritional composition, sensory properties and consumer acceptability of buns (mandazi) based on wheat-jackfruit seed composite flour.

#### **1.3.2 Specific objectives**

- i. To develop Jackfruit seed flour and its wheat composite products (buns)
- ii. To determine proximate composition of the flour, and its based products (composite flour and composite buns)
- iii. To assess mineral content of the flour, and its based products (composite flour and buns)
- iv. To evaluate sensory profile and consumer acceptability of buns.

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## CHAPTER TWO

### PAPER ONE

#### **2.0 Proximate and Mineral Composition of Jackfruit Seed Flour and the Product Developed from Wheat Jackfruit Seed Composite Flour Composite Products**

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## Abstract

The proximate and mineral composition of jackfruit seed flour from the locally grown jackfruits was determined in this study. Jackfruits were collected from four regions namely; Morogoro Tanga, Zanzibar and Coast and their seeds were processed into flour, composite flour with wheat flour and finally composite buns. The composite flours were prepared by substituting wheat flour at 0, 10, 20 and 30 %, whereby 100% wheat flour and its developed bun were the control samples. There were significant ( $p < 0.05$ ) differences in proximate composition of jackfruit flour between locations except for moisture contents. Significantly ( $p < 0.05$ ) higher and lower ash content of 3.6 and 0.4 g/100 g DM were reported in Morogoro and Zanzibar samples respectively. The moisture contents ranged from highest 9.9 to 7.7 for Zanzibar and Morogoro samples respectively. The lowest fat content of 2.1 and 0.9 g / 100 g DM were found in Zanzibar and Morogoro samples respectively. Protein content ranged from 15.0 g/100 g DM for Zanzibar and 12.6 g/100 g DM for Coast region samples whereby highest and lowest fibre contents of 5.1 and 3.7 g/100 g DM were respectively observed in Morogoro and Zanzibar samples. The carbohydrate content ranged from 65.8 for Zanzibar to 70.5 g/100 g DM for Morogoro samples. Furthermore, potassium was found to be the most abundant mineral and varied significantly from highest value of 1454.4 mg/100 g in Morogoro samples to the lowest value of 1357.2 mg/100g in Coast region samples. Calcium was found to be in the lowest amount compared to all other macro minerals.

The findings also showed that, there were significant increase and decrease in proximate composition parameters as the level of wheat flour substitution increased in the composite products. Moisture content decreased from 20.5 g / 100 g DM in control bun (100% wheat flour) to 18.8 up to 11.6 g/ 100 g DM in composite flour. Ash contents increased from low values of 0.3 g/ 100g in control bun to higher value of 0.6 -1.8 g/ 100 g DM in the composite buns, fat contents decreased from  $31.4 \pm 0.23$  g/ 100 g DM to 24.5

- 30.5 g/ 100 g DM in composite buns. Protein increased from 5.9 g/ 100 g in the control bun to 6.1 - 7.2 g/ 100 g DM in composite bun whereby fibre content increase from 1.5 g/ 100 g in control bun samples to 1.6 - 3.6 g/ 100 g/ DM in composite buns. Carbohydrate content increased from  $40.4 \pm 0.05$  in control samples to 48.5 g/100 g DM in the composite buns. In conclusion, the substitution of a portion of wheat flour with jackfruit seed flour enhanced nutrient contents in the composite buns. A progressive increase in protein, fibre and ash content as well as in mineral contents were observed in the developed product . Therefore jackfruit flour can be in-cooperated into wheat flour to enhance nutritional contents of the final products.

*Key words: Jackfruit, Composite buns, flour substitution,*

## 2.1 Introduction

Jackfruit is the third largest genus in the *Moraceae* family and it is distributed from Southeast Asia to Oceania and includes several economically important species such as breadfruit (*A. altilis*) and jackfruit (*A. heterophyllus*) that are cultivated throughout the tropics (Rahman *et al.*, 1999). Its seed is enclosed in a white aril which covers a thin light brown spermoderm which encircling a fleshy white cotyledon (Singh *et al.*, 1991). The seed can be oval in shape, oblong ellipsoid or rounded. However, both the fruit and the seeds are perishable with shorter shelf life which leads to high wastage of the fruit. Therefore to reduce the loss the seeds can be dried, roasted and ground to make flour which can be stored for a long time and used for value addition when blended with other flour such as wheat flour to make different composite products without affecting functional and sensory properties of the final products (Banarjee and Datta 2015).

Basically, composite flour technology refers to the process of mixing wheat flour with cereals or legumes to make use of local raw materials to produce high quality food products in an economical way. In many cases, this implies the partial substitution of wheat flour in a staple diet with other cereals or flour derived from legumes as a mean of diversifying and upgrading the local agricultural food products (UNECA, 1985). The development of food products using composite flour has increased and is attracting much attention from researchers, especially in the production of bakery products and pastries.

The positive effects of the use of composite flour can be seen in the final product related to the functional and physicochemical properties and health benefits of raw blended flour along with percentage blending (Hasmadi *et al.*, 2014). Jackfruit seeds are rich in protein,

starch and dietary fibre (Chowdhury *et al.*, 2012) and can be incorporated in wheat flour to produce composite products such as flour and confectionary like buns.

Buns (*Mandazi*) are among foods which are made up of wheat flour as its major ingredient and is mostly used for breakfast. Buns can also be eaten at any time of a day as a snack with tea, milk or juice. In Tanzania, buns are usually made locally at home and then sold in the streets or at the bus stations especially in the morning. Due to rapid change in life style of people that has led to an increase in the number of bakeries and fast food restaurants, buns are now available easily in many places in town. They can be consumed by people of different ages including school children, youth and elderly. Despite adequate literature review, information on the use of wheat composite flour in developing buns and the confectionaries and their nutritional values is lacking.

The objective of this study was to determine the nutritional content of jackfruit seed flour, its developed wheat jackfruit composite flour and composite buns. Due to the fact that Jackfruit seeds are rich in protein, starch and dietary fibre (Chowdhury *et al.*, 2012) its inclusion in wheat flour buns may lead to the final product with many health advantages to its consumers.

## **2.2 Material and Methods**

### **2.2.1 Study area**

The study was conducted at the Departments of Food Technology, Nutrition and Consumer Science laboratory (DFTNCS), Animal Sciences (DAS) and Soil Sciences (DSS) laboratories at, Sokoine University of Agriculture in Morogoro region.

### **2.2.2 Materials**

Mature and fresh jackfruits were purchased directly from local farmers in Tanga, Morogoro and Coast regions and Zanzibar. The areas were purposively selected as they are

the famous for growing jackfruit in Tanzania. Other materials were purchased from respective shops in Dar es Salaam and Morogoro regions. Analytical reagents and chemicals were obtained from DFTNCS, DSS and DAS laboratories and/or purchased from suppliers in Dar es Salaam.

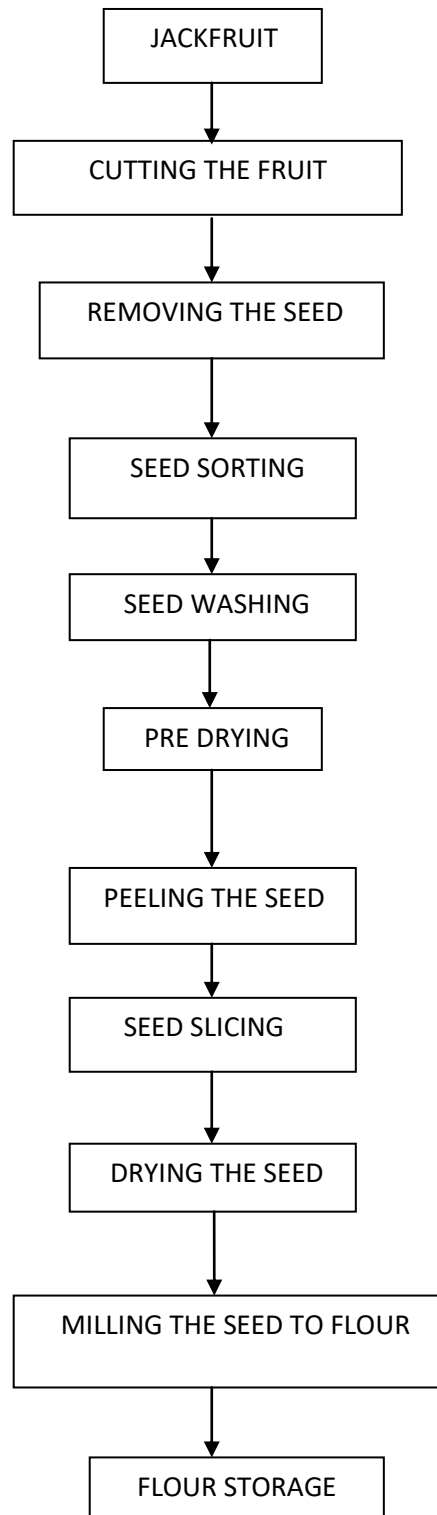
### 2.2.3 Research design

Factorial experimental design with two principal factors (location and product formulation) was used in this study. The effect of these factors on proximate and mineral contents of jackfruit flour and composite buns were assessed and compared. The mathematical model is shown in equation below.

$$Y_{ij} = \mu + \alpha_i + \beta_j + \varepsilon_{ij}$$

### 2.2.4 Preparation of Jackfruit Seed Flour

The Fruits were cut in two halves and the seeds were removed from the pulp. The seeds were cleaned by water, pre-dried and their coat was manually peeled off before sliced into thin chips and sun dried. The dried seeds were milled to flour, and packed in polyethylene pouches and stored in a refrigerator (<10° C) prior to chemical analysis and preparation of buns (*Mandazi*). The flow chart for flour processing is shown in Figure 2.1

**FLOW CHART OF JACKFRUIT SEED****FLOUR PROCESSING****Figure 2.1: Flow chart showing Jackfruit seed flour Processing**

### 2.2.5 Formulation of wheat and jackfruit seed composite flour

Jackfruit seed flour from each region was separately combined to form a composite flour with wheat flour at three different levels, 10, 20 and 30 % of wheat flour substitution as shown in Table 2.1.

**Table 2.1: Three formulations of developed jackfruit based buns**

| Composite flour   | Flour Proportion (%) |           |
|-------------------|----------------------|-----------|
|                   | Wheat                | Jackfruit |
| Whole wheat 0%)   | 100                  | 0         |
| Composite 1 (10%) | 90                   | 10        |
| Composite 2 (20%) | 80                   | 20        |
| Composite 3 (30%) | 70                   | 30        |

### 2.2.6 Preparation of buns (*Mandazi*)

About 500 g of flour was weighed and kept in a clean bowl, dry ingredient including 65 g sugar, 10 g vegetable fat, 3.5 g yeast and 1.5 g salt were added and mixed thoroughly to obtain a uniform mixture of all ingredients. Water was added gradually into the mixture, and was kneaded to soft dough. The dough was left to leaven for 45 minutes and then cut into small pieces of the desired shape and by using a knife and left to stay for 10 minutes. Pieces of dough were deep fried in a hot oil of 150<sup>0</sup>C until the golden brown colour was attained. Buns were removed from hot oil, kept in a metal sieve to drain the oil and left to cool on a clean plate at room temperature. The cooled buns were preserved in a food grade polyethylene bag and stored in a refrigerator (<10° C) prior to chemical analysis.

## 2.2.7 Chemical analyses

### 2.2.7.1 Moisture content

Moisture content was determined according to method number 925.09 (AOAC, 1995). The crucibles were washed and dried in an oven at 105°C for three hours and cooled in desiccators. Then crucibles were weighed. About 5 g of the sample was weighed in the crucible. The sample was spread in the crucible and subjected to drying in an oven (Wagtech model -H.O.V.200CIAO300HYO, Britain) at 105° C for approximately 24 hrs. After drying, samples were cooled in desiccators for 30 minutes. The crucibles were reweighed after cooling. The percentage moisture content was then calculated with the formula shown in equation bellow.

Calculation:

$$\% \text{ moisture content} = \frac{(W1 - W2) \times 100}{W1}$$

Whereby; W1 is weight of sample (gm) before drying and W2 is weight of sample (gm) after drying.

### 2.2.7.2 Protein content

Crude protein content of jackfruit seed four was determined by macro Kjeldah method number 920.87 (AOAC, 1995). About 0.25 gm portion of was weighed from each sample and transferred into a Kjeldahl digestion tube. A blank was prepared by dropping a piece of filter paper without sample into a separate 100 ml digestion tube. To each tube, copper two sulphate catalyst was added and then 6.0 ml of concentrated sulphuric acid was added and the sample was allowed to boil for 1hour at a temperature of 450°C. Samples were digested until a clear, blue solution was obtained and digestion continued further to allow the nitrogen held in the heterocyclic ring to be released. The digest was cooled for 20 minutes. 30 ml of distilled water was added to dissolve the content; 30 ml of 40% sodium

hydroxide was added to the digest to facilitate the release of ammonia. The diluted digest was distilled using macro-distillation apparatus (Kjel ROC Distillation Unit, KD 210- A-1016). Ammonia was extracted by steam distillation and collected in a conical flask containing 25mls of boric acid to mark 150mls. The distillate was titrated to the end point with 0.1085N HCl standard solution using bromocresol green methyl red mixture as an indicator. Nitrogen content was calculated using the formula shown in equation below.

$$\text{Nitrogen} = \frac{14.01 \times (\text{Titre value ml} - \text{blank value ml}) \times \text{conc. of acid} \times 100}{\text{Weight of samples (g)} \times 1000}$$

Percentage protein was calculated from the percentage nitrogen using the factor 6.25

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

#### 2.2.7.3 Ash content

The ash content of all samples were determined by using a muffle furnace (Carbolite, Aston Lane, Hope, Sheffield, S30 2RR, England) as described in standard method (AOAC, 1995), official method 923.03. About 3 grams of each sample in duplicate were placed in a pre-weighed crucible and placed in muffle furnace at 550 C for 4 hours until white or grey ash was obtained. Samples were then cooled for 30 minutes in desiccators to room temperature and weighed. Percentage ash was calculated by using the following equation.

$$\% \text{ Ash} = \frac{\text{weight of undried sample (g)} - \text{weight of dried sample (g)} \times 100}{\text{Weight of sample (g)}}$$

#### 2.2.7.4 Fat content

Crude fat were determined by ether extraction using the Soxtec System (Soxtec™ 2055 FOSS model 2012) AOAC (1995) method number 920.65 was used. The method involved extracting crude fat from the samples into petroleum ether (40-60°C), which

was then evaporated, and the weight of the crude fat was determined. 3 grams of samples were weighed and placed into extraction thimble (W1). The thimbles were covered with a thin layer of cotton wool and then thimbles were inserted into the Soxtec apparatus. The extraction cups were dried and pre-weighed (W2). 50 ml of petroleum ether were added into each cup and then the cup was inserted in to the Soxtec. Extraction process took place for approximately one hour whereby 15 minutes for boiling and 45 minutes for rinsing. After extraction, the cups with fat extract were further dried in the oven at 105°C for 30 minutes, and then cooled in desiccators for 30 minutes and the cup were weighed (W3). Percentage crude fat content was calculated as shown bellow.

$$\% \text{ Crude fat} = \frac{\text{weight of cup and dried sample} - \text{weight of cup}}{\text{Weight of sample}} \times 100$$

#### **2.2.7.5 Fibre content**

Dietary fiber was determined by method number 920.86 (AOAC, 1995). About one gram of each samples were taken for crude fibre determination with Fibertec (TM1020 FOSS model 2012). The samples were first digested by dilute sulphuric acid (0.125M) for 30 minutes and washed three times with hot water. The residue was then digested by dilute alkali (0.125M KOH) for another 30 minutes and then washed by hot water three times. Digested residue was dried in an oven for 5 hours then cooled and weighed. The residue was then placed in muffle furnace – (Carbolite, Aston Lane, Hope, Sheffield, S30 2RR, England) and incinerated for 2 hours temp 525°C, then cooled and weighed again. Total fibre content was calculated by using the formula shown bellow

$$\% \text{ crude fibre} = \frac{\text{weight of dry residue before incineration (g)} - \text{weight after incineration (g)}}{\text{Sample weight (g)}} \times 100$$

#### **2.2.7.6 Determination of carbohydrate**

Carbohydrate content was calculated as percentage by difference (AOAC, 1995).

% Carbohydrate = 100 – (% Moisture+ % Protein + % Crude fibre +% Crude fat +% Ash).

#### **2.2.7.7 Determination of mineral content**

The analysis of minerals was done according to the AOAC (1995) procedures. One gram of test samples was ashed at 600°C for 3 hours in a muffle furnace and digested by adding 10 mls of HCl (6N). The solutions were filtered and levels of minerals content were determined. For calcium 1ml of filtrate was taken and 2ml of Lanthanum Chloride and 7ml of distilled water were added. Lanthanum was added to free Calcium. For other elements Mg, K and P 1ml of filtrate was taken and diluted by 9ml of distilled water. Ca and Mg were determined by Unicam 919 Atomic Absorption Spectrometer (AAS). Potassium was determined using flame photometer (flame analyzer) and phosphorous was determined using UV-VIS spectrophotometer.

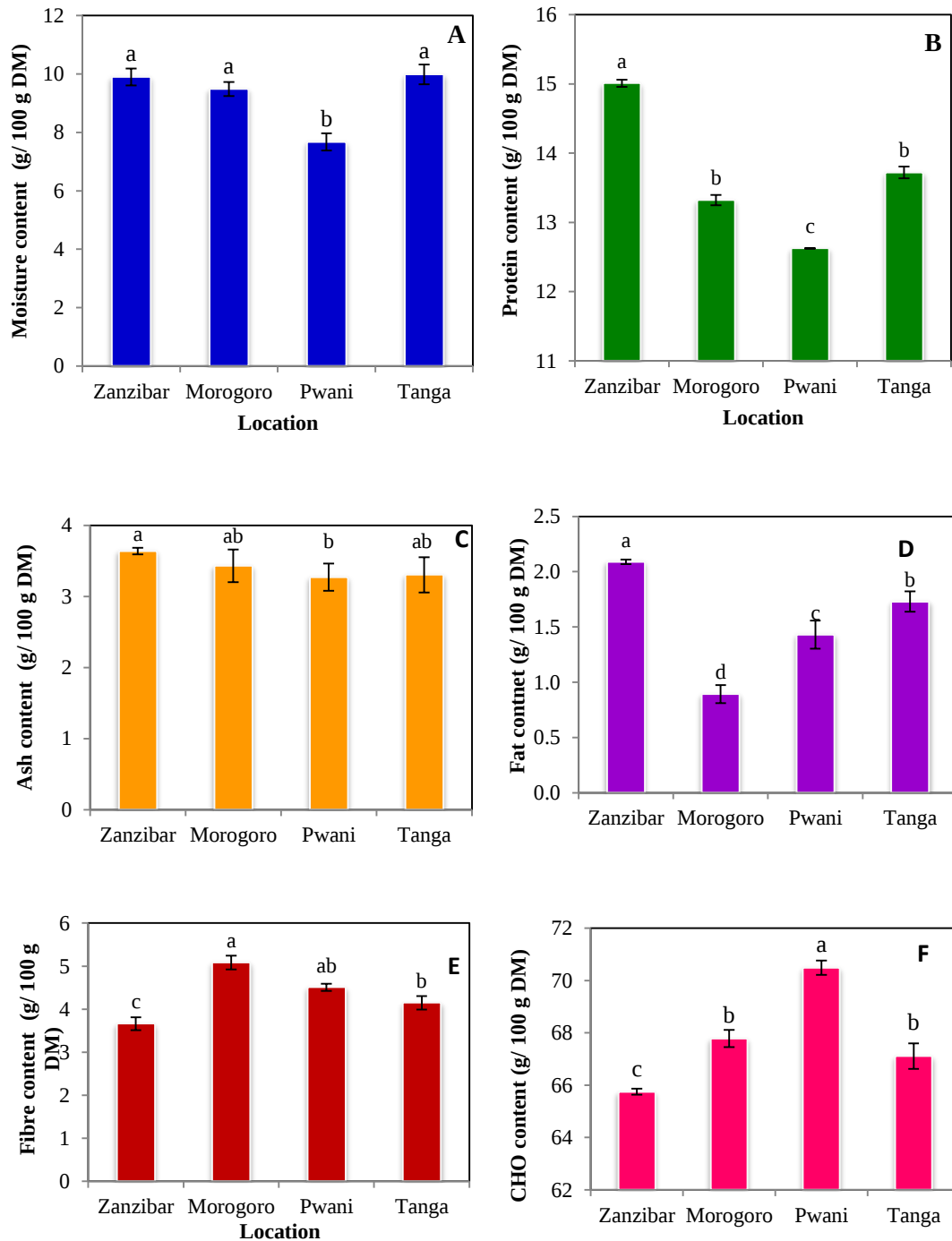
#### **2.2.8 Statistical data analysis**

Data were analysed by using the R statistical package (R Development Core Team, Version 3.0.0 Vienna, Austria) for Analysis of variance (Anova) to determine the significant differences in nutrient composition jackfruit seed flour, composite flour and the developed composite buns made from wheat jackfruit composite flour from different locations. Means were separated using Tukeys Honest Significant difference ( $p < 0.05$ ). Principal Component Analysis (PCA) was used to determine the systematic variations in the data using Latentix Software (LatentiX Aps Team, version 2.12, Frederiksberg Denmark) (Martens and Martens, 2001). Results were presented as arithmetic mean and standard deviation in Tables and graphs as well as in PCA bi plots.

## **2.3 Results and Discussion**

### **2.3.1 Proximate composition of Jackfruit Seed Flour (JSF) from different locations**

Variations of proximate composition of Jackfruit flour between locations are shown in Figure 2.2 (a-f). There were significant ( $p < 0.05$ ) differences in proximate composition between locations except ash contents. The moisture contents were significantly higher in Zanzibar Morogoro and Tanga samples with value of 9.5 - 9.9 g/100 g than Coast samples with value of 7.7 g/100 g DM (Figure 2.2 a). Protein content differed significantly ( $p < 0.05$ ) with Zanzibar and Coast region samples having highest and lowest values of 15 and 12.6 g/100 g DM respectively (Figure 2.2 b) whereas highest and lowest fat contents of 2.1 and 1.4 g / 100 g DM were respectively observed in Zanzibar and Coast regions samples (Figure 2.2 c). Furthermore, the results showed the variation in fibre contents between locations was significant ( $p < 0.05$ ) with Morogoro and Zanzibar having highest and lowest values of 5.1 and 3.7 g/ 100 g DM. Coast samples had significantly highest carbohydrate contents of 70.5 g/ 100g DM than all other regions.



**Figure 2.2: (A-F) Variation of proximate composition of Jackfruit flour between locations. Values are expressed as mean  $\pm$ SD (n=40). Bars having mean values with different letters are significantly different at  $p<0.05$**

Results show that the moisture content of jackfruit seed flour from all four locations were within the safe level and if properly stored can be kept for a long time to be used in the future. Moisture in flour typically limited to 14% and if rises above 14 percent, flour become susceptible to fungus and mold growth, flavour changes, enzyme activity, and insect infestation (<http://www.ndsu.edu> 2018). The lower the flour moisture the better its storage stability, flour having 9 to 10 g/ 100 g moisture content is suitable for extended shelf life (Nassir, 2003). For these reasons, flour must be stored properly, covered and in a cool, dry place. The significantly lower moisture content observed in coast region samples might have been attributes to weather fluctuation on the drying days. The findings of this study are similar to those obtained by Chowdhury *et al.* (2011) who found out, moisture content of 10.7 g/100 g for the jackfruit seed four with brown seed coat and 10.1 g/ 100 g for the jackfruit seed four without brown Seed coat. On a contrary, the highest moisture content of 14.07 g/100 g and 15.88g/100 g were reported by Airan (2007) and (Islam *et al.*, 2015) respectively where by Ocloo *et al.* (2010) reported the lowest moisture content of 6.09%.

The observed variation in protein contents between the locations might have been contributed by the weather condition in which the trees were grown, the soil type, and the seed varieties used (Jean, 1995). Chowdhury *et al.* (2012) reported similar results of 14.02g and 12.6g/ 100g in jackfruit seed flour with brown seed coat and the one with no seed coat respectively. Abedin *et al.* (2012) found a varied level of protein content ranging from 13.13% to 18.13%. The variety named Khoja with 13.13% had almost similar values close to the one obtained in this study from Morogoro and Tanga regions. Another variety named Gala with 14.813 g/ 100 g was similar to that of Zanzibar as found in this study. The Durosha variety had 18.128% which is the highest score as compared to all protein content obtained from this study. However Babio *et al.*, (1978) reported 12.3%

protein which agreed with the result of protein content of the seed from the Coast region in this study. Despite the significant variation in protein content between locations, jackfruit seed flour had higher values than wheat flour with value of 8.5 g/ 100 g DM

Moreover, the study revealed that jackfruit seed flour is low in fat content. Currently foods that contain low-calorie sugar- and fat-replacers are popular due to increase in nutritional and health awareness in calorie reduction in the diet (Dilek *et al.*, 2007). Similarly values like that of Tanga sample of 1-1.1 g/ 100 g DM were also reported by Gupa *et al.* (1996). Airani (2007) found 1.1 g of fat in jackfruit seed flour. Also result which is closely similar to this study ranged from 0.4 to 0.43 g DM was reported by Azad (2000) which agrees with the result of fat content obtained in Morogoro sample as found in this study.

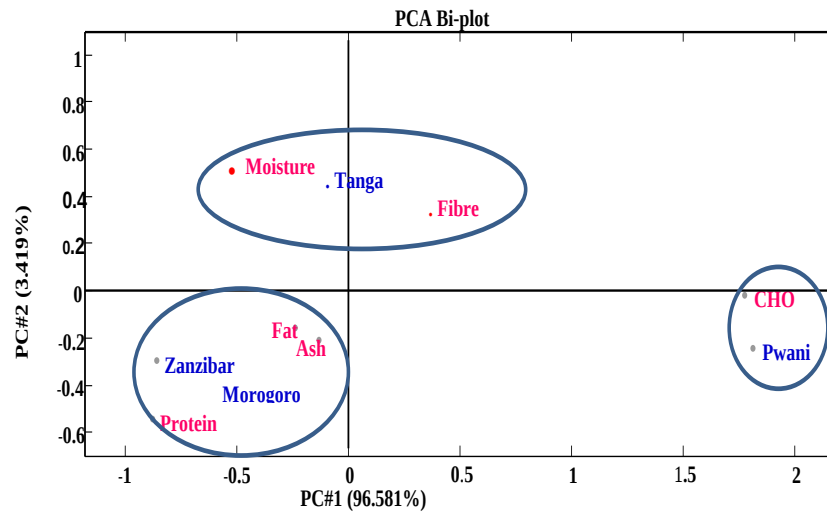
Result shows that jackfruit seed flour contains more ash content than pure patent wheat flour which had 0.4 g/100 g. Abedin *et al.* (2012) found different levels of ash content in three different varieties of jackfruit which ranges from 2.127% which is the lowest value as compared to this study and 3.3% which is similar to the results obtained in two samples of Morogoro and Tanga in this study. Contrary to this study Abedin *et al.* (2012) also reported the highest value of 4.073%.

Although results in fibre content found to be significant this study revealed that jackfruit seed flour from all four locations contained higher fibre than wheat flour which scored  $1.4 \pm 0.31$ . The significant variation in fibre content might be due to different locations in which the tree was grown, soil type and the seed varieties used. Similar results to Zanzibar sample was reported by (Hettiarachchi *et al.*, 2011 and Ocloo *et al.*, 2010) who obtained value of 3.19% and Abedin *et al.* (2012) with value ranged from 1.56-3.7.

Contrary to this Chowdhury *et al.* (2011) reported the lowest result which ranges from 1.47 to 1.8%.

Results revealed that jackfruit seed flour is lower in carbohydrate than pure patent wheat flour which scored  $82.3 \pm 0.64$ . Chowdhury *et al.* (2012) reported result which is similar to this, they found the varied amount of carbohydrate content in jackfruit seed flour which ranged from 66.86 to 70.22g/100g. This result agrees with the result which was obtained in this study. Different results from this study were reported by Gupta (2011) who found carbohydrate content in jackfruit seed flour to be 26.2g/100g. This is the lowest result as compared to the one obtained from this study. Ocloo *et al.* (2010) reported 79.3 g which is a little bit high compared to those obtained from this study.

Moreover, the bi-plot of principal component analysis shows that PC1 accounts for 96.58% of the total variation and it is a contrast between Coast region sample associated with high carbohydrate contents and the rest of the samples associated with high protein, ash and fat. PC2 accounts for 3.42% of the variation and it is a contrast between Tanga sample associated with high moisture and fibre contents and the rest of samples associated with other proximate parameters.



**Figure 2.3: PCA Biplot showing variation of proximate composition between locations**

Principal Component Analysis is an important multivariate statistical technique which identifies the smallest number of latent variables known as principal component. It helps to explain the greatest amount of observed variability in a data set (Mongi, 2015). The findings show that samples were differentiated by the amount of proximate contents they contained which support the results in Figure 2.2.

### 2.3.2 Proximate composition of composite flour in each location

Proximate composition of wheat, jackfruit and wheat-jackfruit composite flours are shown in Table 2.2. There were significant ( $p < 0.05$ ) differences in proximate composition parameters between the wheat and jackfruit flours samples with jackfruit having higher ash content of 3.3-3.6 g/ 100 g DM, fat content of 0.9-2.1 g/ 100 g DM, protein content of 12.6-15 g/ 100 g DM, and fibre content of 3.7-5.1 g/ 100 g DM than respective lower values of 0.4, 1.0, 8.5, and 1.4 g/ 100 g DM in wheat flour.

Within each location, there was progressive increase in all proximate parameters as substitution of wheat flour with jackfruit flour increased except carbohydrate. It was observed that ash contents increased from 0.4 to 1.6 g/ 100 g DM, fat from 1 to 2.1 g/ 100 g DM, protein from 8.5 to 11.1 g/ 100 g DM and fibre from 1.4 to 5.6 g / 100 g DM. Carbohydrate content decreased from 82.3 to 72.3 g/ 100 g DM.

The progressive increase in protein, ash, fat and fibre contents in a composite flour samples was due to the fact that jackfruit seed flour was richer in these content than wheat flour. On their study of wheat jackfruit composite cake Khan *et al.* (2016) found content of protein, ash, and fibre in jackfruit seed flour to be higher with value of 13.23%, 2.72% and 3.09% respectively than the respective lower values 10.76%, 1.2% and 1.4% in wheat flour. This implies that if a certain portion of wheat flour is substituted with this jackfruit seed flour the nutritional values of the resulting composite flour sample will be enhanced.

**Table 2.2: Proximate composition of wheat and jackfruit seed (g/ 100 g DM)**  
**composite flour within each location**

| Locations   | %<br>Formulation | Moisture              | Ash                   | Fat      | Protein                | Fibre                 | CHO                    |
|-------------|------------------|-----------------------|-----------------------|----------|------------------------|-----------------------|------------------------|
| Wheat flour | Wheat (100%)     | 11.6±0.28             | 0.4±0.02              | 1.0±0.2  | 8.5±0.24 <sup>c</sup>  | 1.4±0.31              | 82.3±0.64 <sup>a</sup> |
| Zanzibar    | ZJF (100%)       | 9.9±0.29 <sup>a</sup> | 3.6±0.05              | 2.1±0.0  | 15.0±0.05 <sup>a</sup> | 3.7±0.15 <sup>a</sup> | 65.8±0.12              |
|             | ZWJC (90:10)     | 8.3±0.22 <sup>b</sup> | 0.8±0.01 <sup>d</sup> | 1.0±0.25 | 10.8±0.04              | 1.9±0.06 <sup>b</sup> | 77.2±0.04              |
|             | ZWJC (80:20)     | 9.7±0.96 <sup>b</sup> | 1.2±0.12 <sup>c</sup> | 1.3±0.05 | 10.8±0.09              | 2.9±0.12 <sup>a</sup> | 74.2±0.10 <sup>c</sup> |
|             | ZWJC (70:30)     | 9.2±0.97 <sup>b</sup> | 1.5±0.02 <sup>b</sup> | 1.4±0.07 | 11.1±0.16              | 3.1±0.55 <sup>a</sup> | 73.8±0.67 <sup>c</sup> |
| Morogoro    | Wheat (100%)     | 11.6±0.28             | 0.4±0.02 <sup>d</sup> | 1.0±0.27 | 8.5±0.24 <sup>d</sup>  | 1.4±0.31 <sup>d</sup> | 82.3±0.64 <sup>a</sup> |
|             | MJF (100%)       | 9.5±0.24 <sup>b</sup> | 3.4±0.33 <sup>a</sup> | 0.9±0.48 | 13.3±0.07 <sup>a</sup> | 5.1±1.16 <sup>a</sup> | 67.8±1.63 <sup>c</sup> |
|             | MWJC (90:10)     | 8.3±0.65 <sup>b</sup> | 0.8±0.01 <sup>c</sup> | 1.0±0.01 | 10.1±0.02 <sup>c</sup> | 1.8±0.27 <sup>c</sup> | 78.0±0.91              |
|             | MWJC (80:20)     | 9.5±0.08 <sup>b</sup> | 1.3±0.03 <sup>b</sup> | 1.3±0.08 | 10.6±0.08              | 2.8±0.05 <sup>b</sup> | 74.6±0.10              |
|             | MWJC (70:30)     | 8.9±0.11 <sup>b</sup> | 1.5±0.01              | 1.2±0.04 | 10.7±0.07              | 2.9±0.16 <sup>b</sup> | 74.8±0.31              |
| Coast       | Wheat (100%)     | 11.6±0.28             | 0.4±0.02 <sup>d</sup> | 1.0±0.27 | 8.5 ±0.24 <sup>c</sup> | 1.4±0.31 <sup>b</sup> | 82.3±0.64 <sup>a</sup> |
|             | CJF (100%)       | 7.7±0.30 <sup>b</sup> | 3.3±0.19 <sup>a</sup> | 1.4±0.13 | 12.6±.01 <sup>a</sup>  | 4.5±0.08 <sup>a</sup> | 70.5±0.27 <sup>c</sup> |
|             | CWJC (90:10)     | 8.9±0.02 <sup>b</sup> | 0.9±0.01 <sup>c</sup> | 1.5±0.06 | 10.7±0.04              | 1.7±0.21 <sup>b</sup> | 76.2±0.22              |
|             | CWJC (80:20)     | 8.5±0.78 <sup>b</sup> | 1.2±0.01 <sup>b</sup> | 1.0±0.01 | 10.8±0.12              | 3.3±0.11 <sup>a</sup> | 75.2±1.01              |
|             | CWJC (70:30)     | 8.5±0.77 <sup>b</sup> | 1.5±0.07 <sup>b</sup> | 1.2±0.09 | 10.8±0.03              | 5.6±1.27 <sup>a</sup> | 72.3±2.10              |
| Tanga       | Wheat (100%)     | 11.6±0.28             | 0.4±0.02 <sup>e</sup> | 1.0±0.27 | 8.5±0.24 <sup>c</sup>  | 1.4±0.31 <sup>c</sup> | 82.3±0.64 <sup>c</sup> |
|             | TJF (100%)       | 10.0±0.34             | 3.3±0.45 <sup>a</sup> | 1.7±0.09 | 13.7±0.09 <sup>a</sup> | 4.1±0.56 <sup>a</sup> | 67.1±0.49 <sup>a</sup> |
|             | TJC (90:10)      | 9.1±0.27 <sup>b</sup> | 0.9±0.04 <sup>d</sup> | 1.7±0.03 | 10.3±0.38              | 2.3±0.44 <sup>b</sup> | 75.7±0.28              |
|             | TJC (80:20)      | 8.5±0.79 <sup>b</sup> | 1.2±0.02 <sup>c</sup> | 1.1±0.00 | 11.1±0.13              | 2.6±0.20 <sup>b</sup> | 75.4±0.74              |
|             | TJC (70:30)      | 8.5±0.73 <sup>b</sup> | 1.6±0.02 <sup>b</sup> | 2.1±0.03 | 11.1±0.05              | 2.9±0.13 <sup>b</sup> | 73.9±0.83              |

Values are expressed as mean ±SD (n=40). Bars having mean values with different letters are significantly different at p<0.05

Key: C = Coast region, M = Morogoro, T = Tanga, Z= Zanzibar, JF = Jackfruit flour, WJC = wheat jackfruit composite

### 2.3.3 Proximate composition of wheat jackfruit composite buns

Variations of proximate composition of wheat Jackfruit buns within each location are shown in Table 2.3. There were significant ( $p < 0.05$ ) differences in proximate composition between the control bun and composite buns within each location. Furthermore, there were progressive increases in all proximate parameters with increase in wheat flour substitution except fat and moisture contents. The ash contents increased from 0.3 to 1.8 g/ 100 g DM, protein from 5.9 to 7.3 g/ 100 g DM and fibre from 1.5 to 2.9 g / 100 g DM. Carbohydrate contents increased from 40.4 to 48.5 g/ 100 g DM. The fat content decreased from 31.4 to 24.5 g/100 g DM whereby moisture decreased from 20.5 – 11.6 g/100 g DM.

These results are in agreement with the results reported by Khan *et al.* (2016) who were evaluating quality characteristics of wheat and jackfruit flour composite cake and observed increase in all proximate parameters except fat and moisture content. The observed increase in ash, protein and fibre content in the composite bun were also reported by Sultana *et al.* (2014) on composite Chapati and Arpit *et al.* (2015) when studying the effect of different level of jackfruit seed flour in the chocolate cake. Also the increment in protein was found by Abraham *et al.* (2014) on the analytical study of jackfruit seed four and its in cooperation in pasta. Contrary to this Islam (2015) and Airan (2007) found decrease in protein content. However, results revealed that the variation of the mentioned parameters were small at 10% and 20% wheat flour substitution, this might be due to the availability of the nutrients present in the added flour in lesser amount (Abraham *et al.*, 2014). The observed decrease in fat content in this study is contrary to the study by Islam (2015) on biscuits and Sultana *et al.* (2014) on wheat jackfruit composite chapatti where they found the increase in fat content from 1.03 to 1.67 g and decrease in carbohydrate content from 65.09 to 61.24g.

**Table 2.3: Proximate composition of wheat-jackfruit composite buns (g/100g DM)**

| Location     | Formulation | Moisture                            | Ash                   | Fat                    | Protein               | Fibre                 | CHO                     |
|--------------|-------------|-------------------------------------|-----------------------|------------------------|-----------------------|-----------------------|-------------------------|
| Zanzibar     | WFB (100)   | 20.5±0.10 <sup>a</sup>              | 0.3±0.01 <sup>d</sup> | 31.4±0.23 <sup>a</sup> | 5.9±0.07 <sup>d</sup> | 1.5±0.00 <sup>d</sup> | 40.4±0.05 <sup>c</sup>  |
|              | WJB(90:10)  | 18.8±0.29 <sup>b</sup>              | 0.8±0.03 <sup>c</sup> | 28.9±0.07 <sup>b</sup> | 6.1±0.00 <sup>c</sup> | 1.7±0.01 <sup>c</sup> | 43.7±0.31 <sup>b</sup>  |
|              | WJB(80:20)  | 17.6±0.44 <sup>c</sup>              | 1.3±0.02 <sup>b</sup> | 25.1±0.11 <sup>c</sup> | 6.6±0.03 <sup>b</sup> | 2.3±0.00 <sup>b</sup> | 47.0±0.49 <sup>a</sup>  |
|              | WJB(70:30)  | 16.4±0.00 <sup>d</sup>              | 1.7±0.05 <sup>a</sup> | 24.5±0.00 <sup>d</sup> | 7.2±0.07 <sup>a</sup> | 3.6±0.01 <sup>a</sup> | 46.7±0.01 <sup>a</sup>  |
| Morogoro     | WFB (100)   | 20.5±1.31 <sup>a</sup>              | 0.3±0.01 <sup>d</sup> | 31.4±0.03 <sup>a</sup> | 5.9±0.07 <sup>c</sup> | 1.5±0.00 <sup>c</sup> | 40.4±0.05 <sup>b</sup>  |
|              | WJB(90:10)  | 18.4±0.64 <sup>ab</sup>             | 0.9±0.02 <sup>c</sup> | 28.8±0.11 <sup>b</sup> | 6.2±0.00 <sup>b</sup> | 1.6±0.00 <sup>c</sup> | 44.1±0.78 <sup>ab</sup> |
|              | WJB(80:20)  | 17.9±0.00 <sup>a</sup> <sup>b</sup> | 1.3±0.03 <sup>b</sup> | 27.5±0.48 <sup>c</sup> | 6.5±0.07 <sup>b</sup> | 2.3±0.07 <sup>b</sup> | 44.6±0.59 <sup>ab</sup> |
|              | WJB(70:30)  | 15.6±0.28 <sup>b</sup>              | 1.5±0.00 <sup>a</sup> | 26.7±0.08 <sup>c</sup> | 7.1±0.07 <sup>a</sup> | 2.9±0.02 <sup>a</sup> | 46.3±0.27 <sup>a</sup>  |
| Coast region | WFB (100)   | 20.5±0.10 <sup>a</sup>              | 0.3±0.01 <sup>d</sup> | 31.4±0.03 <sup>a</sup> | 5.9±0.07 <sup>c</sup> | 1.5±0.00 <sup>c</sup> | 40.4±0.05 <sup>d</sup>  |
|              | WJB(90:10)  | 17.8±0.22 <sup>b</sup>              | 0.6±0.00 <sup>c</sup> | 30.5±0.14 <sup>a</sup> | 6.5±0.05 <sup>b</sup> | 1.7±0.00 <sup>c</sup> | 42.8±0.43 <sup>c</sup>  |
|              | WJB(80:20)  | 14.9±0.00 <sup>c</sup>              | 1.4±0.00 <sup>b</sup> | 29.3±0.38 <sup>b</sup> | 6.7±0.02 <sup>b</sup> | 2.2±0.07 <sup>b</sup> | 45.5±0.48 <sup>b</sup>  |
|              | WJB(70:30)  | 11.6±0.10 <sup>d</sup>              | 1.8±0.02 <sup>a</sup> | 28.3±0.23 <sup>c</sup> | 6.9±0.00 <sup>a</sup> | 2.7±0.07 <sup>a</sup> | 48.5±0.03 <sup>a</sup>  |
| Tanga        | WFB (100)   | 20.5±0.10 <sup>b</sup>              | 0.3±0.01 <sup>d</sup> | 31.4±0.03 <sup>a</sup> | 5.9±0.07 <sup>c</sup> | 1.5±0.00 <sup>c</sup> | 40.4±0.05 <sup>b</sup>  |
|              | WJB(90:10)  | 19.1 ±0.29 <sup>a</sup>             | 0.8±0.01 <sup>c</sup> | 27.2±0.08 <sup>b</sup> | 6.5±0.02 <sup>b</sup> | 1.7±0.00 <sup>c</sup> | 38.4±0.36 <sup>c</sup>  |
|              | WJB(80:20)  | 18.0±0.21 <sup>c</sup>              | 1.4±0.04 <sup>b</sup> | 26.3±0.00 <sup>c</sup> | 6.9±0.14 <sup>b</sup> | 2.3±0.14 <sup>b</sup> | 45.1±0.25 <sup>a</sup>  |
|              | WJB(70:30)  | 18.2±0.19 <sup>c</sup>              | 1.7±0.00 <sup>a</sup> | 25.3±0.00 <sup>d</sup> | 7.3±0.08 <sup>a</sup> | 2.9±0.07 <sup>a</sup> | 44.6±0.36 <sup>a</sup>  |

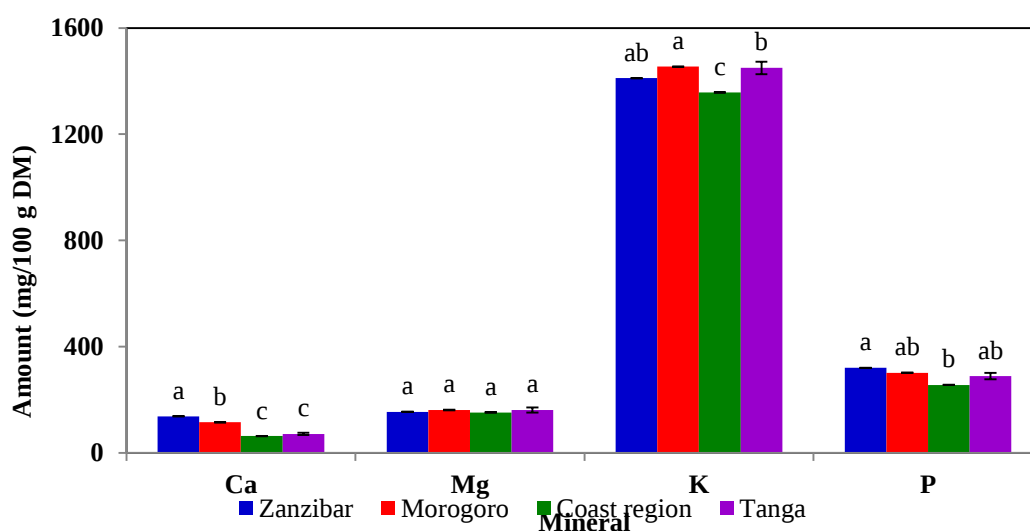
Values are expressed as mean ±SD (n=40). Bars having mean values with different letters are significantly different at p<0.05

Key: WFB = Wheat flour ban, WJB = Whet jackfruit ban

### 2.3.5 Mineral content

#### 2.3.5.1 Mineral composition of 100% jackfruit seed flour from different locations

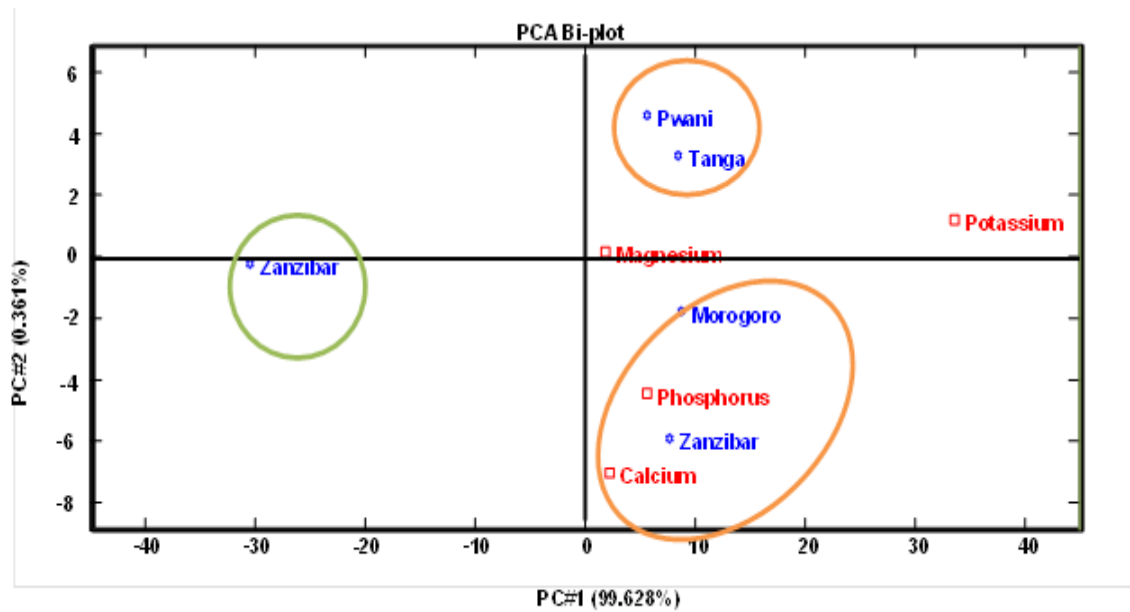
Figure 4 shows variations of mineral content (mg/100g) of jackfruit seed flour from different. Potassium was found to be in abundant quantity in all four samples from different locations followed by phosphorus, magnesium and the lowest was calcium. There were significant ( $p < 0.05$ ) difference in all mineral contents between locations except in magnesium. Potassium content was found to be highest in Morogoro sample amounted to 1454.4 mg/100g DM and the lowest 1357.2 mg/100 g DM in Coast region. Phosphorus content was found to be high in Zanzibar and low in Coast region with the score of 319.9 mg/100g and, 255.8 mg/100 g DM respectively. Calcium content ranged from 63.3 to 80.5 mg/100 g DM for Coast region and Zanzibar samples respectively. Coast region had the lowest score in all four macro minerals analyzed in this study (Figure 2.4).



**Figure 2.4: Mineral content of jackfruit seed flour from different locations** Values are expressed as Mean $\pm$ SD. Bar with mean values bearing different letters are significantly different at  $p < 0.05$ .

Results revealed that jackfruit seed flour from all four locations are rich in minerals however variation in their content might be due to inherent variability (age, maturity, species, variety and cultivar) climatic and environmental conditions as well as processing factors such as storage time and preservation temperature (Jean,1995) . Results from other study also found abundant quantity of potassium in jackfruit seed flour which was 2470.00 mg/100 as obtained by Ajayi, (2008). Abedin *et al.* (2012) reported phosphorus content of 119.3 to 139.0 mg/100g which is close to the findings of his study whereby (Gunaseena *et al.*, 1996 and Azad (2006) reported the lowest phosphorus content ranged from 38 – 97 mg/100. Abedin *et al.* (2012) also reported magnesium content of 150 to 210 mg/100g which is closely related to what was obtained in this study which ranged from 151.8 to 161.6 mg/100g. Whereby the lowest magnesium content of 54 mg/100 g was reported by Gunaseena *et al.*(1996) and Azad (2006). This study also found the low calcium content in jackfruit seed flour which ranged from 63.3 to 80.5 mg/100 g. This is compared with the result reported by Gunaseena *et al.*, 1996) and Azad (2000) who reported low calcium content of 50 mg/100 g in jackfruit seed flour.

Figure 2.5 shows variation of mineral content of jackfruit seed flour between different locations PC1 contribute 99.628% and it is contrast between Zanzibar associated with no any mineral and other locations associated with all minerals. PC2 contributes 0.361% of the total variations and it's a contrast between Coast and Tanga associated with potassium which had low loading effect on one side and Morogoro and. There is a strong correlation between Zanzibar, Morogoro in phosphorus and calcium whereby Coast region and Tanga relate positively in magnesium and potassium.



**Figure 2.5: PCA Biplot showing variation of mineral composition between locations**

### **2.3.6 Mineral contents of wheat and jackfruit composite flour within each location (g/100 gm)**

Mineral composition of wheat, jackfruit seed flours and composite flours are shown in Table 2.4. There were significant ( $p < 0.05$ ) differences in mineral contents between wheat and jackfruit flours samples with jackfruit flour having higher amount of potassium content ranged from 1357.2 to 1454.4 mg/ 100 g, phosphorus content ranged from 255.8 to 319.9 mg/ 100 g DM, magnesium content from 151.8 to 161.6 mg/ 100 g DM, and calcium content from 68.4 to 80.9 mg/ 100 g DM than their respective lower values of 137.5, 79.8, 14.4, and 13.4 mg/ 100 g DM in wheat flour. Within each location, there were progressive increases in all minerals with increase in wheat flour substitution. Potassium contents increased from 137.5 to 604.3 mg/ 100 g DM, phosphorus from 79.8 to 165.8 mg/ 100 g DM, Magnesium from 14.5 to 61.9 mg/100 g DM and calcium from 13.4 to 56.5 mg/100 g DM.

**Table 2.4: Mineral contents of wheat and jackfruit composite flours within each location (mg/100 gm DM)**

| <b>Location</b>     | <b>% Formulation</b> | <b>Calcium</b>         | <b>Magnesium</b>        | <b>Potassium</b>         | <b>Phosphorus</b>        |
|---------------------|----------------------|------------------------|-------------------------|--------------------------|--------------------------|
| <b>Zanzibar</b>     | Wheat (100%)         | 13.4±0.07 <sup>e</sup> | 14.5±0.07 <sup>b</sup>  | 137.5±0.71 <sup>e</sup>  | 79.8±0.74 <sup>e</sup>   |
|                     | ZJ (100%)            | 80.9±0.58 <sup>a</sup> | 154.7±0.70 <sup>a</sup> | 1411.3±0.71 <sup>a</sup> | 319.9±0.85 <sup>a</sup>  |
|                     | ZWJC (90:10)         | 34.2±0.70 <sup>d</sup> | 28.2±0.13 <sup>e</sup>  | 271.1±1.28 <sup>d</sup>  | 113.7±1.89 <sup>d</sup>  |
|                     | ZWJC (80:20)         | 41.3±0.70 <sup>c</sup> | 48.6±0.60 <sup>d</sup>  | 423.1±0.70 <sup>c</sup>  | 144.5±0.41 <sup>b</sup>  |
|                     | ZWJC (70:30)         | 55.9±0.70 <sup>b</sup> | 54.2±0.49 <sup>c</sup>  | 507.3±0.85 <sup>b</sup>  | 137.7±0.51 <sup>c</sup>  |
| <b>Morogoro</b>     | Wheat (100%)         | 13.4±0.07 <sup>e</sup> | 14.5±0.07 <sup>b</sup>  | 137.5±0.71 <sup>e</sup>  | 79.8±0.74 <sup>e</sup>   |
|                     | MJF (100%)           | 68.4±0.70 <sup>a</sup> | 161.6±0.25 <sup>a</sup> | 1454.4±1.39 <sup>a</sup> | 301.7±2.26 <sup>a</sup>  |
|                     | MWJC (90:10)         | 26.9±0.87 <sup>d</sup> | 31.3±0.89 <sup>e</sup>  | 319.8±0.09 <sup>d</sup>  | 122.6±0.56 <sup>d</sup>  |
|                     | MWJC (80:20)         | 41.9±0.25 <sup>c</sup> | 51.6±1.70 <sup>d</sup>  | 508.4±7.78 <sup>c</sup>  | 131.6±2.04 <sup>c</sup>  |
|                     | MWJC (70:30)         | 56.5±0.70 <sup>b</sup> | 61.9±0.08 <sup>c</sup>  | 604.3±0.08 <sup>b</sup>  | 154.9±0.10 <sup>b</sup>  |
| <b>Coast region</b> | Wheat (100%)         | 13.4±0.07 <sup>d</sup> | 14.5±0.07 <sup>b</sup>  | 137.5±0.71 <sup>e</sup>  | 79.8±0.74 <sup>d</sup>   |
|                     | CJF (100%)           | 76.6±0.17 <sup>a</sup> | 151.8±0.72 <sup>a</sup> | 1357.2±1.44 <sup>a</sup> | 255.8±15.29 <sup>a</sup> |
|                     | CWJC (90:10)         | 19.7±0.52 <sup>c</sup> | 28.8±0.55 <sup>e</sup>  | 259.5±1.59 <sup>d</sup>  | 104.9±0.51 <sup>cd</sup> |
|                     | CWJC (80:20)         | 20.2±0.15 <sup>c</sup> | 38.5±0.21 <sup>d</sup>  | 371.4±1.89 <sup>c</sup>  | 112.5±0.61 <sup>bc</sup> |
|                     | CWJC (70:30)         | 41.7±0.71 <sup>b</sup> | 52.3±0.92 <sup>c</sup>  | 524.4±0.43 <sup>b</sup>  | 134.9±0.10 <sup>b</sup>  |
| <b>Tanga</b>        | Wheat (100%)         | 13.4±0.07 <sup>e</sup> | 14.5±0.07 <sup>b</sup>  | 137.5±0.71 <sup>e</sup>  | 79.8±0.74 <sup>e</sup>   |
|                     | TJF (100%)           | 68.4±0.70 <sup>a</sup> | 161.3±0.72 <sup>a</sup> | 1449.7±0.21 <sup>a</sup> | 288.9±0.60 <sup>a</sup>  |
|                     | TWJC (90:10)         | 27.1±0.70 <sup>d</sup> | 29.6±0.44 <sup>e</sup>  | 285.3±0.03 <sup>d</sup>  | 116.4±0.47 <sup>d</sup>  |
|                     | TWJC (80:20)         | 41.3±0.70 <sup>c</sup> | 51.5±0.56 <sup>d</sup>  | 488.7±0.66 <sup>c</sup>  | 165.8±2.19 <sup>b</sup>  |
|                     | TSWJC (70:30)        | 56.4±0.38 <sup>b</sup> | 57.1±0.22 <sup>c</sup>  | 598.7±0.12 <sup>b</sup>  | 158.6±0.3 <sup>c</sup>   |

Values are expressed as mean ±SD (n=40). Bars having mean values with different letters are significantly different at p<0.05

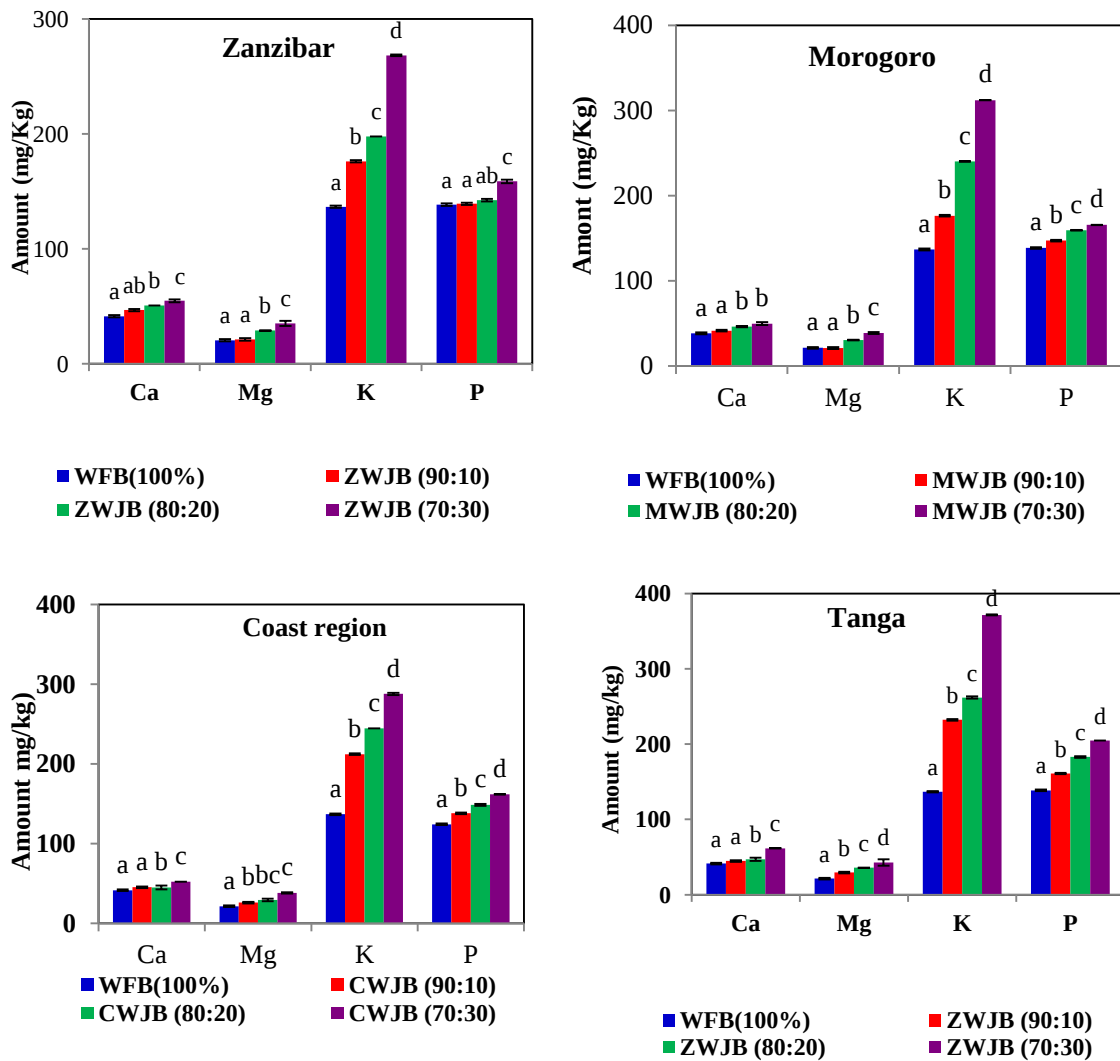
Key: C = Coast region, M = Morogoro, T = Tanga, Z = Zanzibar, JF = Jackfruit flour, WJC = wheat jackfruit composite

Results on mineral contents of composite flour revealed that the substitution of wheat flour with jackfruit seed flour is of great importance due to the fact that all mineral elements in the composite flour have been enhanced. Data on mineral composition of wheat jackfruit seed composite flour were lacking for reference.

### **2.3.7 Mineral composition of wheat and jackfruit seed composite flour buns**

Figure 2.6 (a-d) presents mineral contents of wheat jackfruit flour composite buns from different locations. Potassium was found to be in large quantity in all samples in all four locations followed with phosphorus, calcium and magnesium. The variation in mineral contents between products in all locations were significant ( $p < 0.05$ ). The composite buns with 30% jackfruit seed flour (WJB 30%) had the highest score in all mineral elements followed by WJB 20% and least in WJB10%. However, there was no significant ( $p < 0.05$ ) difference in calcium content between wheat and WJB 10% buns in all four locations. Specifically, there was no significant ( $p < 0.05$ ) difference in magnesium content between control buns and WJB 10% composite buns in Zanzibar and Morogoro.

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**Figure 2.6: Mineral contents of wheat jackfruit flour composite buns at different levels of wheat flour substitution within each location. Values are expressed as Mean $\pm$ SD. Bar with mean values bearing different letters are significantly different at  $p < 0.05$ . WJB means wheat jackfruit bun**

**Key: WFB= Wheat flour bun, WJB= wheat jackfruit bun, C= Coast region, M= Morogoro, T= Tanga, Z= Zanzibar**

The findings suggest that, the mineral contents of composite products increased as the percentage of wheat flour substitution with jackfruit flour increased in a sample. Airani (2007) similarly observed a progressive increase in total mineral content of wheat jackfruit composite biscuits amounted from 0.76, 1.0, 1.25, 1.52, 1.80 and 2.08g/ 100 g for control biscuit (100% wheat flour), 10, 20, 30, 40 and 50% of wheat jackfruit substitution respectively. Composite buns have been found to contain good amount of minerals especially potassium which is a very important element in the human body for both cellular and electrical functions. It is necessary for bone health, energy metabolism and the maintenance of the electrochemical balance that allows nerve cells to transmit impulses and muscles to contract (Dickson, 2002). It is one of the main blood minerals called "electrolytes". Epidemiological and clinical studies show that a high- level of potassium in once diet lowers blood pressure in individuals with high blood pressure and reduces cardiovascular disease mortality. Furthermore, a high-potassium diet may also prevent or at least slow the progression of renal disease. An increased potassium intake lowers urinary calcium excretion and plays an important role in the management of hypercalciuria and kidney stones and is likely to decrease the risk of osteoporosis (He and MacGregor, 2008).

## **2.4 Conclusion**

This study revealed that the locally grown jack fruit seed flour are very rich in protein, fibre, ash and carbohydrate as well as calcium, magnesium, potassium and phosphorus. Substitution of wheat flour with these flour in composite flour technology enhances protein, ash, fibre calcium, magnesium, potassium and phosphorus contents of the processed composite flour and buns. Mineral content (Ca, Mg, K and P) were very high in Jackfruit seed flour from all four locations than in 100% wheat flour and this has contributed to the increase of these minerals in all composite flour samples as well as

their corresponding final products (buns). In all four locations potassium was the macro mineral which was found to be in abundant quantity in jackfruit seed flower followed by phosphorus, magnesium, and calcium which was in small quantity. It is therefore concluded that Jack fruit seed flour can be mixed with other flour with low nutrients to improve the nutrients content of the developed final product.

### 3.1 Introduction

Buns are famously known as *Mandazi* in swahili and are one of the breakfast snacks which are made of wheat flour as its major ingredients. It is mostly consumed with tea in the morning however it can be consumed any time of a day with milk or juice. Mostly buns are prepared from 100% wheat flour which is a highly refined flour made from the inner most part of the endosperm which results to flour with low nutritional content. Jackfruit seed is very rich in many nutrients like protein, ash and fibre as well as minerals like potassium, magnesium, phosphorus and calcium (and Singh *et al.*, 1991 and Abedin *et al.*, 2012) and can therefore be mixed with wheat flour to develop baked products and confectionaries. This in turn would enhance nutritional composition of the developed products as well as nutritional status and people's health. Furthermore, incorporation of locally grown non-wheat crops' flour in baked products and confectioneries through composite flour technology would reduce amount of currency which used for wheat importation. Wheat is not grown in tropical countries and hence many countries spend substantial amount of their foreign currency to import wheat to meet their local demands (USDA, 2017). Sensory evaluation is a scientific discipline used to evoke measure, analyse and interpret reactions to the characteristics of foods and materials as they are perceived by the senses of sight, smell, taste, touch and hearing. It is very important quality parameters in food and beverage industries since it tells to what degree that the product has been accepted (Stone *et al.*, 2004) and decision to purchase of food products (Berian *et al.*, 2009). Therefore, assessing product sensory profile and level of consumer acceptability are crucial during product development and marketing. However, despite adequate literature review, information on the use of jackfruit seed flour in developing composite flour and baked products, their sensory profile and consumer acceptability are limited in the country. Therefore, this study was carried to develop and assess sensory profiles and consumer acceptability of wheat jackfruit composite buns.

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## **CHAPTER THREE**

### **PAPER TWO**

#### **3.0 Sensory Profile and Consumer Acceptability of Wheat and Jackfruit Seed Flour**

##### **Composite Buns**

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**Abstract**

Development and assessment of sensory profile and consumer acceptability of Wheat and Jackfruit Seed Flour Composite Buns were investigated in this study. Jackfruit seeds from Zanzibar, Morogoro, Coast region and Tanga regions were processed to form flour and separately mixed with wheat flour to form composite flour at the ratio of 10, 20 and 30% wheat flour substitution and then developed into composite buns. The products were then subjected to both Quantitative Descriptive Analysis (QDA) and Consumer acceptability using 9-point hedonic test. There were significant ( $p < 0.05$ ) differences in intensity score of all attributes between wheat flour bun (control bun) and 30% (WJB 30%) samples with the former having significantly ( $p < 0.05$ ) higher values. Mean intensity crumb colour scored  $7.5 \pm 1.72$  and  $6.3 \pm 2.18$ , aroma scores of  $6.7 \pm 2.09$  and  $5.8 \pm 2.49$ , were respectively observed in wheat flour bun (control bun) and 30% composite buns. Furthermore, overall acceptability show that control bun was highly acceptable by 8.08 points followed by WJB 10% by 7.85 points, WJB 20% by 7.05 points and lastly WJB 30% by 6.23 points. Therefore, this study conclude that jackfruit seed flour can be in cooperated with wheat flour up to 10% jackfruit seed flour to produce a product without compromising its sensory quality attributes.

*Key words: composite buns, Quantitative Descriptive, organoleptic*

### 3.1 Introduction

Buns are famously known as *Mandazi* in swahili and are one of the breakfast snacks which are made of wheat flour as its major ingredients. It is mostly consumed with tea in the morning however it can be consumed any time of a day with milk or juice. Mostly buns are prepared from 100% wheat flour which is a highly refined flour made from the inner most part of the endosperm which results to flour with low nutritional content. Jackfruit seed is very rich in many nutrients like protein, ash and fibre as well as minerals like potassium, magnesium, phosphorus and calcium (and Singh *et al.*, 1991 and Abedin *et al.*, 2012) and can therefore be mixed with wheat flour to develop baked products and confectionaries. This in turn would enhance nutritional composition of the developed products as well as nutritional status and people's health. Furthermore, incorporation of locally grown non-wheat crops' flour in baked products and confectioneries through composite flour technology would reduce amount of currency which used for wheat importation. Wheat is not grown in tropical countries and hence many countries spend substantial amount of their foreign currency to import wheat to meet their local demands (USDA, 2017). Sensory evaluation is a scientific discipline used to evoke measure, analyse and interpret reactions to the characteristics of foods and materials as they are perceived by the senses of sight, smell, taste, touch and hearing. It is very important quality parameters in food and beverage industries since it tells to what degree that the product has been accepted (Stone *et al.*, 2004) and decision to purchase of food products (Berian *et al.*, 2009). Therefore, assessing product sensory profile and level of consumer acceptability are crucial during product development and marketing. However, despite adequate literature review, information on the use of jackfruit seed flour in developing composite flour and baked products, their sensory profile and consumer acceptability are limited in the country. Therefore, this study was carried to develop and assess sensory profiles and consumer acceptability of wheat jackfruit composite buns.

## **3.2 Material and Methods**

### **3.2.1 Study area**

The study was conducted at the departments of Food Technology, Nutrition and Consumer Science laboratory (DFTNCS), Animal Sciences (DAS) and Soil Sciences (DSS) laboratories at, Sokoine University of Agriculture in Morogoro region.

### **3.2.2 Materials**

Mature and fresh jackfruits were purchased directly from local farmers in Tanga, Morogoro and Coast regions and Zanzibar. The areas were purposively selected as they are the famous for growing jackfruit in Tanzania. Other materials were purchased from respective shops in Dar es Salaam and Morogoro regions. Analytical reagents and chemicals were obtained from DFTNC and DAS laboratories and/or purchased from suppliers in Dar es Salaam.

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### **3.2.3 Preparation of jackfruit seed flour**

The Fruits were cut in two halves and the seeds were removed from the pulp. The obtained Jackfruit seeds were cleaned by water and then pre-dried and the seed coat was manually peeled off. Seeds were then sliced into thin chips and sun dried. The dried seeds were milled into flour, and packed in polyethylene pouches and stored in a refrigerator ( $<10^{\circ}\text{C}$ ) prior to preparation of buns (*Mandazi*).

### Flow Chart of Jackfruit Flour Processing

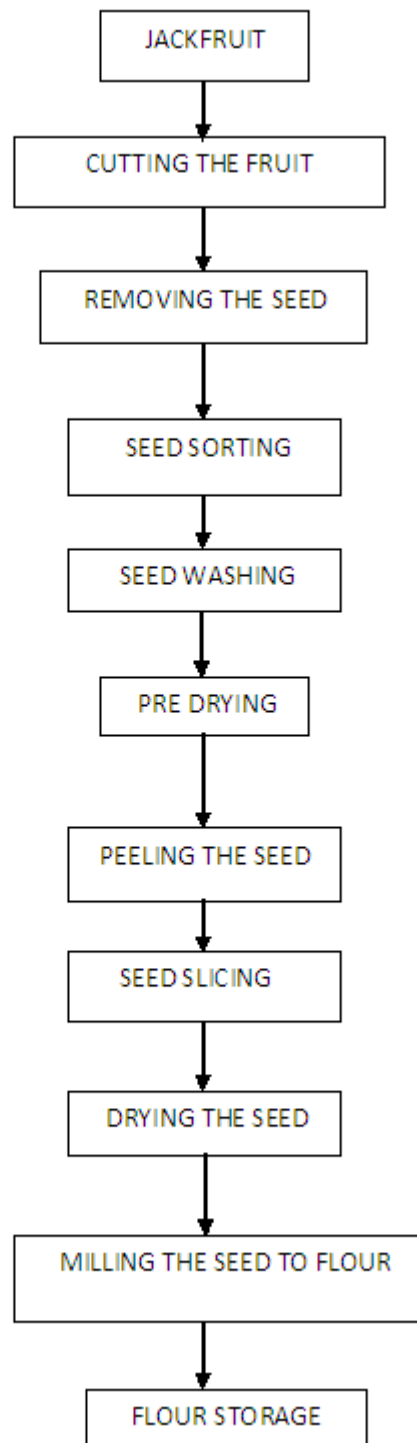


Figure 3.1: Flow chart show in g jackfruit seed flour proceeding

### 3.2.4 Formulation of wheat and jackfruit seed composite flour

Jackfruit seed flour from each region was separately combined to form a composite with wheat flour in three treatment of 90% wheat flour + 10% jackfruit seed flour, 80% wheat flour + 20% jackfruit seed flour, and 70% wheat flour + 30% jackfruit seed flour as shown in Table 3.1.

**Table 3.1: Three formulations of developed jackfruit based buns**

| S/N | % Wheat Flour | % Jackfruit Flour |
|-----|---------------|-------------------|
| 1.  | 90            | 10                |
| 2.  | 80            | 20                |
| 3.  | 70            | 30                |

### 3.2.5 Preparation of Buns (Maandazi)

500 g of flour was weighed and kept in a clean bowl, dry ingredient including 65g sugar, 10 g vegetable fat, 3.5 g yeast and 1.5g salt were added and mixed thoroughly to obtain a uniform mixture of all ingredients. Water was added gradually into the mixture, and then kneaded to soft dough. The dough was left to leaven for 45 minutes and then cut into small pieces of the desired shape and size by using a knife and left to stay for 10 minutes. Then sized pieces of dough were deep fried in a hot oil of 150<sup>0</sup>C until the golden brown colour was attained. Buns were removed from hot oil and kept in a metal sieve to drain the oil and left to cool on a clean plate at room temperature. The cooled buns were preserved in a food grade polyethylene bags at room temperature ready for sensory evaluation on the next day.

### **3.2.6 Sensory Evaluation**

#### **3.2.6.1 Quantitative Descriptive Analysis**

A total of 8 trained panelists comprising of 3 male and 5 female with age ranging from 23 to 30 years participated in descriptive sensory analysis of buns according to method described in Lawless and Heyman (2003). The test was conducted at the Department of Food Technology, Nutrition and Consumer Sciences (DFTNCS) laboratory. Before being subjected to the actual exercise the selected assessors undergone a three days training according to ISO 8586 (1993). During training panelists developed and agreed on the terminologies to be used on the analysis. They agreed on the following attributes aroma, crumb colour, crust colour, mouth feel, oiliness, softness and sweetness as shown in (Table 3.2). Assessors also developed and agreed on unstructured 10 line scale which was used for rating the intensity of the agreed attributes. The left side of the scale corresponded to the lowest intensity of each attribute (value 1) and the right side corresponded to the highest intensity (value 10). All samples were coded with 3-digit random numbers and were served to each panelist in a randomized order. The average responses obtained from the panelist were used in the univariate and multivariate analyses. Both pre- trial test and panel performance assessment to ascertain agreement of panelist in discriminating samples and their reproducibility were done.

**Table 3.2: Sensory terminologies as agreed by the panelists**

| <b>Attribute</b> | <b>Definition</b>                                                                                           | <b>Anchor</b>                   |
|------------------|-------------------------------------------------------------------------------------------------------------|---------------------------------|
| Aroma            | Aromatic associated with bun                                                                                | Less bun smell – More bun smell |
| Crumb colour     | Cream colour associated with crumb colour of the bun, a representative sample was a bun from antique bakery | Not cream – Cream               |
| Crust colour     | The brown colour of a normal bun, a representative sample was from Mama K restaurant                        | Light brown - deep brown        |
| Mouth feel       | Stickiness when chewed                                                                                      | Too sticky – Less sticky        |
| Oiliness         | Bun should have less oily content                                                                           | More oily – less oily           |
| Softness         | Softness associated with a normal bun represented with the bun from antique bakery                          | Not soft – Very soft            |
| Sweetness        | Sweetness associated with a normal bun represented with the burn from antique bakery                        | Less sweet – Sweet              |

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Source: Study panelists

### **3.2.7 Consumer study**

#### **3.2.7.1 Consumer panel characteristics**

Consumer panel was comprised of 40 panelists whereby 26 panelists who are equal to 75% were male and 14 panelists who are equal to 35% were female. All panelists were undergraduate students in the age group of 20-27 years who are pursuing different programs at the University. 24 of the panelists were frequent user of buns on daily basis,

8 once a week, 5 once per month and 3 were seldom users of buns. This was equal to 60%, 20%, 12.5% and 7.5% respectively.

#### **3.2.7.2 Consumer acceptability test**

The sensory test for consumer acceptability was conducted at the DFTNCS by 40 untrained consumers of both sexes aged between 20-30 years. Were by 26 which are equal to 75% were males and 14 which are equal to 35% were females. All panelists were undergraduate students of Sokoine University of Agriculture from 1<sup>st</sup> to 3<sup>rd</sup> year who were pursuing different degree programs. Small pieces of buns were placed on disposable plates coded with three digit random numbers and the plates were served to the panelists in a randomized manner. A 9 point hedonic scale (where 1 = dislike extremely and 9 = like extremely) as described by Lawless and Heyman (2003) was used to evaluate the overall acceptability of bun samples.

#### **3.2.8 Statistical data analysis**

Data were analysed by using the R statistical package (R Development Core Team, Version 3.0.0 Vienna, Austria) for Analysis of variance (Anova) to determine the significant differences in sensory attributes and consumer acceptability of buns made from wheat jackfruit composite flour from different locations. Means were separated using Tukeys Honest Significant difference ( $p < 0.05$ ). Principal Component Analysis (PCA) was used to determine the systematic variations in sensory data using Latentix Software (LatentiX Aps Team, version 2.12, Frederiksberg Denmark) (Martens and Martens, 2001). Results were presented as arithmetic mean and standard deviation in Tables and graphs as well as in PCA bi plots.

### 3.3 Results and Discussion

#### 3.3.1 Sensory Evaluation

##### 3.3.1.1 Quantitative Descriptive Analysis

Table 3.3 presents descriptive mean intensity scores in different sensory attributes for control buns and composite buns within each location. There were significant ( $p < 0.05$ ) variations in mean intensity scores of all attributes between control bun and all composite buns except in aroma. Also control bun had the highest mean intensity score in all attributes except in crust colour. Crust colour shows significant ( $p < 0.05$ ) differences with the highest mean intensity score of  $8.7 \pm 0.87$  and  $8.4 \pm 1.31$  for WJB 30 and 20% both from Zanzibar respectively. The lower mean values of  $6.9 \pm 1.62$  and  $6.9 \pm 1.26$  were scored by WJB 10% from Zanzibar and WJB 20% from Coast region respectively. Results show significant ( $p < 0.05$ ) difference in crumb colour whereby the highest mean intensity score of  $7.5 \pm 1.83$  followed by  $6.3 \pm 2.18$  and  $6.3 \pm 2.12$  were scored by control bun, followed by WJB 10% from Morogoro and Tanga respectively. The lowest mean intensity of  $3.9 \pm 2.96$  and  $4.1 \pm 2.87$  were scored by WJB 30% from Tanga and Zanzibar respectively. There was significant ( $p < 0.05$ ) difference in sweetness with the highest mean intensity of  $6.9 \pm 1.77$  scored by control bun and  $6.8 \pm 1.6$  scored by WJB 10% from Morogoro whereby all WJB 30% had the lowest mean intensity scores. Results show significant ( $p < 0.05$ ) difference in the attributes mouth feel, oiliness and softness whereby control bun had the highest mean intensity of  $7.4 \pm 1.78$ ,  $7.6 \pm 1.09$  and  $7.3 \pm 1.53$  respectively. This was followed by the respective sensory attributes with mean intensity of  $6.6 \pm 1.82$  which was scored by WJB 10%, from Zanzibar,  $7.2 \pm 1.24$  WJB 20% and  $6.4 \pm 1.75$  WJB 10% both from Tanga.

**Table 3.3: Mean intensity score of wheat and jackfruit flour composite buns within each location**

| Sample                 | Crust colour            | Crumb colour            | Sweetness                | Aroma                 | Mouthfeel              | Oilness                | Softness                |
|------------------------|-------------------------|-------------------------|--------------------------|-----------------------|------------------------|------------------------|-------------------------|
| <b>MWJB (10%)</b>      | 7.1±1.71 <sup>bc</sup>  | 6.3±2.18 <sup>ab</sup>  | 6.8±1.60 <sup>ab</sup>   | 6.1±2.31 <sup>a</sup> | 6.3±2.12 <sup>ab</sup> | 6.8±1.61 <sup>ab</sup> | 6.1±1.75 <sup>ab</sup>  |
| <b>MWJB (20%)</b>      | 7.6±1.54 <sup>abc</sup> | 5.8±2.32 <sup>abc</sup> | 6.0±2.13 <sup>abcd</sup> | 6.1±2.16 <sup>a</sup> | 6.2±2.46 <sup>b</sup>  | 6.9±1.95 <sup>ab</sup> | 5.0±1.15 <sup>bcd</sup> |
| <b>MWJB (30%)</b>      | 7.9±1.5 <sup>abc</sup>  | 4.6±3.00 <sup>bcd</sup> | 5.6±2.25 <sup>d</sup>    | 5.6±2.31 <sup>a</sup> | 5.6±2.55 <sup>b</sup>  | 6.2±1.72 <sup>b</sup>  | 4.0±1.31 <sup>de</sup>  |
| <b>CWJB (10%)</b>      | 7.3±1.61 <sup>bc</sup>  | 4.8±2.46 <sup>bcd</sup> | 6.7±1.99 <sup>abc</sup>  | 6.1±2.32 <sup>a</sup> | 6.2±2.26 <sup>b</sup>  | 6.6±1.78 <sup>ab</sup> | 5.1±1.91 <sup>bcd</sup> |
| <b>CWJB (20%)</b>      | 6.9±1.26 <sup>c</sup>   | 4.7±2.77 <sup>bcd</sup> | 6.5±1.89 <sup>abcd</sup> | 6.4±2.42 <sup>a</sup> | 6.5±1.93 <sup>ab</sup> | 6.6±1.59 <sup>ab</sup> | 5.3±2.32 <sup>bcd</sup> |
| <b>CWJB (30%)</b>      | 7.6±1.41 <sup>abc</sup> | 4.0±3.00 <sup>cd</sup>  | 5.8±2.19 <sup>bcd</sup>  | 5.6±2.47 <sup>a</sup> | 5.9±2.45 <sup>b</sup>  | 6.8±1.76 <sup>ab</sup> | 3.1±1.73 <sup>e</sup>   |
| <b>TWJB(10%)</b>       | 7.6±1.36 <sup>abc</sup> | 6.3±2.12 <sup>ab</sup>  | 6.9±1.96 <sup>ab</sup>   | 6.5±2.19 <sup>a</sup> | 6.1±2.55 <sup>b</sup>  | 7.0±1.55 <sup>ab</sup> | 6.4±1.75 <sup>ab</sup>  |
| <b>TWJB (20%)</b>      | 8.4±1.31 <sup>ab</sup>  | 5.0±2.39 <sup>bcd</sup> | 6.1±2.24 <sup>abcd</sup> | 6.1±2.21 <sup>a</sup> | 6.1±2.45 <sup>b</sup>  | 7.2±1.24 <sup>ab</sup> | 4.8±1.87 <sup>bcd</sup> |
| <b>TWJB (30%)</b>      | 8.7±0.87 <sup>a</sup>   | 3.9±2.96 <sup>d</sup>   | 5.6±2.28 <sup>d</sup>    | 5.8±2.49 <sup>a</sup> | 5.9±2.54 <sup>b</sup>  | 6.2±2.21 <sup>b</sup>  | 4.4±1.31 <sup>cde</sup> |
| <b>ZWJB (10%)</b>      | 6.9±1.62 <sup>c</sup>   | 5.9±2.62 <sup>ab</sup>  | 6.7±1.74 <sup>abc</sup>  | 5.9±2.06 <sup>a</sup> | 6.6±1.82 <sup>ab</sup> | 6.9±1.31 <sup>ab</sup> | 5.7±1.08 <sup>abc</sup> |
| <b>ZWJB(20%)</b>       | 8.1±1.69 <sup>abc</sup> | 5.3±2.67 <sup>bcd</sup> | 6.2±2.00 <sup>abcd</sup> | 5.9±2.39 <sup>a</sup> | 6.3±2.55 <sup>ab</sup> | 6.3±2.21 <sup>ab</sup> | 4.8±1.81 <sup>bcd</sup> |
| <b>ZWJB (30%)</b>      | 8.1±1.61 <sup>abc</sup> | 4.1±2.87 <sup>cd</sup>  | 5.6±2.42 <sup>cd</sup>   | 6.1±2.28 <sup>a</sup> | 6.3±2.41 <sup>ab</sup> | 6.3±2.15 <sup>b</sup>  | 4.3±1.73 <sup>cde</sup> |
| <b>WFB/control bun</b> | 7.2±1.72 <sup>bc</sup>  | 7.5±1.82 <sup>a</sup>   | 6.9±1.77 <sup>a</sup>    | 6.7±2.09 <sup>a</sup> | 7.4±1.78 <sup>a</sup>  | 7.6±1.09 <sup>a</sup>  | 7.3±1.53 <sup>a</sup>   |

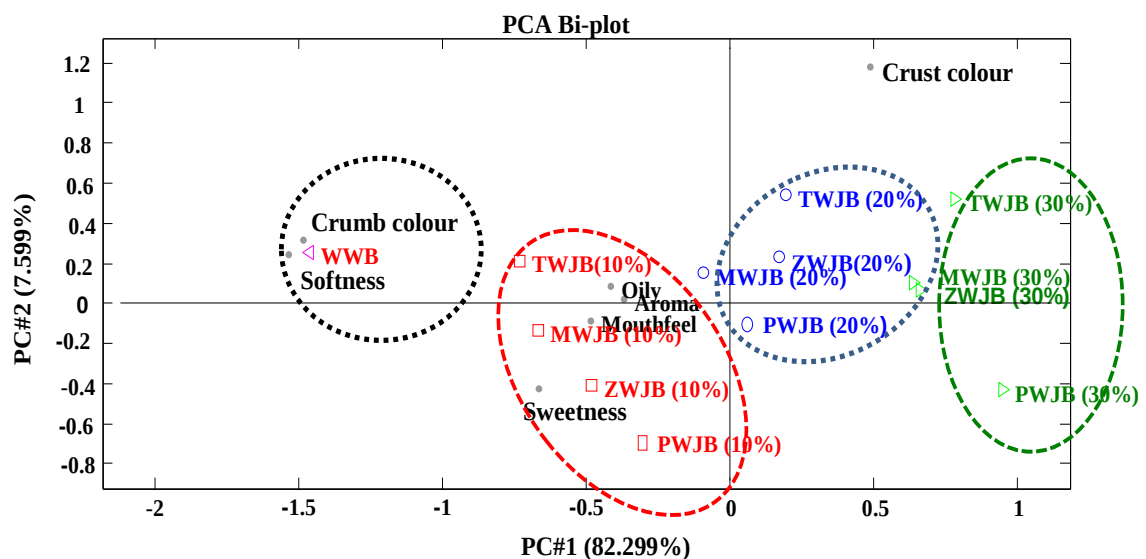
Values are expressed as mean SD

Mean values with different superscript letters along the columns are significantly different at  $p < 0.05$

Key:M= Morogoro, C= Coast region, T= Tanga, Z= Zanzibar, WJB= Wheat -Jackfruit bun

### 3.3.2 Principal component analysis

Figure 3.2 shows that PC1 contributes 82.299% and PC2 contributes about 7.599 of the total variability. PC1 shows a clear separation between control bun (WFB) and all composite buns made of 10% jackfruit seed four (WJB 10%) from all locations on the left side against all composite buns WJB 20 and 30% from all four locations on the right side. This means that there was strong correlation between control bun and all WJB 10% in the attributes crumb colour, softness, oiliness, aroma, mouth feel and sweetness however control bun seems to be much softer with creamy crumb colour than WJB 10%. Also all composite buns WJB 20 and 30% from all four locations do relate positively in their crust colour which is also a reason of separation between control bun and composite buns WJB 10% on one side against WJB 20 and 30% on the other side along PC1. Variation in PC 2 is also contributed with crust colour. Grouping of the samples from different formulations was also clearly observed.



**Figure 3.2: Principal component analysis Biplot for Quantitative Descriptive Analysis**

Key: WFB= Wheat flour bun, WJB= Wheat jackfruit bun, C= Coast region M= Morogoro, T= Tanga, Z= Zanzibar

Generally, results from sensory evaluation (QDA and PCA) show that control bun was ranked first in all sensory attribute except in crust colour such that all buns made of 30% jackfruit seed flour had the highest mean score which means the crust had high intensity in brown colour. Also the control bun seems to comply with the composite buns WJB 10% in all attributes and with WJB 20% to some attributes such as in sweetness, oiliness, mouth feel and aroma. Results also show that as the percentage of wheat flour substitution increased many sensory attributes found to have low average mean scores. The significant variation in sensory attributes might be due to addition non wheat flour in a sample. Incorporation of orange fleshed sweet potato in wheat flour has an effect on the bun products (Mongi *et al.*, 2015). The deep brown crust colour in composite buns WJB 20 and 30% might have been contributed with the presence of brown spermoderm that surround jackfruit seed which affected the colour of jackfruit seed flour. Moreover the deep brown colour of the crust may be associated with the maillard reaction between reducing sugars and amino acids in protein (Phisut and Jiraporn, 2013). This results is in agreement with the results reported by Islam *et al.*, (2015) on wheat jackfruit composite biscuits who found the decrease in mean scores on sensory attribute due to increase in cooperation of jackfruit seed flour in the wheat flour. The low mean score in softness in the composite buns may be resulted with the addition of fibrous non-wheat flour which led to less retention of carbon dioxide gas, increased water absorption and harder texture (Gomez *et al.*, 2003).

### **3.3.3 Consumer study**

#### **3.3.3.1 Consumer panel characteristics**

Table 3.4 shows the summary of the characteristics of consumer panel which was comprised of 40 panelists.

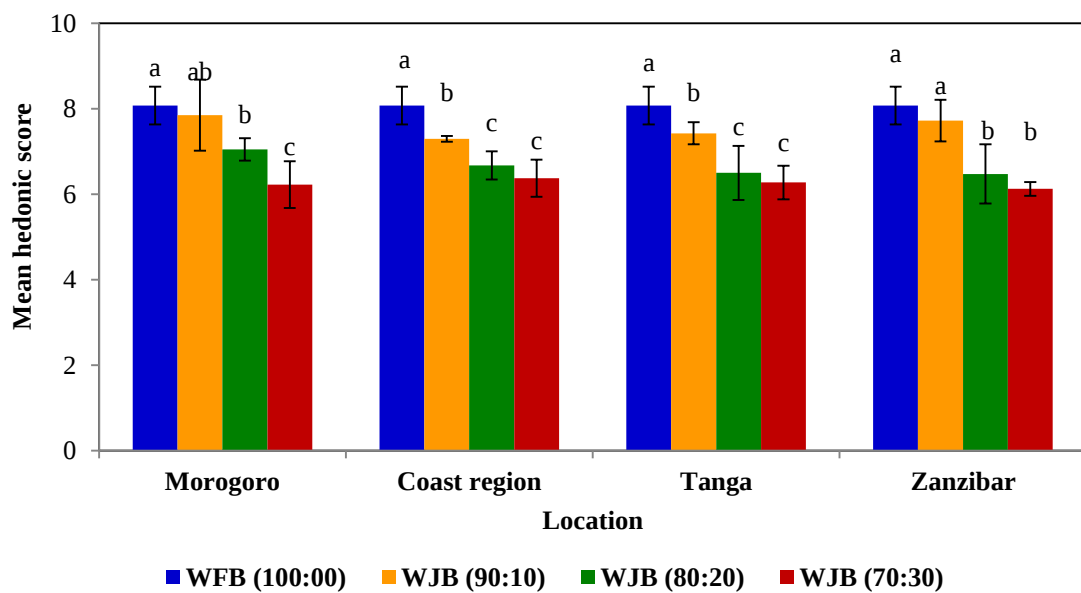
**Table 3.4: Characteristics of the consumer acceptability panel (n=40)**

| <b>Attribute</b>        | <b>Category</b> | <b>Frequency (n)</b> | <b>Percentage (%)</b> |
|-------------------------|-----------------|----------------------|-----------------------|
| <b>Gender</b>           | Male            | 26                   | 75                    |
|                         | Female          | 14                   | 35                    |
|                         | <b>Total</b>    | <b>40</b>            | <b>100</b>            |
| <b>Age group</b>        | 19-30           | 40                   | 100                   |
|                         | 31-40           | 0                    | 0                     |
|                         | <b>Total</b>    | <b>40</b>            | <b>100</b>            |
| <b>Education group</b>  | Undergraduate   | 40                   | 100                   |
|                         | Postgraduate    | 0                    | 0                     |
|                         | <b>Total</b>    | <b>40</b>            | <b>100</b>            |
| <b>Consumption</b>      | Daily           | 24                   | 60                    |
|                         | Once/week       | 8                    | 20                    |
|                         | Once/month      | 5                    | 12.5                  |
|                         | Seldom          | 3                    | 7.5                   |
|                         | <b>Total</b>    | <b>40</b>            | <b>100</b>            |
| <b>Brand preference</b> | WFB100%         | 18                   | 45                    |
|                         | WJB10%          | 15                   | 37.5                  |
|                         | WJB20%          | 4                    | 10                    |
|                         | WJB30%          | 3                    | 7.5                   |
|                         | <b>Total</b>    | <b>40</b>            | <b>100</b>            |

### 3.3.4 Hedonic results

Figure 3.3 shows significant ( $P < 0.05$ ) difference in the mean hedonic scores of bun samples in the overall acceptability of consumers between control bun (100% wheat flour bun = WFB) and composite buns (wheat jackfruit bun = WJB) within each location. The results show that control bun had the highest mean hedonic score than all composite bun samples from all four locations. The mean scores of the buns in each location started with the highest score from control bun (WFB 100%) followed with (WJB) 10% 20% and lastly 30% which had the lowest mean score. This implies that most consumers accepted the control bun followed by composite bun WJB 10%, 20% and last 30%. There was no significant ( $P < 0.05$ ) difference between control buns and composite buns WJB10 % from

Morogoro and Zanzibar. This means that consumer failed to distinguish between control bun and composite buns WJB10% from the mentioned locations. Results show that there is significant difference between control bun and composite buns In Coast region and Tanga which means that consumers managed to distinguish control bun from all composite buns in the respective region. However they failed to distinguish composite buns made of 20% jackfruit seed four and 30% jackfruit seed four in Coast region, Zanzibar and Tanga.



**Figure 3.3: Mean hedonic scores for overall acceptability of buns samples by consumers between control bun and composite buns within each location, values are expressed as mean  $\pm$ SD (n=40)**

**Key: WFB = Wheat flour bun, WJB = Wheat jackfruit bun**

## 2.4 Conclusion

Despite the fact that control bun was ranked first in all attributes except in crust colour, findings from QDA, show no significant difference between control bun and composite buns (WJB 10%) in all attributes of aroma, crumb and crust colour, mouthfeel, oiliness, softness and sweetness as well with 20% jackfruit seed flour to some attributes such as sweetness, oiliness, mouth feel and aroma. Results found further that as the percentage of substitution of wheat flour with jackfruit seed flour increased up to 30% many sensory attributes were found to have low average mean scores. On assessing overall acceptability of the consumers, it was found that There was no significant ( $P < 0.05$ ) difference between control buns and composite buns WJB 10% from Morogoro and Zanzibar which means consumers failed to distinguish between control bun from composite buns (WJB 10%) from the respective regions. This implies that control bun is related positively with WJB 10%. However control bun was found to be highly acceptable followed by WJB 10%, 20% and last 30%. It can be concluded that, jackfruit seed flour can be mixed with wheat flour up to 10% to produce a value added buns without compromising its sensory quality attributes.

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## APPENDICES

### Appendix 1: Quantitative Descriptive Analysis of Buns

Name .....Date.....Time.....

Please evaluate each sample in the order they are listed. Choose appropriate number in a scale from 1 to 10 where 1 is a low density and 10 is high density. How do you find the mentioned characteristics of the sample (buns), tick the appropriate number against each characteristic

Sample number....

#### Crust colour

|   |   |   |   |   |   |   |   |   |    |
|---|---|---|---|---|---|---|---|---|----|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|----|

Less brown  Brown

#### Crumb colour

|   |   |   |   |   |   |   |   |   |    |
|---|---|---|---|---|---|---|---|---|----|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|----|

Not cream  Cream

#### Sweetness

|   |   |   |   |   |   |   |   |   |    |
|---|---|---|---|---|---|---|---|---|----|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|----|

Less sweet  Sweet

#### Aroma

|   |   |   |   |   |   |   |   |   |    |
|---|---|---|---|---|---|---|---|---|----|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|----|

Not aromatic  Very aromatic

#### Mouth feel

|   |   |   |   |   |   |   |   |   |    |
|---|---|---|---|---|---|---|---|---|----|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|----|

Too stick  Less sticky

**Oiliness**

|   |   |   |   |   |   |   |   |   |    |
|---|---|---|---|---|---|---|---|---|----|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|----|

Oily  Less oily

**Softness**

|   |   |   |   |   |   |   |   |   |    |
|---|---|---|---|---|---|---|---|---|----|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|----|

Not Soft  Very soft

## Appendix 2 Consumer Test Form

Name.....

Date..... Time.....

You are provided with 6 coded samples of buns/mandazi, you are required to test all samples and indicate how much you like or dislike each sample attribute according to the provided scale.

Before testing the next sample you are required to rinse your mouth with water.

Scale of liking

9 – Like extremely

8 – like very much

7 – Like moderately

6 – Like slightly

5 – Neither like nor dislike

4 –Dislike slightly

3 – Dislike moderately

2 – Dislike very much

1 – Dislike extremely

| Sample | Crust colour | Crumb colour | Aroma | Taste | Texture | Overall acceptability |
|--------|--------------|--------------|-------|-------|---------|-----------------------|
| 985    |              |              |       |       |         |                       |
| 814    |              |              |       |       |         |                       |
| 583    |              |              |       |       |         |                       |
| 312    |              |              |       |       |         |                       |
| 447    |              |              |       |       |         |                       |
| 791    |              |              |       |       |         |                       |

Comments

.....  
 .....  
 .....  
 .....

**ADDITIONAL QUESTIONS**

Please answer the questions bellow by circling the appropriate answer

1. Gender
  - a. Male
  - b. Female
  
2. Age
  - a. 19 – 30
  - b. 31 – 40
  - c. 41 – 50
  
3. Education level
  - a. Diploma
  - b. Undergraduate
  - c. Post graduate
  
4. Tendency of consuming the product
  - a. Daily
  - b. Once in a week
  - c. Once in a month
  - d. Seldom
  
5. Brand preferred
  - a. 985
  - b. 814
  - c. 583
  - d. 312
  - e. 447
  - f. 791

**CONSUMER TEST FORM**

Name.....

Date..... Time.....

You are provided with 7 coded samples of buns/mandazi, you are required to test all samples and indicate how much you like or dislike each sample attribute according to the provided scale.

Before testing the next sample you are required to rinse your mouth with water.

Scale of liking

9 – Like extremely

8 – like very much

7 – Like moderately

6 – Like slightly

5 – Neither like nor dislike

4 –Dislike slightly

3 – Dislike moderately

2 – Dislike very much

1 – Dislike extremely

| Sample | Crust colour | Crumb colour | Aroma | Taste | Texture | Overall acceptability |
|--------|--------------|--------------|-------|-------|---------|-----------------------|
| 458    |              |              |       |       |         |                       |
| 148    |              |              |       |       |         |                       |
| 233    |              |              |       |       |         |                       |
| 564    |              |              |       |       |         |                       |
| 505    |              |              |       |       |         |                       |
| 820    |              |              |       |       |         |                       |
| 528    |              |              |       |       |         |                       |

Comments

.....

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**ADDITIONAL QUESTIONS**

Please answer the questions bellow by circling the appropriate answer

1. Gender
  - a. Male
  - b. Female
  
2. Age
  - a. 19 – 30
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3. Education level
  - a. Diploma
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  - c. Post graduate
  
4. Tendency of consuming the product
  - a. Daily
  - b. Once in a week
  - c. Once in a month
  - d. Seldom
  
5. Brand preferred
  - g. 458
  - h. 148
  - i. 233
  - j. 564
  - k. 505
  - l. 820