KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI, GHANA

COLLEGE OF SCIENCE

DEPARTMENT OF FOOD SCIENCE AND TECHNOLOGY

OPTIMIZATION OF FORMULATION BLENDS OF ORANGE AND CABBAGE JUICES AND ASSESSING THE QUALITIES OF THE OPTIMUM JUICE BLENDS

BY

SARPONG Frederick

SEPTEMBER 2015

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI, GHANA

COLLEGE OF SCIENCE

DEPARTMENT OF FOOD SCIENCE AND TECHNOLOGY

OPTIMIZATION OF FORMULATION BLENDS OF ORANGE AND CABBAGE JUICES AND ASSESSING THE QUALITIES OF THE OPTIMUM JUICE BLENDS

Thesis Submitted to the Department of Food Science and Technology, Kwame Nkrumah University of Science and Technology in Partial Fulfilment for the Requirement of the Award of Master of Science Degree in Food Science and Technology

BY:

SARPONG, Frederick

SEPTEMBER 2015

DECLARATION

I hereby declare that this thesis is as a result of my own original research and that it has neither in part nor in whole been presented for another certificate in this university or elsewhere.

Sarpong Frederick	…………………………….......	…………………..…
(Student)	Signature	Date
Rev. Joseph Adubofuor	…………………………….......	…………………..…
(Supervisor)	Signature	Date
Prof. Ibok N. Oduro	…………………………….......	…………………..…
(Head of Department)	Signature	Date

DEDICATION

To my wife (Mrs Leticia Peace Sarpong) for the strength we are putting together through this fight for the better future we dream of. The little things done and sacrifice made, the good Lord will proclaim it.

ACKNOWLEDGEMENT

Completing my research and writing this thesis has in many ways been, like a journey with many moments of discouragement.

I am forever grateful to God first, for the strength, provision and the encouragement. My gratitude also goes to my Supervisor Rev. Joseph Adubofuor who provided sound guidance throughout the work. Without his patience and encouragement, this project would not have seen the life of day. I am indebted to Mr. Armah Daniel at Ghana Standards Authority, for helping me through the mineral analysis. Also deserving mention is Mr Addo of Nugochi Memorial Institute for Medical Research, Legon, who assisted me immensely in the determination of pro-vitamin A. I am also grateful to all the research assistant at Renewable Natural Resources, KNUST for the help I received in physico-chemical analyses.

I was fortunate to have sat across the office desks of many lecturers who provided pieces of advice and information. I thank Dr. (Mrs) Wireku and Mr Ofosu for their input in the work.

I am also grateful to Mrs. Priscilla Amankwaa of SDA Senior High School for all the effort which cannot be evaluated in this project. I say God richly bless you so much.

I thank my course-mates who have been there through the thick and thin of the academic period.

ABSTRACT

Fruits and vegetables are very importance class of foods which supply human diet with various nutritive requirements including vitamins and minerals which are essential for normal body health and growth. A survey was conducted through a questionnaire to gather information of consumptions patterns, responses and preference of beverage. A study was carried out to determine the sensory qualities, physico-chemical properties, vitamins and mineral compositions of cabbage-orange juice produced from oranges and cabbage. Two varieties of orange (late Valencia and blood orange) and cabbage (Oxylus variety) were processed into nine blends of juice developed from Design Expert (8.0.7.1 version) software. Sensory analysis was conducted on the 9(nine) formulations and were optimized by the same software. Each optimum from each orange variety was selected and with a control (100% late Valencia and blood orange), subjected to physico-chemical analyses and determination of vitamin C and pro vitamin A content. The sensory evaluation results shown that the cabbageorange juice with a formulation ratio of 80% late Valencia orange and 20% cabbage was selected as optimum by the design expert among the 9 formulations for late Valencia orange variety whiles 74% of blood orange and 26% of cabbage was also selected in the case of the blood orange variety. The results indicated significant differences ($p < 0.05$) in all the characteristic sensory properties which were under aroma, colour, taste, aftertaste and clarity for the both late Valencia and blood orange-cabbage juice blends. However the amounts in blood orange and its optimum were not significantly different ($p > 0.05$). There were significant differences ($p < 0.05$) in the physico-chemical analyses with the exception of the total ash content. Pro-vitamin A (β-carotene) contents of two orange varieties and their optimum were significantly different ($p < 0.05$). The vitamin C content of the two orange varieties and their optimum blends were also significantly different ($p < 0.05$). The juices from the two varieties and optimum blends were subjected to mineral analyses such as zinc, potassium, magnesium, iron and calcium and a significant difference ($p < 0.05$) between the blends and the orange varieties were also established. Late Valencia-cabbage juice was accepted in the orange fruity scent, sourness, tooth-itching and orange colour attribute while blood orange-cabbage juice was accepted in the sweetness attribute in the sensory analysis. A significant increase ($p < 0.05$) in the total soluble solids, pH, minerals and the beta carotenes were established whiles a decreased was observed in the total solids, titratable acidity and vitamin C.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the study

Fruit and vegetables are eaten or cooked or preserved by drying, canning or processed into other products such as juices. Carbohydrates including starch and sugar constitute the principal nutritional material. Citrus fruit are primarily source of vitamin C and most fruit and vegetables contain quantities of vitamin A and B. These vitamin contents are sharply reduced during storage of processed fruits. (Shils *et al*., 2006).

Juices are the pressed liquid from fruit and vegetable and are sources of nutrients including vitamins, minerals, natural sugars and phytochemicals. Juices from fruits and vegetables in any diet contribute to physical and mental functioning of the body. Vegetable juices are lower in calories than fruit juices and the most common ones are carrots, tomatoes and mixed vegetable juices. Fruit juices include temperate fruit juice (such as apple, pear, peach, apricot, prune and cherry), berry juice (including strawberry), grape juice, melon juice, citrus juice and tropical juices (Emebu and Anyika, 2011).

Sweet orange (*Citrus sinensis*) is one of the commercial citrus varieties growing in many parts of the forest region in Ghana (Ofosu-Budu *et al*., 2007). The development and production of orange juice products have undergone limited progress in Ghana. The few orange processing enterprises in Ghana encounter problems with quality of the juice with respect to browning, loss of ascorbic acid as well as spoilage during storage. In addition to these, competition from foreign market is growing rapidly.

Cabbage has traditionally been used sorely for medicinal purpose as well as for cooking. It anti-inflammatory properties are exploited to prevent cancer. The ancient Greeks are known to use fresh white cabbage juice to relieve sore or infected eyes and juice from the cabbage stem is a good remedy for preventing diseases as such ulcers. The Romans and Egyptians would drink the juice before big dinners to prevent intoxication as a cultural practice. The seeds of cabbage are said to prevent hangovers (Norman and Shealy, 2007).

Commercial production of juice has been mainly limited to oranges, pineapple, apple and grapes. Small scale productions of juice from several vegetable such as carrots, tomatoes and some berries have commenced. It is the intention of the processor to preserve as possible much flavours, colour and nutritive values of the original product from which juice is made to provide a balanced diet and not as a replacement or substitute for any beverages (Ayed and Al-Tamimi, 2007).

The Codex Alimentarius Commission (a joint FAO/WHO for food Standard programme) define fruit juice intended for comsumption as unfermented but fermentable non-alcoholic drink intended for consumptions obtained by mechanical process from sound ripe fruit and vegetable preserved extensively by physical means or preservatives (Codex alimentarius commission, 2004).

The quality of orange juice is determined by factors such as processing condition and storage conditions. Studies have shown that at elevated temperature, there is ascorbic acid loss in single strength orange juice (Abrams, 2002). Geographical locations of fruit have an effect of juice properties and for that matter the storage characteristics. Adhikari in 2006, reported that juice during the late Valencia season were noticeably lower in fungal than those obtained during other processing seasons.

1.2 STATEMENT OF THE PROBLEM AND JUSTIFICATION

According to a research conducted by Amoah *et al.,* (2006), Ghana recorded a 45.7% loss of all the fruit in 2009 against a 2008 loss figure of 18%. Orange ranked first in post-harvest loss in 2008 and the percentage of 30.6%.

Alzamora *et al*., (2000) has reported that about 30-50% of fruits and vegetables harvested in developing countries including Ghana are never consumed due to spoilage during transportation, storage and processing. Post-harvest loss of cabbage and other green leafy vegetable has also reached 20-40 percent because harvesting, processing or storage techniques are inefficient and therefore resulted in unstable supply (Mrema and Rolle, 2002).

According to Boyer *et al*., (2009), the shelf life of cabbage is seven days when it is refrigerated. Even though cabbage is produced throughout the country all year round, It is known to have a limited use in pastries, stews, soups and salads. Beside its use in sauerkraut production, cabbage has not been subjected to other preservative methods (Nyarko and Timbilla, 2004).

The local consumption do not much up for its production due to the large in-flow of both orange and cabbage into the Ghanaian market hence there is the need to exploit other possible uses of the fruit and vegetable which could arrest the alarming post-harvest loss.

1.3 MAIN OBJECTIVE

This work seeks to establish through a survey consumption and knowledge on fruit and vegetable juices as well as to optimize formulation blends of orange and cabbage juices.

1.4 SPECIFIC OBJECTIVES

- To conduct a survey on consumption and consumer preference of fruits and vegetables juices.
- To establish through sensory evaluation the optimum formulation of cabbage (Oxylus variety) juice blended with juices from two varieties of orange.

- To determine the physico-chemical properties of the optimum juice blends.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 BACKGROUD OF FRUIT AND VEGETABLE JUICES

Fruit juices are unfermented but fermentable products obtained from fresh, ripe and healthy fruits. They can be produced from a single type of fruit or mixture of fruits and are also known to be very good sources of vitamins and minerals (Kabasakalis *et al*., 2000, Bates *et al*., 2001). Fruit juice consumption is on the rise over the last decades due to its various health benefits (Bates *et al*. 2001, Liu 2003, Borenstein *et al*., 2005).

Vegetable juice is a drink basically prepared from blended vegetable. Vegetable juices are often mixed with fruit flavour. It is often touted as a low-sugar alternative to fruit juice, although some commercial brands of vegetable juices use fruit juices as sweeteners (Wilson, 2010). In general, vegetable juices are recommended as supplements to whole vegetable, rather than as a replacement. A study by Shenoy *et al.,* (2008) reveal that drinking vegetable juice daily significantly increased drinkers' chances of meeting the daily recommended number of vegetable servings. Having an easy source of vegetable encouraged drinkers to incorporate more vegetables into their diets.

Juices are prepared by mechanically squeezing or macerating fresh fruit or vegetable without the use of heat or solvents. Juices are often consumed for their nutritional and health benefits whiles others enjoy them as food supplements. To achieve maximum sensory and nutritive attribute, different sources of juices are mixed together. Torregosa *et al.,* (2006) combined orange juice (which has high vitamin C content) and carrot juice that contains high level of carotene. The mixture of orange juice and carrot juice was rich dietetic source of antioxidants. Similarly, a blended beverage of cashew and apple juice and orange aiming to reduce the acidity of the cashew apple juice was reported by Inyang and Abah (1997).

Flavanoids content of fruit juices, especially grape and orange juice products, reduces the risk of coronary artery diseases (CADs) by inhibiting platelet aggregation (Southon, 2000). Evidence from Southon, (2000) reveals that increased consumption of carotenoid rich fruit and vegetable juice outperforms carotenoids dietary supplements in increasing low density lipoproteins (LDL) oxidation resistance, lowering DNA damage and inducing higher repair activity in human.

2.1.1 Composition of fruit juice

Research work by Craig and Beck (1999), reveals that fruit and vegetable juice play a significant role in human nutrition, especially as sources of vitamins C, A, thiamine (B_1), niacin (B_3), pyridoxine (B_6), folacin (also known as folic acid or folate) (B_9), E, minerals, and dietary fibre. Their contribution is estimated at 91% of vitamin C, 48% of vitamin A, 30% of folacin, 27% of vitamin B6, 17% of thiamine, and 15% of niacin in the U.S. diet. They also supply 16% of magnesium, 19% of iron, and 9% of the calories. Other important nutrients supplied by fruit and vegetable juice include riboflavin (B2), zinc, calcium, potassium, and phosphorus. Beside these, there are antioxidants and phytochemicals (carotenoids and flavonoids which are all considered phytochemicals).

The phytochemicals prevent oxidative damages and decrease the risk of chronic illnesses. It was alleged that low fruit and vegetable intake increase the risk of cancer. Fruit were found to have protective effects on the cancers of oesophagus, oral cavity and larynx (Liu 2003).

2.1.2 Benefits of consumption of fruits and vegetables

Fruit juices provide a range of vitamins, minerals and antioxidants. These elements are essential for the total development of the human body and also for the prevention of diseases.

The most common vitamin in fruit and vegetable is vitamin C which has been establish to prevent scurvy, aid in the healing of wounds and boasting the immune system (Garrow *et al.,* 2003). Research suggests that fruits and vegetables increases iron bioavailability two fold (Harats *et al.,* 1998). In addition, the potential role of vitamin C in the prevention of chronic disease has been highlighted in the recently released Nutrient Reference Values for Australia and New Zealand (Sapers and Miller 1995)

Increased attention has been given in decades ago to possible therapeutic effects of polyphenols (Guy *et al*., 1989). Polyphenol is believed to act as antioxidants to protect the body‟s tissues against oxidative stress, cancer and cardiovascular disease. Relations between polyphenol-rich foods and reduction of specific health conditions include lycopene in tomatoes reducing the incidence of prostate cancer (Sapers and Miller, 1995), cranberry juice reducing the incidence of urinary tract infections in women (Tong and Hicks, 1991) and grape juice having beneficial effects on markers of coronary heart disease. The new role of polyphenols in brain functions such as learning and memory has lately received much attention (Sapers and Miller, 1995)

Folate has always been an essential vitamin in cell production. Fruit and vegetable juices are significant contributors to folate intake, particularly for children, provides up to 9.1% of total folate (Gershoff, 1993). Folate is associated in formation of reproductive tube of child bearing woman and also ensuring its proper functioning. (Balasubramaniam *et al*., 2008). Folate also has important implications in heart health (Bill, 2001).

Many fruit and vegetable juices are important sources of potassium and sodium. These elements are known to prevent blood pressure and protect against the development of renal stones (Appel *et al.,* 1997). Increasing dietary fibre has been linked to lower rates of obesity, cardiovascular disease, diabetes and certain cancers. Most fruit and vegetable juices currently available contain dietary fibre. Clearly, 100% fruit and vegetable juice is a nutrient dense beverage and as such is an important part of a varied and healthy diet as it contributes a range of nutrients and phytonutrients vital for good health and disease prevention (Bill, 2001).

2.2. PRODUCTION AND GLOBAL DISTRIBUTION OF ORANGE

Over the last two decades the world's orange production has increased from 40 million tonnes to 62.5 million tonnes. The world's two largest producers (Brazil and the United States of America) account for half of the orange production. A global orange consumption has also increased by an average of 1.9% per annum between 1990 and 2004, i.e. much lower than general Fruit and Vegetable consumption growth of 4.5% globally (FAO, 2007).

Two areas around the globe dominate orange production and especially in processing of orange juice. These areas are the south-east coast of Brazil and the Mid-south Florida of United States of America (USA). The southeast coast of Brazil, surrounding São Paulo, produces more oranges than the next subsequent three countries combined. Almost 99% of the orange fruit from this region is processed for export; it is the overwhelming giant in worldwide orange juice production (FAO, 2007).

Mid-south Florida produces about half as many oranges fruit as Brazil; however, about 90% its orange juice produced is sold domestically. The Indian River area of Florida is branded for the high quality of its juice, which is often sold fresh in the USA. Due to the low yield and high quality of Indian River oranges, their juice is often blended with juice from other regions (Beach, 2008). It is also estimated that production of orange juice between these two countries makes up roughly 85% of the world market.

Table 2.1: Top orange producers in 2005 and 2008 around the world.

Top orange producers	**2005 (million tonnes)**	**2008 (million tonnes)**
Brazil	17.8	18.5
USA	8.4	9.1

India	3.1	4.4
Mexico	4.1	4.3
China	2.4	3.7
Spain	2.3	3.3
Iran	2.0	2.6
Italy	2.2	2.3
Egypt	1.8	2.1
Pakistan	1.6	1.7
World total	61.7	68.5

(Source: FAO, 2005 and 2008)

2.2.1 Varieties of orange

In Ghana the important commercial varieties of citrus are the sweet orange (*Citrus sinensis*) which are classified based on the maturity. Basically the maturity periods are grouped into three seasons. The seasons include the early maturing which is harvested around August and October. It includes the ovaletto and sekkan orange variety. The mid-season harvested around October and January includes the Obuasi, Mediterranean sweet and the Blood orange. Lastly the late-season is harvested in march to April and includes Late Valencia, Olinda and Frost Valencia (MOFA, 2001).

Tangerine (*Citrus reticulate*) is another commercial variety which has Satsuma (May-June) and purcan (Sept.-Oct.) maturity season. Other important commercial varieties are grapefruit, lemons, lime, tangors, tangelos and ortanique.

Central, Eastern, Volta and Ashanti regions are suitable areas of production in Ghana (MOFA, 2001).

Plate 2.1: Varieties of orange (MOFA, 2011)

2.2.2 Nutrient composition and uses of orange

Economos and Clay (1999) established that citrus and citrus products are a rich source of vitamins, minerals and dietary fibre (non-starch polysaccharides) that are essential for regular growth and development and overall nutritional well-being of an individual.

Orange is mostly thought as a good source of vitamin C. However, like most other whole foods, orange fruit also contain a striking list of other essential nutrients, including glycaemic and non-glycaemic carbohydrate (sugars and fibre), potassium, folate, thiamin, niacin, vitamin B6, phosphorus and calcium. Other minerals include magnesium, sodium, potassium, zinc, phosphorus, copper, riboflavin, pantothenic acid and a variety of phytochemicals. In addition, orange contains no fat or sodium and cholesterol. The average energy value supply by the fresh orange is low and hence can help control excess body weight (D‟Amico *et al.*, 2006). The composition of nutrients in orange is shown below in table 2.2

Table 2.2: Nutrient composition of 100g orange

Component	Amount
Calories	354kJ
Total carbohydrate	21.1g
Total fat	0.2g
Protein	1.7g
Vitamin A	405 IU
Vitamin C	95.8mg
Vitamin E	0.3mg
Folate	54mg
Calcium	72.0mg
Iron	0.2mg
Magnesium	18.0mg
Phosphorus	25.2mg
Potassium	326mg
Zinc	0.1mg
Selenium	0.9mcg

Source: Food and Nutrition Board, (2001)

Carbohydrate

The main energy-yielding nutrient in orange fruit is carbohydrate; orange contains the simple carbohydrates (sugars) fructose, glucose and sucrose, as well as citric acid which can also provide a small amount of energy. Orange fruit also contain non-starch polysaccharides (NSP), also known as dietary fibre, which is a complex carbohydrate with important health benefits. The major type of fibre in orange is pectin, making up 65 to 70 percent of the total fibre. The remaining fibres are in the form of cellulose, hemi-cellulose and traces of gums. Orange also contains lignin, a fibre-like component in minute amount. In the body, NSP holds water-soluble nutrients in a gel matrix which delays gastric clearing and slows digestion and absorption. This promotes satiety, and reduces the rate of glucose uptake following consumption of glycaemic (available) carbohydrate, and help to prevent an increase in blood glucose levels. Improper regulation of blood glucose results in either hyperglycaemia (high blood glucose) or hypoglycaemia (low blood glucose). NSP can also interfere with the re-absorption of bile acids which may help in lowering plasma cholesterol levels. A reasonable goal for dietary NSP/fibre intake is 25 to 30 g/day, but in many developed countries the actual average intake is closer to 15 g (USDA, 2010; Cleveland, *et al*, 1996). With one medium orange containing approximately 3.0 g of NSP, orange fruit can make a valuable contribution to meeting the daily fibre intake (Dani *et al*., 2007).

Vitamin C

Vitamin C (ascorbic acid), an essential water-soluble vitamin, plays an important role in the formation of collagen, a primary component of much of the connective tissue in the body.

Sufficient collagen synthesis is essential for strong ligaments, tendons, dentin, skin, blood vessels and bones, and for wound healing and tissue repair. The weakening of these tissues is a symptom of vitamin C deficiency. Vitamin C is a key aid in the absorption of inorganic iron; it has also been shown to aid in the treatment of anaemia and stress. Vitamin C does not seem to prevent the onset of the common cold, but in some studies it has been reported to reduce the length and severity of the symptoms. Modern interest in vitamin C centres on its ability to perform antioxidant functions. As an antioxidant, it aids in preventing the cell damage done by "free radical" molecules that oxidize protein, fatty acids and deoxyribonucleic acid (DNA) in the body. These free radicals damage has been reported to be linked to the development of several diverse diseases including cancer, cardiovascular disease and cataract formation

(Gershoff, 1993; Harats *et al*., 1998; Jacques *et al*., 1997). As a good source of antioxidants, if often consumed, orange fruit can be an important part of a diet aimed at reducing the risk of such chronic disease. Only 10 mg of vitamin C per day are required to prevent vitamin C deficiency and the devastating disease scurvy (Harats *et al*., 1998). Despite the 10 mg daily requirement, for good health and sufficient body storage of vitamin C, 30 to 100 mg/day is generally recommended, although some recent studies have provided evidence that more than 200 mg/day may be most advantageous for the prevention of chronic disease. Too much vitamin C (i.e. above 500 mg), generally seen with very high levels of supplementation, may be dangerous, particularly for those at risk of iron overload. Consuming five servings of fruit and vegetable each day can result in an intake of about 200 mg of vitamin C. Orange fruit are a particularly good source of vitamin C, with one medium orange or grapefruit providing roughly 70 mg and 56 mg, respectively. It is reported that a 225 ml glass of orange juice contains approximately 125 mg of vitamin C (Fleming *et al*., 1998).

Potassium

Potassium is a vital mineral that works to maintain the acid and body"s water balance. As an important electrolyte, it plays a function in transmitting nerve impulses to muscles, in muscle contraction and in the safeguarding of normal blood pressure. The daily requirement of potassium is approximately 2000 mg. There is also concern that a high sodium-to-potassium intake ratio may be a risk factor for chronic disease. Increased consumption of orange fruit and juices is a good means of increasing potassium intake. A medium orange and one 225 ml glass of orange juice provide approximately 235 mg and 500 mg of potassium respectively (Gokce *et al*., 1999).

Zinc

Zinc is an essential mineral that is naturally present in some food that is involved in numerous cellular metabolism aside it involvement in the catalytic activities of many enzymes. It also plays a role in immune functions, protein synthesis and cell divisions. The recommended dietary allowances for adult (19+) is 11mg while orange juice is capable of supplying 0.1 mg per serving (Food and Nutrition Board, 2001).

Magnesium

Magnesium is essential to good health and about 50 percent is found in the bones whiles the other half is found in the cell of body tissues and organs (Rude, 1998). It is needed to keep a lot of biochemical reaction running in the body whiles helping in the maintenance of the normal muscle and nerves functions. The recommended dietary allowances for adult (19+) is 400 mg whiles orange juice is capable of supplying 18.0 mg per serving (Beach, 2008).

Iron

Iron is essential to most life forms and to normal human physiology. Iron is a vital part of many proteins and enzymes that sustain good health and life in general. It is also essential for the regulation of cell growth and differentiation of cell of the organism ((Hurrell, 2002). A deficiency of iron restricts oxygen delivery to cells, resulting in fatigue, poor work performance, and decreased immunity. However, excess amounts of Iron can result in toxicity and even death (Karadeniz, 2004). Daily requirement of iron in 18-50 adult male is 8 mg/day and 12 mg/day for females. Orange juice is one of the plant produce that supplies non-heme irons in small amount of 0.2 mg per every serving (Hurrell, 2002).

Calcium

This is found in several foods including the orange juice. Calcium is required for vascular contraction and vasodilation, muscle functions, nerves transmissions, intercellular signalling and hormonal secretion (Jacques *et al*., 1997). The recommended dietary allowances for adult (19+) is 2500 mg but orange juice can only supply 72.0 mg per serving (Karadeniz, 2004).

Folate

Folate is a water-soluble vitamin important for new cell production and growth. It aids in the production of DNA and ribonucleic acid (RNA) and the maturing of red blood cells, which eventually prevent anaemia. Daily recommendation of folate is 180 mcg for females and 200 mcg for males. However, it has become clear over the past decade that higher levels of folic, 400 mcg, are associated with the prevention of neural tube defects, a severe birth defect (Centers for Disease Control and Prevention, 1992). A 225 ml glass of orange juice supply 75 mcg of folic acid (Whitney and Rolfes, 1999).

2.2.3 Processing of orange into juices

Harvested orange fruit is washed after the sorting of stems and leaves. It is reported by Bates, *et al*., (2001) that washing helps to reduce the load of microorganisms. After cleaning and separation, the peel oil is removed in order to avoid oxidation caused by its terpene content. In the orange juice processing, the equipments which are used to get the juice from the fruit are known as extractors. The fruit is pressed while the juice is collected in a container (Cemeroglu, 2004). Raw orange juice contains some solid particles referred to as pulp. The pulp extractors are used to separate the solid particles from the fruit juice. Almost 65- 90 % (w/w) of the pulp is removed by the pulp extractor. The remaining part of the solid particles after pulp extraction, still contain some enzymes which can cause some degree of

deterioration if they are not inactivated. In the concentration process, pasteurization of citrus juices is needed for two reasons: it deactivates the enzymes which would cause cloud loss in the juice or gelation of concentrates and destroys other microorganisms which would otherwise cause fermentation and spoilage in the juice. Inactivation of Pectinmethylesterase (PME) enzyme is the target for pasteurization because of its resistance to heat. Since orange juices have low pH values, even at 75°C the juices become microbiologically sterile (Cemeroglu, 2004). It is reported that, PME has more thermal resistance than the pathogenic microorganisms which can be found in orange juices. Thus, deactivation of PME is used as an indicator for pasteurization sufficiency. The recommended temperature and time need for achieving a reduction in PME activity and commercial stability is 90°C for 1 minute (Gokce *et al*., 1999)..

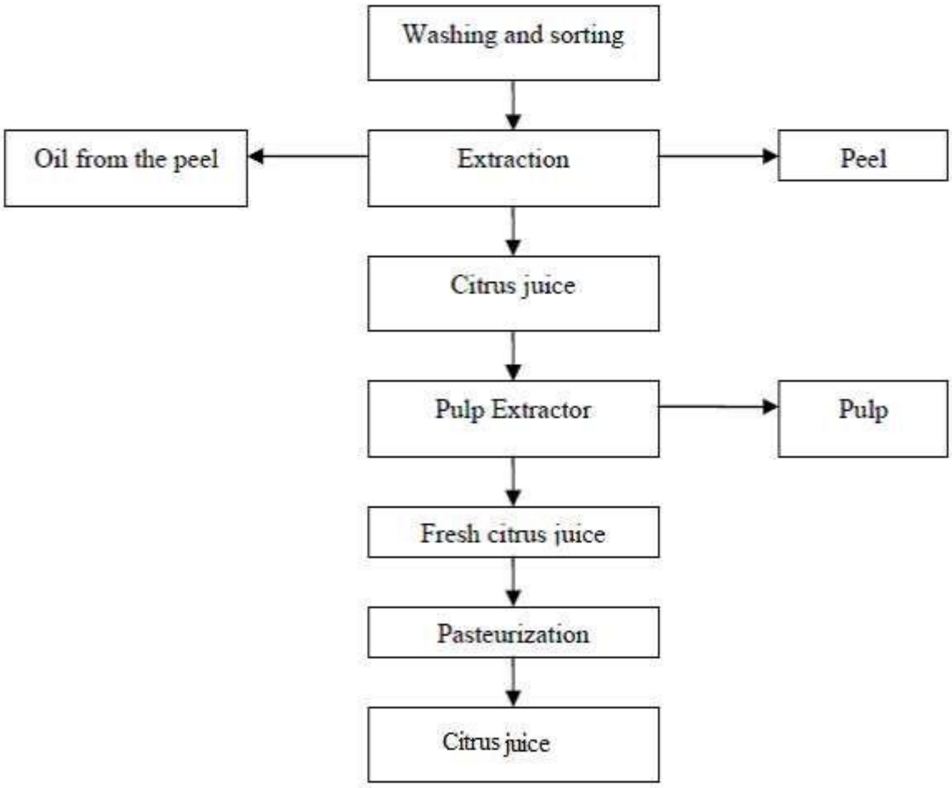


Figure 2.1: Orange juice production. (Source: Cemeroglu, 2004)

2.2.3 Physicochemical Properties of Orange Juice

Bengi (2009) reported soluble solids (SS) of orange juice to be 13.74 °Brix at 20°C. Karadeniz (2004) reported the citric acid content of orange juices (sweet variety) as 1.338 g/100mL.

According to Bengi‘‘s (2009) work more dilution of orange juice is needed in order to obtain a reasonable absorbance measurement of optical property of 71.715 (1/cm). He also stated that turbidity measurements of orange juice have significantly ($p< 0.05$) higher amounts of suspended particles than other juice such as grape in which he recorded 4061 Nephelometric Turbidity Unit (NTU) value. Other work on turbidity proven by Donahue *et al*., (2004) demonstrated that turbidity is highly correlated with colour. It was reported that as the juice colour gets darker, the turbidity increases directly. Carotenoid pigments found in the plastids in the juice cells are said to be responsible for the yellow colour of orange juice (Cortes *et al*., 2008). In summary other physico-chemical properties of fresh orange juice is summarized below in table 2.3.

Table 2.3: Physico-chemical properties of fresh orange juice.

Physiocochemical property	Oranges
Relative density (at 20ºC)	1.033
pH (at 20 ºC)	3.716
Turbidity (NTU)	4061
Refraction index (at 20ºC)	1.347
Sugar content (%)	11.1

Source: Costescu, *et al*., (2006)

2.3 PRODUCTION AND GLOBAL DISTRIBUTION OF CABBAGE

Cabbage (*Brassica oleracea)* is one of the most popular cultivar of the Family *Brassicaceae* (or *Cruciferae)* grown around the world. The species is describe as herbaceous, biennial and dicotyledonous flowering plant distinguished by a short stem upon which is crowded a mass of leaves, usually green but in some varieties red or purplish, which while immature form a characteristic compact, globular cluster (Masamba and Nguyen, 2008).

Cabbage is cultivated commercially for its large, leafy head which is rich in vitamin C. It is considered as the most important member of the *Cruciferae* or mustard family and has remained one of the world's leading vegetable crops. In 2005, the United States was the world's ninth-largest producer of cabbage, accounting for nearly 5 per cent of total production (FAO, 2007).

The world production has gradually been improved over the last decade because of the demand by countries for various dishes the leafy vegetable can be used to prepare. In 2005,
China was the largest producer of cabbage, followed by India and then the Russian Federation (FAO, 2007).

Table 2.4: Global production and distribution of cabbage around the globe.

Country	Production of cabbage (tonnes)
Republic of China	36,335,000
India	5,283,200
Russia	4,054,000
South Korea	3,000,000
Japan	2,390,000
Poland	1,375,900
Ukraine	1,300,000
Indonesia	1,250,000
United State of America	1,171,350
Romania	1,120,000
World	69,214,270

Source: FAO, (2005)

2.3.1 Varieties of Cabbage

Varieties of cabbage are based on shape, colour and time of maturity. Cabbages that mature late in autumn and in the beginning of winter are called "coleworts". This is because their leaves do not form a compact head. "Colewort" is sometimes referred to a young cabbage by some experts. A "drumhead" cabbage has a rounded but flattened head. Another variety worth mentioning is the “ox-heart” cabbage which has an oval or conical head. A "pickling" cabbage, such as the red-leafed cabbage, is suitable for pickling; 'Krautman' is the variety mostly used for commercial production of sauerkraut. Red cabbage is a small, round-headed variety with dark red leaves. Savoy cabbages have a round, compact head with crinkled and curled leaves (Damrosch, 2007).

Other established varieties include white cabbage, 'Late Flat Dutch', 'Early Jersey Wakefield' (a conical variety), 'Danish Ball-head' (late, round-headed), 'Cuor-di Bue-Grosso' (conical heads, from Italy), 'Copenhagen Market Cabbage' (large round heads, from Denmark), and 'Mammoth Red Rock' (large round heads with deep red leaves).

About nine cabbage varieties are produced in Ghana, namely Copenhagen market, Oxylus, K-K cross, Tenzier, Gloria, K-Y cross, Holland and master globe. The two most popular varieties are the Oxylus and K-K Cross which are noted to mature in 3½ and 3 months respectively (Nyarko and Timbilla, 2004). In Nyarko and Timbilla"s work, even though the production of cabbage was observed to be rising in all the regions, Greater Accra, Central and Ashanti recorded a declined trend due to lack and cost of the few available lands. The increase is as a result of increasing demand by local consumers and also increases in the population of foreigners in the urban centres.

2.3.2 Nutrient Composition and Uses of Cabbage

Cabbage is believed to have a high nutritive value, supplying the body essential vitamins, proteins, carbohydrates and vital minerals (Norman, 1992). The summary of nutritive content is found in the table 2.5 below.

Table 2.5: Nutritional Composition of raw Cabbage (per 100g)

Energy	Amount
Carbohydrates	5.8 g
Fat	0.1 g
Protein	1.28 g
Thiamine (Vit B1)	0.061 mg
Riboflavin (Vit. B2)	0.040 mg
Niacin (Vit B3)	0.234 mg
Folate	53 ug
Vitamin C	36.6 mg
Vitamin K	76 ug
Calcium	40 mg
Iron	0.47 mg
Magnesium	12 mg
Phosphorus	26 mg
Potassium	170 mg
Zinc	0.18 mg

Source: USDA Nutrient Database, (2010)

Cabbage, both red and green, is one of the green vegetable that supply large amount of vitamin C to the body. Raw cabbage juice may be taken when citrus fruit are not available or forbidden, in combination with other juice, such as celery or tomato (Norman, 1992).

Raw cabbage is a reasonable source of vitamin A, a good source of vitamin B1, and contains some vitamin G. Cabbage again has a high amount of cellulose or roughage, and very low calorie content. It is believed that the outside leaves of cabbage (those leaves that are very green) have as much as 40 percent more calcium than the inside leaves (Dani *et al.,* 2007).

There are many minerals that are also found in raw cabbage. It is rich in calcium and potassium, phosphorus, zinc and magnesium. It also contains chlorine, iodine, sodium, and sulphur in small quantities. Red cabbage contains more calcium but a little less of the other minerals than white or green cabbage (Kader *et al*., 2004).

2.3.3 Health Benefits of Cabbage

In Switzerland, various varieties of curly cabbage are used as a pack for eczema and for various leg conditions such as varicose veins and leg ulcers. This external pack is made by chopping the cabbage into fine pieces and mixing it with distilled water. The pack is placed on the affected area and wrapped with a linen cloth. The sulphur in the cabbage helps destroy fermentation in the blood, and is especially good for any skin trouble when used both internally and externally. Sulphur is one of the elements that increase body heat, so people with cold feet can include cabbage in their diet if effort is spent in preventing them (Allen and Allen, 2009).

Cabbage is also very effective in preventing constipation due to its large amount of fibres. Sauerkraut, or sauerkraut juice, is also good for a sluggish intestinal tract and for more serious cases of constipation. Sauerkraut juice with little lemon juice added is helpful for diabetes. Raw sauerkraut juice mixed with tomato juice is used as a laxative due to it high vitamin C and lactic acid content (Amoah *et al*., 2006).

Cabbages are used in a variety of dishes for its naturally spicy flavour. The "cabbage head" is widely consumed raw, cooked, or preserved in a variety of dishes. It is the major ingredient in coleslaw and sauerkraut production (Baldwin, 1995).

A study conducted in University of Utah School of Medicine on 600 men revealed that those who ate mostly cabbage had a much lower risk of colon cancer. They again caution that, excessive consumption of cabbage may contribute to thyroid problems, possibly goitre. A famous remedy for healing peptic ulcers is drinking cabbage juice. A medical study at Stanford University‟s School of Medicine also gave thirteen ulcer patients five doses a day of cabbage juice and all were healed within seven to ten days (Allen and Allen, 2009).

It has been known for the past 20 years that phyto-nutrients in cabbage and other food ingredients work as antioxidants to savage free radicals before they can damage DNA cell membrane and fat containing molecules such as cholesterol and phospholipids. New research is now revealing that phyto-nutrients in crucifers such as cabbage work at a deeper level. These compounds essentially signal genes to increase production of enzymes which is concerned in detoxification. Current studies shows that people who consume cabbage have a much lower risk of prostate, colorectal and lung cancer when compared to those who regularly eat other vegetable (Lin, 2008).

Cabbage is also very useful in reducing cholesterol in the body. This works in way that gets together all the bile acids in the digestive system and removes them out of the body thus, reducing the levels of cholesterol in the body. It is more effective when the cabbage is consumed in raw or in any salad than in cooked state. It is recommended for people who find it difficult to consume the raw state to lightly boil the cabbage, add a pinch of pepper and salt, and then be eaten during breakfast or as a snack. This is very rich in fibre and has all the returns of the fibre food (Amoah *et al*., 2006).

The anti-oxidants (imdole-3-carbinol) in cabbage help to prevent the risk of various cancers and heal few cancer types which have been clinically proved after various research work and studies. Another effective anti-cancer ingredient present in cabbage is the glucosinolates which is rich in cabbage. These glucosinolates function in a way that when digested they are changed into the isothiocyanate compounds which work radically against the cancer cells and destroy them (Tong and Hicks, 1991)

Studies by Allen and Allen (2009) has proved that cabbage which is rich in fibre helps to keep digestive system in good conditions. This not only helps in maintaining digestive system but also heals the ulcers in the stomach which are referred to as the peptic ulcers. Cabbage which is rich in all the proteins, minerals, vitamins helps and enhances very good digestive tract and is believed to heal all the stomach and intestinal disorders. Both the anti-oxidants and amino acids present in cabbage help to balance the generation of healthy bacteria inside the digestive system and help maintain healthy intestines.

Another important supplement of cabbage is high energy which helps in keeping one active and energetic. The important component is vitamin B which is in high supply in cabbage and is responsible for generating the high energy in the body (Rawal, 2005).

Lastly, cabbage has a massive amount of anti-aging compounds like the beta carotene bundled with a bulk of vitamin C. These help in repairing the damages cells of the skin and help to have a glowing skin, thus preventing aging of the skin (Rude, 1998).

2.4 SENSORY EVALUATION OF JUICES

Sensory evaluation is the scientific discipline used to evoke measure, analyse and interpret reactions to stimuli characteristics of foods and materials as perceived through the senses of sight, smell, taste, touch and hearing (Anonymous, 1975). For the purpose of quality control, maintenance and development of food products, human senses are the most reliable, complete and meaningful means of measuring organoleptic characteristics of food though advances have been made in the development of instrumental tests that seek to measure individual quality factors (Poste *et al.*, 1991).

Generally, there are four groups of sensory panels precisely highly trained experts, trained laboratory panels, laboratory acceptance panels and large consumer panels. These grouping are basically based on the rationale of the sensory tests. Between 1 and 3 highly trained experts are suitable for the evaluation of quality of products with a very high degree of acuity and reproducibility such as wine, beer, tea, and coffee connoisseurs. Evaluations by proficient and trained laboratory panels can be useful for experiment control purposes, for directing product development and improvement of product and for evaluating quality. Between 10 and 20 panellists can be particularly suitable and useful in assessing changes in product attribute for which there is no enough instrumentation. Sensory analyses performed by laboratory acceptance panels (25-50 people) are valuable in forecasting consumer reaction to a product. Large consumer panels (more than 100 people) are used to conclude consumer reaction to a product (Amoah *et al*., 2006). Sensory evaluation also finds relevance in shelf life study of food and beverage products especially when it is difficult to obtain kinetic data of deteriorative reactions for predictive purposes. Such a situation is frequently the case for chain reactions and microbial growth which have both a lag and log phase with different rate constants (Lin, 2008).

2.4.1 Classification of Sensory Evaluation Methods

The three basic classes of sensory evaluation include discriminative tests, descriptive tests and affective tests. Discriminative tests are used to establish a difference existing between samples. Descriptive tests on the other hand are used in determining the nature and intensity of the differences between samples. Affective tests are concerned with the assessment of preference (or acceptance) or the measure to determine the relative preference or opinion of the panellists towards a product. In sensory analyses tests to find differences (discriminative) are used in quality maintenance, cost reduction, selection of new sources of supply and effect of a new packaging material on product storage stability (Hurrell, 2002). Examples of discriminative tests include triangle test, duo-trio test, two-out-of-five test, paired comparison test and ranking test.

2.4.2 Triangle Test

A triangle test is one of the tools used in sensory analysis to assist in the selection of panellists for their ability to discriminate a given difference. This method is useful in quality control work to determine if samples are different from the rest of the production. It is also used as an important tool in determining whether ingredient substitution or some other change in manufacturing results in a detectable difference in the product (Rainey, 1986).

Usually, the samples vary only in the variable being studied. Thus the test is inadequate to products that are homogeneous. There are six possible orders in which the three samples in a triangle test can be presented and thus the order of evaluation of each sample by the panellists is specified with code numbers. The results of a triangle test specify whether or not a detectable difference exists between two samples. However, higher levels of significance do not specify that the difference is greater or in a direction but that there is a greater probability of a real difference. (Lawless and Heymann, 1998).

2.4.3 Selection of Sensory Panellists

Sensory panels are the analytical instrument in sensory analysis. The objectivity, reproducibility and accuracy of judgment of the panellists are of important value in any reliable sensory evaluation programme. The criteria for selection include the health, interest, availability, punctuality and verbal skills of persons within reach of the sensory programme as reported by Poste *et al.*, (1991). Training of panellists is said to enhance the sensitivity and memory of the panellists to provide precise, consistent and standardized sensory measurements that can be reproduced. The interest of panellist can be persistent by motivating them with incentives such as gifts, appreciation notices and updates of the outcome of their participation in a sensory programme (Stone and Sidel, 1993).

2.4.4 Sample Preparation and Serving in Sensory Analysis

The preparation and serving of samples to panellists have an influence on the results that one would obtain from a sensory evaluation programme. For beverages, the serving temperature known to the product is recommended to give uniformity for all samples (Moskowitz, 1996). For instance, orange drink is best served chilled. It has been observed that some panellists often use the temperature difference of samples to make judgments instead of the sensory property under study. It is empirical therefore that preparation and serving method are made as much as possible not to mask, add or alter the basic sensory characteristics of the product (Stone and Sidel, 1993). Other important contemplations in preparation and serving of product samples consist of dilution of product, product containers, amount or size of sample and number of samples per panellist. Other criteria are reference samples, coding, order of presentation, palette cleanser, time of day and information about samples. These should be done appropriately to minimize errors and avoid cost. Research has shown that late morning and mid-afternoon are generally the best times for sensory testing. Exclusion of persons directly involved in the experiment from the panel is necessary. Many researchers prefer taste-neutral water at room temperature for oral cleansing but when fatty foods are being tested, warm water, warm tea, lemon water, or a slice of apple is more effective cleansing agent. Unsalted crackers, celery, and bread have all been used for removing residual flavours from the mouth in some cases (Poste *et al.*, 1991).

2.4.5 Orientation and Training of Respondents

Respondent orientation and training for analytical testing is planned to familiarize a respondent with test procedures, improve a respondent's ability to distinguish and identify sensory attributes in complex product systems, and advance a respondent's sensitivity and memory so that panellist will provide precise, consistent, and standardized sensory measurements that can be reproduced. Training is not appropriate for affective testing, but it is appropriate to give some orientation to naive respondents (consumers) to help them understand the test (Hurrell, 2002).

Trained panellists are used to carry out most of the methods put forward for vocabulary generation and assessment of products through sensory evaluation. Several regulatory institutions advocate performing sensory profiling with a trained or an expert panel. This is essential because training enables the panellists to adopt an analytical frame of mind. On the contrary, untrained consumers are said to act non-analytically when scoring attributes (Lawless and Heymann, 1998). However, free preference profiling which does not require training of panellists has also been used successfully (Guy *et al*., 1989; Gains and Thomson, 1990).

Lately, many authors have contrasted the performance of trained and untrained panels, presenting different conclusions. This is because the studies in both circumstances varied extensively in terms of the nature and size of the covered product range, the methodology and the data analysis (Labbe *et al*., 2003). Many published studies have established lack of consensus on the impact of training on sensory descriptive analysis. Authors of publications showed that training actually impacted on panel performance:

In a research performed by Wolters and Allchurch (1994) where four different panels each made up of six to eight subjects assessed sixteen oranges, they discovered that training increased the number of discriminating and consensual attributes of the orange juices. The panels differed in duration of training and in the number of scored attributes (60 hours/97 generated attributes, 30 hours /70 generated attributes, 15 hours /36 pre-defined attributes, less than an hour /free choice profiling).

Although some authors have seen no significance of training, many agree that training is necessary in carrying out a descriptive sensory evaluation. Training actually orients the minds of the panel to have a general understanding of the meanings of the attributes selected and score products in a similar and objective way. But for consumer acceptance, untrained panel always provides reliable information since scoring is based on preference other than description (Labbe *et al*., 2003).

2.4.6 Scaling

Scaling methods are designed to give a value by respondents that indicate the type or intensity of a response. A dimension of evaluation is always specified; for example, a product characteristic or attribute. Scales are necessarily not numerical. Graphic lines or other methods of measuring intensity (order) are also adopted by respondents to specify their perceptions. Non-numerical scales usually are converted to numerical values for purposes of statistical analysis (Labbe *et al*., 2003).

Scales traditionally have been classified into four major divisions: nominal, ordinal, interval, and ratio.

(a) Nominal data define the type or category of a acuity and does not indicate a quantitative relationship among the categories. Usually, nominal data are used to describe respondents in terms of categories (such as gender, age, or user affiliations) where no relative advantage can be assigned to the categories. An indication of whether an attribute is "present" or "not" in a product is, very fundamental, in a nominal scaling procedure (Guy *et al*., 1989).

(b) Ordinal data classify relationships of attribute on a "more" or "less" basis. An example is "ranking" or "rank-order" testing. Scaling that generates an ordinal data requires three or more objects arranged in ascending or descending order based on the intensity, quantity, or size of some specified characteristic. Ordinal data often are used to select a series of samples to detect outliers or other products that do not need more thorough investigation. Preference testing perhaps is the most common scaling task resulting in ordinal data (Chollet and Valentine, 2001).

(c) Interval data comprises successive, equal-interval units that specify the magnitude or intensity of a product characteristic. The units are assigned numbers (most often beginning at 0 or 1) that increase as the degree of magnitude increases. Most often, scales that produce interval data are anchored at various points with terms that indicate the magnitude of a response. Due to its flexibility, interval-type scales are used at length in "descriptive analysis" to establish the intensity of a specified attribute (Guy *et al*., 1989).

(d) Ratio data indicates the magnitude of response and stipulates the relative ratio relationship of two or more responses. Numbers are allocated to the intensity that reflects ratio differences among products. Scales that produce ratio data have been used in tests such as those described for interval scaling. It appears to be most useful when studying the relationships of single sensory characteristics to physical stimuli, such as the relationship of sweetness and sugar concentration.

All scaling methods are used in diverse applications. Any perceptual measurements that can be theoretically understood and quantified are often used as scaled (Chollet and Valentin 2001).

CHAPTER THREE

MATERIALS AND METHODS

3.1 CONSUMPTION PATTERNS OF BEVERAGE

A questionnaire was used to obtain information from student in Kokofu Health Assistance Training Nursing School in the Ashanti Region. Information obtained includes personal data and health status of respondents, consumption of beverages and juice as a well as other perceptions on beverages fruit and vegetable juice consumption. The questionnaire is exhibited at the Appendix A1.

3.2 SOURCE OF RAW MATERIALS

The two varieties of the orange (late Valencia and blood orange) and the cabbage were procured from a farm at Boaman near Bekwai in Ashanti region. The samples were washed to remove dirt, well drained and rinsed in distilled water. They were packed into sterilized polythene bags and transported for juice extraction at the Natural Renewable Resource Laboratory at the Kwame Nkrumah University of Science and Technology (KNUST), Kumasi. Cabbage and ginger were purchased from satellite market in Ashanti Bekwai.


Late valencia


Blood orange


Oxylus cabbage

Plate 3.1: Two varieties of orange and cabbage

3.3 ORANGE AND CABBAGE JUICE EXTRACTION

3.3.1 Orange Juice

Each orange was washed thoroughly in tap water and washed again with treated water (boiled at 100 ^{o}C and cooled). The oranges were peeled to remove the outer bitter covering before sliced into pieces (5cm long) to remove the seeds. The pieces were then blended using an electric blender Binatone Blender (China, Model BLG401). Blending was done at short intervals from time to time to avoid overheating and excessive foaming in the juice. A cheese cloth was used to extract the juice from the pulp to obtain a clear orange juice which was mixed with cabbage juice and ginger extract before pasteurized at 62 ^{o}C for 30 minutes (Aurand *et al.*, 1987) and kept in high density poly-ethylene (HDPE) packaging material. The juice was then kept in a refrigerator at a temperature of 4^{o}C.

All the measurements were weighed using a beam balanced (Ohaus, Scout Pro).

Table 3.1: Average weight of orange (late Valencia and blood) and cabbage determined in the research

ITEM	AVERAGE WEIGHT (kg x 10^{-1})	JUICE (mL)
LATE VALENCIA	2.6	1.02
BLOOD ORANGE	3.8	1.50
CABBAGE	9.2	9.00

3.3.2 Cabbage Juice

Fresh cabbage (*Oxylus* variety) outer covers were removed before washed thoroughly in tap water and sliced (2 cm thick) with a clean knife to ensure easy blending. This was steam blanched at 80ºC ± 2 for 10 minutes. The 200g of cabbage and 200 ml of distil water were blended with using an electric blender Binatone Blender (China, Model BLG401) and filtered using a cheese cloth to obtain the juice. The juice was kept in refrigerator at a temperature of 4ºC.

Plate 3.2: Two varieties of orange (late Valencia and blood orange) and cabbage juice in a bottle

3.3.3 Ginger Extraction Preparation

Ten grams of ginger (*Zingiber officinale*) rhizomes were thoroughly washed, cleaned, peeled and sliced (0.5 cm) using a sterilized knife. Blending was done using an electric blender Binatone Blender (China, Model BLG401) with 20 ml of water. Blending was done in short interval from time to time to avoid overheating. A cheese cloth was used to sieve the mixture to obtain a clear ginger extract and kept in HDPE packaging material. It was then kept in a refrigerator at a temperature of 4°C.

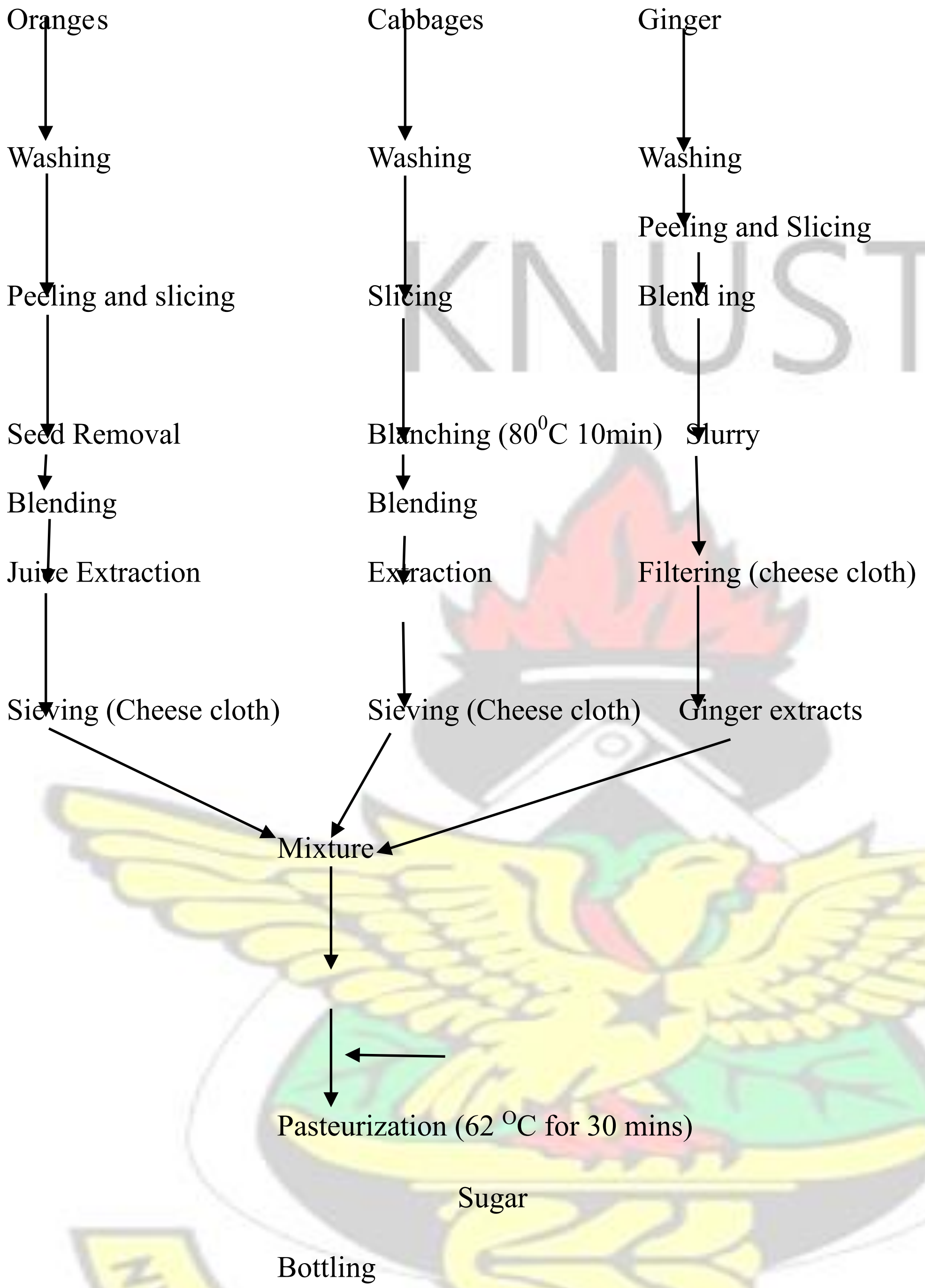


Figure 3.2: Orange-cabbage juice preparation.

3.3.4 Juice Formulations

A plausible lower and upper level for the two component mixture of the juices was chosen for the formulation in table 3.2.

Table 3.2: Lower and upper limits of the juice formulation

Component Name	Lower Limit (%)	Upper Limit (%)
Orange	50	100
Cabbage	0	50

Based on the set limits, the Design Expert version 8.0.7.1 was used to generate the various compositions of the juice formulations using mixture study and optimal design type. The compositions were generated as shown in table 3.3

Table 3.3: Formulation ratios of the juice blends

Formulation Number	Orange (%)	Cabbage (%)
1	50	50
2	60	40
3	73	27
4	95	5
5	87	13
6	80	20
7	55	45
8	67	33
9	100	0

The various combinations of orange-cabbage juice blends were prepared and placed in a 500 ml container which was later pasteurized at 80 ºC for 15 minutes before the addition of 14 ml ginger extract and 10 g of sugar to each juice formulation

3.4 SENSORY EVALUATION

3.4.1 Recruitment and selection of Panellists

A questionnaire was used to help select potential panellists who had no impairment with their senses and were also available and willing to participate in the sensory analysis throughout the sensory period. In all fifty questionnaires were issued out and 39 were selected for further sensory testing

Panellist selection consisted of research orientation, familiarization of panellists with test procedures, sensory recognition and confirmation tests.

3.4.3 Research Orientation

Panellists were introduced to the research and purpose of the study. They were further informed about a descriptive vocabulary needed to be developed for fruit-vegetable juice.

The panellists were taken through the basic principles of sensory evaluation.

Plate 3.3: Sensory orientation section conducted at the Kokofu Health Assistance School Hall

3.4.4 Recognition Test

Sensory recognition tests were performed during the processes of selection of potential panellist. This test included taste and aroma recognition test.

In the taste recognition test, an ice cream was prepared and different concentrations of salt, sugar and citric acid as described by Chambers and Lee (2007) in reference table 3.5 were added and panellists were tasked to identify those additives present. Panellists who were able to identify each of the samples were selected to further undergo the training.

Table 3.4: Reference samples for taste recognition.

Sensory attribute	Concentration of additives
Sweet taste	0.1% sucrose
Sour taste	0.035% citric acid
salty taste	0.1% sodium chloride

Source: Chambers and Lee (2007)

In the aroma recognition test, an ice cream was prepared and an amount of 0.1% of banana, vanilla and pineapple essences were added and panellists were asked to identify the type of essence. Panellists who were able to identify each of the essences correctly were selected to further undergo the training.

Table 3.5: Reference samples for aroma recognition

Samples	Type of essence
Banana flavoured ice cream	Banana essence
Pineapple flavoured ice cream	Pineapple essence
Vanilla flavoured ice cream	Vanilla essence

Plate 3.4: A section of the sensory panellist during the selection and orientation section.

3.4.5 Confirmation Test

A triangle test was performed by the selected panellist using three samples of ice cream where two samples contained equal concentration of 0.1% sugar whiles the third sample contained 0.15% of sucrose and panellist were asked to identify the odd one out of the three sample.

In all 15 panellists out of 50 recruited panellists were selected and it consisted of five males and ten females whose ages ranged from 24 to 45 years. They were grouped into three to generate the sensory attribute to be used in the sensory analyses.

Plate 3.5: The selected panellist for the main sensory evaluation

3.5. TRAINING OF PANELLISTS

3.5.1 Definitions and Grouping of Descriptors

General procedures for developing definitions and references were from the flavour profile method (Keane, 1992). Leaders were selected for each group by members. The panel leader instructed the panellists to make individual notes on descriptors for the sensory attributes of the orange-cabbage juices. Afterwards the panel leader then led a discussion to reach agreement on the descriptors of the orange-cabbage juice samples. Once the panel came to an agreement on the descriptors, a concise definition was provided for each descriptor. Synonymous descriptors were identified and eliminated. The panellists were provided with references for each descriptor. As much as possible, panellists were made to use reference that was representative and exhibiting a specific attribute as suggested by Keane (1992). Specific attention were given to references because they could be used to overcome communication difficulties (Barcenas *et* *al.,* 1999) are helpful in lowering variability in scoring panellists (Stampanoni, 1994) and help reduce the time needed to train a panel (Rainey, 1986).

During the training of the panellists, a total of 7 descriptors were generated, defined, referenced and scored by the panellists. These were grouped into aroma, colour, taste, clarity and aftertaste descriptors.

Table 3.6: Definitions and reference descriptors for cabbage-orange juice blend

Sensory parameters	Descriptor	Definition	Reference
aroma	Fruity scent	Intensity of orange fruit smell of orange-cabbage juice	Orange juice
Colour	greenness	Intensity of green colour of orangecabbage juice	Cabbage juice
	Orange colour	Intensity of orange colour of the orange-cabbage juice	Orange juice
Taste	sweetness	Taste sensation typical of sucrose	Sucrose
	sourness	Taste sensation typical of acid	Lemon juice
Clarity	Cloudiness	Turbidity of the orange-cabbage juice	Voltic water
Aftertaste	Astringency	Drying-out and roughness felt in the mouth	Lemon juice

Source: Chambers and Lee (2007)

3.6 SENSORY EVALUATION OF ORANGE-CABBAGE JUICE BLENDS

The panel was also introduced to the 15-point numerical line scale where „0" represents „very weak" and „15" represents „very strong" as described by Munoz and Civille, (1998).

In the sensory evaluation, the panellists evaluated the sensory characteristics of the orangecabbage juice based on the descriptors generated during training. The aroma attributes were evaluated first followed by the colour and taste attributes. The rest of the assessed attribute were aftertastes and clarity. The nine products were presented to each subject in the order based on a balanced incomplete block design to prevent any biasing effect. Sessions of the evaluation took three days where three samples were presented in a day. The evaluations occurred at the Lecture Hall of the Kokofu Health Assistance Training Nursing School. All samples were three-digit coded and 25 ml of juice in 200 ml transparent plastic cups were served. Each orange-cabbage juice was given to the panellists in triplicate and was scored as such.

Plate 3.6: Main sensory evaluation with selected panellist

3.7 ANALYSES OF PHYSICOCHEMICAL PROPERTIES OF ORANGE-CABBAGE JUICE

3.7.1 Measurement of pH and determination of titratable acidity

The pH of the juices were determined using a pH meter (model: 526WTW) which was standardized at pH 7.0 with BDH buffers and measurement were taken at room temperature of 25^{0}C. Determination was done in triplicates.

For titratable acidity, ten milliliters (10 ml) of orange-cabbage juice was mixed with 100ml distilled water. The mixture was then titrated against 0.1M NaOH using 1% phenolphthalein as indicator. The acidity was calculated based on citric acid.

% Acidity (as Citric acid) = {(Titre x Factor) ÷ Weight of 10ml of sample} x 100

Citric acid factor = 0.064

3.7.2 Total soluble solids and total solids

The total soluble solids of the samples were determined with Abbe refractometer instrument at temperature of 20^{0}C and the refractive index obtained was used to find the degree Brix from a chart which had a correlation of refractive index with the degree Brix as described by AOAC. (1990). Results were taken in triplicates.

Total solids were determined by measuring 10 ml of the samples and weighed into a 50 mm diameter flat bottomed petri dish. The samples were then evaporated on a boiling water bath until it solidified and was dried for two and a half hours in an oven at a temperature of 100^{o}C. It was then cooled in a dessicator and weighed. The difference in weight between the initial and final weight was recorded as total solids (AOAC, 1990). Measurements were taken in triplicates.

3.7.4 Ash determination

The orange-cabbage juice was heated in water bath to dry most of the moisture content before ashing was determined. The dry ashing method in accordance with AOAC (1990) was used for orange-cabbage samples. Ten millleters of the sample was weigh into a crucible and heated with Gallenkamp Muffle Furnace, England at 550° overnight. The crucible was taken out of the burner and cooled in a dessicator

$$\text{ASH }(\%) = \frac{\text{weight of ash}}{\text{Weight of sample}} \times 100$$

3.8. MINERAL ANALYSIS OF ORANGE-CABBAGE JUICE

3.8.1 Determination of some minerals in the juice

Twenty millilitres of each samples were taken and hydrolysed with 10ml concentrated HCl. This was top up to 100ml volume of distilled water in a volumetric flask. After a well shake with a centrifuge, the solution was filtered to remove solid particles and the filtrate was used in running the analysis in Atomic Absorption Spectroscopy Instrument. Measurement was recorded in triplicate.

Standards were prepared for all the minerals by diluting the stock standard solution of 1000mg/L each of the various metals with 10% hydrochloric acid solution. Dilution made was done using this formula:

$M_1V_1=M_2V_2$ where M=weight of sample taken (mg)

V=volume of distil water for the dilution (L)

For Zinc (Zn) and Magnesium (Mg), 1 and 3mg/L calibration standard ranges were used whiles for Iron (Fe), and Calcium (Ca), 2, 4 and 6 mg/L calibration standard ranges were used. For Potassium (K), 1 and 2mg/L calibration standard ranges were used (Dean and Ma, 2008; Dolan and Capar, 2002; Zafar *et al*., 2010).

3.9. VITAMIN C AND BETA CAROTENE DETERMINATION

3.9.1. Vitamin C Determination by Indophenol Method (AOAC, 1990)

(a) Principle

Aliquots of samples in oxalic acid solution are titrated with standardized sodium 2-6 dichlerophenol dye to a faint pink colour that persists for 5 to 10 seconds. This method is limited to juices of light colour because red pigments obscure the end point.

Reagents;

Indophenol dye 0.04 %

0.2 g of sodium 2, 6 dichlorophenol indophenol was weighed and dissolved in about 200 ml water.

Oxalic acid 0.4 %

4 g oxalic acid was weighed and dissolved in distilled water and made up to 1000 ml mark.

Standardization of dye

2 g of potassium iodide was weighed and dissolved in about 5 ml distilled water in 50 ml Erlenmeyer flask in triplicates. 15 ml of the dye was pipetted and added and then 10 ml 1 N HCl. This was mixed thoroughly and made to stand for 2 minutes. Thesolution was titrated with freshly prepared 0.01 N sodium thiosulfate from a micro burette using 2 ml starch, until there is no change in colour when one drop or less is added.

(b) Procedure

Ten grams of each sample was weighed and this was macerated in a porcelain dish or mortar.

Twenty-five ml of distilled water was added onto the macerated sample to form a solution. Twenty ml of the solution was pipetted into 100 ml volumetric flask and this was made up to the mark with 0.4% oxalic acid and filtered through Whatman filter paper to clarify the solution. Ten ml of the filtrate (aliquot) was pipetted and 15 mls of oxalic (0.4 %) was mixed with the filtrate and this was titrated in a 50 ml Erlenmeyer flask with dye (0.04 %) to a faint pink end point lasting for 5 to 10 seconds. Titration was completed within one minute.

For sample calculation

Ascorbic acid per 100 ml juice = Dye equivalent x titer x dilution if 1.05 ml dye were required for titration

3.9.2 Beta Carotene (Pro-Vitamin A)

The beta carotene was determined using HPLC method with a standard at Nugochi memorial institute for medical research, Legon. The reagents involved were acetone (cold), petroleum spirit, pyrogallel, anhydrous sodium sulphate and nitrogen gas. Hexane and benzene HPLC grades were both used at mobile phase whiles octadeccylsiane (ODS), carbon chain (C18) and Reverse phase column were used as the stationary phase.

Twenty-five millilitres (20g) of the juice was weighed and 2g of pyrogallel was added to prevent oxidation during the extraction process into a mortar. 25ml of cold acetone and 2g of anhydrous sulphate were added to dry the water and to enhance the extraction process. Using a pestle the sample was grounded for five minutes and the mixture filtered with Bunchner funnel fitted with a Whatman Filter paper (Number 4) under the suction pressure generated by water separator. Grinding with the pestle was repeated until the residue appeared colourless.

About 20ml of the petroleum spirit was added to the extract in a 500ml separating funnels for the partition process to take place. The lower acetone aqueous phase was discarded. The upper phase (petroleum extract) was collected over 5g anhydrous sulphate to absorb the residual water in the extract. The extract was evaporated under a stream on nitrogen gas and reconstituted and injected into the HPLC (20µ). The beta carotene was identified based on the elution (retention) time of the standard (1.012 minutes) and sample peaks (1.02±0.2) (Peshkova and Gromova, 1998).

Beta Carotenes =

$$\frac{\text{Max abs x 25 ml x vol. acetone (ml)}}{\text{259.2 x (sample wt. (mg) x dry wt.)}}$$

3.10 EXPERIMENTAL DESIGN

Formulation of the cabbage-orange juice was done using a Design expert (8.0.7.1 version) (Cornell, 1983) for two components. A Balanced Incomplete Block Design (BIBD) was used to assign the nine products obtained from the mixture design for two components to 15 panellists.

3.11. STATISTICAL ANALYSIS

The survey results were presented in tables and pie charts using excel 2007 with values presented in percentages. Data for each sensory attribute was analysed using ANOVA (from the Design Expert Software). Physico-chemical properties, vitamins and minerals analyses were performed using MINITAB 16. Least Significance Difference (LSD) was determined using Fisher"s Method to determine the significance of the differences between the means of the measured parameters.

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 A SURVEY IN KOKOFU NURSING TRAINING SCHOOL ON CONSUMPTION PATTERNS OF BEVERAGE.

4.1.1 The age and gender of respondents

Fifty people (48 nursing student and 2 tutors) were issued with questionnaires to participate in the survey out of which 15 were selected to participate in the sensory analysis. The survey comprised 77.5 % female and the rest being male with age ranging from 20 to 45.This is shown in figure 4.1. Eighty-two per cent of the respondents were within the age of 20-30 years, whiles

18 % were within 31-45 years. The married participants were 27.5 % whiles the majority participants amounting to 72.5 % were still single and none was divorced.

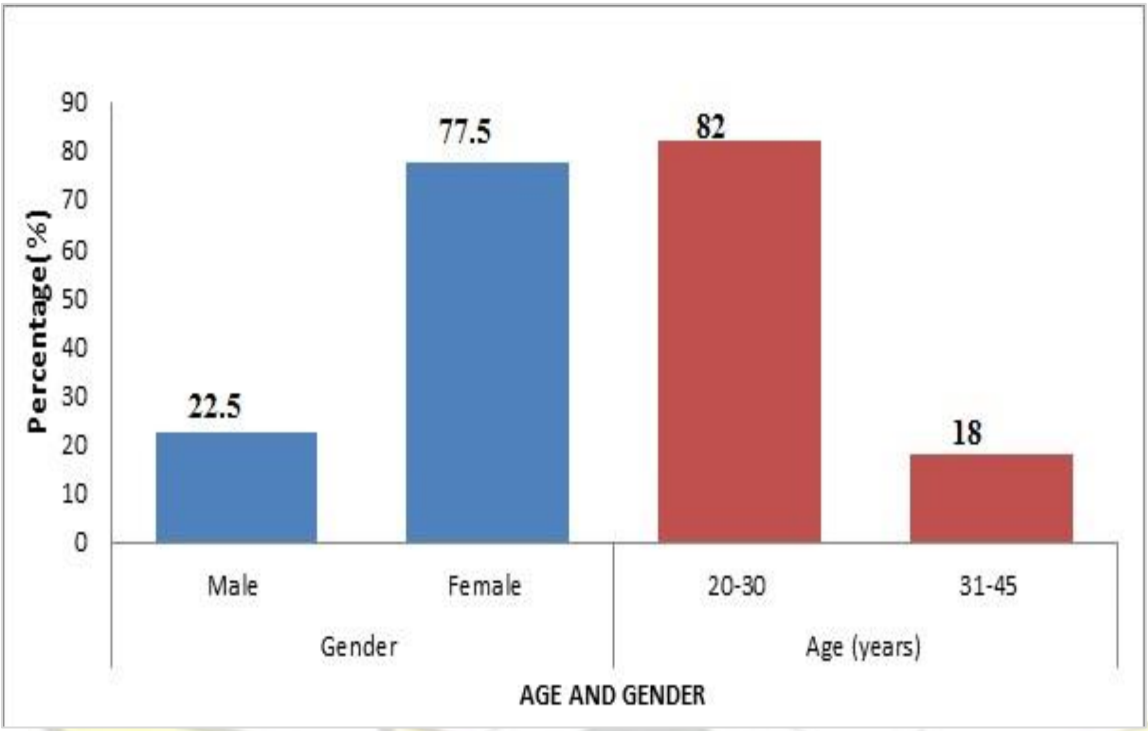


Figure 4.1: Age and gender of the respondent in the survey.

4.1.2 Attribute sought after by respondents when buying juices

Various attributes attract people to the consumption of juices. These attributes included taste which accounted for 80 % followed by all attributes with 10 %. The rest included colour and flavour contributing to 3 and 2% respectively. This was in agreement with Pollard *et al., (*2002) who revealed that pleasure-seeking attribute such taste appears to be a major stimulus for the purchase of tropical fruit juices. It was further revealed that different exotic fruit combinations and their convenience in usage and consumption also form important drivers for the purchase and subsequent consumption of tropical fruit juices Figure 4.2 represents the percentage of the various attributes sought after in juices.

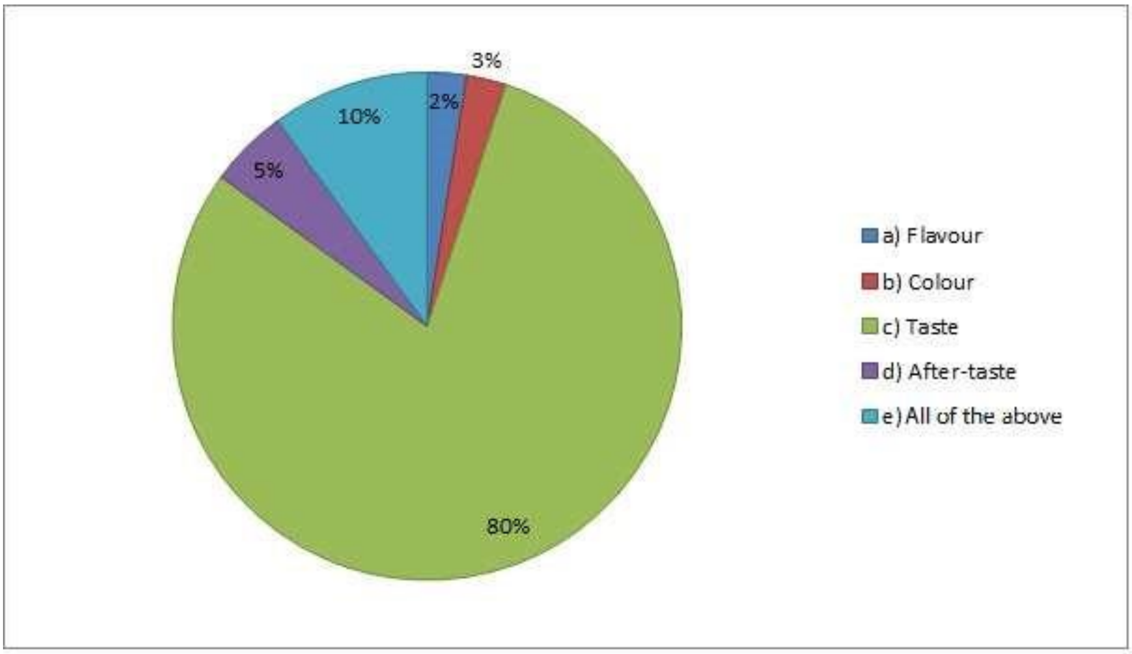


Figure 4.2: The percentage of various attributes sought after in purchasing juices.

4.1.3 General responses to liquid food

The graph in figure 4.3 reveals the general responses to liquid food which included vegetable juice, beverage and fruit juice when tested by consumers. Whiles 99% consumed fruit juice, 90% and 10% of the same consumers opted for beverage and vegetable juice, respectively. This explains how health-conscious consumers are becoming these days and how important fruit juice is considered in diet as it provides most minerals and vitamins. It also shows easy availability and market potential of fruit juices. According to Gyakari (2004), there are several known fruit juice and beverage companies and virtually few or no vegetable juice products on the Ghanaian market and this explains the low awareness and consumption of vegetable juices in Ghana.

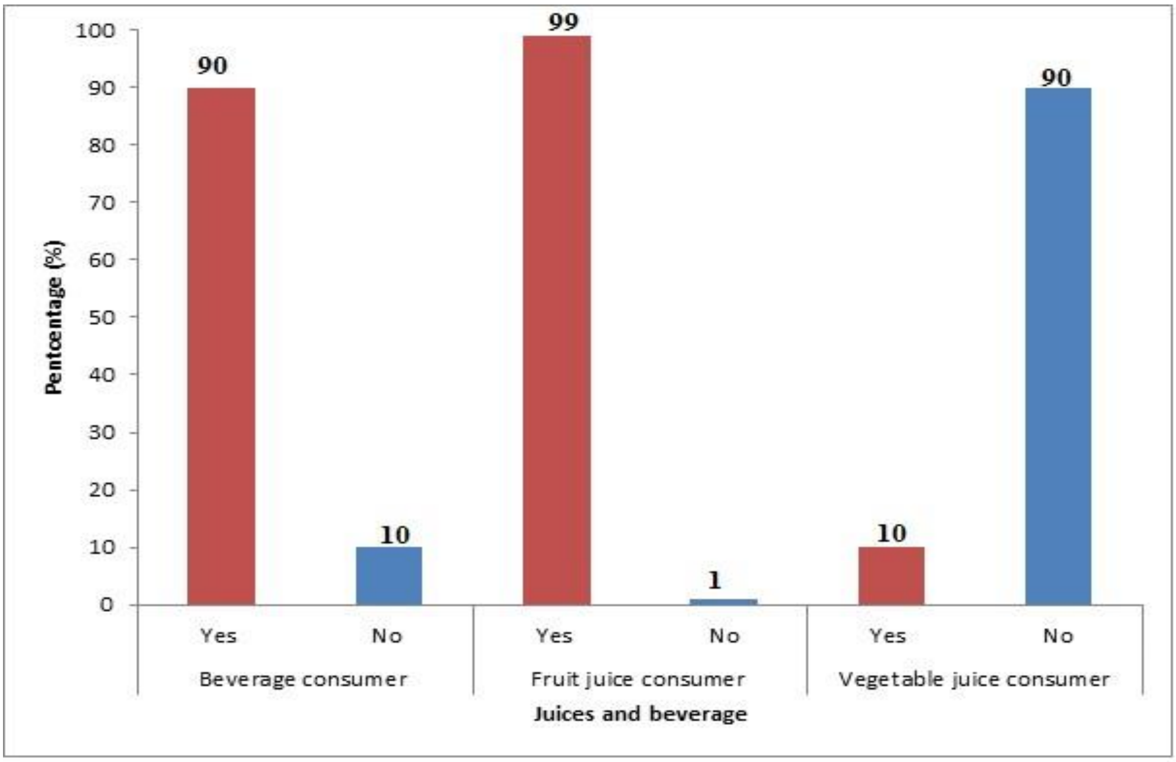


Figure 4.3: Consumer responses to consumption of juices and beverages

4.1.4 Response to preferred juices and herbal beverage.

In figure 4.4 that only 7.5% preferred vegetable juice whiles fruit juice was the most preferred juice with a response of 90.5% and 2.0% preferred herbal juice. Several fruit juice products are on the Ghanaian market today and most of them are imported and have become part of Ghanaian diet as compared to the vegetable juice and herbs beverage which are unpopular (Gyakari, 2004).

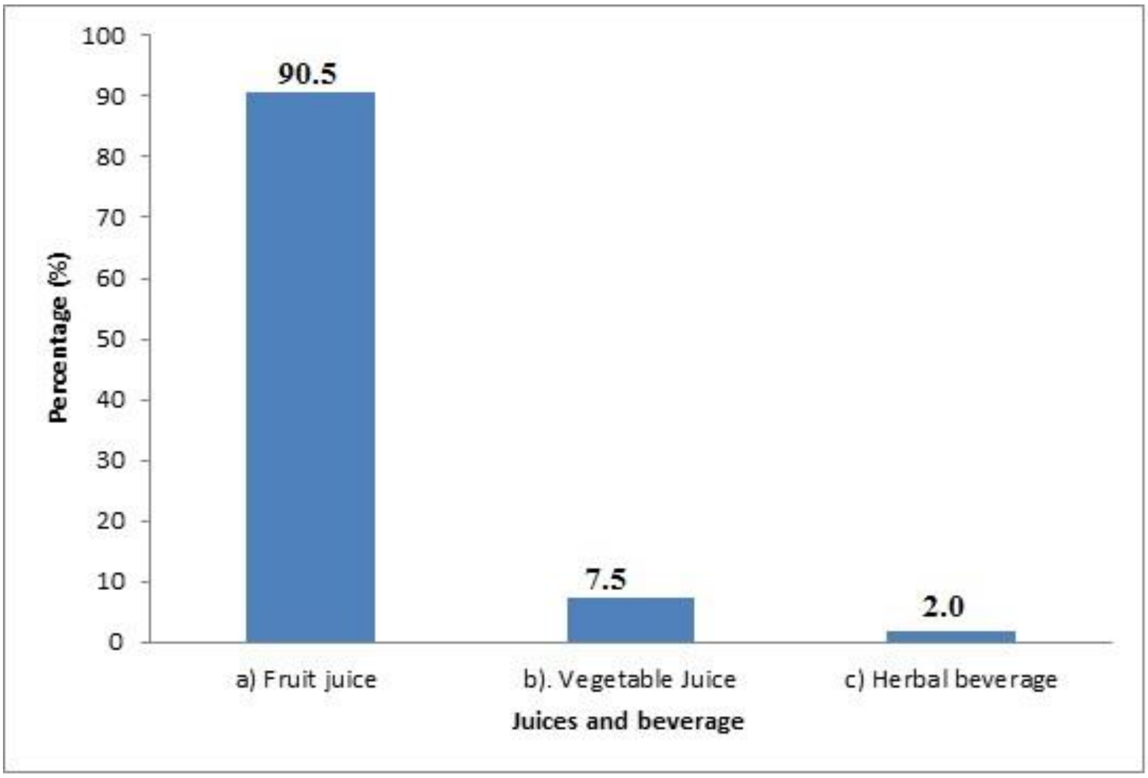


Figure 4.4: Responses of consumers to preferred juice and herbal beverage.

4.1.5 Vegetable Juice Awareness and Allergy

It was revealed that none of the panellists questioned were allergic to cabbage juice as shown in figure 4.5**.** The most common vegetable juice on the market was tomato juice (Gyakari, 2004) but only 37.5% (figure 4.5) knew about it.

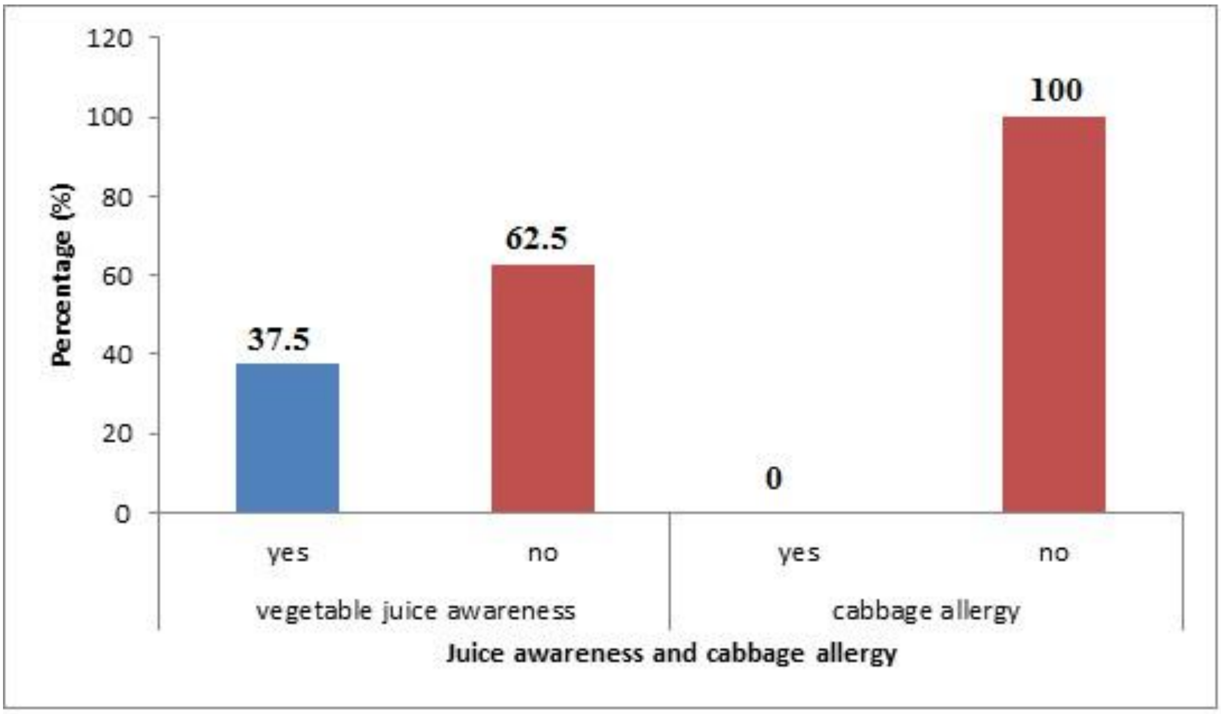


Figure 4.5: Vegetable juice awareness and allergy

4.2. SENSORY PROPERTIES OF CABBAGE – ORANGE JUICE BLENDS

4.2.1 Cabbage juice blended with juice from late Valencia

4.2.1.1 Aroma

Aroma descriptor generated by the trained panel is shown in Table 3.7 along with their definitions and references. The orange fruity aroma was accepted whiles others descriptors namely cabbage and pungent scent were rejected by panellists. Five scale points was used by the panellists (appendix A6.B).

The highest rating in late Valencia was the control, mean of 8.0 (slightly strong) which was followed by F8 (slightly strong) with a mean value of 7.03. This was closely followed by F3 (slightly strong) with a score value of 6.97 and F4 with mean of 6.31 which was also slightly strong. The least accepted fruity smell for aroma was F5 (slightly weak) and closely followed by F2 (slightly weak). This meant that the least quantity of cabbage added to the formulation, the highest it was rated and therefore accepted by panellists. Cabbage releases Dimethyl sulfide (DMS) or methylthiomethane, an organosulfur compound when cooking. This water insoluble flammable liquid compound boils at 37 °C and has a characteristic disagreeable odour (Parliament *et al*, 1977). The orange aroma was hence preferred when compared to cabbage aroma in the cabbage-orange juice formulation.

There was a significant difference ($p < 0.05$) between the various formulations for orange fruity scent parameters (appendix B1, A1).

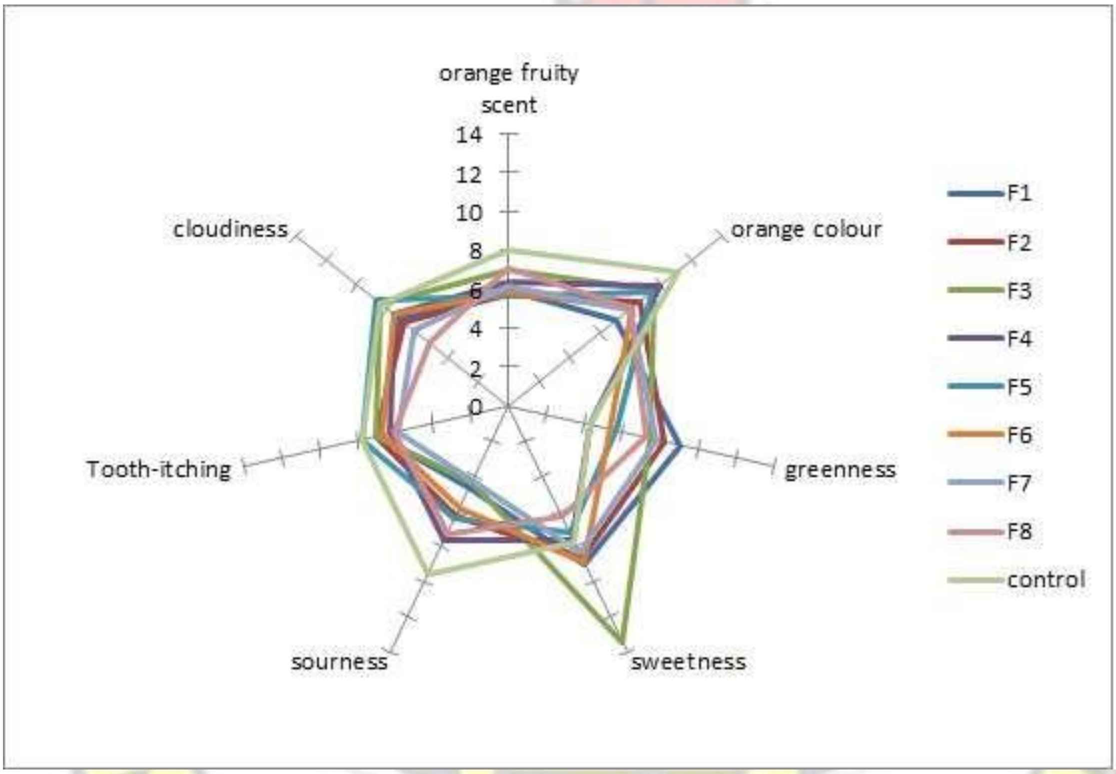


Figure 4.6: Sensory properties of Cabbage-late Valencia orange juice blends

4.2.1.2 Colour

Colour which is a sensation that forms part of the sense of vision, judges the appearance of a food (Jellinek, 1985). Two colour parameters (orange colour and greenness) were accepted by panellists as desired descriptors.

The formulation with the highest mean value beside the control (moderately strong) with a mean value of 9.88 was F4 (moderately strong) as shown in figure 4.6. It was noticed that the higher the percentage of orange juices in the formulation, the higher the mean value therefore preferred by panellists. The least mean value for colour was for F1 (slightly strong) was 7.0 due to the high percentage of cabbage juice present.

There was a significant difference ($p < 0.05$) between the orange-colour of the formulations (appendix B1, A2)

With greenness as a colour parameter, the control was noticed to have score the least mean value of 4.3 as been slightly weak whiles F1 had the highest mean score value of 9.07 as moderately strong. Besides F1, the next formulations with highest mean scores of 8.19 (slightly strong) and 7.73 (slightly strong) were F2 and F7, respectively. These high mean values were as a result of high percentage of cabbage juice in those formulations.

On the contrary, colour preference research by Walsh *et al.,* (1990) suggests that green candy was preferred by children than that of orange colour.

There was a significant difference ($p < 0.05$) between the greenness sensory attribute of the orange-cabbage juice blends (appendix B1, A3).

4.2.1.3 Taste

Two taste characters (sweetness and sourness) were generated and accepted by all panellists. For sweetness as a sensory attribute the least score value was F8 (slightly strong) was 6.23 followed by F5 (slightly strong) and F4 (slightly strong) with scores of 7.17 and 7.60 respectively. The F3 recorded the highest score value of 13.47 as very strong. These values suggest that the higher the cabbage juices in the formulation the better the sweet taste acceptance by the panellists. This can be attributed to the pH of orange which was reduced upon cabbage addition therefore was better appreciated in terms of taste and hence was considered as sweet (Inyang and Abah, 1997). There was no significant difference ($p > 0.05$) between the various formulations for orange-cabbage juice in the sweet sensory attribute (appendix B1, A4).

In sourness sensory attribute the highest mean score was control of 9.6 (moderately strong) whiles the F4 was 7.6 (slightly strong). The least score of was F7 of 4.28 (slightly weak) was closely followed by F3 (slightly weak) and the F1 (slightly weak) of score values of 4.3 and 4.71 respectively. This confirmed the higher the orange juice in the various formulations the sourness the orange-cabbage juice became due the pH of orange hence least accepted by panellists. The pH of juice was from late Valencia and the cabbages were 3.85 and 4.25, respectively. The lower pH in the orange juice made the formulation very sour hence its taste was least accepted so panellists generally consider it as sourness in taste (Karadeniz, 2004).

There was a significant difference ($p < 0.05$) between the various formulations for orangecabbage juice in the sourness sensory attribute (appendix B1, A5).

4.2.1.4 Astringency

One aftertaste characters (Astringency) was accepted by all panellists.

The highest score value of 7.75 was the control (slightly strong) whiles least score value of 5.83 was F7 as slightly weak as shown in figure 4.6. It was noticed that higher the cabbage juice contents in the formulation the weaker the astringency. This meant that orange juices contained high amount of acid and hence had more astringent mouth-feeling (Fuglie, 2001).

There was no significant difference ($p > 0.05$) between the various formulations for orangecabbage juice in the astringency sensory parameters (appendix B1, A6).

4.2.1.5 Cloudiness

One clarity characters (cloudiness) was accepted by all panellists.

The highest score value of 8.67 for cloudiness was F5 (slightly strong). This was closely followed by control (slightly strong) and F3 (slightly strong) with a score value of 8.42 and 8.40 respectively. The least score value of 5.2 was F8 (slightly weak). This meant that the higher the amount of orange juice in the formulation the clearer the juice formulation became. The effect of the cabbage green colour was known to have a decreasing effect on the clarity of the juice (Bate *et al.,* 2001).

There was no significant difference (p> 0.05) between the various formulations for orangecabbage juice in the cloudiness sensory attribute (appendix B1, A7).

4.2.2 Cabbage juice blended with juice from blood orange

4.2.2.1 Aroma

The least score value for orange fruity aroma was F1 which had a rating of slightly weak. This was followed by F8 with rating of slightly weak whiles the control and F5 rated slightly strong with score values of 7.89 and 7.34 respectively as shown in figure 4.7. The least content of cabbage juice in the formulation, the least rating by panellists hence least accepted. Formulation with higher amount of orange juice in the formulation was highly rated hence more accepted. There was no significant difference (p>0.05) between the various formulations for orange-cabbage juice in the orange fruity sensory attribute (appendix B1, B1).

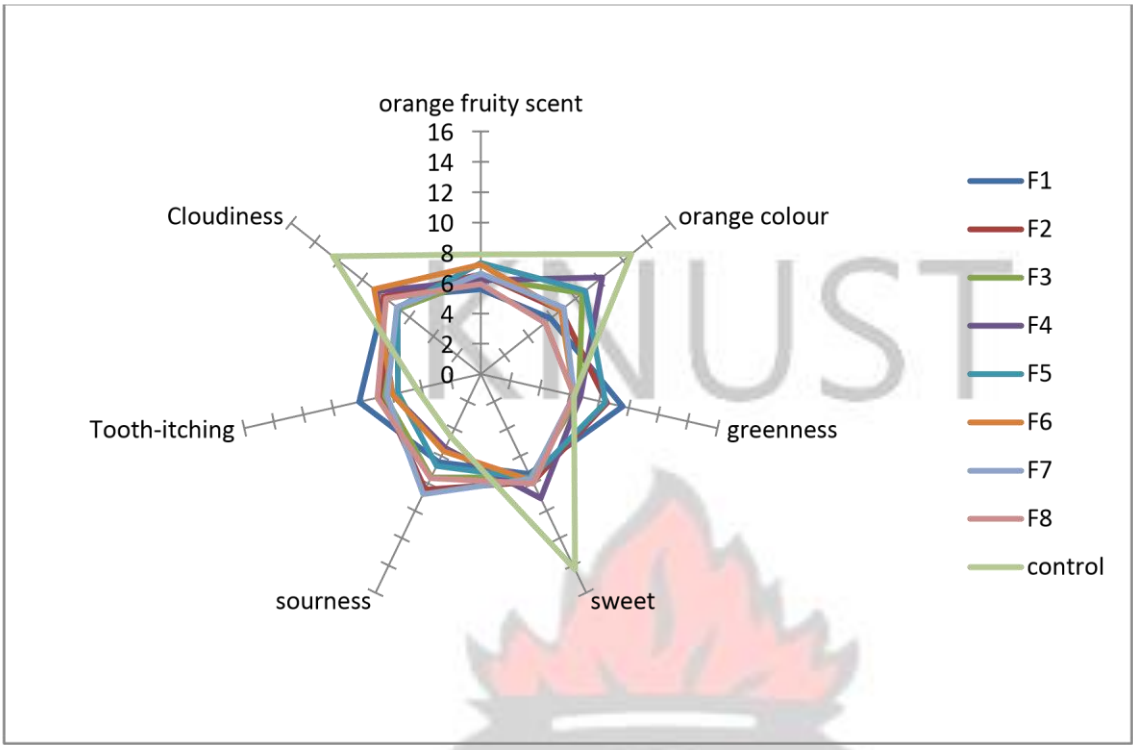


Figure 4.7: Sensory properties of Cabbage-blood orange juice blends

4.2.2.2 Colour

The orange colour with the highest mean value beside the control (very strong) was 10.22 for F4 (moderately strong) whiles the least mean score value was 7.1 for F1 (slightly strong) which was due to the high quantity of cabbage present in the formulation and was in agreement with the late Valencia orange-cabbage juice formulation. It was noticed that the higher the orange quantity in the formulation, the higher the mean score. There was a significant difference ($p < 0.05$) between the various formulations for orange-cabbage juice in the orange colour sensory attribute (appendix B1, B2).

In the case of greenness as a colour parameter, the F6 was noticed to have score the least score value of 6.30 (slightly strong). This was followed by control of score value of 6.53(slightly strong) the whiles the F1 (moderately strong) had the highest score value of 9.60 as shown in figure 4.7.

There was no significant difference ($p > 0.05$) between the various formulations for orangecabbage juice in the greenness sensory attribute (appendix B1, B3).

4.2.2.2 Taste

The formulation with the least mean value was F1 (slightly strong) with 7.30 score value which was closely followed by F3 (slightly strong) and F5 (slightly strong) with a mean value of 7.56 and 7.63 respectively. The control recorded the highest score value of 14.30 with very strong rating, followed by F4 (moderately strong) with a mean value of 9.10. These values suggest that blood was highly rated than late Valencia orange variety. This could be attributed to the less acidity blood orange contains as revealed by the pH values. The high cabbage juice in the formulation generally reduced the sweet nature of the juice blends hence least acceptance by the panellists.

There was a significant difference ($p < 0.05$) between the various formulations for orangecabbage juice in the sweet sensory attribute (appendix B1, B4).

The least score value was the control of 4.56 with slightly weak rating whiles the F7 (slightly strong) and F2 (slightly strong) were the highest score value of 8.78 and 8.45 respectively in sourness

There was no significant difference ($p > 0.05$) between the various formulations for orangecabbage juice in the sourness sensory attribute (appendix B1, B5).

4.2.2.4 Astrigency

The highest score value of 8.22 was the control (slightly strong) whiles least score value of 4.32 was control as slightly weak in the astringency. The general trend of least quantities of cabbage juice in the formulation the least rating was followed. This meant that the blood orange juices contained less amount of acid hence the less astringent mouth-feeling as panellists tasted the juice in the sensory analysis (Fuglie, 2001).

There was a significant difference ($p < 0.05$) between the various formulations for orangecabbage juice in the astringency sensory parameters (appendix B1, B6).

4.2.2.5 Cloudiness

The highest mean value for cloudiness was 12.47 (control) with very strong rating. This was followed by F6 (slightly strong rating) and F4 (slightly strong rating) with a mean value of 8.98 and 8.79 respectively. The least score value of 6.91 was F3 (slightly strong).

There was no significant difference ($p > 0.05$) between the various formulations for orangecabbage juice in the cloudiness sensory attribute (appendix B1, B7).

4.3 OPTIMIZATION OF THE JUICE.

The data from the sensory analysis (appendix A7.1 and A7.2) were imputed into the DesignExpert Software (8.0.7.1 Version) and each of the sensory attribute was optimized with the software. Various graphs for each sensory attribute was obtained from the software as shown in appendix A9.1 and A10.1

A desirability graph (also known as optimal graph) was obtained from the Design-Expert Software (8.0.7.1 Version) using the entire sensory attributes with which optimal peaks or ratio for the formulation of juice blends. Two peaks were obtained for each variety of the orange and these peaks correspond to the orange - cabbage formulation which was labeled as OPT 1 and OPT 2. The OPT 1 and OPT 2 were selected by the software as the optimums among the thirty nine possible sampling points (appendix A9.2 and A10.2).

As shown in figures 4.8 and 4.9 for the late Valencia orange variety, the two regions selected were 80% orange and 20% cabbage as well as 96% orange and 4% cabbage for OPT 1 and OPT

2 respectively. The desirability predicted values were also obtained as 0.527 and 0.317 for OPT 1 and OPT 2 respectively.

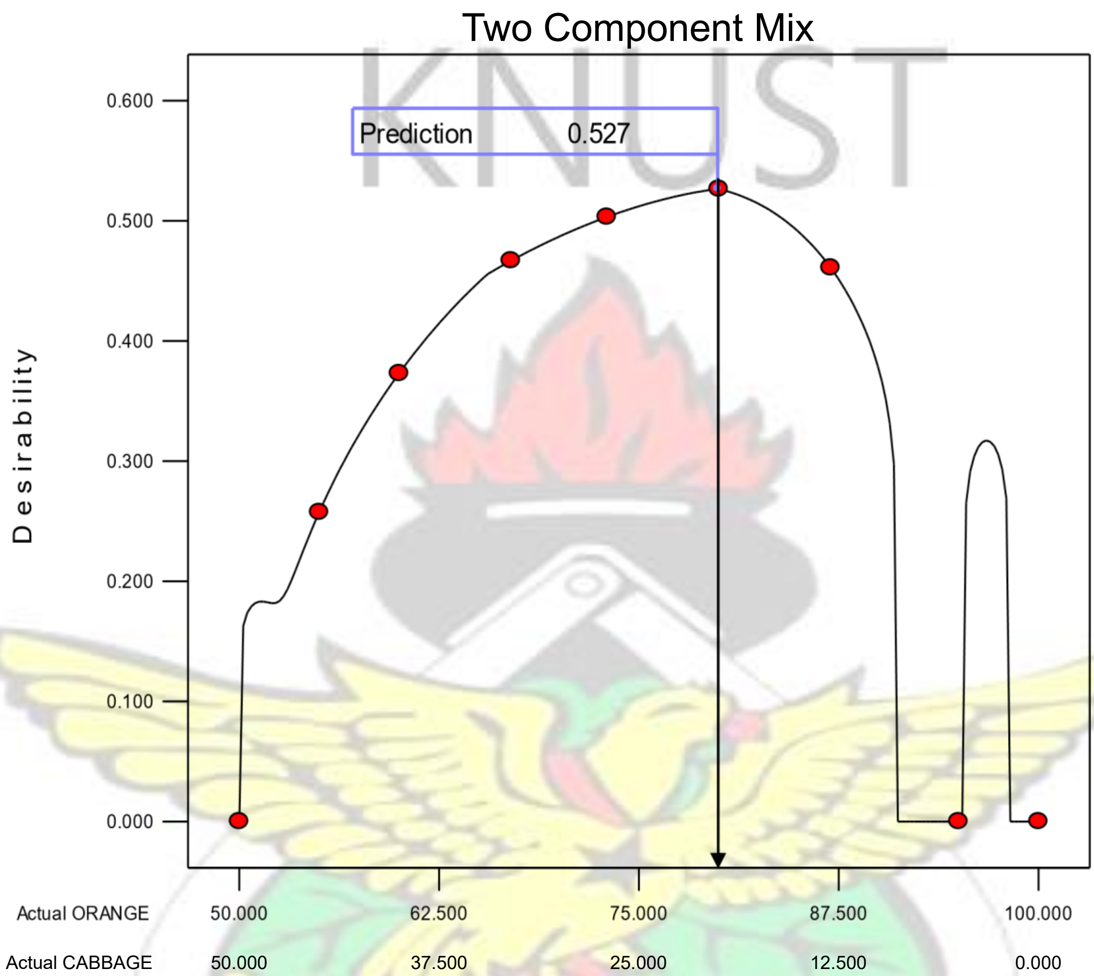


Figure 4.8: Desirability of Late Validity orange – cabbage formulation juice showing the 80% orange and 20% cabbage optimized region (OPT 1)

Two Component Mix

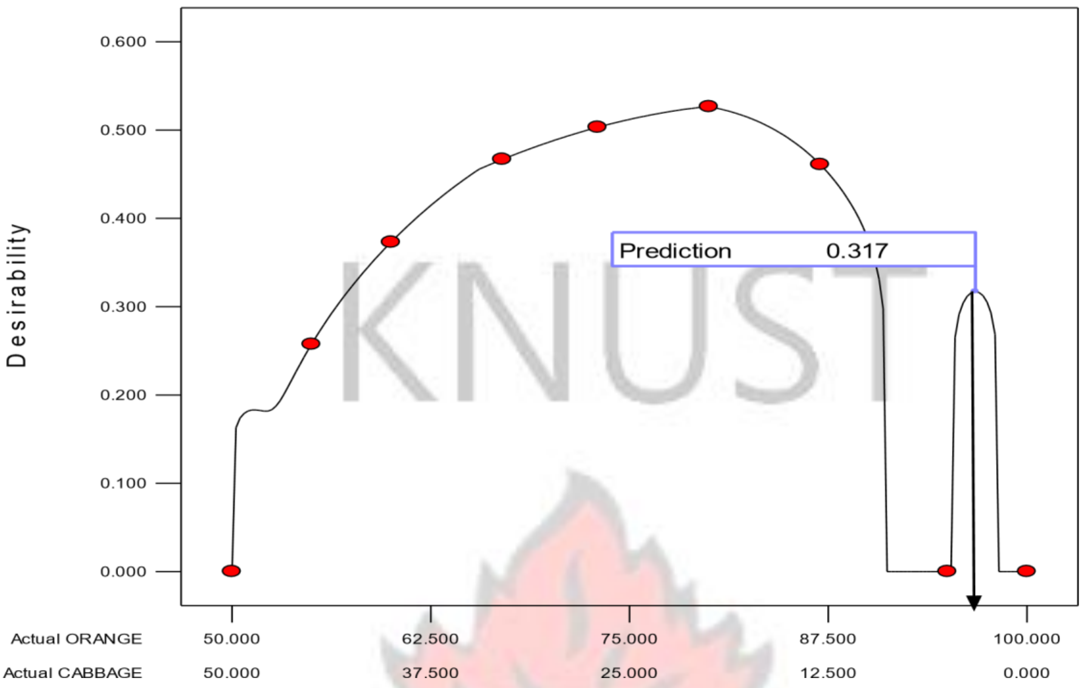


Figure 4.9: Desirability of Late Valencia – cabbage orange formulation juice showing the 96% orange and 4% cabbage optimized region (OPT 2)

The blood orange variety also had two points selected as optimums which were 74% orange and 26% cabbage for OPT 1 and 94% orange and 6% cabbage for OPT 2. The desirability values were 0.362 and 0.348 for OPT 1 and OPT 2 respectively as shown in figures 4.8 and 4.9.

The desirability graph was to select the best optimum values among a possible formulation in a design so that informed choice with relevant data is made.

Two Component Mix

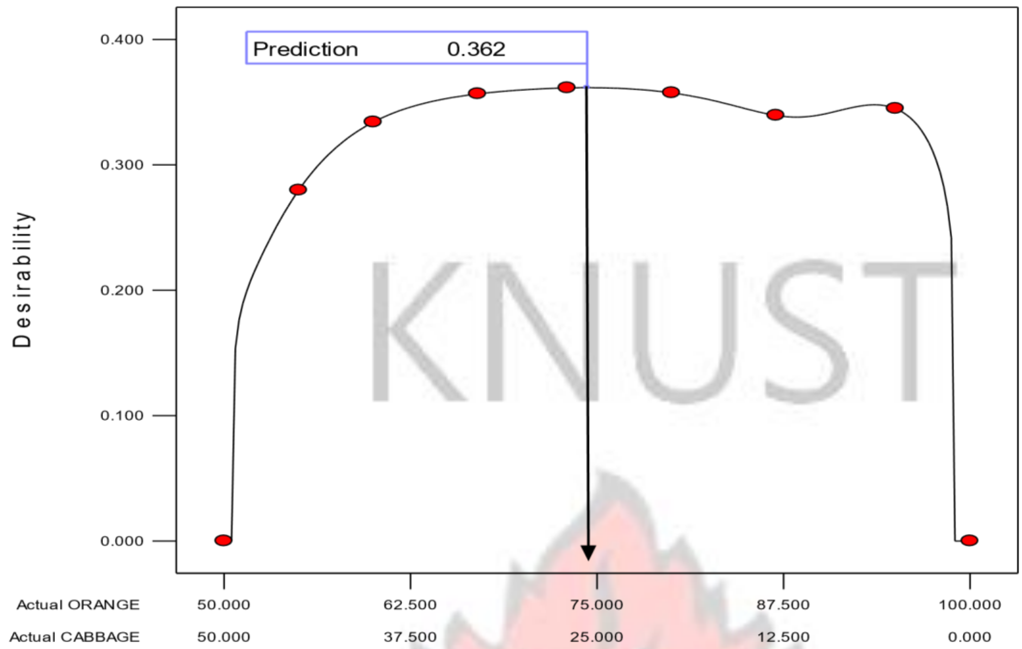


Figure 4.10: Desirability of blood orange – cabbage formulation juice showing the 74% orange and 26% cabbage optimized region (OPT 1)

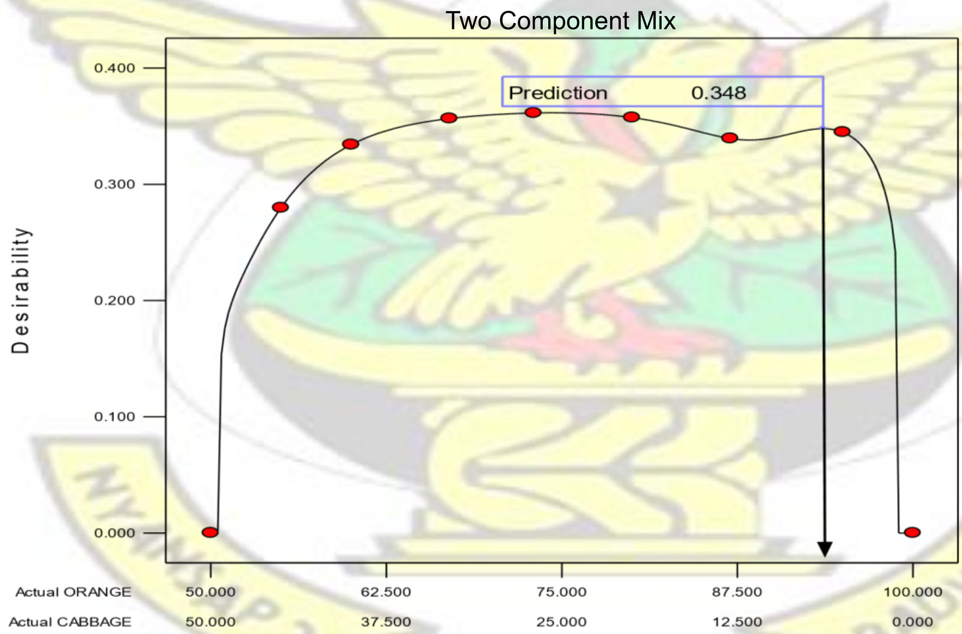


Figure 4.11: Desirability of blood orange – cabbage formulation juice showing the 94% orange and 6% cabbage optimized region (OPT 2)

A validated sensory analysis was then conducted on the two optimums for each variety of the orange and the result is shown in table 4.1. OPT 1 formulation was selected for each of the two varieties of orange based on the following reasons:

1. There was no significant difference ($p > 0.05$) between the result of the prediction (obtained from the design expert software) and validated sensory values (obtained from sensory test). Anova table in appendix B.2.A and B.2.B
2. As one of the justification in promoting the production and consumption of vegetable juices (in this case cabbage juice), OPT 1 for each variety was selected since the cabbage content was higher than OPT 2.

OPT 1 for late Valencia and OPT 1 for blood orange were selected for further studies in this work which was labelled as OPT A (80% late Valencia and 20% cabbage juice formulation) and OPT B (74% blood orange and 26% cabbage)

Table 4.1: Predicted and validated values of selected formulations

Late Valencia

formulation	Predicted/ experimental model	Fruity scent	Orange colour	Greenness	Sweet	Sourness	Tooth itching	Cloudiness	desirability
80:20 OPT 1	predicted	6.58	9.20	6.00	13.47	6.82	6.88	7.48	**0.527**
	experimental	7.02±0.78	8.76 ±0.12	7.23 ±0.34	12.26 ±1.02	6.83 ±0.86	6.55 ±0.64	8.02 ±0.76	
94:6 OPT 2	predicted	6.76	10.22	4.43	7.12	7.82	7.18	8.30	**0.317**

	experimental	7.11 ±0.54	9.83 ±0.66	5.00 ±0.32	6.77 ±0.80	6.49 ±0.76	6.82 ±0.63	8.55 ±0.71	
Blood orange									
74:26 OPT 1	predicted	6.69	6.78	7.34	9.79	6.78	6.51	7.69	**0.362**
	experimental	7.01 ±0.35	6.88 ±0.24	7.03 ±0.71	10.06 ±1.03	6.54 ±0.84	6.06 ±0.26	7.00 ±0.55	
94:6 OPT 2	predicted	7.15	9.86	6.77	9.13	5.59	5.69	9.63	**0.348**
	experimental	7.12 ±0.64	9.75 ±0.93	6.54 ±0.54	9.00 ±0.78	5.68 ±0.49	5.98 ±0.42	9.54 ±0.79	

4.4 PHYSIOCOCHEMICAL PROPERTIES OF CABBAGE JUICE

4.4.1 Total Solids

Total solids measure the dry matters in fruits. As shown in table 4.2 the total solid in the cabbage juice was 7.24 %. The findings of Gyorene *et al.,* (2006) show total solids of most vegetable ranges from 4 to 15%. The cabbage contains high amount of water ranging from 91 to 98% (Costescu, *et al*., 2006).

Table 4.2: Physico-chemical properties of cabbage juice and literature values of fruit and vegetable juices.

COMPONENTS PARAMETER	CABBAGE	Literature Value

	7.24±0.19	4-15.0%[a]
TS (%)	0.49±0.01	0.3 - 2%[a] 10
ASH (%)	10.50±0.06	– 15[b]
TSS (^{O}Brix)	4.25±0.01	3 – 5[c]
pH (25^{0}C) TA (%)	1.23±0.02	0.56 - 3.4%[d]

[a] Gyorene *et al*., (2006) [b] Rawal, (2005) [c] Guerrero *et al*., (2001) [d] Rekha *et al*., (2012).

4.4.2 Ash Contents

Ash content refers to the total mineral composition of a sample. The cabbage ash content was found to be 0.49% (Table 4.2) which is within literature value of 0.3 – 2% (as shown in table 4.2). According to Costescu, *et al*., (2006) the ash content of most vegetables and fruits ranges from 0.3 to 2%. The differences in the ash content could be attributed to cultural practices and the growing medium of the variety of the fruit and vegetable. Guerrero *et al*., (2001) reported that the chemical nature of the growing medium can have a significant effect on the ash content and mineral content of a fruit.

4.4.3 Total Soluble Solids

As shown in table 4.2, the total soluble solids (TSS) of cabbage juice was 10.50%. This value was within the literature value of 10 – 15 % for cabbage (Rawal, 2005). Brix to acid ratio value was 2.47 meant that the juice had less sugar in them to make them sweet. Total soluble solid has overall effect on the juice texture, viscosity and shelf life. Deterioration of the juice increased when total soluble solids were high in juices (Bengi, 2009)

4.4.4 pH of cabbage juice

The pH of cabbage was 4.25 which is within he literature value of cabbage known to range from 3 to 5 according to Guerrero *et al*., (2001) who studied the effect of ultrasound on the survival of *Saccharomyce. cerevisiae* in Sabouraud broth at different temperatures and pH. pH value at 3.5 and below had bactericidal activity in juices according to Bill, 2001. This implies that cabbage juice deteriorated faster when stored at room temperature.

4.4.5 Titratable Acidity

The titratable acidity (TA) of cabbage juice was 1.23% which is also within the literature value of 0.56 -3.4% stated for fruit and vegetable juices by (Rekha *et al*., 2012). The increase in pH might be due to decrease in titratable acidity, as acidity and pH are inversely proportional to each other. High titratable acidity signified immaturity of the fruit (Rekha *et al*., 2012).

4.5 MINERALS, VITAMIN C AND BETA CAROTENE ANALYSES OF CABBAGE JUICE

The minerals in the cabbage juice showed that it contained adequate levels of potassium (935mg/L), calcium (200.63mg/L), magnesium (66.66mg/L), iron (0.95mg/L), and low levels of zinc (1.27 mg/L).

The high levels of potassium, calcium and magnesium make the cabbage juice a good juice for correcting these minerals deficiencies. This is because daily mineral requirement for potassium is 750 to 900 mg/L, calcium (80 to 120mg/L) and magnesium (45 to 60mg/L), (Jensen, 2000).

The vitamin C and pro vitamin A contents shown in Table 4.3 were 32.4 mg/100 mL and 24.40 μg/mL, respectively. The beta carotene of cabbage was lower as expected because cabbage is not known to have higher carotenoids as compared with carrot and mango. The amount of β-carotene is reduced during heat treatment processes such as blanching and this could have accounted for the decrease in beta carotene in blanched cabbage to produce the juice. β-carotene is less stable as heat can convert it to neo-carotene which has no vitamin A activity (Shanna *et al*., 2002).

Table 4.3 Some minerals, Vitamin C and beta carotene components of cabbage juice and literature values for fruit and vegetable juices.

Components	Cabbage	Literature Value
IRON (mg/L)	0.95±0.02	0.2-2.8[a]
ZINC (mg/L)	1.27±0.01	1-2.5[a]
POTASSIUM (mg/L)	935.4±0.52	750-900[b]
MAGNESSIUM (mg/L)	66.66±0.49	45-60[b]
CALCIUM (mg/L)	200.63±0.03	80 – 120[b]
VITAMIN C (mg/100mL)	32.4± 0.70	22.2-65.5[c]
BETACAROTENE ((µg/mL))	24.401± 0.28	25-125[d]

[a] Hurrell (1997) [b]Jensen, (2000) and Fuglie, (2001) [c]Campden and Charleywood (1998**)**

[d]Shanna *et al*., (2002)

4.6 PHYSIOCOCHEMICAL PROPERTIES OF CABBAGE-ORANGE JUICE BLENDS

4.6.1 Total Solids

The total solids of the two varieties of orange were 13.33 and 14.29% (Table 4.4) for late Valencia and blood orange respectively with blood orange variety being the highest. This value was in the range values of 13-19% stated by Aidoo (2011) who worked on various physio-chemical properties of many vegetables including cabbage.

The total solids of the orange and blended juices were significantly different ($p < 0.05$). The presence of cabbage had a significant effect on the total solids ($p < 0.05$). Whiles the late Valencia variety significantly decreased from 13.33 to 9.97% the blood orange also decreased significantly from 14.29 to 10.65%. The high content of total solids in the orange juice is attributed to the high fibre as reported by Gelroth and Ranhotra (2001).

Table 4.4: Physioco-chemical properties of the two varieties of orange and the cabbageorange juices blends.

COMPONENTS / PARAMETER	LATE VALENCIA	BLOOD ORANGE	OPT A (LATE, 80/20)	OPT B (BLOOD, 74/26)
	13.33±0.37^{b}	14.29±1.21^{a}	9.97±0.01^{d}	10.66±0.19^{c}
TS (%)	0.97±0.03^{a}	0.96±0.03^{a}	0.97±0.01^{a}	0.96±0.01^{a}
ASH (%)	10.58±0.11^{c}	13.56±0.01^{a}	11.37±0.04^{b}	13.56±0.01^{a}
TSS (^{O}Brix) pH	3.23±0.01^{c}	5.25±0.01^{a}	3.82±0.03^{b}	5.28±0.04^{a}
TA (%)	1.53±0.04^{a}	1.02±0.01^{c}	1.15±0.02^{b}	1.10±0.01^{b}

NB: Different alphabets in a row show a significance differences between the juices

4.6.2 Ash Content

Ash content refers to the total mineral composition of a sample. The total ash contents were 0.97 and 0.96% for late Valencia and blood orange respectively (Table 4.4) and these were within the expected literature range of 0.3 - 2% for fresh fruit and vegetable (Belitz and Grosch, 1999). There was no significant difference ($p > 0.05$) between the varieties of orange and the optimum blends (OPT A and OPT B). This implies that the cabbage had little or no effect on the total ash content of the optimum formulations of the varieties of orange.

4.6.3 Total Soluble Solids

As indicated in Table 4.4, the values of the total soluble solids of late Valencia and blood orange varieties were 10.58 and 13.56% respectively.

The cabbage total soluble solids had a significant difference ($p < 0.05$) on the two optimums of the cabbage-orange juices. While the late Valencia increased significantly from a value of 10.58 to 11.37% in OPT A, the blood orange remained the same value of 13.56% in its optimum (OPT B). The increase may be attributed to the addition of cabbage during preparation of the juice blend.

4.6.4 pH of the juices

The late Valencia variety of orange had the least pH value of 3.23 as compared to that of blood orange of 5.25 which were within the range of 3 to 5 for fruit and vegetable juices (Harris *et al*., 1991).

There was a significant difference ($p < 0.05$) between the two varieties of orange (late Valencia and blood orange) and the optimums. The late Valencia increased significantly ($P < 0.05$) from 3.23 to 3.82 (table 4.4) whiles there was no significant increase ($p > 0.05$) in that of blood orange and its corresponding optimum (OPT B). However the pH value increased slightly from 5.25 to 5.28. Calculation of Brix to acid ratio revealed that Late Valencia and OPT A values were 6.915 and 9.887 (appendix A 11) which are below 12.0. Hence the juices had less sugar to make them sweet. On the other hand, blood orange and OPT B values were 13.294 and 12.327 which values were above 12.0. This meant that the blood orange and OPT B contained more sugar to enhance it sweetness taste.

4.6.5 Titratable Acidity

The titratable acidity of orange juices varieties were 1.53 and 1.02% for late Valencia and blood orange respectively (Table 4.4). The titratable acidity was higher in the late Valencia than in the blood orange variety and consequently the Valencia orange had a lower pH compared to the blood orange variety.

There was a significant difference ($p < 0.05$) between the titratable acidity of orange varieties and the optimums (OPT A and OPT B). The late Valencia decreased significantly ($p < 0.05$) from 1.53 to 1.15% in its optimum (OPT A) whiles the blood orange variety increased significantly ($p < 0.05$) from 1.02 to 1.10% in its optimum (OPT B).

4.7 MINERALS COMPOSITION OF ORANGE-CABBAGE JUICE BLENDS

4.7.1 Zinc

Zinc is an essential micronutrient for human growth, development and maintenance of immune function and enhances prevention and recovery from infectious diseases (Black, 2003; Walker *et al.*, 2005). The zinc mineral content for late Valencia and blood orange was 0.44 and 0.39mg/L respectively (Table 4.5).

There were significant differences ($p < 0.05$) between the two varieties of orange (late Valencia and blood orange) and the optimums. The zinc content in cabbage was higher than that of the varieties of orange and therefore led to its increase in the cabbage-orange juice. The late Valencia variety increased significantly from 0.44 to 0.84mg/L in OPT A whiles the blood orange also increased significantly ($P < 0.05$) from 0.39 to 0.68mg/L in OPT B.

Table 4.5: Mineral composition of the two varieties of orange and the two selected optimums

Type of Mineral (mg/L)	LATE VALENCIA	BLOOD ORANGE	OPT A (LATE, 80/20)	OPT B (BLOOD, 74/26)
ZINC	0.44 ± 0.01^{c}	0.39 ± 0.01^{d}	0.84 ± 0.02^{a}	0.68 ± 0.01^{b}
POTASSIUM	1700.2 ± 0.02^{d}	1990.05 ± 2.79^{b}	1743.75 ± 1.74^{c}	1995.75 ± 1.48^{a}
MAGNESSIUM	80.54 ± 0.21^{d}	118.02 ± 0.01^{b}	88.75 ± 0.34^{c}	120.08 ± 0.14^{a}
IRON	0.38 ± 0.01^{c}	1.16 ± 0.01^{b}	1.28 ± 0.01^{a}	1.27 ± 0.02^{a}
CALCIUM	74.08 ± 0.01^{d}	110.82 ± 0.92^{b}	87.07 ± 0.08^{c}	111.47 ± 0.04^{a}

NB: Different alphabets in a row show a significance differences between the juices

4.7.2 Potassium

The potassium content in the orange varieties were 1700 and 1990mg/L in the late Valencia and blood orange respectively (Table 4.5). These values were higher as compared to the amount of potassium in other fruits and vegetables aside bananas (2100mg/L) which naturally has high potassium content

There were a significant differences ($p < 0.05$) between the two varieties of orange (late Valencia and blood orange) and the optimums. This can also be attributed to the addition of cabbage to the orange formulations in the selected optimums. The late Valencia variety increased significantly ($p < 0.05$) from 1700.2 to 1743.75mg/L in OPT A whiles the blood orange variety increased significantly ($p < 0.05$) from 1990.05 to 1995.75mg/L in OPT B.

4.7.3 Magnesium

Magnesium is one of the essential minerals required by the body for maintenance of normal muscle and nerve function, keeping a healthy immune system. It maintains heart rhythm, builds strong bones and is normally found in high quantities in fruits, vegetables and other animal products (Appel *et al*., 1997).

There were significant differences ($p < 0.05$) between the two varieties of orange (late Valencia and blood orange) and the optimums. The late Valencia increased significantly ($p < 0.05$) from 80.54 to 88.75mg/L in its optimum (OPT A) whiles the blood orange increased significantly ($p < 0.05$) from 118.02 to 120.08mg/L in its optimum (OPT B).

4.7.4 Iron

Iron (Fe) is an essential mineral required for human growth and orange is one of the plants produce that supplies non-heme irons in small amount. The amount of Fe recorded for the late Valencia and the blood orange were 0.38mg/L and 1.16mg/L respectively (Table 4.5).

Generally, the differences in plant mineral composition may be attributed to the differences in mineral composition of the soils within which the plants were cultivated, which may be affected in turn by general cultural practices such as fertilizer application (Hurrell, 1997). The amount of Fe in the blood orange and cabbage shows that these samples are good sources of Fe.

There were significant differences ($p < 0.05$) between the two varieties of orange (late Valencia and blood orange) as well as the optimums which could be attributed to the addition of cabbage juice in the orange varieties The late Valencia increased significantly ($p < 0.05$) from 0.38 to 1.28mg/L in its optimum (OPT A) whiles the blood orange increased significantly ($p < 0.05$) from 1.16 to 1.27mg/L in its optimum (OPT B). The cabbage-orange juice blends in the selected optimums (OPT A and OPT B) are good sources of Fe since the values exceed the Recommended Daily Allowance. The iron content range from 0.10 to 0.13 mg/L for children; 0.2 to 0.7 mg/L for men; and 0.12 mg/L to 0.16 mg/L for women and breast feeding mothers (Fuglie, 2001).

4.7.5 Calcium

Calcium (Ca) is another essential macronutrient require for strong bones, teeth, muscle and for proper functioning of the nervous system (Jensen, 2000). The calcium content in late Valencia and the blood orange were 74.08 and 110.82mg/L respectively (Table 4.5).

A significant difference ($p < 0.05$) existed between the two varieties of orange and the optimums which can be attributed to the addition of cabbage juice in the orange juices. The late Valencia increased significantly ($p < 0.05$) from 74.08 to 87.07mg/L in its optimum (OPT A) whiles the blood orange increased significantly ($p < 0.05$) from 110.82 to 111.47mg/L in its optimum (OPT B). According to Fennema (1996), calcium in foods is present often as $Ca(OH)_2$, forming Ca^{2+} and OH^- ions in aqueous solution. Due to its alkaline solution, they increase the pH of the solution, making the solution less acidic and therefore less sour hence may also influence the sensory character of beverages.

4.8 VITAMIN C AND BETA CAROTENE IN CABBAGE-ORANGE JUICE BLENDS

4.8.1 Vitamin C (Ascorbic Acid)

The vitamin C contents of late Valencia and blood orange were 45.103 and 55.81mg/100mL (Table 4.6) respectively. Higher vitamin C content was recorded in the blood orange variety than in the late Valencia but all the values were within literature values of 22.2 to 65.5mg/100mL for orange juices (Massaioli and Haddad; 1981). The cabbage had a lower vitamin C content of 32.4mg/100mL (Table 4.8) as compared to the oranges. This was obvious because orange is noted to be one of the fruit with high vitamin C content beside guava (228mg/100mL) papayas (62mg/100mL) and kiwi fruit (93mg/100mL) (Gokce *et al*. 1999).

There was again significant difference ($p < 0.05$) between the two varieties of orange and the optimum blends. The significant difference may also be attributed to heating processing both varieties hence a decrease in Vitamin C content which is lost mainly due to oxidation (Moore, 1995).

The late Valencia decreased significantly ($p < 0.05$) from 45.103 to 37.54mg/L in its optimum (OPT A) whiles the blood orange decreased significantly ($p < 0.05$) from 55.81 to 39.64mg/L in its optimum (OPT B)

Table 4.6: Vitamin C and beta carotenes of the two varieties of orange, cabbage and the two optimums

SAMPLE	VITAMIN C (mg/100mL)	BETA CAROTENE (µg/mL)

LATE VALENCIA	45.103±0.19[c]	587.469± 1.02[b]
BLOOD ORANGE	55.811± 0.21[a]	126.720± 2.63[c]
OPT A (LATE, 80/20)	37.581± 0.26[d]	602.112± 3.33[a]
OPT B (BLOOD, 74/26)	49.646± 0.43[b]	129.545± 1.40[c]

NB: Different alphabets in a column show a significance differences between the juices

4.8.2 Beta Carotene

The beta carotene for late Valencia and blood orange were 587.46µg/mL and 126.72µg/mL respectively which were all below the daily beta carotene requirements for adult men and women which are 5400µg and 4200µg/mL respectively (FNB, 2001).

There were significant differences ($p < 0.05$) between the two varieties of orange and the optimums and this can be due to the addition of cabbage juice in the orange optimums. The late Valencia increased significantly ($p < 0.05$) from 587.46 to 602.112µg/mL in its optimum (OPT A) whiles statistics show no significant differences in the blood orange and its optimum (OPT B)

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The survey revealed that different attributes are sought after in juices by people of different age and gender.

The result from the sensory analysis revealed that in general the blood orange-cabbage juice was only highly rated in the sweetness sensory attribute as compared with late Valencia orange. The late Valencia on the other hand performed better in the orange fruity scent, sourness, tooth-itching and the orange colour sensory attribute. Both varieties of orange when blended with cabbage had virtually equal ratings in terms of their clarity. The red anthocyanin fibres of blood orange were removed when the cheese cloth was used to clarify the juice but their remnants did make impact on the ratings of the blood orange in terms of their orange fruity scent and orange-colour attribute hence lead to the lower scoring.

The sensory evaluation results of the cabbage-orange juice with a formulation ratio of 80% late Valencia orange and 20% cabbage was selected from the sensory analysis as optimum by the Design Expert Software (8.0.7.1 version) among the 9 formulations whiles 74% of blood orange and 26% of cabbage was also selected as the optimum formulation ratio for blood orange variety.

The physio-chemical properties of the juice blends showed significant differences ($p < 0.05$) between the formulations (OPT A and OPT B) and their controls with the exceptions of the ash content where no significant differences existed. There was a significant increase ($p < 0.05$) in the total soluble solids and pH whiles a decreased was observed in the total solids and titratable acidity.

The minerals such as zinc, iron, potassium and calcium in the cabbage-orange juice blends had higher values than the two orange varieties used and therefore contributed significantly in both optimums. A significant increase ($p < 0.05$) in all the minerals analysis and the beta carotenes were established whereas a significant decrease ($p < 0.05$) in the vitamin C contents of the blends was also observed in comparison to the amounts in the two orange varieties.

5.2 RECOMMENDATIONS

The following areas of research are recommended for further studies:

- A full microbiological study on the orange-cabbage juice.
- A shelf-life studies on their storage conditions to study the effect and type of packaging materials of the storage stability on the optimized products.
- A study of the usefulness of cabbage and orange waste resulting from the juice production in incorporation of poultry feed.

REFERENCES

Abrams, S. A. (2002). Effect of a micro-nutrient fortified beverage on growth and biochemical variables in Botswana children. *Journal of the Science of Food and Agriculture*, 84, 101-2.

Adhikari, S. (2006). Country paper: Nepal (2). In: APO. 2006. Postharvest Management of Fruit and Vegetable in the Asia-Pacific Region. Asian Productivity Organization (APO) and FAO. pp. 200-208.

Allen, Z. and Allen, R. (2009).*The Health and Nutritional Benefit of Cabbage*. [on line] Available from: http://www.vegparadise.com/highestPerch33.html [Accessed 28/10/12].

Alzamora, S.M., Tapia, M.S. and **Lo´ pez-Malo, A.** (2000). Minimally Processed Fruit and

Vegetable: Fundamental Aspects and Applications. Gaithersburg, MD: Aspen Publishers Inc. pp:1–62.

Amoah, P., Drechsel, P., Abaidoo, R. C. and Ntow, W.I. (2006). Pesticide and pathogen contamination of vegetables in Ghana‟s urban markets. *Bulletin of Environmental Contamination and Toxicology.* 50, pp:1-6.

Anonymous (2004).The Orange Book, 2nd edition. Lund, Sweden: Tetra Pak Processing Systems AB. On-line available from http://www.tetrapak.com/usprocessing/ pages/default.aspx. Accessed on 14/06/12.

Anonymous (1975) sensory evaluation guide. Institute of Food Technologists – Sensory Evaluation Division, IFT, Chicago, IL. On-line available from http//www. Aufsi.auburn.edu/recommendations/06B01.pdf. Accessed on 12/05/12.

AOAC (1990) Official Methods of Analysis of the Association of Official Analytical Chemists. 15th edition, Washington D.C., pp:992 – 5.

Appel L. J, Moore T. J, Obarzanek E, Vollmer W. M, Svetkey L. P, Sacks F. M,.(1997) A clinical trial of the effects of dietary patterns on blood pressure. *New English Journal of Medicine* 1997;336: pp:1117-24.

Aurand L.W., Woods A.E., Wells M.R. (1987): Food composition and analysis. Van Nostrand Reinhold Publishing Company, New York, N.Y.: pp: 207-13

Ayed A. and E. Al-Tamimi, (2007). Stability of the crude extracts of Ranunculusasiaticusanthocyanins and their use as food colourants. *International Journal of Food Science and Technology,* 42, pp: 985–991.

Baldwin, B. (1995). *History of cabbage.*[on line] Available from http//gardenline. usaskca/veg/cabbage.html [Accessed 27-10-12].

Balasubramaniam, V. M., Farkas, D. and Turek, E. J. (2008). Preserving food through high pressure processing, *Journal of Food Technology*, 11: pp 33-38.

Barcenas, P., Perez Elortondo, F.J., Salmeron, J. and Albisu, M. (1999) Development of a preliminary sensory lexicon and standard references of ewes milk cheeses aided by multivariate statistical procedures. *Journal of Sensory Studies* 14, pp:161 – 179.

Bates, R.P., Morris, J.R. and Crandall, P.G. (2001). Principles and practices of small- and medium-scale fruit juice processing. Food and Agriculture Organization. *Agricultural Services Bulletin* 146: pp:135-149.

Beach V, (2008). History *of the Indian River Citrus League*, Indian River Citrus League, Florida. Retrieved from www.ircitrusleague.org/history.html on 2012-06-11.

Belitz, H.D. and Grosch, W. (1999). Food Chemistry, second Edition translation from the fourth German edition. Springer-Verlag Berlin Heidelberg Publication, New York, pp:6-11

Bengi, H. (2009). UV disinfection of some of the fruit juices. A thesis submitted to the graduate school of engineering and science of izmir institute of technology, Turkey. On-line available from http//www Library.iyte.edu.tr/tezler/master/gidumh /T000781.pdf. Accessed on 6/06/12.

Bill T., (2001). Effects of different storage conditions on preservation of Brassica vegetables. *Journal of Food Processing and Preservation,* 16(1), pp:156-157.

Black, R.E. (2003). Zinc deficiency, infectious disease and mortality in the developing world. *Journal of Nutrition* **133**: pp:1484S – 9S.

Borenstein, A.R., Dai, Q., Wu, Y., Jackson, J.C. and Larson, E.B.(2005). Consumption of fruit and vegetable juices predicts a reduced risk of AD The Kame Project. Presented at Alzeheimer‟s Association International Conference on the Prevention of Dementia, June 18-21, in Washington DC, USA. *The American Journal of Medicine* 119(9), pp: 751-759.

Boyer R. and Mckinney J. (2009). Food storage guidelines for consumers. Virginia coorperative extension publication Nutrition, 8th Edition, Ciba-Geigy Ltd. pp: 348-960. Online available from http//www.pubs.ext.vt.edu/348/348-960.html

Campden and Chorleywood Food Research Association (1998). Analysis of leaf powder for nutritional composition. *Medicine and Science in Sports and Exercise*, pp:212– 224.

Cemeroğlu, B. (2004). Fruit and Vegetable Processing Technology. 3rd edition Ankara: Capital Stereotype Printing, , pp: 167-200.

Centers for Disease Control and Prevention.(1992). Recommendations for the use of folic acid to reduce the number of cases of spina bifida and other neural tube defects. *Morbidity and Mortality Weekly Report (MMWR),*Review 41(RR-14): pp:1-7.

Chambers, H.D. and Lee, J. (2007) A lexicon for flavour descriptive analysis of green tea. *Journal of Sensory Studies* 22,pp: 256 – 272.

Chollet, S. and Valentin, D. (2001). Impact of training on beer flavour perception and description: are trained and untrained subjects really different? *Journal of Sensory Studies* 16 pp: 601 – 618.

Cleveland, L., Goldman, J. and Borrud, L. (1996). Results from USDA"s 1994 Continuing Survey of Food Intakes by Individuals and 1994 Diet and Health Knowledge Survey, Riverdale, Md., USA, USDA. pp. 1-68. Online version available www.mcb.berkley.edu/courses/mcb135e/kidneyfluid.html retrieved on 22/7/2012

Codex alimentarius commission (2004). Joint FAO/WHO food standards programme. Report of the fourth session of the ad hoc codex. Intergovernmental task force on fruit and vegetable juices. Fortaleza (ceará), brazil, october 2004. Online available at http://www.justice.gov.md/file/Centrul%20de%20armonizare%20a%20legislatiei/Baza%20de%20date/Materiale%202010/Legislatie/Codex%20Stan%20247-2005.pdf

Costescu, C. D., Pârvu, A. and Riviş D. I. (2006). *Journal of Agroalimentary Processes and*

Technologies, XII (2), pp. 429-432.

Cornell, J.A. (1983). How to Run Mixture Experiments for product Quality. American Society for Quality Control, Milwaukee, WI, *Journal of Food Processing and Preservation* pp:35-54.

Cortes, C., Esteve, M.J. and Frigola, A. (2008). Colour of orange juice treated by high intensity pulsed electric fields during refrigerated storage and comparison with pasteurized juice. *Journal of Food Control* 19, pp:151-158.

Craig, W. and Beck, L. (1999). Phytochemicals: health protective effects. *Canadaian journal of dietetic. practice and research*. 60, pp;78-84.

D'Amico, D. J., Silk, T.M., Wu, J., Guo, M. (2006). Inactivation of microorganisms in milk and apple cider treated with ultrasound, *Journal of Food Protocol* 69(3), pp: 556-563.

Damrosch B. (2007). The Joy of Savoy Cabbage. The Avi Publishing Company Inc Washington pp: 07.

Dani, C., Oliboni, L.S., Vanderlinde, R., Bonatto, D., Salvador, M. and Henriques, J.A.P. (2007). Phenolic content and antioxidant activities of white and purple juices manufactured with organically- or conventionally-produced grapes. *Food and Chemical Toxicology* 45, pp:2574-2580.

Dean , J. R. and. Ma R. (2008). Atomic absorption, atomic emission, and inductively coupled plasma spectroscopies in food analysis. Hanbook of Food Analysis Instruments, Otles 7th Edition. CRC Press, Taylor and Francis Group, pp:319-346

Dolan, S. P., and S. G., Capar. (2002). Multi-elements analysis of food by microwave digestion and inductively coupled plasma atomic emission spectroscopy. *Journal of Food Composition and Analysis*. 15(5), pp:593-615.

Donahue, D.W., Canitez, N. and Bushway, A.A., (2004). UV inactivation of *E. Coli* O157:H7 in apple cider: quality, sensory and shelf life analysis. *Journal of Food Processing and Preservation* 28pp:368-387.

Economos C. and ClayW. D. (1999)**.** An article summary of paper presented at the Twelfth Session of the Intergovernmental Group on Citrus Fruit, 22 to 25 September 1999, Valencia, Spain. Online available from http://onlinelibrary.wiley.com/doi/10.1111/ j.1541-4337.2012.00201.x/pdf

Emebu P.K. and Anyika J.U., (2011).Vitamin and Antinutrient Composition of Kale (*Brassica oleracea*) Grown in Delta State, Nigeria*. Pakistan Journal of Nutrition* 10 (1): pp:76-79.

FAO Statistics for 2005 and 2008.Retrieved from www.fao.org/es/ess/top/commodity.html. Retrieved on 19/06/12.

FAO., (2007): Economic And Social Department: The Statistical Division".Food and Agriculture Organization. http://faostat.fao.org/site/567. /DesktopDefault.aspx?PageID=567#ancor. Retrieved on 22 June 2012.

Fennema, R.O. Karel, M., Sanderson, G.W., Tannenbaum, S.R., Walstra, P., Witaker, J.R.(1996). 3rd edition. Food Chemistry, Marcel Dekker Inc. New York. 52.

Fleming, D., Jacques, P., Dallal, G., Tucker, K., Wilson, P. and Wood, R. (1998). Dietary determinants of iron stores in a free living elderly population: The Framingham Heart Study. *American Journal of Clinical Nutrition,* 67, pp: 722-733.

Food and Nutrition Board (FNB), **(2001).** Institute of Medicine. *Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc*. Washington, DC: National Academy Press, pp:245-264.

Frankel, E. N.; Bosanek, C. A.; Meyer, A. S.; Silliman, K.; Kirk, L. L., (1998) Commercial grape juices inhibit the in vitro oxidation of human low-density lipoproteins. *Journal of*

Agriculture and Food Chemistry., *46*, pp:834-838. **Fuglie, L.G**. (ed.) (2001). The Miracle Tree. *The Multiple Attributes of Moringa.* CTA,

Publishing Company Inc Wageningen, Netherlands; pp: 668 – 749.

Gains, N. and Thomson, D.M.H. (1990).Sensory profiling of canned lager beers using consumers in their own homes. *Journal of Food Quality and Preference* 2**,** pp: 39 – 47.

Garrow, J. S. (2003). Human Nutrition and Dietetics. 9th edition. Churcill Press. Livingstone, Edinburg, UK pp: 203-14

Gelroth J. and Ranhotra G.S. (2001).Food Uses of Fiber. In: Cho S, DreherM,editors. Handbook of dietary fiber. New York: Marcel Dekker, Inc. New York, NY, USA, pp: 435–480.

Gershoff, S. (1993). Vitamin C (ascorbic acid): new roles, new requirements? *Nutrition Reviews,* 51(11), pp: 313-326.

Gokce N, Keaney J. F. and Frei B, (1999). Long-term ascorbic acid administration reverses endothelial vasomotor dysfunction in patients with coronary artery disease. From the Evans Memorial Department of Medicine, Cardiology Section and Whitaker Cardiovascular Institute, Boston University School of Medicine. A Circulation. 99(25), pp: 3234-3240. Online version available from www.freepatentonline.com/detail.asp?id=704 Retrieved on 4/7/12

Guerrero, S., López-Malo, A. and Alzamora, S. M. **(2001)**. Effect of ultrasound on the survival of *Saccharomyces cerevisiae*: Influence of temperature, pH and amplitude, *Innovative Food Science and Emerging Technologies, 2*, pp:31–39.

Guy, C. Piggott, J.R., and Marie, S. (1989) Consumer profiling of Scotch whisky. *Journal of Food Quality and Preference* 1, pp: 69 – 73.

Gyakari N. A., (2004). Survey of fruit juice processing in some part of Ghana, A dissemination of project to department of biochemistry Kwame Nkrumah University of Science and Technology, pp: 45-56.

Gyorene KG, Varga A, Lugasi (2006). A comparison of chemical composition and nutritional value of organically and conventionally grown plant derived foods. *Journal of the Science of Food and Agriculture*. 147(43), pp: 2081-90.

Harats, D., Chevion, S., Nahir, M., Norman, Y., Sagee, O. and Berry, B. (1998). Citrus fruit supplementation reduces lipo-protein oxidation in young men ingesting a diet high insaturated fat: presumptive evidence for an interaction between vitamins C and E *in vivo*. *American Journal of Clinical Nutrition*, 67, pp: 240-245.

Harris A, Key J, Silcocks B. (1991). Dietary carotene. 3rd edition. Prenticehall Press, NY. pp. 63-68.

Hurrell R.F. (2002) Fortification: Overcoming technical and practical barriers. *Journal of Nutrition*; 132: pp: 806–12.

Institute of Medicine.Food and Nutrition Board (2001**)**. Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium and Zinc.2nd edition National Academy Press Washington, DC:.

Inyang, U.E. and Abah, U.J (1997). Chemical composition and organoleptic evaluation of juice from steamed cashew apple blended with orange juice. *Plant Foods for Human Nutrition* (50), pp 295–300.

Jacques, P., Taylor, A., Hankinson, S., Willet, W., Mahnken, B., Lee, Y., Vaid, K. and Lahav, M. (1997). Long-term vitamin Csupplement use and prevalence of early agerelated lensopacities. *American Journal of Clinical Nutrition*, 66, pp: 911-916.

Jellinek, G. (1985). Sensory Evaluation of Food.Theory and Practice.Ellis Horwood international publishers in science and technology, Chichester Publishing Company. England, pp 145,159.

Jensen, B. (2000). Guide to Body Chemistry and Nutrition. Keats Publishing, Illinois, U.S.A. pp. 55 – 80.

Kabasakalis, V., Siopidou, D. and Moshatou, E. (2000). Ascorbic acid content of commercial fruit juices and its rate of loss upon storage. *Journal of Biological. Chemistry* 70, pp:325-328.

Kader Adel A., Penelope Perkins-Veazie, and Gene E. Lester (2001): Nutritional Quality of Fruit, Nuts, and Vegetable and their Importance in Human Health. On-line available from: http://www.ba.ars.usda.gov/025nutrition.pdf [Accessed 22/9/12].

Keane, P. (1992). The flavour profile. In ` Manual on Descriptive Analysis Testing for Sensory Evaluation. 3rd edition, R.C. Hootman Publishing Company, Philadelphia, P.A. pp:2 – 15.

Karadeniz, F. (2004).Main organic acid distribution of authentic citrus juices in Turkey. *Turkey Journal of Agriculture* 28, pp:267-271.

Labbe, D. Rytz, A. and Hugi, A. (2003). Training is a critical step to obtain reliable product profiles in a real food industry context. *Journal of Food Quality and Preference* 15, pp: 341 – 348.

Lawless, H. T. and Heymann, H. (1998) Sensory Evaluation of Food: Principles and Practices, Chapman and Hall Press, New York.,pp:139 – 146.

Lin, H. Z., (2008). The Medicinal Properties of Cabbage. Optimize Cells Detoxification or Cleaning Ability of Cabbage. On-line Available from:http//www.whfoods.com/ genpagephp?tname= food spice &bid=49. Accessed 1-10-12.

Liu, R.H., (2003). Health benefits of fruit and vegetable are from additive and synergistic combinations of phytochemicals. *American Journal of Clinical in Nutrition,* 78, pp:517-520.

Marsh K. and Bugusu B.(2007). Antigenotoxic effects of coconut meat, coconut milk and coconut water. *Journal of the Science Of Food and Agriculture* 39(72), pp:67-9

Masamba K. G. and Nguyen, M. (2008). Determination and comparison of vitamin C, calcium and potassium in four selected conventionally and organically grown fruits and vegetables. *African Journal of Biotechnology*. 7 (16), pp. 2915-2919,

Massaioli D. and Haddad P. R. (1981).Stability of the vitamin C content of commercial orange juice. *Journal of Food technology in Australia.* 33(3), pp: 136-138

MOFA, (2001). Profile of District Agricultural Development in Ejisu-Juaben District.

Technical document. Accra, Ghana, pp 1-8. Online available from www.mofa.gh/agric./td/mejd135e/832+mgh.pdf

Moore, D., (1995). Human Nutrition and Dietetic. 9th edition, Churchhill Livingstone Publishers, NY, pp: 335-339.

Moskowitz, H. (1996). Descriptive analysis of perceptions. In Product testing and sensory evaluation of foods. Westport, CT: Food Nutrition Press, pp: 20 – 78.

Mrema, C.G. and Rolle, S.R. (2002). Status of the postharvest sector and its contribution to agricultural development and economic growth. Proceeding of the 9th *Japan International Research Center For Agricultural Science* (JIRCAS). International Symposium, (JIRCAS-08), Value-Addition to Agriculture Products, Ibaraki, Japan, pp:13-20.

Munoz, A.M. and Civille, G.V. (1998). Universal, product and attribute specific scaling and the development of common lexicon in descriptive analysis. *Journal of Sensory Studies* 13, pp: 57 – 75.

Norman, J. C. (1992). *Tropical Vegetable Crops*. Arthur H. Stockwell Ltd. Ilfracombe, Devon. Pp: 160-161.

Norman, C. and Shealy, M. D. (2007). Illustrated Encyclopedia of Healing Remedies. Elements Book Inc. 160 North Washington Street. Boston MA.

Available from: http://www.hcvn.com/healthandhealingz/kcabbage/ index.htm

[Accessed17/06/12].

Ofosu-Budu, K.G., Monney E.O., Quaye E., Amankwah A., Mintah P., Asare C.M. and Agboka M.(2007).*Citrus Production In Ghana*. Agricultural Information Support Unit Press, Accra. pp1- 6.

Parliment, T. H. Kolor, M. G. Maing, I. Y. (1977). "Identification of the Major Volatile Components of Cooked Beets". *Journal of Food Science* 42 (6): 1592–1593.

Peshkova V. M, Gromova M. I. (1998) *Practical Guide on Spectrophotometry and Colorimetry*. Original Russian Text. *Journal of Petroleum Chemistry* (2006 edition). 46(3), pp. 221–225.

Pollard, J., Kirk, S.F.L. and Cade, J.E. (2002) Factors affecting food choice in relation to fruit and vegetable intake: A review. *Nutrition Research Reviews* 15, pp. 373-387.

Poste L.M., Mackie D. A., Gail, B. and Larmond, E. (1991), Laboratory Methods for Sensory Analysis of Food, Research Branch Agriculture Canada Publication 1864/E, Canada Communication Group-Publishing Centre, Ottawa, Canada, pp: 23-25, 32-35.

Rainey, B.A. (1986) Importance of reference standards in training panelists. *Journal of Sensory Studies* 1, pp: 149 – 154.

Rawal S (2005). Tomato processing and production.2nd ed. Academic press .Inc. San Diego USA. pp. 67, 85.

Rekha, C. Poornima G., Manasa M., Abhipsa V., Pavithra J (2012). *Journal of Chemistry Science Transition.* 1(2), pp:303-310

Rude R.K.(1998). Magnesium deficiency. A cause of heterogenous disease in human. *Journal of Bone and Mineral Research.* 13,pp:749-58.

Sapers, G. M. and Miller, R. L. (1995). Heated ascorbic/citric acid solution as browning inhibitor for pre-peeled potatoes. *Journal of Food Science* 60, pp: 762-766.

Shenoy, S., Kazaks, A., Holta R. and Keena C. (2008). "Vegetable Juice Is an Effective and Acceptable Way to Meet Dash Vegetable Recommendations". *Journal of the American Dietetic Association* 108(9), pp:104.

Shanna M. E., Tilberry S. and Valerie N. X. (2002). Effect of processing on vitamins and antioxidant activity of tomatoes. *Journal of Food Science*. 37, pp: 434- 456, 543.

Shils, M.E., Shike, M., Ross, A.C., Caballero, B. and Cousings, R.J. (2006).Modern nutrition in health and disease. 10th Edition. Lippincott Williams and Wilkins A Wolters Klumer Company, pp: 280-281.

Southon, S. (2000). Increased fruit and vegetable consumption within the EU: Potential health benefits. *Food Research International.* 33, pp: 211-217.

Stampanoni, C.R. (1994). The use of standardized flavour languages and quantitative flavour profiling technique for flavoured dairy products. *Journal of Sensory Studies* 9, pp: 383 – 400.

Stone, H and Sidel, J.L. (1993), Sensory Evaluation Practices, 2nd Edition Academic Press Inc., San Diego, USA, pp: 1-8, 11-13, 21-23, 29-30, 38-39, 43-44.

Tong, C. B. S. and Hicks, K. B. (1991). Sulphated polysaccharides inhibit browning of apple juice and diced apples. *Journal of Agricultural and Food Chemistry* 39: pp 1719-1722.

Torregosa, F., Esteve, M.J., Frigola, A. and Cortes, S. (2006). Ascorbic acid stability during refrigerated storage of orange–carrot juice treated by high pulsed electric field and comparison with pasteurized juice. *Journal Food Engineering* (73), pp: 339– 345.

USDA. (2010). Dietary Guidelines for Americans.Washington, DC, Government Printing Office.On-line available from http//www.cnpp.usda.gov/dietaryguidelines.htm. Accessed on 12/19/12.

Walker, C.F., Kordas, K., Stoltzfus, R.J. and Black, R.E. (2005) Interactive effects of iron and zinc on biochemical and functional outcomes in supplementation trials. *American Journal of Clinical Nutrition* **82**(1), pp: 5 – 12.

Walsh L. M., Toma R.B., Tuveson R.V and Sondhi L. (1990). Colour Preference and Food Choice among Children. *The Journal of Psychology* 124(6), pp:645-53

Wargovich, M. J.,(2000). Anticancer properties of fruit and vegetable. *American Society for Horticultural Science* 35, pp: 573-75.

Whitney, E. N. and Rolfes, S. R. (1999). Understanding Nutrition . 8th edition. West Publishing Company, New York, pp: 6-9.

Wilson, T. (2010). *Nutrition Guide for Physicians* Nutritional Health: Strategies for Disease Prevention Humana Press, 3rd edition pp:101-13.

Wolters, C. J., and Allchurch, E. M. (1994). Effect of training procedure on the performance of descriptive panels. *Journal of Food Quality and Preference*, 5, pp:203–214.

Zafar, M., Khan, A.M., Ahmad, M., Jan, G., Sultana, S., Ullah, K., Marwat, K.S. and Ahmad, F. (2010). Elemental analysis of some medicinal plants used in traditional medicine by Atomic Absorption Spectrophotometer. *Journal of Medicine for Plant Research* 4(19), pp:1987-1990

APPENDIX

APPENDIX A1

A. KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY DEPARTMENT OF BIOCHEMISTRY AND BIOTECHNOLOGY JUICE DEVELOPMENT PROJECT

Questionnaire to select panellist for further training.

1. Date………………. 2. Name ………………................. 3.Tel..........................…

A. RESPONDENTS

4. Sex………… M/F

5. Age [ ] 20-30 [ ] 31-40 [ ] 41-50 [ ] 51-60

6. Educational status

a) None d) Elementary [ ]   b) Sec/Tech/Comm. [ ]   e) Voc [ ]

c) Tertiary [ ]   f) Other (specify)...............................

7. Marital status…………S/M/D/W

B. PRODUCT

8. Do you drink beverages?...........Y/N?

If yes, indicate the form of beverage you **drink**.

Products	**N/Y**
Coffee	
Tea	
Food drinks (e.g. Milo, Soya milk)	
Fruit Juice	
Vegetable Juice	
Energy drink	
Other non-carbonated drinks	
Carbonated drinks	

If you drink juices, please answer the following:
9. How often do you drink juices?
a) Once/week [ ]   b) More than once/week [ ]
c) Occasionally [ ]   d) Hardly [ ] 10.
Why do you drink juices?
a) Snack [ ]   b) Nutrient requirement [ ]   c) As food supplement [ ]
d) Inexpensive   [ ]   e) Other (specify)…………………………………
11. What characteristic attributes do you look for in a juice?
a) Flavour [ ] b) Colour [ ] c) Taste [ ]   d) After-taste
e) Overall acceptance [ ]   f) All of the above [ ] 12.
What type of juice do you prefer?

a) Fruit juice [ ] b). Vegetable Juice [ ] c) Herb juice [ ]

13. Are you aware of any vegetable juice? ....N/Y

If yes, what kind of vegetable juice do you know of? ....

C. HEALTH

14. Do you have a health problem with your sight .... N/Y
15. Do you have a health problem with your smell .... N/Y
16. Do you have a health problem with your tasting...................... N/Y
17. Do you have any allergy with cabbage................................... N/Y
18. Do you have any allergy with orange...................................... N/Y
19. Do those good health claims influence your choice of juice? ……………Y/N
20. Do you know of any health problems associated with the consumption of juices? ……….Y/N

If yes list them ....

…………………………………………………………………………………………

21. Do you know of any good health claims attributed to juices? …………..... Y/N

If yes list them ....

………………………………………………………………………………………....

22. Do those good health claims influence your choice of juice? ……………Y/N

Thanks for your cooperation

A2 FREQUENCIES OF THE RESPONSES IN THE SURVEY

Parameters	Category	Percent (%)
Gender	Male	**22.5**
	Female	**77.5**
Age (years)	20-30	**82.0**
	31-45	**18.0**
Marital status	Single	**72.5**
	Married	**27.5**
	Divorced	**0.0**
Beverage consumer	Yes	**90**
	No	**10**
Juice consumer	Yes	**99 1.0**
	No	
Vegetable juice	Yes	**10**
	No	**90**

Attributes to look for in a juice	a) Flavour	**2.0**
	b) Colour	**3.0**
	c) Taste	**80**
	d) After-taste	**5.0**
	f) All of the above	**10**
juice preferred	a) Fruit juice	**90.5**
	b). Vegetable Juice	**7.5**
	c) Herb juice	**2.0**
awareness of vegetable juice	Yes	**37.5**
	No	**62.5**
allergy with cabbage	Yes	**0.0**
	No	**100.0**

A3 TASTE RECOGNITION TEST

Assessor No............................. Name..

Date.. Gender .... Age..............................

Instructions

You are provided with samples with various codes and are asked to identify the type of present taste in them. Products are meant to be tasted. Use the palate cleanser provided to rinse the mouth before tasting the next sample.

Product Codes	Type of taste present
....	....
....	....
....	....

A4 AROMA RECOGNITION TEST

Assessor No............................. Name..

Date.. Gender .... Age..............................

Instructions

You are provided with samples with various codes and are asked to identify the various aroma in them. Products are meant to be smelt and not to be tasted.

Product Codes	Type of aroma present
....	....
....	....
....	....

A5 TRIANGLE TEST SCORE SHEET Assessor No............................. Name..

date..

Instructions:

Taste the samples on the tray from left to right. Two samples are alike; one is different. Select the odd/different sample and identify it by placing a X in the corresponding box

SAMPLES CODES Indicate the odd one out Remarks

.... ☐ ....

.... ☐ .... If you wish to comment on the reasons for your choice or the characteristics of the sample, you may do so under the remarks.

..

..

.. A6.A

SENSORY CHARARISTICS SCORE CARD

Assessor No............................ Name...

Date.. Gender .... Age............................

Instructions

You are provided with coded juice samples. Please assess the products as you have been trained and place your corresponding perception on the line scale.

Product Code ....

1. Aroma

☐ ORANGE FRUITY SCENT

1

15

Very Weak *Very Strong*

2. Colour

☐ ORANGE COLOUR

1 15

Very Weak *Very Strong*

☐ GREENNESS

1

15

Very Weak *Very Strong*

3. Taste

☐ SWEETNESS

1 ◆———————————————————————————◆ 15

Very Weak *Very Strong*

 SOURNESS

1 ◆———————————————————————————◆ 15

Very Weak *Very Strong*

4. After taste

 ASTRIGENCY

1 ◆———————————————————————————◆ 15

Very Weak *Very Strong*

5. Clarity

 CLOUDINESS

1 ◆———————————————————————————◆ 15

Very Weak *Very Strong*

Comments..
....
....
....
....

A6.B FIVE POINT SCALE

0 – 2.99 VERY WEAK

3 – 5.99 SLIGHTLY WEAK

6 – 8.99 SLIGHTLY STRONG

9 – 11.99 MODERATELY STRONG

12 – 15 VERY STRONG

A7 RESULT FOR SENSORY ANALYSIS

A7.1. LATE VALENCIA

Sensory Profiles of Cabbage-orange juice blends of nine formulations for late Valencia orange variety. Numerical scale (15-points) where „0" represents „very weak" and „15" represents „very strong".

formulations		orange fruity scent	orange colour	greenness	sweetness	sourness	Toothitching	cloudiness
50:50	F1	**5.92±1.21**	**7.10±1.34**	**9.07±1.73**	**9.00±0.58**	**4.71±1.73**	**6.90±1.37**	**7.20±0.82**
60:40	F2	**5.73±1.57**	**8.62±1.73**	**8.19±0.65**	**8.69±1.73**	**6.32±1.53**	**6.96±0.63**	**6.88±0.90**

73:27	F3	6.97±1.81	9.57±1.99	7.40±1.35	13.47±1.63	4.32±1.73	6.97±0.35	8.40±0.35
95:5	F4	6.31±0.91	9.88±0.89	4.30±1.26	7.60±0.63	7.65±0.91	6.27±0.53	7.60±0.73
87:13	F5	5.64±1.24	9.40±1.29	5.60±1.44	7.17±1.02	6.42±0.73	7.70±0.74	8.67±0.53
80:20	F6	5.86±2.21	8.14±2.33	5.30±1.98	8.86±1.02	5.83±2.42	6.64±2.02	7.54±0.74
55:45	F7	6.13±0.82	7.93±0.75	7.73±3.31	8.33±0.87	4.28±0.84	5.83±1.20	6.27±2.05
67:33	F8	7.03±1.22	8.00±1.43	7.20±1.85	6.23±1.99	7.30±0.58	6.10±1.24	5.20±1.30
100:0	control	8.00±1.02	11.1±1.86	4.3±1.08	7.75±1.63	9.60±1.21	7.75±0.84	8.42±0.90

A7.2. BLOOD ORANGE

Sensory Profiles of Cabbage-orange juice blends of nine formulations for blood orange variety. Numerical scale (15-points) where „0" represents „very weak" and „15" represents „very strong".

formulations		orange fruity scent	orange colour	greenness	sweetness	sourness	Toothitching	Cloudiness
50:50	F1	5.60±1.33	5.90±2.03	9.60±1.56	7.30±0.93	6.44±0.91	8.22±1.23	8.12±2.48
60:40	F2	6.60±0.53	6.75±2.83	8.54±1.21	7.90±0.87	8.45±0.98	6.63±0.41	8.20±3.32
73:27	F3	6.36±0.23	8.56±0.99	6.63±1.55	7.56±0.87	7.56±1.41	6.50±0.92	6.90±0.65
95:5	F4	6.20±1.25	10.24±3.2	6.73±0.90	9.10±1.76	5.40±0.41	5.97±0.62	8.79±1.71
87:13	F5	7.34±0.91	8.80±2.40	8.42±1.29	7.63±1.51	6.73±0.54	5.60±0.43	7.03±2.63
80:20	F6	7.23±0.50	6.75±0.46	6.30±0.87	7.80±1.03	5.64±0.97	5.97±0.98	8.98±2.52
55:45	F7	6.63±1.04	7.00±0.90	6.73±0.43	7.67±0.97	8.78±1.26	6.35±0.23	7.07±0.98
67:33	F8	5.93±2.38	5.43±1.25	7.27±1.21	8.00±0.91	7.62±1.21	7.00±1.21	8.00±1.76

100:0	control	**7.89±1.37**	**12.7±2.89**	**6.53±0.85**	**14.30±2.4**	**4.56±0.23**	**4.32±0.34**	**12.47±2.42**

A9.1 DESIGN EXPERT GRAPHS FOR SENSORY PARAMETERS

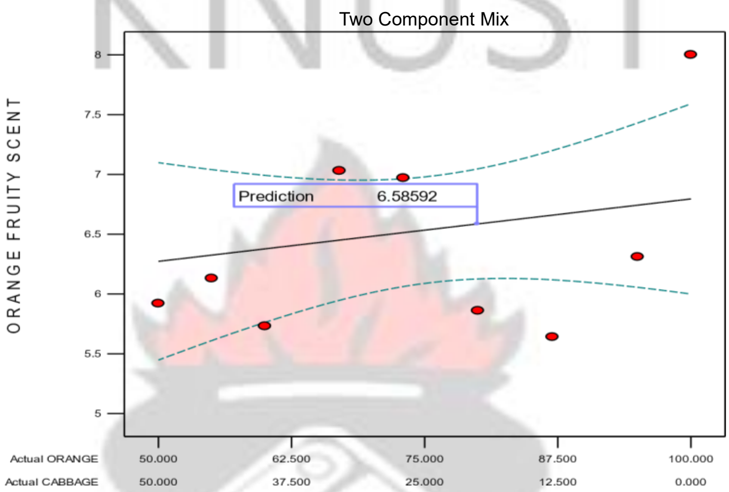
1. LATE VALENCIA

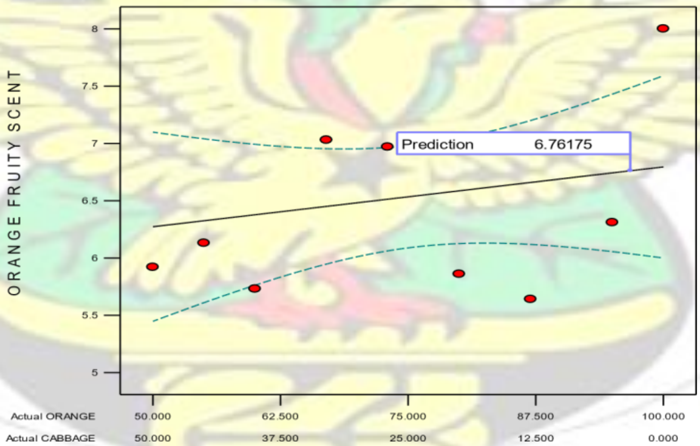
A. AROMA (80/20)

Design-Expert® SoftwareComponent Coding: Actual
ORANGE FRUITY SCENT

CI Bands
Design Points

X1 = A: ORANGE
X2 = B: CABBAGE





AROMA (96/4)

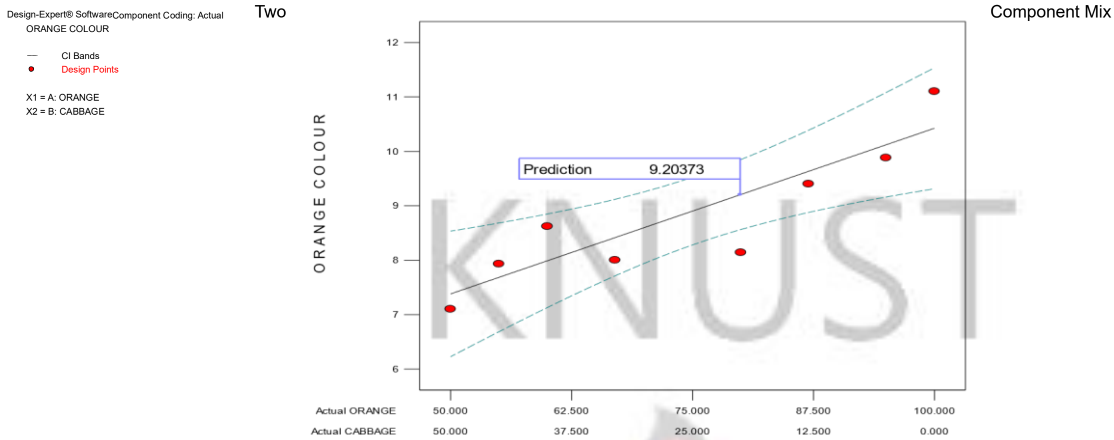
Design-Expert® Software
Component Coding: Actual
ORANGE FRUITY SCENT

CI Bands
Design Points

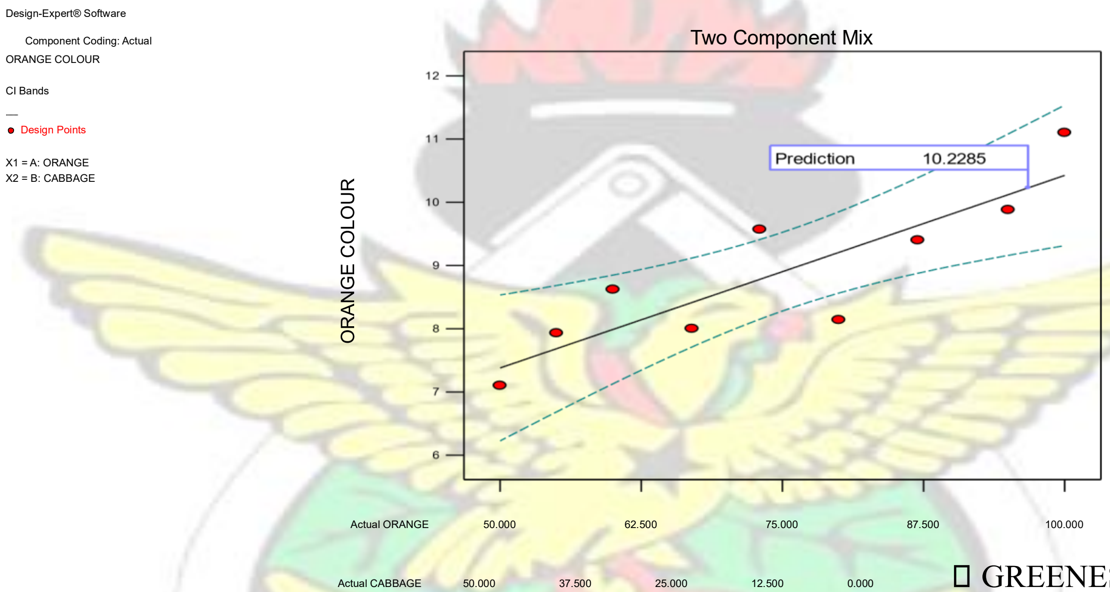
X1 = A: ORANGE
X2 = B: CABBAGE

Two Component Mix

B. COLOUR (ORANGE COLOUR) 80/20

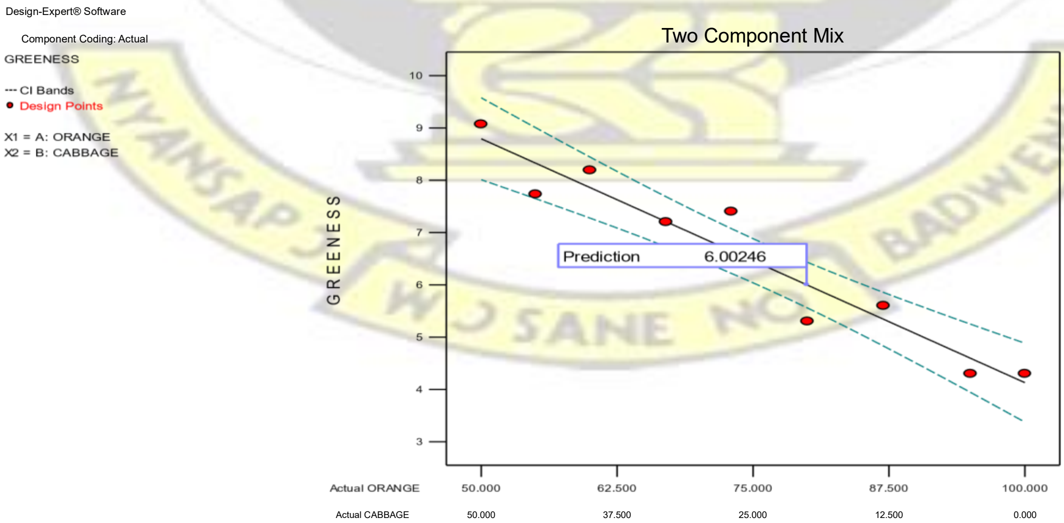


 ORANGE COLOUR (96/4)

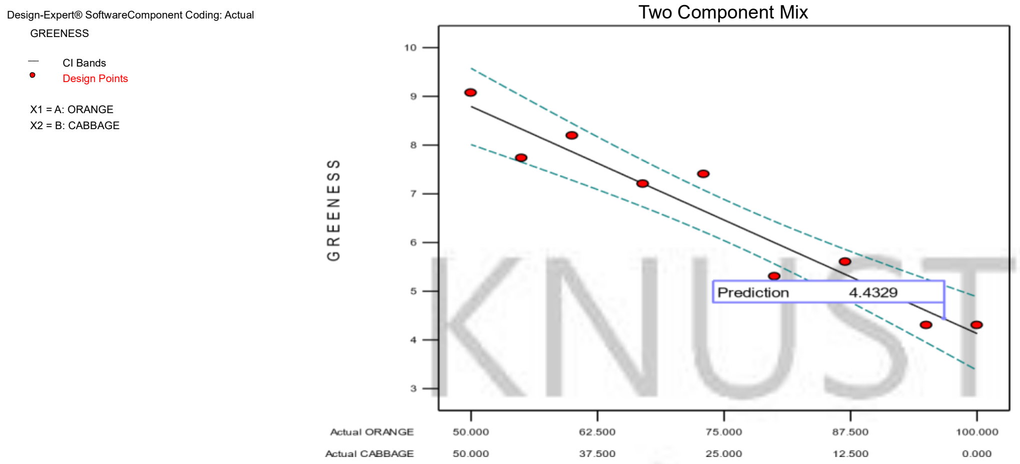


 GREENESS

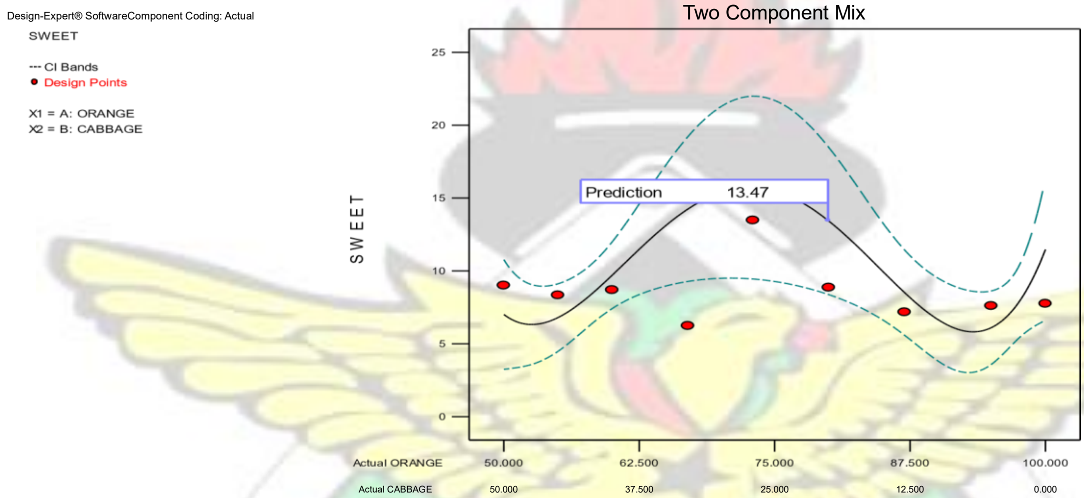
COLOUR (80/20)



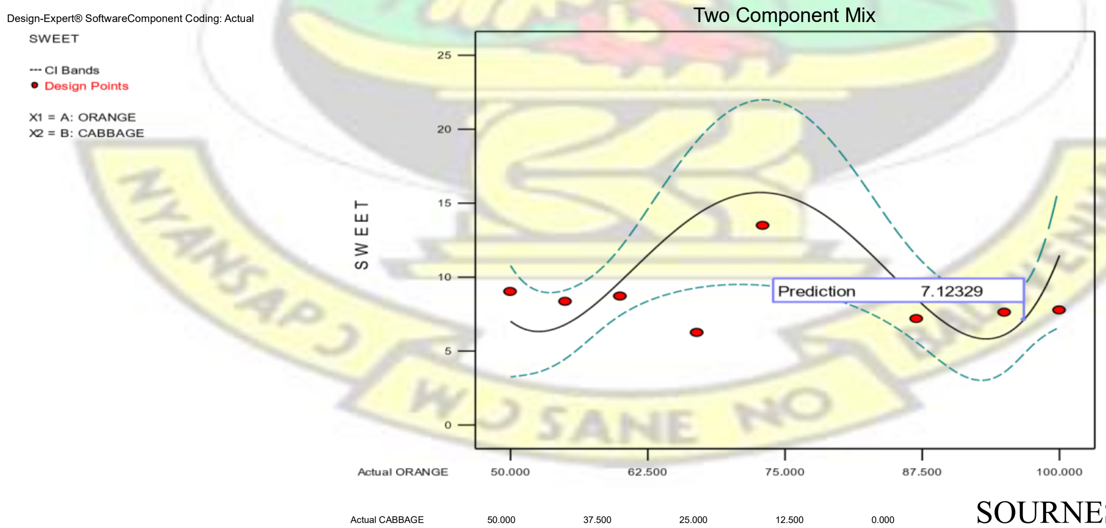
GREENESS COLOUR (96/4)



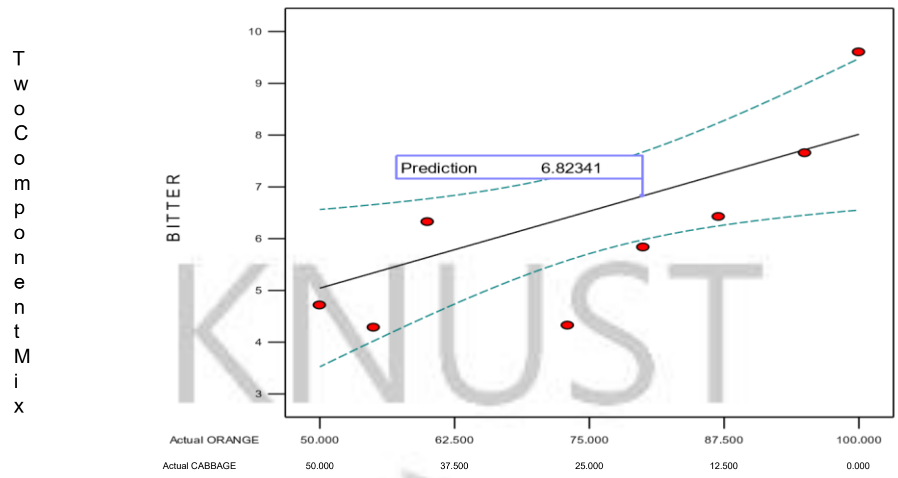
C. TASTE (SWEET) 80/20



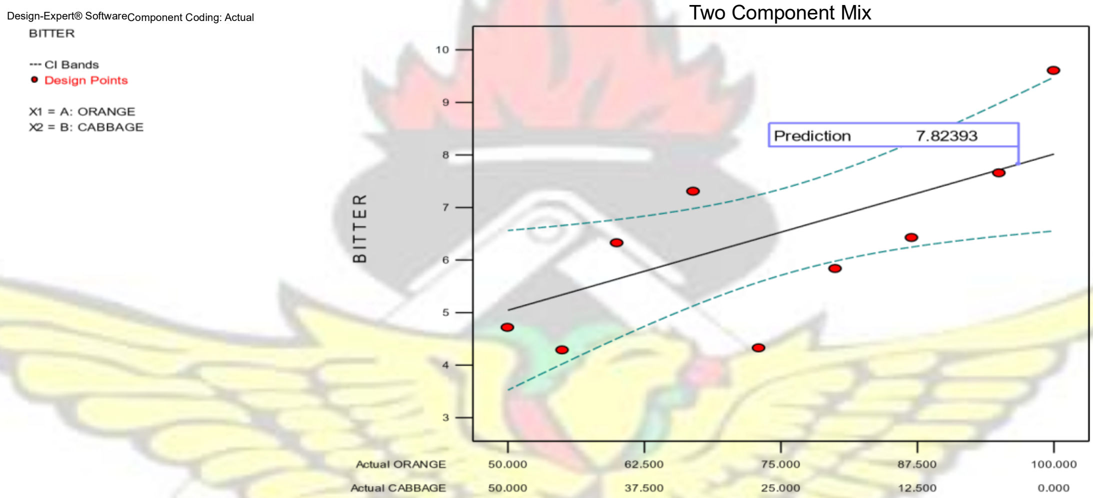
SWEET (96/4)



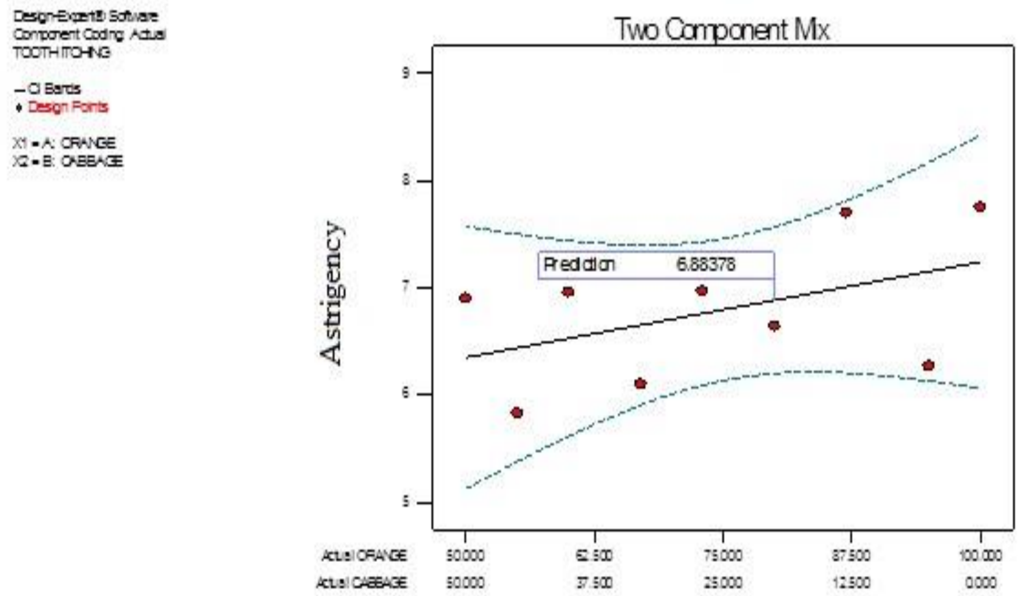
SOURNESS (80/20)



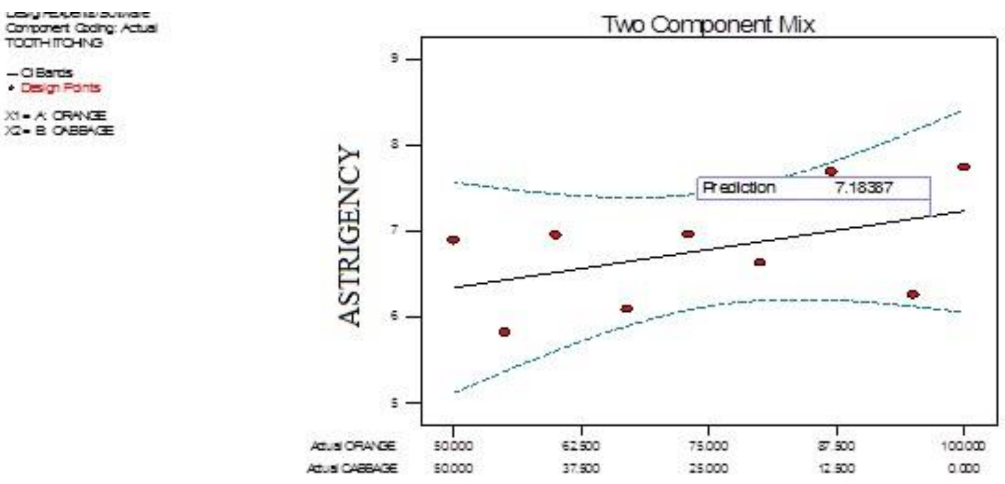
SOURNESS (96/4)



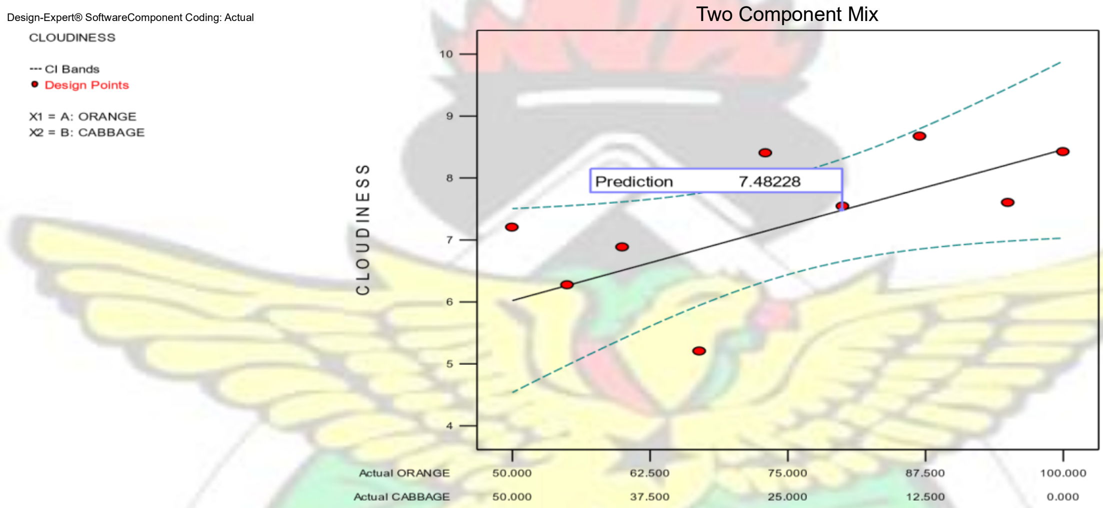
D. AFTERTASTE (ASTRIGENCY) 80/20



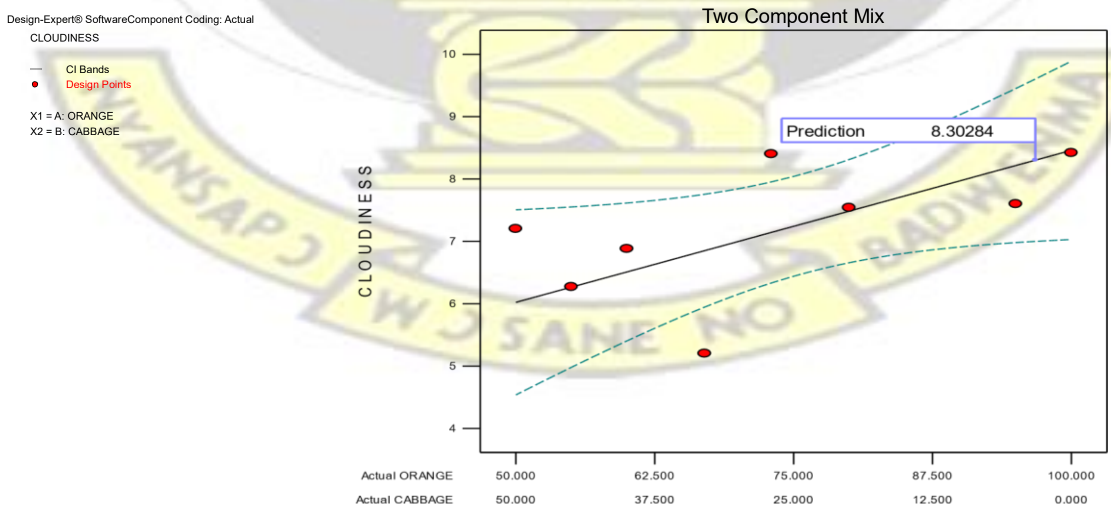
ASTRIGENCY (96/4)



E. CLOUDINESS (80/20)



CLOUDINESS (96/4)



A9. 2 LATE VALENCIA SAMPLING POINTS

Number of Starting Points: 39 (EXTRAPULATION BY THE DESIGN EXPERT)

ORANGE	**CABBAGE**
80.000	20.000
87.000	13.000
100.000	0.000
67.000	33.000
73.000	27.000
95.000	5.000
60.000	40.000
55.000	45.000
50.000	50.000
63.550	36.450
72.302	27.698
69.507	30.493
74.431	25.569
62.564	37.436
61.437	38.563
99.209	0.791
67.615	32.385
63.916	36.084
79.018	20.982
73.004	26.996
53.871	46.129
82.050	17.950
56.717	43.283
77.981	22.019
90.482	9.518
71.426	28.574
94.224	5.776
66.914	33.086
60.913	39.087
91.476	8.524
91.929	8.071
95.193	4.807
99.232	0.768
92.801	7.199
65.593	34.407
54.192	45.808
59.941	40.059
59.151	40.849
99.035	0.965

A10. 1

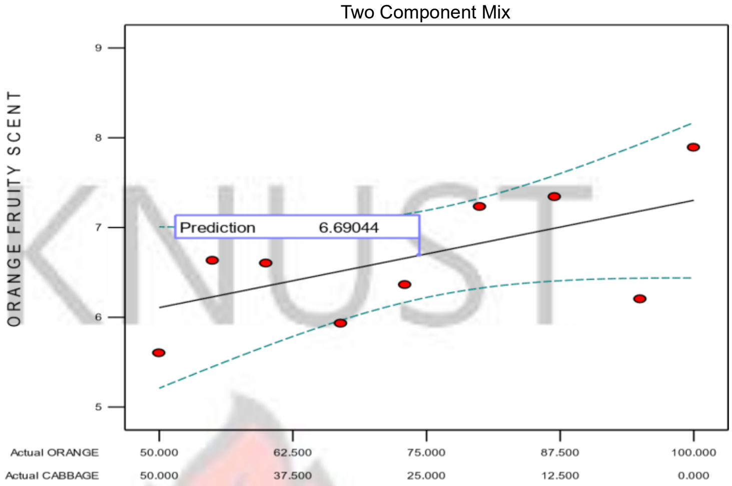
2. BLOOD ORANGE

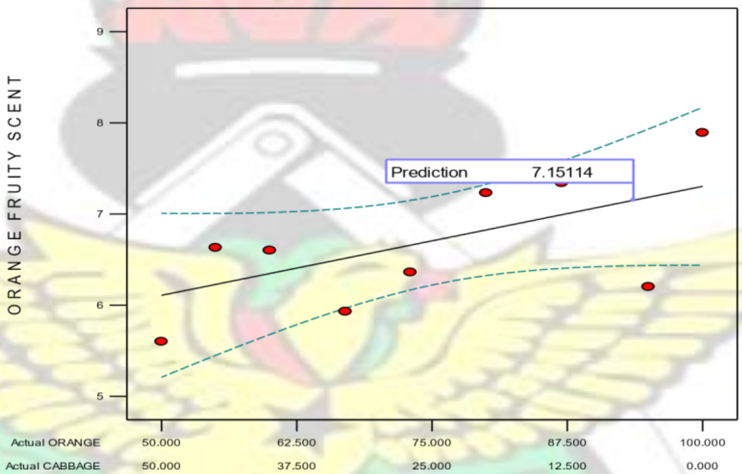
A. AROMA (74/26)

Design-Expert® SoftwareComponent Coding: Actual
ORANGE FRUITY SCENT

— CI Bands
● Design Points

X1 = A: ORANGE
X2 = B: CABBAGE





AROMA (94/6)

Design-Expert® Software
Component Coding: Actual
ORANGE FRUITY SCENT

— CI Bands
● Design Points

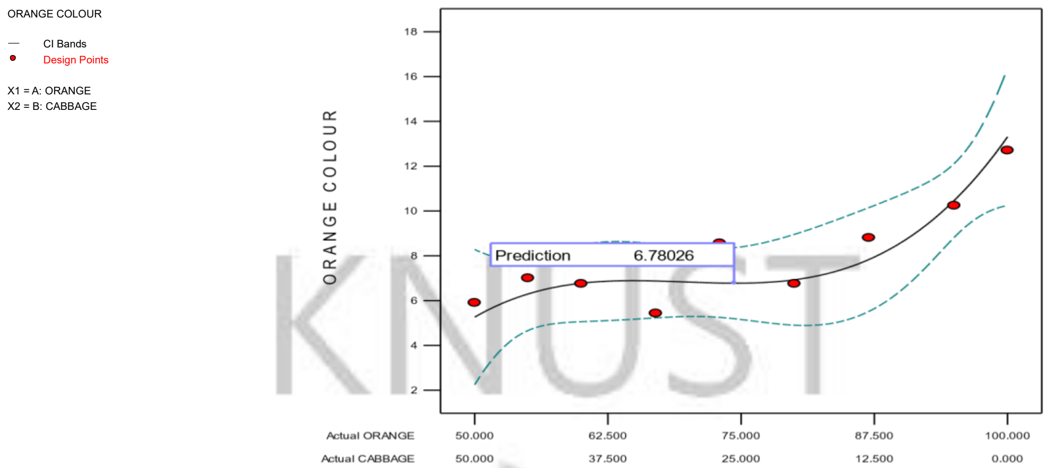
X1 = A: ORANGE
X2 = B: CABBAGE

Two Component Mix

B. COLOUR (ORANGE COLOUR) 74/26

Design-Expert® SoftwareComponent Coding: Actual

Two Component Mix


ORANGE COLOUR
CI Bands
Design Points
X1 = A: ORANGE
X2 = B: CABBAGE
ORANGE COLOUR
Prediction 6.78026
Actual ORANGE 50.000 62.500 75.000 87.500 100.000
Actual CABBAGE 50.000 37.500 25.000 12.500 0.000

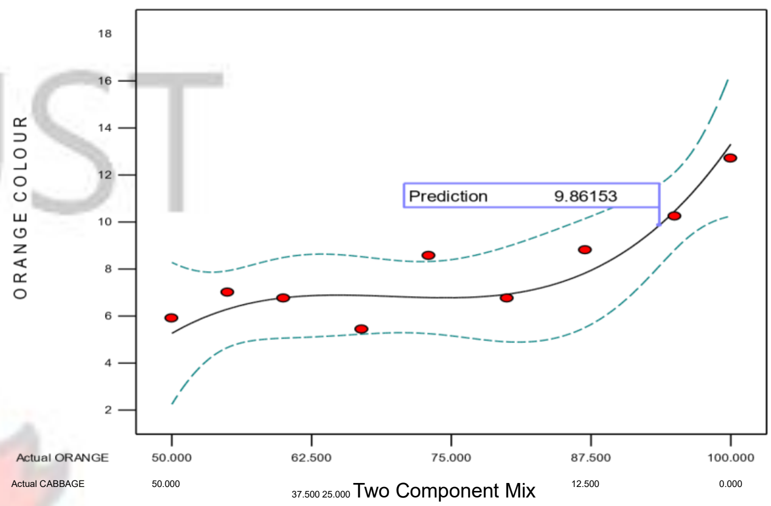
ORANGE COLOUR (94/6)

Design-Expert® Software
Component Coding: Actual
ORANGE COLOUR

CI Bands

Design Points

X1 = A: ORANGE
X2 = B: CABBAGE



Two Component Mix

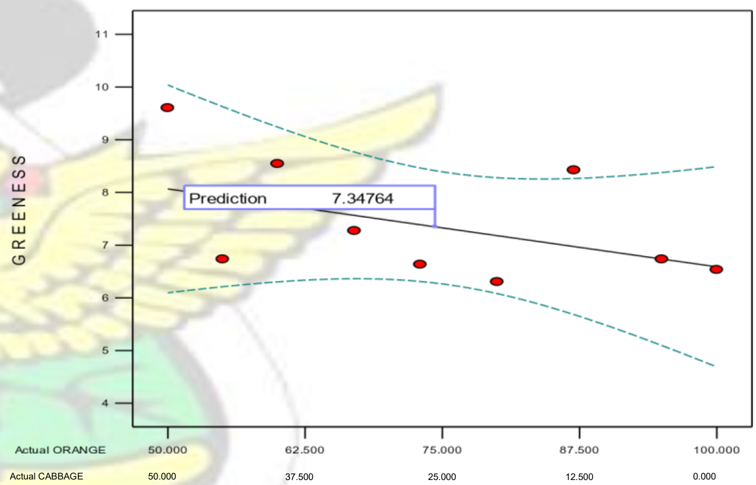
GREENESS (74/26)

Design-Expert® Software
Component Coding: Actual
GREENESS

CI Bands

Design Points

X1 = A: ORANGE
X2 = B: CABBAGE



Two Component Mix

GREENESS (94/6)

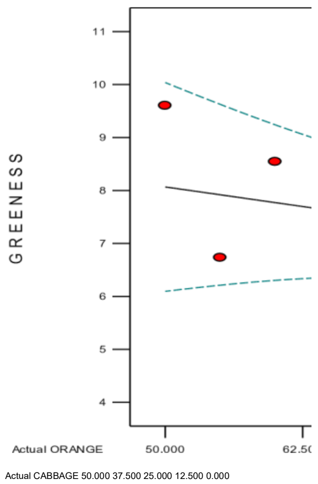
Design-Expert® Software
Component Coding: Actual
GREENESS

CI Bands

Design Points

X1 = A: ORANGE
X2 = B: CABBAGE

Two Component Mix



SOURNESS (74/26)

Design-Expert® Software
Component Coding: Actual
BITTER

CI Bands

Design Points

X1 = A: ORANGE
X2 = B: CABBAGE

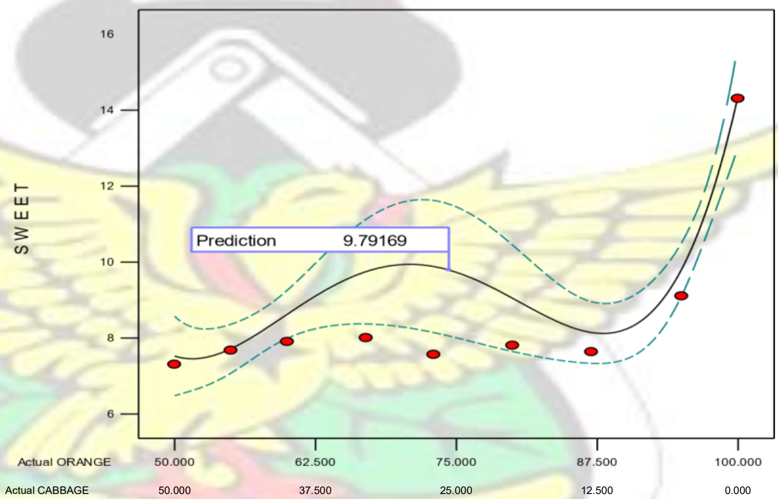
C. TASTE (SWEET) 74/26

Design-Expert® Software
Component Coding: Actual
SWEET

CI Bands

Design Points

X1 = A: ORANGE
X2 = B: CABBAGE



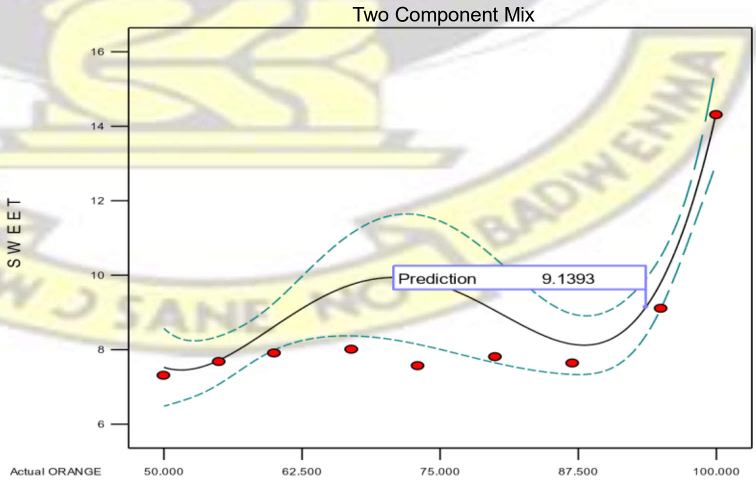
SWEET (94/6)

Design-Expert® Software
Component Coding: Actual
SWEET

CI Bands

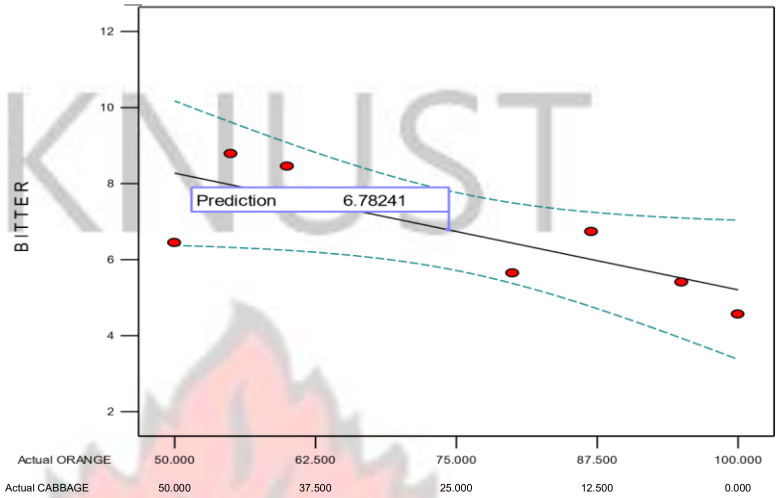
Design Points

X1 = A: ORANGE
X2 = B: CABBAGE



Actual CABBAGE 50.000
37.500
25.000
12.500
0.000

Two
Component
Mix

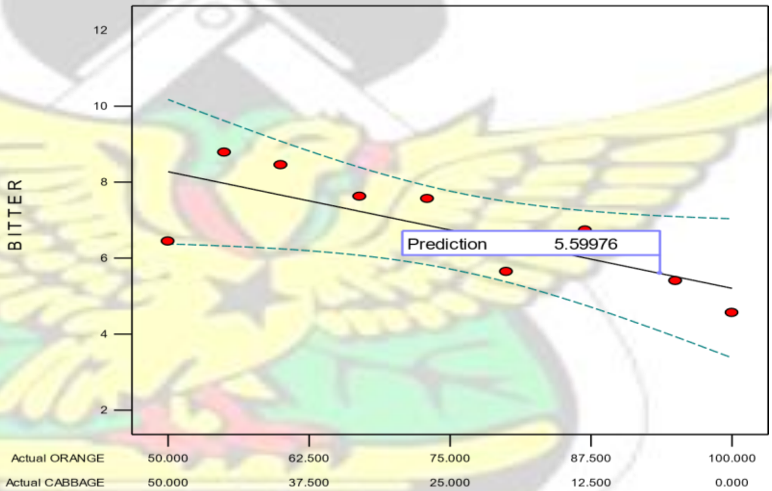


SOURNESS (94/6)

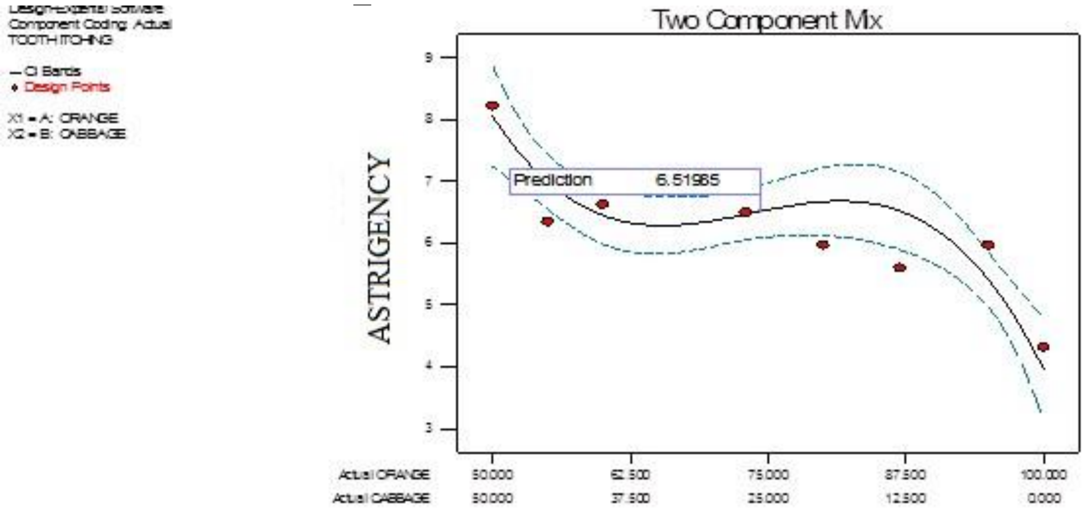
Design-Expert® Software
Component Coding: Actual
BITTER

--- CI Bands
● Design Points

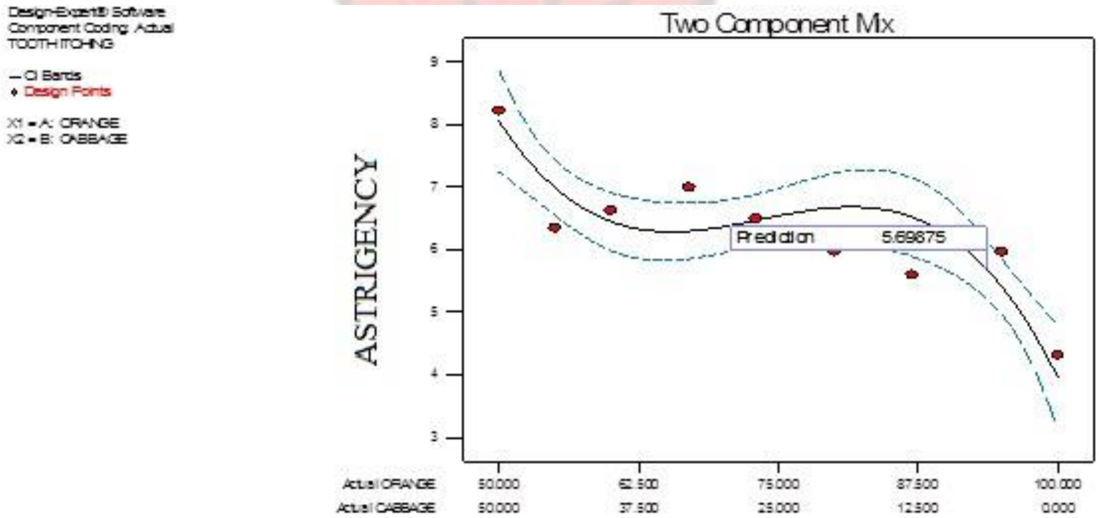
X1 = A: ORANGE
X2 = B: CABBAGE



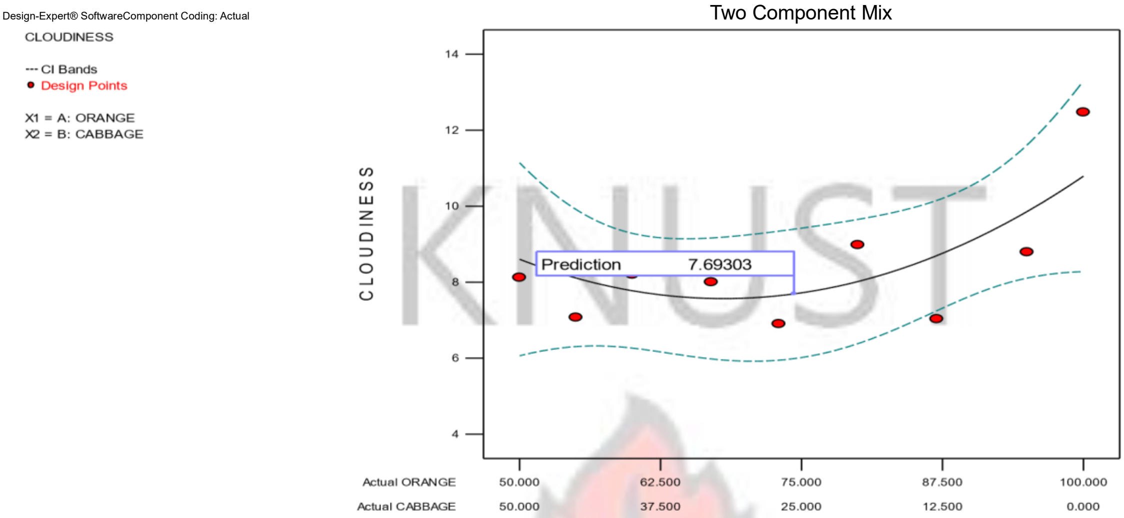
D. AFTERTASTE ASTRIGENCY (74/26)



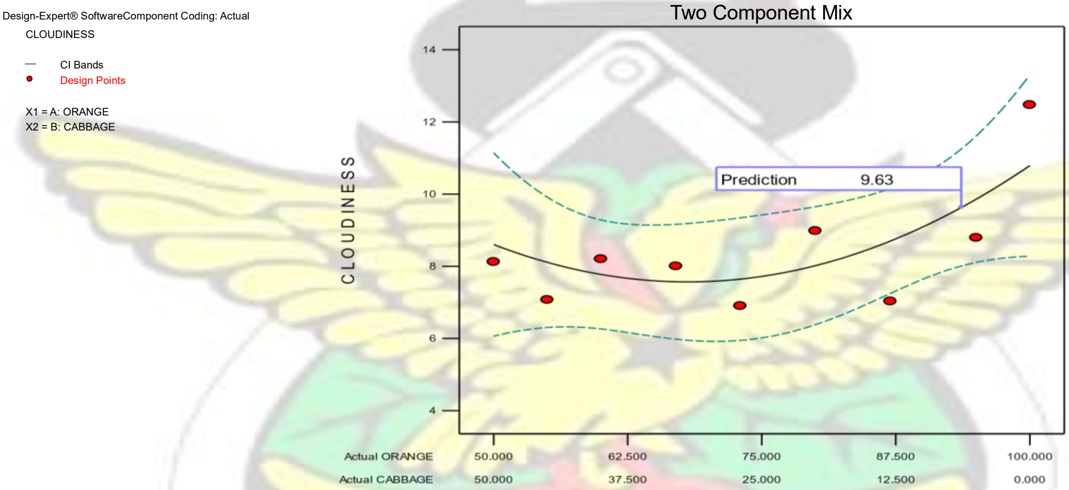
ASTRIGENCY (96/4)



E. CLOUDINESS (74/26)



CLOUDINESS (94/6)



A10.2 BLOOD ORANGE SAMPLING POINTS

Number of Starting Points: 39

ORANGE	CABBAGE
67.000	33.000
100.000	0.000
80.000	20.000
73.000	27.000
60.000	40.000
87.000	13.000
55.000	45.000
50.000	50.000
95.000	5.000
63.553	36.447
84.513	15.487

59.119	40.881
54.121	45.879
79.725	20.275
60.419	39.581
50.433	49.567
79.725	20.275
61.632	38.368
81.681	18.319
99.371	0.629
57.497	42.503
64.609	35.391
67.282	32.718
88.348	11.652
52.864	47.136
91.031	8.969
64.443	35.557
87.978	12.022
77.266	22.734
76.092	23.908
76.149	23.851
65.315	34.685
71.670	28.330
57.215	42.785
61.517	38.483
54.117	45.883
50.627	49.373
93.800	6.200
81.765	18.235

A11. Table of total soluble solid (sugar) to acid ratio in juices

	LATE VALENCIA	BLOOD ORANGE	OPT A	OPT B
TSS/TA	6.915	13.294	9.887	12.327

APPENDIX B

SUMMARY OF ANALYSIS OF VARIANCE

B.1. ANOVA FOR SENSORY PROPERTIES

A. LATE VALENCIA

A1. Response	1	orange fruity scent			

ANOVA for Linear Mixture Model						
*** Mixture Component Coding is L_Pseudo. ***						
Analysis of variance table						
	Sum of		Mean	F	p-value	
Source	Squares	df	Square	Value	Prob > F	
Block	2.036689	2	1.018344			
Model	2.347201	1	2.347201	22.25264	0.0053	significant
Linear Mixture	2.347201	1	2.347201	22.25264	0.0053	
Residual	0.527399	5	0.10548			
Cor Total	4.911289	8				

Std. Dev.	0.324776	R-Squared	0.816532
Mean	6.398889	Adj R-Squared	0.779838
		Pred R-Squared	0.449435

A2. Response	2	orange colour				
ANOVA for Linear Mixture Model						
*** Mixture Component Coding is L_Pseudo. ***						
Analysis of variance table						
	Sum of		Mean	F	p-value	
Source	Squares	df	Square	Value	Prob > F	
Block	0.8574	2	0.4287			
Model	10.32427	1	10.32427	54.33112	0.0007	significant
Linear Mixture	10.32427	1	10.32427	54.33112	0.0007	
Residual	0.950125	5	0.190025			
Cor Total	12.1318	8				

Std. Dev.	0.435919	R-Squared	0.915727
Mean	8.86	Adj R-Squared	0.898873
		Pred R-Squared	0.69457

A3. Response	3	greenness			

Transform:	Square Root	Constant:	0			
ANOVA for Linear Mixture Model						
*** Mixture Component Coding is L_Pseudo. ***						
Analysis of variance table						
	Sum of		Mean	F	p-value	
Source	Squares	df	Square	Value	Prob > F	
Block	0.575148	2	0.287574			
Model	0.355342	1	0.355342	63.58383	0.0005	significant
Linear Mixture	0.355342	1	0.355342	63.58383	0.0005	
Residual	0.027943	5	0.005589			
Cor Total	0.958432	8				

Std. Dev.	0.074757	R-Squared	0.927097
Mean	2.541469	Adj R-Squared	0.912516
		Pred R-Squared	0.75258

A4. Response	4	sweet					
ANOVA for Linear Mixture Model							
*** Mixture Component Coding is L_Pseudo. ***							
Analysis of variance table							
	Sum of		Mean	F	p-value		
Source	Squares	df	Square	Value	Prob > F		
Block	15.1962	2	7.5981				
Model	1.350394	1	1.350394	0.400634	0.5546	not significant	
Linear Mixture	1.350394	1	1.350394	0.400634	0.5546		
Residual	16.85321	5	3.370641				
Cor Total	33.3998	8					

Std. Dev.	1.835931	R-Squared	0.074183
Mean	8.566667	Adj R-Squared	-0.11098
		Pred R-Squared	-2.18114

A5. Response	5	sourness			
ANOVA for Linear Mixture Model					

*** Mixture Component Coding is L_Pseudo. ***						
Analysis of variance table						
	Sum of		Mean	F	p-value	
Source	Squares	df	Square	Value	Prob > F	
Block	6.258867	2	3.129433			
Model	10.60773	1	10.60773	6.976567	0.0459	significant
Linear Mixture	10.60773	1	10.60773	6.976567	0.0459	
Residual	7.602401	5	1.52048			
Cor Total	24.469	8				

Std. Dev.	1.233078	R-Squared	0.582518
Mean	6.27	Adj R-Squared	0.499022
		Pred R-Squared	-0.49591

A6. Response	6	astringency					
ANOVA for Linear Mixture Model							
*** Mixture Component Coding is L_Pseudo. ***							
Analysis of variance table							
	Sum of		Mean	F	p-value		
Source	Squares	df	Square	Value	Prob > F		
Block	0.248422	2	0.124211				
Model	1.420927	1	1.420927	3.852129	0.1069	not significant	
Linear Mixture	1.420927	1	1.420927	3.852129	0.1069		
Residual	1.84434	5	0.368868				
Cor Total	3.513689	8					

Std. Dev.	0.607345	R-Squared	0.435164
Mean	6.791111	Adj R-Squared	0.322197
		Pred R-Squared	-1.36171

A7. Response	7	cloudiness				
ANOVA for Linear Mixture Model						
*** Mixture Component Coding is L_Pseudo. ***						

Analysis of variance table							
	Sum of		Mean	F	p-value		
Source	Squares	df	Square	Value	Prob > F		
Block	2.649267	2	1.324633				
Model	4.174463	1	4.174463	6.330949	0.0534	not significant	
Linear Mixture	4.174463	1	4.174463	6.330949	0.0534		
Residual	3.29687	5	0.659374				
Cor Total	10.1206	8					

Std. Dev.	0.812018	R-Squared	0.558731
Mean	7.353333	Adj R-Squared	0.470477
		Pred R-Squared	-0.72848

B. BLOOD ORANGE

B1 Response	1	orange fruity scent					
ANOVA for Linear Mixture Model							
*** Mixture Component Coding is L_Pseudo. ***							
Analysis of variance table							
	Sum of		Mean	F	p-value		
Source	Squares	df	Square	Value	Prob > F		
Block	1.501889	2	0.750944				
Model	1.282004	1	1.282004	4.34265	0.0916	not significant	
Linear Mixture	1.282004	1	1.282004	4.34265	0.0916		
Residual	1.476062	5	0.295212				
Cor Total	4.259956	8					

Std. Dev.	0.543335	R-Squared	0.46482
Mean	6.642222	Adj R-Squared	0.357784
		Pred R-Squared	-1.66552

B2 Response	2	orange colour				
ANOVA for Cubic Mixture Model						
*** Mixture Component Coding is L_Pseudo. ***						
Analysis of variance table						
	Sum of		Mean	F	p-value	

Source	Squares	df	Square	Value	Prob > F	
Block	3.043031	2	1.521515			
Model	36.63942	3	12.21314	10.41847	0.0428	significant
Linear Mixture	28.70254	1	28.70254	24.48482	0.0158	
AB	6.737661	1	6.737661	5.747592	0.0961	
AB(A-B)	2.644273	1	2.644273	2.255709	0.2301	
Residual	3.516774	3	1.172258			
Cor Total	43.19922	8				

Std. Dev.	1.082709	R-Squared	0.912423
Mean	8.014444	Adj R-Squared	0.824845
		Pred R-Squared	0.103244

B3 Response	3	greeness					
ANOVA for Linear Mixture Model							
*** Mixture Component Coding is L_Pseudo. ***							
Analysis of variance table							
	Sum of		Mean	F	p-value		
Source	Squares	df	Square	Value	Prob > F		
Block	1.5875	2	0.79375				
Model	1.961074	1	1.961074	1.380372	0.2929	not significant	
Linear Mixture	1.961074	1	1.961074	1.380372	0.2929		
Residual	7.103426	5	1.420685				
Cor Total	10.652	8					

Std. Dev.	1.191925	R-Squared	0.216347
Mean	7.416667	Adj R-Squared	0.059616
		Pred R-Squared	-1.22153

B4 Response	4	sweetness			

ANOVA for Quartic Mixture Model						
*** Mixture Component Coding is L_Pseudo. ***						
Analysis of variance table						
	Sum of		Mean	F	p-value	
Source	Squares	df	Square	Value	Prob > F	
Block	17.04572	2	8.522861			
Model	21.47965	4	5.369913	38.37749	0.0256	significant
Linear Mixture	9.412927	1	9.412927	67.27195	0.0145	
AB	10.13614	1	10.13614	72.44058	0.0135	
AB(A-B)	4.548239	1	4.548239	32.50518	0.0294	
AB(AB)^2	1.868389	1	1.868389	13.35293	0.0674	
Residual	0.279847	2	0.139924			
Cor Total	38.80522	8				

Std. Dev.	0.374064	R-Squared	0.987139
Mean	8.584444	Adj R-Squared	0.961417
		Pred R-Squared	-1.03351

B5 Response	5	sourness					
ANOVA for Linear Mixture Model							
*** Mixture Component Coding is L_Pseudo. ***							
Analysis of variance table							
	Sum of		Mean	F	p-value		
Source	Squares	df	Square	Value	Prob > F		
Block	1.301281	2	0.65064				
Model	8.448587	1	8.448587	6.399778	0.0525	not significant	
Linear Mixture	8.448587	1	8.448587	6.399778	0.0525		
Residual	6.600688	5	1.320138				
Cor Total	16.35056	8					

Std. Dev.	1.148972	R-Squared	0.561395
Mean	6.797778	Adj R-Squared	0.473674
		Pred R-Squared	-0.31435

B6 Response	6	astringency				
ANOVA for Cubic Mixture Model						
*** Mixture Component Coding is L_Pseudo. ***						
Analysis of variance table						
	Sum of		Mean	F	p-value	
Source	Squares	df	Square	Value	Prob > F	
Block	2.260756	2	1.130378			
Model	6.435475	3	2.145158	24.98326	0.0127	significant
Linear Mixture	4.871233	1	4.871233	56.73207	0.0049	
AB	0.302949	1	0.302949	3.528245	0.1569	
AB(A-B)	1.476133	1	1.476133	17.19155	0.0255	
Residual	0.257592	3	0.085864			
Cor Total	8.953822	8				

Std. Dev.	0.293025		R-Squared	0.961514
Mean	6.284444		Adj R-Squared	0.923027
			Pred R-Squared	-0.02348

B7 Response	7	cloudiness					
ANOVA for Quadratic Mixture Model							
*** Mixture Component Coding is L_Pseudo. ***							
Analysis of variance table							
	Sum of		Mean	F	p-value		
Source	Squares	df	Square	Value	Prob > F		
Block	8.864431	2	4.432215				
Model	8.563913	2	4.281956	2.953543	0.1630	not significant	
Linear Mixture	4.172303	1	4.172303	2.877908	0.1650		
AB	4.39161	1	4.39161	3.029177	0.1568		
Residual	5.799079	4	1.44977				
Cor Total	23.22742	8					

Std. Dev.	1.204064	R-Squared	0.596249
Mean	8.395556	Adj R-Squared	0.394373
		Pred R-Squared	-1.50044

B.2. ANOVA RESULT

A PREDICTED LATE VALENCIA VALUES VERSUS EXPERIMENT VALUES

ANOVA: prediction versus validated sensory values

Source DF SS MS F P codes
3 38.825 12.942 127.59 0.160
Error 5 0.811 0.101
Total 8 39.637

S = 0.8185 R-Sq = 47.95% R-Sq(adj) = 37.19%

B PREDICTED BLOOD ORANGE VALUES VERSUS EXPERIMENT VALUES

ANOVA: prediction versus validated sensory values

Source DF SS MS F P codes
3 43.342 13.426 137.43 0.214
Error 5 0.643 0.325
Total 8 45.432

S = 0.8083 R-Sq = 53.23% R-Sq(adj) = 47.34%

B.3. ANOVA FOR PHYSIOC0CHEMICAL PROPERTIES

1. **One-way ANOVA: pH versus codes**

Source DF SS MS F P
codes 3 8.927425 2.975808 16231.68 0.000012
Error 8 0.001467 0.000183
Total 11 8.928892

S = 0.01354 R-Sq = 99.98% R-Sq(adj) = 99.98%

Grouping Information Using Fisher Method

codes N Mean Grouping
blood orange 3 5.2467 A OPT
B 3 5.2267 A late
valencia 3 3.8267 B OPT A
3 3.2833 C

Means that do not share a letter are significantly different.

2. One-

way ANOVA: total solid versus codes

Source DF SS MS F P codes
3 38.825 12.942 127.59 0.000119
Error 8 0.811 0.101
Total 11 39.637

S = 0.3185 R-Sq = 97.95% R-Sq(adj) = 97.19%

Grouping Information Using Fisher Method

codes N Mean Grouping
blood orange 3 14.2933 A late
valencia 3 13.3333 B OPT B
3 10.6633 C
OPT A 3 9.9667 D

3. One-way ANOVA: total soluble solids versus codes

Source	DF	SS	MS	F	P
codes	3	20.86382	6.95461	6136.42	0.000000
Error	8	0.00907	0.00113		
Total	11	20.87289			

S = 0.03367 R-Sq = 99.96% R-Sq(adj) = 99.94%

Grouping Information Using Fisher Method

codes N Mean Grouping OPT B 3
13.5533 A blood orange 3 13.5533 A OPT A 3
11.3667 B late valencia 3 10.5833 C

4. One-way ANOVA: ASH versus codes

Source	DF	SS	MS	F	P
codes	3	0.000200	0.000067	0.50	0.693
Error	8	0.001067	0.000133		
Total	11	0.001267			

S = 0.01155   R-Sq = 15.79%   R-Sq(adj) = 0.00%

Grouping Information Using Fisher Method

codes N Mean Grouping late valencia
3 0.97333 A OPT A 3 0.96667 A
OPT B 3 0.96333 A blood orange 3
0.96333 A

5. One-way ANOVA: TA versus codes

Source	DF	SS	MS	F	P
codes	3	0.484092	0.161364	968.18	0.000051
Error	8	0.001333	0.000167		
Total	11	0.485425			

S = 0.01291   R-Sq = 99.73%   R-Sq(adj) = 99.62%

Grouping Information Using Fisher Method

codes N Mean Grouping late valencia
3 1.55000 A OPT A 3 1.16333 B
OPT B 3 1.11000 C blood orange 3
1.02667 D

Means that do not share a letter are significantly different.

B3. ANOVA FOR MINERALS PROPERTIES

1. One-way ANOVA: ZINC(mg/L) versus CODES

Source	DF	SS	MS	F	P

2. One-

CODES	3	0.2673000	0.0891000	1188.00	0.000022
Error	4	0.0003000	0.0000750		
Total	7	0.2676000			

S = 0.008660 R-Sq = 99.89% R-Sq(adj) = 99.80%

Grouping Information Using Fisher Method

CODES N Mean Grouping
OPT A 2 0.84000 A OPT B
2 0.67500 B late valencia 2
0.43500 C blood orange 2 0.39000
D

way ANOVA: POTASSIUM(mg/L) versus CODES

Source	DF	SS	MS	F	P
CODES	3	149586.6	49862.2	30324.96	0.00000
Error	4	6.6	1.6		
Total	7	149593.2			

S = 1.282 R-Sq = 100.00% R-Sq(adj) = 99.99%

Grouping Information Using Fisher Method

CODES	N	Mean	Grouping
OPT B	2	1995.60	A
blood orange	2	1990.12	B
OPT A	2	1744.00	C
late valencia	2	1700.20	D

3. One-way ANOVA: MAGNESSIUM(mg/L) versus CODES

Source	DF	SS	MS	F	P
CODES	3	2424.821	808.274	36043.42	0.00000
Error	4	0.090	0.022		
Total	7	2424.911			

S = 0.1497 R-Sq = 100.00% R-Sq(adj) = 99.99%

Grouping Information Using Fisher Method

CODES N Mean Grouping

OPT B	2	120.090	A
blood orange	2	118.015	B
OPT A	2	89.040	C
late valencia	2	80.535	D

4. One-way ANOVA: IRON(mg/L) versus CODES

Source	DF	SS	MS	F	P
CODES	3	1.097937	0.365979	182.62	0.0000011
Error	4	0.000350	0.000088		
Total	7	1.098287			

S = 0.009354   R-Sq = 99.97%   R-Sq(adj) = 99.94%

Grouping Information Using Fisher Method

CODES	N	Mean	Grouping
OPT A	2	1.27500	A
OPT B	2	1.27000	A
blood orange	2	1.15500	B
late valencia	2	0.38500	C

5. One-way ANOVA: CALCIUM(mg/L) versus CODES

Source	DF	SS	MS	F	P
CODES	3	2062.947	687.649	6437.91 0	.0000012
Error	4	0.427	0.107		
Total	7	2063.374			

S = 0.3268   R-Sq = 99.98%   R-Sq(adj) = 99.96%

Grouping Information Using Fisher Method

CODES	N	Mean	Grouping
OPT B	2	112.000	A
blood orange	2	110.670	B
OPT A	2	87.080	C
late valencia	2	74.075	D

2. One-

C. ANOVA FOR VITAMINS PROPERTIES

1. One-way ANOVA: VIT C (mg/100mL) versus CODES

Source	DF	SS	MS	F	P
CODES	3	376.4513	125.4838	2105.87	0.000001
Error	4	0.2384	0.0596		
Total	7	376.6897			

S = 0.2441 R-Sq = 99.94% R-Sq(adj) = 99.89%

Grouping Information Using Fisher Method

CODES	N	Mean	Grouping
blood orange	2	55.810	A
OPT B	2	49.646	B
late valencia	2	45.103	C
OPT A	2	37.560	D

way ANOVA: BETA CAROTENES versus CODES

Source	DF	SS	MS	F	P
CODES	3	436226.3	145408.8	57205.60	0.00000
Error	4	10.2	2.5		
Total	7	436236.5			

S = 1.594 R-Sq = 100.00% R-Sq(adj) = 100.00%

Grouping Information Using Fisher Method

CODES	N	Mean	Grouping
OPT A	2	602.11	A
Late valencia	2	587.47	B
OPT B	2	129.54	C
Blood orange	2	126.72	C