ANALYSIS OF THE V ARIA TI ON OF VITAMIN C CONTENT IN DIFFERENT VARIETIES OF PASSION FRUITS FROM KABALE CENTRAL MARKET

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A RESEARCH PROJECT REPORT SUBMITTED TO THE FACULTY OF EDUCATION KABALE UNIVERSITY IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AW ARD OF THE BACHELOR OF SCIENCE WITH EDUCATION DEGREE OF KABALE UNIVERSITY

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DECLARATION

I SSENOGA REGAN, Registration Number: **17/A/BSCED/0568/GF** hereby declares that the work presented in this research project report is a product of my own effort. The work is original and has never been presented to any examination board for the award of any qualification.

Signature ~~-

Date:01/02/2021

APPROVAL

This project report *titled 'Analysis of the variation of vitamin C content in different varieties of* passion fruits from Kabale central marke**t'** has been submitted by **Ssenoga Regan** Registration Number: **17/ A/BSCED/0568/G/F** in partial fulfillment of the requirements for the award of the Bachelor of Science with education Degree of Kabale University under my supervision and approval.

Signature.. ~- '. Date:02/02/2021

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DEDICATION

I dedicate this work to the Almighty God our provider for enabling me to accomplish this work. Also, I dedicate this work to my beloved mother, friends and whoever has given me a hand while doing this work. Thanks for your unconditional support with my studies. I am proud of you all and therefore this work is my reward to you all.

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ABSTRACT

In Uganda there are three commercially grown passion fruits namely the small purple Grandilla, the Yellow variety and the Kawanda hybrid. Industries which process passion fruits for juice and people who consume these varieties on market do not consider nutrient content while making preferences on the variety to use. They make choices basing on the colour of the outer cover of the fruit and availability. This study analyses and the compares the nutrient content of the three common varieties of passion fruits common in Kabale Central Market. Samples of each of the three varieties were obtained and juice from each representative sample of the varieties was obtained and collected. The concentration of Vitamin C was determined quantitatively by iodometric titration. The study found out that the Yellow variety had high levels of Vitamin C, followed by the Kawanda hybrid, and the small purple Grandilla had the lowest content. However, when the-juice of the small purple Grandilla was mixed with that of the other varieties higher concentrations of Vitamin Cwere observed, hence mixtures of juice from the varieties can provide generally high vitamin C contents.

Key words: small purple Grandilla, yellow variety, Kawanda hybrid, vitamin C, mixtures of juice, iodometric titration,

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LIST OF ACRONYMS AND ABBREVIATIONS

AA:	Ascorbic Acid
AOAC:	Association of Official Analytical Chemists
DHAA:	Dehydroascorbic Acid
K 1:	Kawanda hybrid passion fruit variety
L-AA:	Levorotatory Ascorbic Acid
L-AA:	The reduced form of vitamin C
LC:	Liquid Chromatography
P 1:	Small Purple Grandilla passion fruit variety
RDA:	Recommended Daily Allowance
Scurvy :	malnutrition disease due to deficiency of vitamin C
UHPLC:	Ultra High Performance Liquid Chromatography
US:	United States
Vitamin C:	trivial name for compounds exhibiting full or partial biological activity of L-AA
Yl:	Yellow passion fruit variety

CHAPTER ONE: INTRODUCTION

1.0 Introduction

The research project was conducted under the topic **'Analysis of the variation of vitamin C content in different varieties of passion fruits from Ka bale Central Market'.**

This chapter covers the background of the study, problem statement, research objectives and research questions, significance of the study and justification of the study.

1.1 Background to the study.

According to (Dupriez and De Leener, 1989), Passion fruit *(Passiflora edulis.)*, a native of tropical America (Brazil), belongs to the family Passifloraceae and is a high value and export oriented crop. Passion fruit stands out not only for its exotic and unique flavour and aroma but also for its amazing nutritional and medicinal properties.

It is cultivated in countries like Kenya, Australia, New Zealand, Hawaii, South Africa and Srilanka. India, too, has its place in passion fruit history. For several years, India has enjoyed a moderate harvest of purple passion fruit in the Nilgiris, Wynad, Kodaikanal, Shevroys, Coorg and Malabar in the South and in various parts of Northern India, especially Himachal and North East states like Manipur, Nagaland, Mizoram and Meghalaya (Gurung *et al.*, 2014). Passion fruit vines are found wild and cultivated to some extent in many parts of the world including the highlands of Java, Sumatra, Malaya, Western Samoa, and Norfolk islands, Cook Islands, Solomon Islands, Guam, the Philippines, the Ivory Coast, Zimbabwe and Taiwan. Brazil has long had a well-established passion fruit industry with largescale juice extraction plants. Other countries which produce passion fruits include India, Australia, New Zealand, Kenya, Uganda, Rwanda, etc. (Rocky Thokchom and Goutam Mandal, March, 2017).

Common names of passion fruit are granadilla, parcha, parchita, parchita maracuja, or ceibeyin Spanish, maracuja perobain Portuguese and grenadille, or couzouin French. The purple form is called purple, red, or black granadilla, or, lilikoiin Hawaii, mountain sweet cup in Jamaica and linmangkonin Thailand. The yellow form is widely known as yellow passion fruit and is called yellow lilikoiin Hawaii, golden passion fruit in Australia and parchaamarillain Venezuela (Tripathi, P. C, 2018).

Passion fruit is a perennial, vigorous, climbing, woody vine that produces round or ovoid fruits. Fruits have a tough, smooth, waxy dark purple/yellow coloured rind with faint, fine white specks. Fruit

contains orange colored pulpy juice with large number of small, hard, dark brown to black pitted seeds (Tripathi, P. C.2018).

There are two recognized forms of edible passion fruits: purple and yellow Pruthi (Martin, & Nakasone, 1970). The purple passion fruit is a native of tropical America while the yellow -passion fruit is considered a mutant of the purple variety, or as a natural hybrid between the purple and another related species of passion fruit (Strohalm *et al.,* 2007; Watson *et al.,* 2008). The purple variety is mainly grown for fresh juice and its flavor is a vital attribute which makes the juice desirable ingredient for many formulated beverages (Farid *et al.,* 2010). The unique flavor of passion fruit is attributed to the several volatile compounds which get deteriorated with increasing temperature (Strohalm *et al.,* 2017). In Uganda there are three commercially cultivated varieties of the fruit and these include the purple passion fruit variety, the yellow variety, and the Kawanda hybrid passion fruit. The other variety grows in the wild on its own and is called sweet calabash passion fruit. The fruit has high nutritional and medicinal value. It is a rich source of vitamins A and C and contains fair amounts of Iron, Potassium, Sodium, Magnesium, Sulphur, and Chlorides (Rocky Thokchom and Goutam Mandal, 2017).

1. 1. 1 Varieties of passion fruits

There are two recognized forms of edible passion fruit: purple *(Passiflora edulis)* and yellow *(Passiflora flavicarpa).* Purple and yellow are commonly cultivated in different parts of the world including Uganda, India, Brazil, and so many others. The other less prominent varieties of passion fruit include *Passiflora quadrangularis,* the giant granadilla, is also cultivated to a limited extent for local consumption. It grows better in hot, moist climate and produces round or oblong, pale-yellow to yellowish-green fruits when ripe, which may reach up to 8 inches in size.

Passiflora foetida wild species bears very small fruits and has unique characters of being highly precocious and very short fruit maturity period.

Purple passion fruit *(Passiflora edulis);* Vines are productive at higher elevations. Fruits are 4-Scm in diameter, deep purple when ripe each weighing 35-45g. The juice content varies from 31-35 percent.

Yellow passion fruit *(Passiflora flavicarpa);* the variety is suitable for lower elevation and is less productive at higher elevations due to its sensitivity to low temperature. The fruit is bigger in size than the purple variety, each weighing about 60g, round in shape with yellow mottled spots, turns golden yellow when ripe. Juice is more acidic and seeds are brown.

Giant granadilla; it has large leaves, and bears very striking flower. The greenish-yellow fruits of *P quadrangularis* resemble melon and are the largest in the genus. The fruits are 15-20cm long and about 600g weight. The fruits are oblong, with a delicate aroma and a thin smooth skin. Fruit contains thick pulp with large seeds.

Kaveri hybrid passion fruits; it is a hybrid between purple and yellow passion fruit developed at Central Horticulture Experimental Station, Indian Institute of Horticulture, Chettalli, Karnataka. It is a high yielding variety and each fruit weighs 85-110g. The fruits are purple in color, fruit quality comparable to that of purple variety (Rocky Thokchom and Goutam Mandal, 2017).

However much there are many varieties of passion fruits *(Passiflora edulis),* there are no serious studies carried out so far to analyze. the nutrient content of these known edible passion fruits. In Uganda the grown passion fruit varieties include the yellow passion fruit *Passiflora edulis var. flavicarpa,* the purple Passion fruit *Passiflora edulis var. edulis,* the purple Kawanda hybrid, which is a cross between the yellow and purple passion fruit varieties and, the light-yellow apple passion fruit *Passiflora maliformis L(* Nyanzi, S. A., Carstensen, B., & Schwack, W).To increase resistance to soil-borne fungal diseases in the purple passion fruits, a scion of the purple variety is grafted onto the rootstock of the yellow passion fruit to produce the high-yielding *Kawanda* hybrid. The small purple passion fruit variety is commonly cultivated in the District of Kabale while the Yellow variety is prominent in the districts of Soroti and Mbale whereas the Kawanda hybrid is commonly grown in the districts of Masaka, Mubende and Mityana. The light-yellow apple passion fruit *Passiflora maliformis L* grows wildly in all areas around Uganda.

1.2 Problem statement

Passion fruit *(Passi/flora edulis)* is a natural rich source of vitamin C required in our diets across the world because of its nutritive values. Vitamin C is involved in wound healing, tyrosine metabolism, conversion of folic acid to folinic acid, carbohydrate metabolism, resistance to infections and cellular respiration (Mc Eoy .G.K, 2000) and in addition several epidemiological studies showed that subjects with a higher intake of Vitamin C have lower risk for several chronic diseases, namely heart diseases, diabetes, cancer or neurodegenerative diseases (Jacob and Sotoudeh, 2002) and also it is associated with antioxidant advantages (Peyron, Buhuon, Gontard and Guillard, 2010) and (Sweetman.S.F.et *al.,* 1997). Deficiency of vitamin C leads to a debilitating disorder, scurvy, in man and animals unable to synthesize it (Carole L. Linster and Emille Van Schaftingen, 2006).

In Uganda, human consumption of passion fruits as a source of vitamin C is evidenced in a variety of juice brands available on the market such as *Minute maid, Oner, Splash* and many others which contain passion fruit flavors. However, research on the nutrient content on a number of passion fruits varieties available in the market is very limited more specifically on Vitamin C content. Different varieties of passion fruits may be available in different parts of Uganda. For example, the yellow variety is prominent in Soroti district, the purple grandilla is commonly grown in districts of Kabale, Masaka and Mubende and the Kawanda hybrid is more noticeable in the districts of Central Uganda. The different varieties may contain varying amounts of Vitamin C. Lack of information on the different vitamin C content of these varieties may result into passion fruit juice and passion fruit products consumers to make wrong choices of the varieties to utilize resulting into them facing problems associated with deficiency of vitamin C such as delayed wound healing, difficulties in carbohydrate metabolism, and reduced resistance to infections which affect the metabolic processes of an individual.

The study is intended to determine the Vitamin C content in the three most commercially grow different varieties of passion fruits available on the market in Uganda (Nyanzi, S. A., Carstensen, B., & Schwack, W).Knowledge on the vitamin C content in different varieties of passion fruit will help industry domestic consumers to make informed choices on the varieties of passion fruit that can be used for juice production. Consumers will also make choices on maximum utilisation of passion fruits as a source of vitamin C.

1.3 Objectives of the study.

1.3.1 General objective of the study.

The main objective of the study is to compare the amount of Vitamin C in the purple Grandilla, the purple Kawanda hybrid and Yellow passion fruit.

1.3.2 Specific objectives of the study.

1. To determine the concentration of Vitamin C in the purple Grandilla, Kawanda hybrid and Yellow passion fruit
ii. To compare the concentration of Vitamin C in the purple Grandilla, Kawanda hybrid and Yellow passion fruit
111. To examine the concentration of Vitamin C in different passion fruit juice mixtures of passion fruit juice of purple Grandilla + Kawanda hybrid, purple Grandilla +yellow passion fruit,

Kawanda hybrid+ yellow passion fruit, and purple Grandilla+ Kawanda hybrid+ yellow passion fruit

1.4 Research questions

1. What is the concentration of Vitamin C in the purple Grandilla, Kawanda hybrid and Yellow passion fruit?
2. ls there a difference in the concentration of Vitamin C in the purple Grandilla, Kawanda hybrid and Yellow passion fruit?
3. Is there a difference in the concentration of Vitamin C in the mixture of passion fruit juice of purple Grandilla + Kawanda hybrid, purple Grandilla +yellow passion fruit, Kawanda hybrid+ yellow passion fruit, and purple Grandilla+ Kawanda hybrid+ yellow passion fruit?

1.5 Research hypotheses

1.5.l Null Hypothesis

Ho: There is no fixed concentration of Vitamin C in the purple Grandilla, Kawanda hybrid and Yell ow passion fruit.

Ha: There is no difference in vitamin C concentration of purple Grandilla, highly Kawanda hybrid and Yellow passion fruit.

H: There is no difference in the concentration of Vitamin C in the mixture of passion fruit juice of purple Grandilla + Kawanda hybrid, purple Grandilla +yellow passion fruit, Kawanda hybrid+ yellow passion fruit, and purple Grandilla+ Kawanda hybrid+ yellow passion fruit.

1.5.2 Alternative hypothesis

H,: There is a fixed concentration of Vitamin C in the purple Grandilla, Kawanda hybrid and Yellow passion fruit.

Hi: There is a difference in vitamin C concentration of purple Grandilla, highly resistant Kawanda hybrid and Yellow passion fruit.

H,: There is a difference in the concentration of Vitamin C in the mixture of passion fruit juice of purple Grandilla + Kawanda hybrid, purple Grandilla +yellow passion fruit, Kawanda hybrid+ yellow passion fruit, and purple Grandilla+ Kawanda hybrid+ yellow passion fruit.

1.6 Significance of the study

The major purpose of the study is to give chance to the researcher to go to the field and practice the research method and techniques taught in class. The research study will provide necessary information about the nutrient components of the different studied varieties of passion fruits on market plus their products and or main focus of the study is on Vitamin C. From my research after achieving the research objectives, it will be possible for people using passion fruits for both industrial and domestic uses to make choices of the variety of passion fruit to utilize basing on the nutrient content of them.

1. 7 Justification of the study

The research examined the nutrient composition of the different studied varieties of passion fruits and guides us about. their nutrient relevance. The information from this research if not considered and attended to by the public, there will be continuous utility and consumption of passion fruits and their products without considering the required optimum nutrients by the bodies resulting in increased malnutrition related cases and expensive costs of medication/treatment of nutritional related diseases.

1.8 Scope of the study

The study was entirely hinged on the variation of vitamin C content in the different studied varieties of passion fruit bought from Kabale Central Market cultivated from different parts of Uganda and these were the small purple Grandilla, Yellow and the Kawanda hybrid passion fruit variety. The experimental tests were carried out within a period of two months, from March to April 2020 at Kabale University, Ndorwa Sub County, Kabale district, south western Uganda.

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

This chapter cites some of the previous literature on studies that were carried on the different varieties of passion fruits around the world Uganda inclusive.

Passion fruit *(Passiflora edulis),* a native of tropical America (Brazil), belonging to the family Passifloraceae is a high value and export oriented crop. Passion fruit stands out not only for its exotic and unique flavor and aroma but also for its amazing nutritional and medicinal properties. It is grown mostly in tropical and sub-tropical part of the world. South America is currently the largest producer of passion fruit worldwide (Serna and Maiti, 2009). It is cultivated in countries like Kenya, Australia, New Zealand, Hawaii, South Africa and Srilanka. For several years, Uganda has enjoyed a moderate harvest of passion fruits both yellow and purple fruit from different parts of the country. The fruit can be grown to eat or for its juice, which is often added to other fruit juices to enhance aroma. There is increase in awareness of the crop and production areas under passion fruit. But limited information is available on the variations in the nutrient content of the different varieties of the fruit.

The name "passion fruit" is not derived from any aphrodisiac quality of the fruit but was named, reportedly, by Spanish Catholic missionaries who saw in the flower, the, symbolism of the Passion of Christ where "Passus" means "suffering" and "Flos" means "flower". Passion fruit should more correctly be referred to as the passion flower fruit, but the trade more commonly uses passion fruit. Passion fruit is known in Hawaii as lilikoi, golden passion fruit in Australia, maracuja peroba in Brazil, and yellow granadilla in South Africa.

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Figure 2.0.1 Passion fruit flower

2.1 Origin and distribution of passion fruits

The passion fruit was discovered in 1569 by Spanish explorers in Peru, who saw the flowers as symbolic of the passion of Christ and, therefore, a sign of Christ's approval of their efforts. The major producers of passion fruit are found in South America mainly Brazil, Colombia, Peru and Ecuador(Ruggiero *et al.*, 1996).A few species are economically important e.g. Passiflora edulis botanical form flavicarpa, the yellow passion fruit, whose juice and pulp are used extensively as ingredients of beverages, salads, fruit cocktails and desserts (Donadio, 1983). The purple passion fruit (P. edulis) is adapted to the cooler subtropics or at high altitudes in the tropics, while the golden passion fruit (P. edulis var. flavicarpa) is more suited to the tropical low land conditions. Brazil, Venezuela, South Africa, New Zealand, Australia, Papua, New Guinea, Fiji, Hawaii, Taiwan and Kenya account for 80-90% of the world's passion fruit production. The major exceptions are South Africa, Kenya and New Zealand, where production is dependent on Jines of the purple passion fruit and in Australia where hybrids between the two forms i.e., purple and yellow type is exploited. According to Morton (1987), in Australia, the purple passion fruit was flourishing and partially naturalized in coastal areas of Queensland before 1900; in the early 1930's, New Zealand, had a small but thriving purple passion fruit industry in Auckland Province but in a few years the disease-susceptibility of this type brought about its decline. In Hawaii, seeds of the purple passion fruit, brought from Australia, were first planted in 1880 and the vine came to be popular in home gardens and it quickly became naturalized in the lower forests and, by 1930, could be found wild on all the islands of the Hawaiian chain. Commercial production of purple passion fruit was begun

in Kenya in 1933 and expanded in 1960. The purple passion fruit was introduced into Israel from Australia early in the 20th Century and commonly grown in home gardens all around the coastal plain, with small quantities being supplied to processing factories. Passion fruit vines are found wild and cultivated to some extent in many other parts of the old world including the highlands of Java, Sumatra, Malaya, Western Samoa, Norfolk islands, Cook Islands, Solomon Islands, Guam, the Philippines, the Ivory Coast, Zimbabwe and Taiwan. The yellow passion fruit was introduced into Fiji from Hawaii in 1950. Fiji has exported to Australia, New Zealand, and Canada as well as to nearby islands. In South America, interest in yellow passion fruit production intensified to Colombia and Venezuela in the mid 1950's and in Surinam inl 975. In Colombia, there are commercial plantations mainly in the Cauca Valley. The passion fruit was introduced into Venezuela from Brazil in 1954.In India both purple and yellow passion fruits are grown commercially (Serna and Maiti, 2006) and its cultivation is confined to Kerala, Nilgiris hills and Kodai Kenal of Tamil Nadu, Coorg region of Karnataka. Its cultivation has been extended to some parts of North Eastern hill region particularly Manipur, Mizoram, Nagaland, Meghalaya and Sikkim (Patel etal. 2008). The purple passion fruit is adapted to subtropical conditions and endures a few degrees of winter frost without injury, while the yellow passion fruit is more suited to tropical low land conditions (Roy *et al.,* 2012) and it is tolerant to several diseases and pests.

2.2 Taxonomical classification of Passiflora edulis

According to (Tripathi, P. C.2018), Passion fruit (Passiflora edulis Sims.) belongs to family Passifloraceae which includes 12 genera with more than 500 species. Genus Passiflora has about 400 species out of which few are economic importance. Within these species there are two district forms i.e., the standard purple (P. edulis) and the yellow (P. edulis f. flavicarpa Deg.). The chromosome number ranging from 2n= 18 to 2n=22. Zeven and Zhukosky (as cited in Tripathi, P. C.2018) mentioned is detailed aboutl2 species of Genus Passiflora which are being enumerated.

a *Passiflora alta* Dry land: It is native of Peru and Brazil. It is a woody vine cultivated in Brazil for its fruits.

b. *Passiflora antiquiensis Karst.* (Syn. *P. valxsemii (Len) Traina& Planch.):* It is native of Colombia and known as banana passion fruit. This species is also a woody vine cultivated for its fruit.

c. *Passiflora cearensis Barb:* It is native of Brazil and cultivated for its fruits.

d. *Passiflora edulis Sims.* : **It** is real passion fruit which is native of South Brazil. This species is widely distributed throughout the tropics and subtropics. The fruits are especially used for juice preparation.

e. *Passiflorafoetida* L.: **It** is woody species native of West Indies and South America. **It** is distributed to many tropical countries in Africa and Asia where it has naturalized. The fruits are hardly edible however, in Malaysia and East Africa it is used as cover crop.

f. *Passiflora laurifolia* L.: **It** is native of thickets and forest fringes of West Indies and North-East South America. Cultivated for fruits and spread throughout the tropics Parseglove, 1968 (as cited in Tripathi, P. C.2018).

g. *Passi.flora ligularis Juss:* **It** is native of Tropical America and commonly known as Sweet granadilla. Its sweet fruits are much used in mountainous region of Mexico and Central America).

h. Passiflora maliformis L.: A vine native to Tropical America and cultivated for fruits.

i. *Passi.flora mallissima* (H.B.K.) Bailey. **It** is native of Andes and commonly known as Banana Passion fruit. It is especially cultivated in Equador and Bolivia.

j. Passiflora psilantha (Sodiro) Killip: It is native of Ecuador and known as Gullan. **It** is a vine grown for fruits.

k. Passiflora quadrangularis L.: **It** is commonly known as Giant granadilla and Barbadine and native of tropical South America. Widely distributed in tropics where it is grown for fruits.

1. Passiflora tripartite (Juss.) Poir: It is native of Ecuador and cultivated for fruits. It is commonly known as Tasco

vi.

Figure 2.2.1 Purple or violet passion fruit

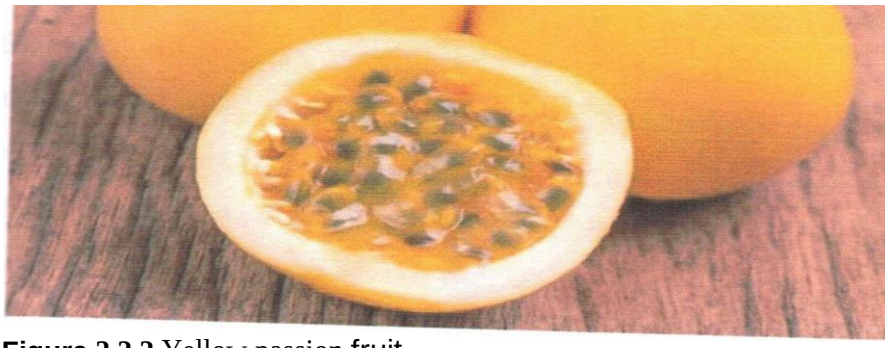

Figure 2.2.2 Yellow passion fruit

Figure 2.2.3 Giant granadilla P. quadrangularis

2.3 Morphology of the passion fruit

According to (Tripathi, P. C.2018), the passion fruit vine is a shallow-rooted, woody, perennial, climber. The leaves are alternate, evergreen leaves, deeply 3-lobed when mature, finely toothed, measuring 7.520 cm long, deep-green and glossy above, and pale and dull beneath. The young stems and tendrils tinged with red or purple, especially in the yellow form. A single fragrant flower, 5-7.5 cm wide is borne at each node on the new growth. The flowers have 3 large, green, leaf like bracts, 5 greenish-white sepals, 5 white petals, a fringe like corona of straight, white-tipped rays, rich purple at the base, also 5 stamens with large anthers. The ovary has triple-branched style forming a prominent central structure. The flowers of the yellow passion fruit are showier. with more intense color. The fruits are round or ovoid, 4-7.5 cm diameter, with tough, smooth, waxy rind. The colour of fruits range from dark-purple with faint, fine white specks, to light-yellow or pumpkin-color. The rind is 3mm thick, adhering to a 6 mm layer of white mesocarp. The fruit cavity is more or less filled with an aromatic mass of doublewalled, membranous sacs filled with orange-colored, pulpy juice with 200-250 small, hard, dark-brown or black. pitted seeds. The flavour is appealing, musky, and guava-like and sub acid to acid.

Figure 2.3.1 Passion fruit vine

2.4 Common passion fruit varieties in Uganda

According to the Daily Monitor of Sunday August 27 2017, the Common types include; purple and yellow passion fruit. On addition to the above varieties also according to the Business focus Monday, February 3, 2020, the purple Grandilla-Is popular for its scent and is locally known as Kasese, Masaka and Kenyan passion fruit variety. Highly resistant Kawanda hybrid is a cross between the local purple and the yellow passion fruits. Yellow passion fruit is grown for its aromatic but rather acidic pulp.

2.5 Uses of passion fruits

Passion fruit juice is a good source of ascorbic acid (vitamin C) and carotenoids (vitamin A). It is rich-flavored and strongly, but pleasantly aromatic. The undiluted juice is highly concentrated but is an excellent additive to other fruit juices, or it may be drunk as an ad if water and sugar are added. The juice makes an excellent jelly, pie filling or cake frosting. Seeds with the surrounding juice sacs are often added to fruit salads in Australia. Fruit of the purple passion fruit (sweeter and less acid than the yellow) may be eaten by itself, seeds and all. Juice of the giant granadilla has a milder flavor than that of the others and is used in confections or drinks. Its melon-like, edible flesh also can be pulverized and used in pies. (Knight, R. J., & Sauls, J. W.(1994)

According to (Patil, *B.Set al.,* 2013) the leaves, vines, and flowers of members of the Passifloraceae family have been used as medicinal herbs.

The leaf of passion fruit is used as a vegetable in the hills of North Eastern India. Boiled extract of fresh tender leaves is prescribed as a remedy for diabetes, hypertension, diarrhoea, dysentry, gastritis, abdominal flatulence and as a liver tonic.

According to the Daily Monitor of Sunday August 27 2017, the fruit is the new goldmine for farmers in Uganda and other East African region because it has become a new enterprise for farmers and gardeners as in generating income.

The Daily Monitor of Sunday February **11,** 2018 adds on that apart from being consumed as a beverage in homes, passion fruits rake in income through saving that would be made on purchases for home consumption.

That said, it is a medicine to _over 64 diseases in humans, source of raw material for honey build up by the bees, for the case of bee keepers .Our body doesn't usually absorb iron from plants very well. However, the iron in passion fruit comes with a lot of vitamin C, which is known to enhance iron absorption (US National Library of Medicine National Institutes of Health).

2.6 Nutrient content of passion fruits *(Passiflora edulis)*

Table 2.6.lNutrients and approximate composition of passion fruit per 100g of edible portions (Tripathi, P.C.2018)

Composition	Species		
	P.edulis	P. edulis var. flavicarpa	**P.** quadrangularis
Moisture (%)	85.6	84.9	88.0
Protein (g)	0.9	0.7	0.9
Fat (g)	0.1	0.2	0.2
Carbohydrate (g)	13.6	13.1	10.1
Ash (g)	0.3	0.5	0.9
Ca (mg)	3.6	3.8	10.0
p (mg)	12.5	24.56	22.0
Fe (mg)	0.2	0.4	0.6
Vitamin A (IU)	717	2410	70
Thiamine (mg)	Trace	Trace	-
Riboflavin (mg)	0.1	0.1	-

Niacin (mg)	1.5	2.2	2.7
Ascorbic acid (mg)	30	20	20

2. 7 Health benefits of vitamin C (Ascorbic Acid)

Vitamin C is one of the most important water-soluble vitamins, naturally present in foods, especially in fruits and vegetables, and is widely used as. a food additive and as an antioxidant (Penicaud, Peyron, Bohuon, Gontard & Guillard, 2010). Antioxidants are substances that can prevent or delay oxidative damage of lipids, proteins arid nucleic acids by reactive oxygen species (Insel, Turner, & Ross, 2002). Vitamin C is a dietary antioxidant required as a co-factor for many enzymes. The reduced form of vitamin C, L-ascorbic acid, is the main biologically active form of this vitamin and it is an effective antioxidant due to its high electron-donating power and ready conversion back to the active reduced form. Several epidemiological studies showed that subjects with a higher intake of vitamin C have lower risk for several chronic diseases, namely heart disease, diabetes, cancer or neurodegenerative diseases (Jacob & Sotoudeh, 2002).

It is essential for collagen, carnitine and neurotransmitters biosynthesis. Most plants and animals synthesize ascorbic acid for their own requirement. However, apes and humans cannot synthesize ascorbic acid due to lack of an enzyme gulonolactone oxidase. Hence, ascorbic acid has to be supplemented mainly through fruits, vegetables and tablets. The current US recommended daily allowance (RDA) for ascorbic acid ranges between 100-120 mg/per day for adults. Many health benefits have been attributed to ascorbic acid such as antioxidant, anti-atherogenic, anti-carcinogenic, immunomodulator and prevents cold etc (Naidu, K. A., 2003).

A comprehensive review of the literature indicates that populations with long-term consumption of higher than RDA levels of vitamin C (> or = 60 mg/day) from foods and/or supplements have reduced risks of cancer at several sites, cardiovascular disease, and cataracts. (Bendich, A.,& Langseth, L, 1995).

2.8 Techniques for determining vitamin C content in passion fruits

Vitamin C, or merely ascorbic acid (AA), is a hydrosoluble and thermolabil vitamin. AA is widely distributed in products of vegetable origin and is mainly found in citric fruits and green leaves (Zhang & Hamauzu, 2004). The Association of Official Analytical Chemists (AOAC) standard methodology for determination of Vitamin C employs a titration method; however, ascorbic acid can also be determined by spectrophotometric, enzymatic and chromatographic methods (Spinola, Mendes, Camara & Castilho, 2013)and(Eitenmiller *et al.,* 2008; Novakova *et al.,* 2008). Liquid chromatographic methods have the

potential for the simultaneous determination of other metabolites, as dehydroascorbic acid. Either reduced or oxidized (dehydroascorbic acid) forms of AA are equally active; though the oxidized form is reduced in natural sources. The transformation of *AA* into dehydroascorbic generally is reversible, allowing either substance to be transformed into another. This transformation capacity works as an oxy-reduction system, carrying hydrogen in the respiration process at the cellular level (Welch, 1995). Natural ascorbic acid levels have been reported at 40-65 mg/100 g for fresh passion fruit (Talcott, Percival, Pittet-Moore & Celoria, 1998; Spinola, Mendes, Camara & Castilho, 2013).L-AA can also be determined directly with iodine and iodate solution in a redox titration, using starch as indicator. As a good reducing agent, L-AA reacts rapidly and stoichiometric with iodine to give iodide ions, while it is oxidized to DHAA. Once all the LAA has been oxidized, the excess iodine solution will react with the starch indicator, forming a blue-dark starch-iodine complex as endpoint of titration (Suntornsuk, Gritsanapun, Nilkamhank, & Paochom, 2002; Zenebon, Pascuet, & Tiglea, 2008). However, these traditional methods suffer from lack of specificity, which limits their use in matrices that contain other interfering substances that are also oxidized by the applied titrants (Eitenmiller *et al.,* 2008; Hernandez *et al.,* 2006; Novakova *et al.,* 2008). This means that L-AA results are normally determined by excess in vegetable extracts usually rich in reducing organic acids, while DHAA is not quantified. However, due to the lack and expense of the Liquid Chromatographic Methods which were not affordable at the meantime, iodometric titration method was used for our experimental tests. for Vitamin C in the study. The main advantages of the iodometric titration method are its simplicity, the use of very elementary equipment, easily available reagents of low cost and speed of reaction of iodine with L-AA (Valente *et al.,* 2011).

Even though for my study iodometric titration was used, Liquid Chromatographic (LC) methods have been more successful for L-AA quantification (Johnston *et al.*, 2007; Valente *et al.*, 2011). The ultrahigh performance liquid chromatography (UHPLC) has recently become a preferred separation technique in many laboratories.

CHAPTERTHREE:METHODOLOGY

3.0 Introduction

This chapter covers materials and methods used in this research study. It involves research design, sampling 'methods, methods and instruments of data collection, laboratory analysis and data analysis.

3.1 Research design

The research design involved qualitative and quantitative analysis which involved food tests and experimentation. The design of the study was built on the experimental results on vitamin C content present in the different experimented varieties of passion fruits. The experiments were conducted from Kabale university Biology laboratory.

3.2 Sampling methods

3.2.lDetermining sample size using formula n=

$$1+Ne$$

Where n=represents desired sample size,
N=represents population size (target population) and,

E= represents degree of freedom/level of precision, which is 0.05. (Israel, G.D. (1992))

For my case, N= (200 for purple Grandilla, 94 for Yellow variety, and 131 for Kawanda hybrid) THEREFORE, after calculation for the sample size from;

$$n= \frac{N}{1+Ne}$$

Therefore n=134 individual purple Grandilla passion fruits out of 200, 97 individual Kawanda hybrids out of 131 and 77 individual yellow variety out of 94 for the experimental tests.

3.2.2 Obtaining samples

200 individual passion fruits of the purple Grandilla variety were bought from the market, 94 individual yellow passion fruits variety and 131 individual Kawanda hybrid passion fruits. Simple random sampling method was used whereby out of 200 passion fruit of purple grandilla variety, 134 were

picked, out of 94 passion fruits of yellow variety, 77 were picked and out of 131 of Kawanda hybrid, 97 were selected at random. All the 200 passion fruits of purple Grandilla variety will be given numbers from 1 up to 200. The same numbers were written on separate pieces of paper and the papers folded and mixed together. Randomly, 134 papers were picked form the 200 to represent purple Grandilla varieties of the study. The same procedure was followed for the remaining two varieties to obtain samples.

This sampling technique was used because the sample size is small and this enabled the study to be carried out without any bias.

3.3 Method and instruments for data collection

3.3.1 Sample preparation

The passion fruit samples were sorted and washed with excess distilled water to remove adhering dirt and other impurity particles.

3.3.2 Preparation of juice from purple Grandilla

10 passion fruits of purple Grandilla variety were cut in half using a knife and scooped out their pulp using a spoon into a sieve placed on a beaker and the content in the sieve was squeezed with the spoon to obtain the juice into the beaker. The same procedure is repeated 13 times to obtain juice from all the 134 purple Grandilla passion fruits. The juice is put in a reagent bottle and labeled **Pl.** From the reagent bottle, the juice was divided into 4 equal parts in 4 beakers. The first part was used in determination of the concentration of vitamin C in purple Grandilla and the other 3 used in combinations.

3.3.3 Preparation of juice from Kawanda hybrid

l 0 passion fruits of Kawanda hybrid variety were cut in half using a knife and scooped out their pulp using a spoon into the sieve placed on a beaker and the content in the sieve was squeezed with the spoon to obtain the juice into the beaker. The same procedure was repeated 9 times to obtain juice from all the 97 Kawanda hybrid passion fruits. The juice is put in a reagent bottle and labeled **Kl.** The juice in the reagent bottle was divided into 4 equal parts into 4 beakers. The first part to be used in determining the concentration of vitamin c in Kawanda hybrid and the other 3 used in combinations.

3.3.4 Preparation of juice from Yellow variety

8 passion fruits of Yellow variety were cut in half using a knife and scooped out their pulp using a spoon into the sieve placed on a beaker and the content in the sieve was squeezed with the spoon to obtain the

juice into the beaker. The same procedure was repeated 9 times to obtain juice from all the 77Yellow passion fruits. The juice is put in a reagent bottle and labeled **Yl.** Juice in the reagent bottle was divided into 4 equal parts in 4 beakers. The first part to be used in determining the concentration of vitamin C in Yell ow variety and the other 3 used in combinations.

3.3.5 Preparation of samples of juice from the combination of the three varieties of passion fruits

The three samples of juices for each variety were used in making combinations that is to say, **Pl +Kl** from combination of juice from the second samples of purple Grandilla and Kawanda hybrid in a beaker, **Pl+ Yl** -from combination of juice from the third sample of purple Grandilla and the second sample of Yellow variety in a beaker, **Kl+ Yl** from the combination of juice from the third samples of Kawanda hybrid and Yell ow variety in a beaker and **Pl+ Kl+ Ylthe** combination of the fourth juice samples of purple Grandilla, Kawanda hybrid, and Yellow variety in the beaker.

These combinations were made in order to examine the concentration of Vitamin C in different passion fruit juice mixtures of passion fruit juice of purple Grandilla + Kawanda hybrid, purple Grandilla +yellow passion fruit, Kawanda hybrid+ yellow passion fruit, and purple Grandilla+ Kawanda hybrid+ yellow passion fruit.

3.4 Reagents preparation

1 % Starch Indicator Solution: Starch solution (1 %) was prepared by weighing lg of starch into a 250ml beaker and 100ml of distilled water will be added. The mixture was heated at a temperature of 79°C for 5 minutes with stirring until the starch dissolved; the resulting solution was allowed to cool.

O.lM Hydrochloric Acid: 2.15ml of hydrochloric solution (specific gravity of 1.18g, 35.4% pure and RFM of 36.5) was measured into a 250cm' volumetric flask and made up to the mark with distilled water.

0.016M Potassium iodate solution: 1. 70g of 99% pure potassium iodate were weighed and dissolved in 500ml of distilled water in a volumetric flask.

Potassium iodide solution: 2g of solid potassium iodide were dissolved in 50 ml of distilled water in a 250 ml volumetric flask and diluted to 250 ml with distilled water.

3.5 Laboratory determination of vitamin C content in the passion fruit juice samples of the three different varieties

The concentration of ascorbic acid in the passion fruits was determined by redox titration of the solutions extracted from the three selected varieties with a standard solution of acidified Potassium Iodate in the presence potassium iodide using starch indicator. Redox titration was used for the experiments because of the fact that this method does not require technical knowledge therefore easy to use and the apparatus required for this method are available in Kabale University Biology Laboratory.

Experiment procedure

25cm' of the sample were pipetted into a conical flask, 5ml of Potassium Iodide solution, 5ml of 0.1 M Hydrochloric acid and 1 ml of 1 % starch indicator added. The mixture was then titrated against 0.016M Potassium Iodate solution from the burette until the blue-black end point is reached. The titration was repeated two more times to obtain consistent results and the average titre value was calculated. The same procedures were repeated for the rest of the sample solutions to obtain their vitamin C content.

The average titre value for each sample was calculated using the formula below;

$$\text{AVERAGE titre} = \frac{(\text{Experiment 1} + \text{Experiment 2} + \text{Experiment 3})}{3}$$

3.5.1 Experimental findings

Volume of pipette used: 25cm'

Table 3.5.1.1 Results for the different varieties of passion fruits

SAMPLE	EXPERIMENT	Final burette reading/em'	Initial burette reading/em'	Volume of KIO3 used /em'
Pl	1	0.50	0.00	0.50
	2	1.10	0.50	0.60
	3	1.60	1.10	0.50
Kl	1	0.80	0.00	0.90
	2	1.50	0.80	0.70
	3	2.30	1.50	0.80

Yl ,	1	0.90	0.00	0.90
	2	1.70	0.90	0.80
	3	2.60	1.70	0.90
Pl+Kl	1	1.00	0.00	1.00
	2	2.00	1.00	1.00
	3	2.90	2.00	0.90
Pl+Yl	1	0.80	0.00	0.80
	2	1.50	0.80	0.70
	3	2.30	1.50	0.80
Kl+Yl	1	1.00	0.00	1.00
'	2	1.90	1.00	0.90
	3	2.70	1.90	0.80
Pl+Yl+Kl	1	1.40	0.00	1.40
	2	2.60	1.40	1.20
	3	3.60	2.60	1.00

Average volume of Potassium Iodate solution used in each solution was calculated.

Average titre value for all the samples was calculated

Pl; Average= (0.50+0.60+0.50)/3 = 0.533

Kl; Average = (0.90+0.80+0.70)/3 = 0.80

Yl; Average= (0.90+0.80+0.90)/3 = 0.85 **PI+Kl;**

Average = (1.00+ l.00+0.90)/3 = 0.95 **Pl+Yl;**

Average = (0.80+0.70+0.80)/= 0.75 **Kl+Yl;**

Average= (l.00+0.90+0.80)/ = 0.90 **P1+K1+Yl;**

Average = (1.40+1.20+1.00)/= 1.20

Table 3.5.1.2 Average titre values of the different varieties of passion fruits

SAMPLE	**Average volume of KIO, used/em'**
Pl	0.533
Kl	0.80
Yl	0.85
PI+KI	0.95
Pl+Yl	0.75
71LV1	0.00
Pl+Kl+Yl	1.20

3.5.2 Determination of vitamin C concentration

The vitamin C concentration of all the samples of passion fruit was computed using experimental results.

The moles of Potassium Iodate that were used in the experiments were calculated.

Using the equation of the reaction below between the Iodate and the Iodide ions, the moles of iodine solution formed were calculated.

$IO_3^-{}_{(aq)} + 5I^-{}_{(aq)} + 6\,H^+{}_{(aq)} \qquad 3I_2 + 3H_20$

The moles of Vitamin C were calculated from the mole ratio reaction with iodine below.

$C_6H_8O_6 + I_{2\,(aq)} \qquad C_6H_6O_6 +$

The concentration of Vitamin **C** is then calculated.

$1000cm^3$ of Potassium Iodate solution contain 0.016 moles.

0.533 of p·Idl ·. 0.016x0.533 . cm o otassmm o ate so ution contam ---

$$\cdot \quad 1000$$

$$= \underline{8.52810° \text{ moles.}}$$

vii.

From the equation of the reaction below

$IO_3^-{}_{(aq)} + 5I^-{}_{(aq)} + 6\,H^+{}_{(aq)}$ 31+ 3H20

1 mole of Potassium Iodate reacted to give 3 moles of Iodine solution.

8.52810"moles of Potassium Iodate reacted to give (3x8.52810) moles.

=2.558410moles of iodine.

From the equation of the reaction below

$C_6H_8O_6 + I_{2\,(aq)}$ $C_6H_6O_6 + 2I^-$

l mole of Iodine solution reacts with l mole of Ascorbic acid.

2.5584x 10^{-5} moles oflodine solution react with 2.558410° moles of Ascorbic acid.

25.0cm^3 of Ascorbic acid contain 2.558410moles.

1000cm^3 of Ascorbic acid contain: $\frac{1000 \times 2.5584 \times 10^{-5}}{25.0}$ moles.

Moles of Ascorbic acid = 1.0233610 moles of Ascorbic acid

=1.0233610%M

RFM of Ascorbic acid= 12x6 + 8xl + 6x16= 176 I

mole of Ascorbic acid weighs 176g

1.0233610 moles of Ascorbic acid weigh (1.0233610%176) = 0.1801g/L

Concentration of Ascorbic acid in mg/lOOml = 0.1801100 = 18.0mg/100ml

Going through the above procedures and steps, the concentration of Ascorbic acid in mg/100ml for all the samples was calculated and represented in the **table 4.1.1 and** ' + •1·.l. .

3.6 Data collection

These experiments were carried out on the same day and using observation technique data was recorded in the tables after carrying out each individual experiment.

3.7 Data analysis

Descriptive statistics and inferential statistics were used to analyze the data collected. In descriptive statistic, the average concentration of vitamin C of each variety was calculated and was used to draw a bar graph to compare the Vitamin C concentration of the varieties and correlation statistics was used to compare the significant difference between the vitamin C content of the three studied varieties.

3.8Limitations and possible challenges

Some of challenges which came up during data collection include errors arising due to; errors in the measuring apparatus, miscalculation by the researcher, and failure to access the laboratory due to constant use by other learners for lectures and practical. Also getting samples harvested at different times.

CHAPTER FOUR: RESULT PRESENTATION, ANALYSIS AND DISCUSSION

4.0Introduction

This chapter represented, interpreted and discussed the experimental results according to the research experiments.

4.1 Results presentation

Table 4.1.1 Concentration of vitamin c in mg/100ml of the samples PI, K1, and YI

SAMPLE	Observed Concentration of Ascorbic acid 1n mg/lOOml
Pl	18.0
Kl	27.0
YI	28.7

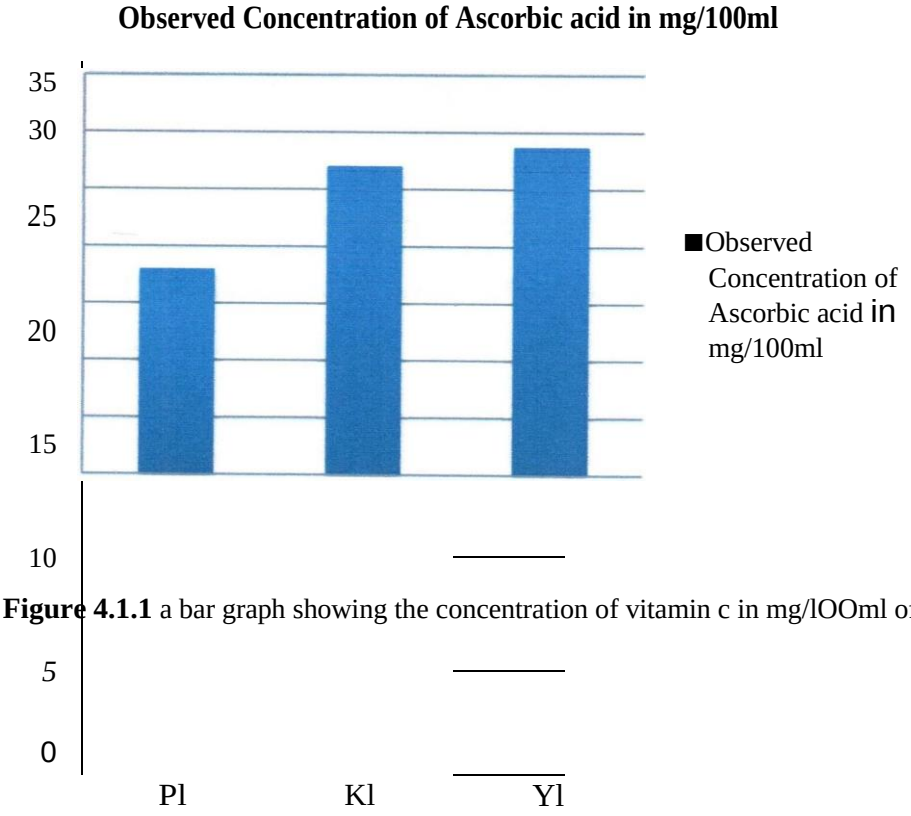

Figure 4.1.1 a bar graph showing the concentration of vitamin c in mg/lOOml of the samples Pl, Kl, and YI

Table 4.1.2 concentration vitamin C of Samples Pl+Kl, Pl+Yl, Kl+Yl, and Pl+Kl+Yl

SAMPLE	Observed Concentration of Ascorbic acid in mg/100ml	Calculated Concentration of Ascorbic acid inmg/lOOml
Pl+Kl	32.1	22.5
Pl+Yl	25.3	23.35
K1+YI	30.4	27.85
Pl+Kl+Yl	40.5	24.57

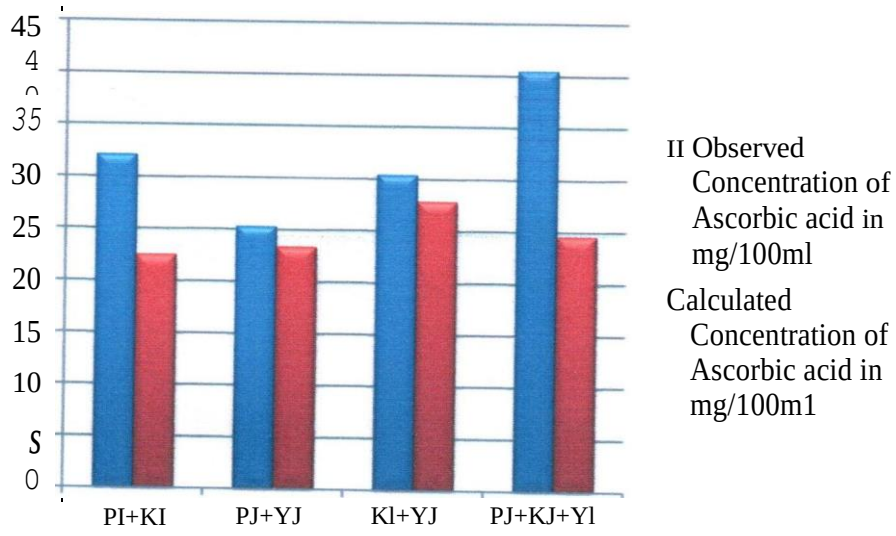

Figure 4.1.2 a bar graph showing observed and calculated concentration of Ascorbic acid in mg/lOOml **Table 4.1.3** Volume of KIO3 used /cm3 corresponding to Vitamin C content in PI, K1, and Y1

SAMPLE	**Volume of KIO used /em"**
PI	0.50
	0.60
	0.50
KI	0.90
	0.70
	0.80

Yl	0.90
	0.80
	0.90

Table 4.1.4 Correlation between Pi., Kl, and Yl

	Pl	Kl	Yl
Pl	1		
Kl	-0.86603	1	
Yl	-1	0.866025	1

4.2 Analysis of results

From the **table 4.1.3,** For Pl it indicates a negative correlation or no significant similarities with Kl (r= -0.86603) and neutral with variety YI (r= 0.000) this is because they are of different varieties as supported by Pruthi, 1963.

For variety Kl, it shows a strong positive statistically significant correlation with variety Yl and this could be because of Kl is a cross between Pl and Yl. This means they are closely related, and a negative correlation with Kl as stated above.

For each of the sample varieties there was a very great statistical significant correlation with r=l, between same varieties because the juice of all the individual varieties was mixed and the resultant was used for testing.

4.3 Discussion of results for Pl, Yl, and Kl

Results from this study show that purple Grandilla had a Vitamin C content of 18.0mg/1 00ml.This is comparatively lower than 21.9-69.9mg/100g, the range described by (Pruthi and Lal, 1959) on a similar study carried out in India. The difference in the vitamin C content could be as a result of the differences in time after picking and sample analysis, and geographical location of the variety of passion fruits (Pruthi, 1963).

In support on the date of picking (Pruthi, 1963) noted that detailed analysis of ripe purple passion fruits picked at fortnightly intervals from the same orchard revealed that differences in all physiochemical characteristics were highly significant (at 0.1 % level) except in reducing sugars (Pruthi etal, 1959). The passion fruits samples were bought from Kabale Central market which means they were not fresh from the garden and kept at home for 5 days due to fixed schedules of the laboratory and kept under common storage in a rack.

Also in support of difference it could have been due to locality or region, (Pruthi, 1963) the concentration of vitamin C in yellow passion fruits was different in those from Hawaii with range of 7.020.2mg/1 00g (Boyle etal, 1955) and 3 .5-24.5mg/1 00g of those in India (Pruthi, 1958). This was because these two areas have different soil types and climatic changes. Kabale in Uganda has different soil type and climate compared to Hawaii and India.

The yellow variety gave 28.7mg/100ml of vitamin C which is slightly higher than the range given by (Pruthi, 1958) and Boyle etal, (1955) 3.5-24.5mg/100g and 7.0-20.2mg/100g respectively. This is in support by (Pruthi, 1963) that different localities or regions where the passion fruits are grown can results into different concentrations of vitamin C due to the differences in the soil type and climatic changes of the different localities.

The Kawanda hybrid which is a cross between the yellow variety and the purple granadilla and purple in colour gave 27.0mg/100ml of vitamin c which falls in the range 21.9-69.9mg/100g as cited by (Pruthi, 19633) hence agrees.

The study found out that the highest concentration of vitamin C was found in the yellow variety (28. 7mg/100ml), the least was obtained in the purple Grandilla (18.0mg/100ml) and the vitamin C content of the purple Kawanda hybrid obtained was 27.0mg/100ml. These results are different possibly due to the fact that Ascorbic acid content in fruits depends on several factors like genotype or geographic location (Celikel, Demirsoy, & Demirsoy, 2008; Latocha,\ Jankowski, & Radzanowska, 2011).

Different varieties of passion fruit have been reported to have different Vitamin C content as supported by (Valente *et al.*, 2011) in his research on Ascorbic Acid content in exotic fruits where he pointed out that different passion fruits contain variable amounts of Ascorbic acid. Banana passion fruit had a mean value for Ascorbic acid content (40.5 mg/100 g) lower than the concentrations (63-93 mg/100 g)

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CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This chapter presents summary of the results, conclusions and recommendations of the study.

5.1 Conclusion

In order for an individual to acquire the great amount of vitamin c content directly from the passion ruits, one may consume purple Kawanda hybrid and yellow passion fruits which are high in vitamin c ontent. And when all the varieties are available one can make equal combination of all the three mrieties. It arofse after considering the percentage contribution of each variety to the daily requirement f Vitamin C in the body. According to Naidu, K. A., 2003, the current US recommended daily llowance (RDA) for ascorbic acid ranges between 100-120 mg/per day for adults. This means that by getting the mean of the RDA range, Pl provides 16.36%, KI provides 24.55%. YI provides 26.09%. >]+Kl provides 29.18%, Pl+Yl provides 23.0%, Kl+Yl provides 27.64% and Pl+Kl+Yl provides 16.82%.

i.2 Recommendation

with regards to the findings and conclusions made in this study about the **analysis of the variation of vitamin c content in different varieties of passion fruits from Ka bale central market,** the researcher gives the following recommendations.

people with high blood pressure (hypertension) should take passion fruit juice daily to lower it because passion fruits have good concentrations of Vitamin C.

vitamin C helps in the production of white blood cells known as lymphocytes and phagocytes, which elp protect the body against infections and boost body's immunity. Thus, people should often take passion fruit juice.

[igh vitamin C intakes from food or supplements have been shown to have a protective effect on 1inking and memory with age. People who have aged should take more passion fruit juice more often.

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