KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY,

KUMASI, GHANA

COLLEGE OF AGRICULTURE AND NATURAL RESOURCES

FACULTY OF AGRICULTURE

EFFECT OF POST HARVEST QUALITY MANAGEMENT PRACTICES ON FRUIT JUICES OF SMALL SCALE INDUSTRIES IN GHANA: A CASE STUDY OF FRUIT JUICE PRODUCERS IN THE ASHANTI REGION OF GHANA

BY

AMEYAW ISAAC

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A THESIS SUBMITTED TO THE DEPARTMENT OF HORTICULTURE, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF PHILOSOPHY (MPHIL POSTHARVEST TECHNNOLOGY)

BY

AMEYAW ISAAC

SEPTEMBER, 2016

DECLARATION

I, Ameyaw Isaac certify that except where due acknowledgement has been made, the research is that of my findings alone; the work has not been submitted previously, in whole or in part, to qualify for any other academic award; the content of the thesis is the result of research work which has been carried out since the official commencement date of the approved research program. Any omissions that may be detected in this work are my responsibility and not the institution.

AMEYAW ISAAC ………………………….. ……………………
(STUDENT) Signature Date

Certified by:

MR. PATRICK KUMAH ………………………….. ……………………
(MAIN SUPERVISOR) Signature Date

Certified by:

DR. LAURA ATUAH ………………………….. ……………………
(CO-SUPERVISOR) Signature Date

Certified by:

DR. B. K. MAALEKUU ………………………….. ……………………
(HEAD OF DEPARTMENT) Signature Date

DEDICATION

I dedicate this Thesis to God Almighty, who gave me life and strength throughout my study, and my family and friends, especially my elder brother Martin Mensah, my wife Deborah Anane and my daughter Martina Afia Sarpomaa Mensah whose prayers this work has become a success.

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ABSTRACT

Recent negative perception of people about locally produced fruits and vegetables have made the supervisory bodies to monitor the juice producers on the hazards associated with the unconcerned attitude to hygienic processing, packaging and transport of locally produced fruit and vegetable juices. However, little attention has been given to the hygienic handling of processed fruits and vegetables at the processing companies to the final consumer. This study, thus investigated the effect of postharvest quality management practices on fruit juices of small scale industries in Ghana, sought to assess people's perception, producers handling practices, the challenges as well as to assess the quality of the locally made fruit juice products on the market. A field survey was conducted in Tanoso, Tafo, Bremang, Ejisu, Mampong, Offinso,Obuasi and Konongo of the Ahsanti Region of Ghana. Interviews together with structured questionnaire were used in data collection of 35 employees from seven (7) pineapple and orange juice processing companies and 265 consumers randomly selected from the study areas. Laboratory work was also conducted at the Biochemistry and Biological Science laboratories (KNUST) – Kumasi, Ghana. Quality parameters assessed during the study included pH, Vitamin C, Ash, Total Titratable acidity, Total soluble solids, Total viable count, Yeast and mould and *Staphylococcus aureus* counts. 40% of consumers indicated that, imported fruit and vegetable juices were better than the locally made ones, 28.66% agreed that imported fruit juices were better whilst 21.01% of the consumers disagreed that imported fruit juices were better. Only a few (28.6%) of the juice producers used sodium hypochlorite to wash fruits, whilst majority (71.4%) did not wash fruits under running with sodium hypochlorite. The chi-square analysis showed that, major challenges like finance, non-existence of cold storage transport vehicles and the use of old processing equipments were significantly higher ($P<0.05$) within the processing companies. There were significant differences in physico-chemical and microbial parameters of juices from the companies to the markets. The levels of pH, vitamin C, TSS, TTA, Ash as well as microbial loads within the processing companies were significantly different from the codex standard. However, juice from the processing companies 1 and 5 were within the range for consumption from the codex and Ghana standards.

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LIST OF ABBREVIATIONS

EU	:	European Union
FDA	:	Food and Drug Authority
GEDC	:	Ghana Enterprise Development Commission
NBSSI	:	National Board for Small Scale Industries
SME	:	Small and Medium Enterprise
SSE	:	Small Scale Enterprise
SSFPI	:	Small Scale Food Processing Industries
UNIDO	:	United Nations Industrial Development Organization
USAID	:	United States Agency for International Development
FPMAG	:	Food Processing and Manufacturers Association of Ghana
WTO	:	World Trade Organisation
FAO	:	Food and Agricultural Organisation

CHAPTER ONE

1.0 INTRODUCTION

The world today is categorized by improving human well being and consumer health with the aim of ensuring the quality of food. Additionally, dietary and physical properties of foods are presently known as active and protective agents. Fresh cut fruits and vegetables and their processed products stand out as novel foods for the health needs of the consumer (Corbo *et al.*, 2010).In recent times, processed fruits consumption has increased mainly for the need to ensure balance diet and the health benefits associated with it. For instance low calories of fruits and vegetables consumption have eliminated many deficiency diseases. (Mohammed, 2007).

There is no doubt that food processing companies play major roles in Ghana's economy. Cereals and starchy crops are the major food crops generally grown in Ghana. Most of the processed foods in Ghana like fruit juices are done by small and medium enterprises.

Government of Ghana has initiated several policies with the aim of adding value to Ghana's Agricultural raw materials such as oil palm, cashew, cotton, cocoa and others. There have been many efforts by government to double the volume of locally processed raw materials for the last ten years. Generally, there have been tremendous improvement in local marketing and export of processed fruits and vegetables in Ghana (Boapeah, 1993).

The high production of perishable fruits in Ghana and failure on the part of the Government in establishing processing firms have made individuals using their own processing skills and techniques to process perishable fruits. About 30% of Ghana's annual food harvest is wasted due to the lack of storage facilities and underinvestment in the nation's food processing industry (Boapeah, 1993).Fruit juice plays significant roles in Ghana's meal from the catering and hospitality industries to individual's houses. It reduces food spoilage problems in the Ghanaian economy due to its long shelf life, convenience in terms of availability, ease of use. In spite of all the benefits to be derived from fruit juice production, no attention has been given to this sector of the industry. As a result of in adequate attention given to small food processing industries, its development has been hampered and it is faced with challenges (Boapeah, 1993). The concept of small scale food processing enterprises entails basic manufacturing activities of raw materials processing, artisans, repair and construction services. In Ghana, small scale enterprises can be described in two ways, that is the one which is based on the size of employment and the one based on capital requirements (Abor, 2006). However, the Ghana statistical service (GSS) and National Board for small scale industry (NBSSI) defines small scale industry as an industry which does not employ more than 30 persons and the one whose capital requirement for plants and other machines not more than hundred thousand U. S Dollars respectively. (Boapeah, 2006)

Small scale enterprise can be distinguished from large scale enterprises with regards to innovations and technology. (Kayanula and Quartey, 2000) from the researchers, the most commonly used criteria in defining small scale enterprise is the number of employees of the enterprise.

There have been transformations in the political, economic and other developmental forces which have created enabling environment for which worldwide leaders have expressed mutual desire in exploring new ways of improving the quality of their processed food. Due to this, globalization and the free market policies under the structural adjustment programmes has resulted to new opportunities and access to new resources and markets.

Recently, due to the busy schedule of work and other activities, the trend in consumption patterns of Ghanaians has changed tremendously. (Abor, 2006).People need fast foods that are ready to eat like fruit juice to avoid time wastage. Moreover, recent negative perception of people about the locally produced fruits and vegetables has resulted to investigate the effect of postharvest quality management practices on fruit juice producers.

The research sought to identify the postharvest quality management practices on pineapple and orange juice producers to determine their constituent's quality parameters. The research also assess product standard and minimized the tendencies of pineapple and orange juice products variability to meet the consumer's acceptability on the market
The main objective of this study therefore was to assess the quality management practices of fruits juice producers in Ashanti region and their effects on the quality of fruit juice produced.

Specifically the study sought to assess;

1. peoples' perception about locally made fruit juice products,
2. the producers handling practices at the production site,
3. the challenges in the fruit juice production chain and
4. the quality of locally made fruit juice products on the market.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 INTRODUCTION

This chapter presents the relevant information on effect of postharvest quality management practices on fruit juices of small scale industries in Ghana.

2.2 CONCEPT OF SMALL SCALE FOOD PROCESSING INDUSTRIES IN GHANA

The small scale food processing industries in Ghana highlights on general manufacturing of raw materials into useful products such as processing of fruits and vegetables into juices, sheanuts into sheabutter, palm fruits into palm oil, cocoa pods into soap etc. (Abor, 2006). The National Board for Small Scale Industries (NBSSI) provides numerous services in the area of innovation and technology to the local manufacturers as a means of improving quality by adding value in order to make our local products meet the demands of the international market. Moreover, the Food Processing and Manufacturers Association of Ghana (FPMAG) also provides guidelines to improving quality of the locally produced foods.

The fruit and vegetables processing industries in Ghana primarily produce juices from pineapple, mango, orange, melon, a mixture of banana and pineapple (Banapine Juices) etc. The major markets of these processing companies are in the Ashanti, Greater Accra, Brong Ahafo, Eastern region and the Northern region of Ghana (Kayanula and Quartey, 2000).

The juice industries use equipment's like boilers, blenders and packaging machine with in-depth knowledge and expertise in the production of natural fruits juices without excessive addition of fruit additives. This is achieved with the effort of research institutes, such as Food Research Institutes, at the Biochemistry Department of Kwame Nkrumah University of Science and Technology (KNUST-Kumasi, Ghana).

Small scale enterprise concept is defined in several ways as micro, small or mediumsized or large firms (Parker *et al.*, 1995). The micro firms use low skills, inputs and fewer labour with low capital for lower priced products. According to USAID report (2011) Kenya had less than twenty employees in most small firm enterprises. Moreover, a report from UNIDO, (2004) described firms with its employees ranging from 5-19 as small scale businesses in developing countries. According to Gisela and Daniel (1992) micro industries are with employees not more than five (5). On the other hand, the Ghana enterprise development commission (GEDC) defines it as those whose machines and raw materials for production total cost do not exceed one thousand Ghana cedis. Small firms can also be defined as a manufacturing unit whose workers do not exceed 30 workers (Kayanula and Quartey, 2000).

2.3 PERCEPTIONS PEOPLE HAVE ABOUT LOCALLY MADE FRUIT JUICE DRINK

Ghanaians have the perception that foreign fruit juices are healthier than the locally made ones in spite of all the modifications going on in the local industries. In the 60's and 70's the local processing industries had bad character for value addition. Our producers were experimenting on trial and error basis without conducting hygienic and standardization of what they produced. The inspectorate Authorities were not up and doing in monitoring what were produced and this resulted into several complains from consumers.

Most consumers believe that manufacturers of fruit juice do not produce under sanitized conditions. Another thought of problem related to this is that manufacturers in the metropolis do not have any association through which they can enforce any standard on its members.

The FDA has been providing support to the various industries in the area of quality assurance including massive sensitization and Education (Louknaan, 2010).

On the contrary, even though the inspectory bodies seem to be working, their efforts have little impact on the activities of the small scale food processors as most of them are seen operating under un healthy conditions especially in the open lorry stations and by the road sides with their products uncovered. The effects of such introduction of ready to eat foods to dust for instance make the food a habitat for micro-organism before they are consumed (Oppong, 2014). However, many consumers who are in the known of such situation tend to move away from consuming such foods. The supervisory bodies seem to give go ahead to some companies without inspecting their premises, equipments and labour force. Fruit juice consumers consider perceptual issues such as hygiene practices which borders on quality management practices like washing of raw materials, equipments etc.

A report by Aworh (1994) revealed that, majority of the people living at Nkawie, Toase, Afari selected suburbs in the Atwima Nwabiegya District of the Ashanti region considered foods such as "Waakye", "emotuo", "Shito" and "kenkey" to be produced under unhygienic conditions which make it unfit for human consumption in those areas. Furthermore, a comparative analysis conducted by Osei (2000) also made evident that, consumers practically were found to be more thoughtful to price change concerning locally made products. The authors found out that consumers attached prestige to buying imported products at higher prices than buying same for locally made products

2.4 MAJOR CHALLENGES OF SMALL SCALE FOOD PROCESSING INDUSTRIES

Small scale industries particularly those into food processing are the major source of living for most people globally, specifically those in rural folks (Osei, 2000). The local processing companies produce a wide range of products for the market locally, sometimes, they export some of their products. Despite these vital roles played by the local industries in socio-economic development, processors have challenges in the area of inputs, poor conditions of micro-economic development, low technology on production, inadequate inputs etc. Due to these challenges, there is the need for processing companies to adopt a comprehensive skill to address the bottle necks in order to ensure product quality (Osei, 2000). Small scale food processors in Ghana were not up and doing in the early 60's. The then Government, (Dr. Nkrumah) initiated policies to encourage local industries to improve on quality (Abor, 2006).

The local food processing industries were seen as political threat despite the extensive economic reforms introduced in Ghana. These food processing industries had difficulty in production, absorption of large fixed cost and higher cost of service (Kayanula and Quartey, 2000). There are numerous constrains associated with small scale processing industries. These are

2.4.1 Financial Constraints

Small organizations are normally under- resourced. That is, the terms and conditions on loans granted to Small Scale Enterprises do not suit their needs. On the contrary, even when small scale enterprises including fruit and vegetable juice producers are able to access loans, however the collateral and other conditions surrounding it makes it difficult for these enterprises. Sometimes they are given short terms loans for which they have no option, since it is the only way of getting their raw materials and equipments (Kayanula and Quartey,2000) Aryeetey *et al*., (1994) indicated that, 38 % of small scale food processing industries surveyed revealed credit sourcing as the major constraints. This support the fact that SSFPIs have inadequate access to credit for their business expansion.

Foreign Direct Investment (FDI) is an indispensable element for economic transformation by countries requiring to achieving sustainable economic growth and poverty alleviation. In addition to Aryeetey's position, SSEs especially fruit juice producers in Ghana are not positioned strategically to attract investors. Fruit juice producers like any other small scale food processors in Ghana face the challenge with investment, inadequate capabilities of investment promotion and less access to potential investors as well as difficulty in obtaining financing from the financial institutions. In contrast, those that are able to obtain financing from the financial institutions have had to grapple with high rates of interests which in the end consume a big chunk of the returns on the investment.

Accessing credit remains a key constraint to small scale food processing industries in Ghana as between 24-52% are still under resourced (Parker *et al.*, 1995). However, the cause of this problem ban be linked to both the firm and the financial institutions. There is a low level of managerial skills, no proper credit history, no knowledge in preparing business plans and difficulty in securing collaterals. These are the key factors explaining why entrepreneurs are unable to access loans from the banks. However, at the financial institutions levels, there is high risk of contracting loans to small firms since the recovery rate is very low. There is an also high administrative charge of applying business with small scale, food processing industries. The enabling environment within which they operate and access credit for their business expansion relates to non-financial constraints. This in sum has contributed to the poor financing of small scale firms in Ghana and the effect leads to food insecurity and the provision of substandard products for human consumption. Nevertheless, small scale industries can form associations in order to command group interests to which the financial institutions can be well confident to offer financial assistance to the firms.

2.4.2 Labour and Market

Labour markets are also limitation to SSEs looking at the extensive under employment and unemployment rates in the country. In a situation where SSEs need skilled workers, they tend to reducing cost and this affects operation. Aryeetey *et al.*, (1994) reported that, about 2% of SSEs had problems of acquiring skilled labour whilst 9% of them had problems of finding skilled personnel.

Generally there exist the perceptions that food processing or preparation is the mainstay of women and for that matter the number of females into food processing far outweighs males. However, considering the size of operations of small scale food processors in Ghana as compared to other European countries usually does not require a lot of hands in its activities. Aryeetey *et al.*, (1994) found out that 62% of the small scale firms surveyed were sole proprietors and had employees less than or equal to 5 workers.

Normally what the SSFPI produced are generally sold in the local markets but that notwithstanding, there has been efforts of value addition to ensure that what is being produce are sent to the international market. Recently, about 30% of the locally produced fruit and vegetable juices are exported to the neighbouring countries like Cote D'Ivoire, Burkina Faso, Togo, Nigeria etc. (Abor, 2006).

2.4.3 Equipments and Technology

Again in the study by Aryeetey *et al.*, (1994), they reported that, more than 4% of Ghanaian small scale food processing industries has difficulties in gaining access to relevant information and technologies. Due to this, there has been limitation of innovation and competitiveness of SSEs. Small scale processors such as fruit juice producers besides other constraints on capital and labour is also challenged by difficulties surrounding innovation, new technologies to value addition.

Due to this, small scale food processors have glued to their old ways of processing food except for food preservation which has experienced a little bit of improvement. However, very few food processing firms have now engaged in the use of gas and ovens for the provision of heat for food preparation.

2.4.4 Demand at the Local Market

There has been a decline in the operations of state enterprises due to recent economic policies, however the private enterprises have created opportunities for small scale food processing industries (Abor, 2006). Difficulty in accessing public contracts and subcontracts couple with hard bidding processes and scarce access to proper information and documentation have slowed down SSEs participation in the domestic market. Although, small scale food processing industries have problems in product distribution such as inefficient transport and packaging. These pose high limitations to access domestic market for smaller firms, particularly fruit juice production. The way and manner the product is packaged and displayed on shelves in the various markets makes it difficult for the consuming public to make out which in a way prevents the fruit juice producers from meeting the local demand.

2.4.5 Demand at the International Market

Small scale food processing industries are now competing with the international market and hence the need to add value in order to expand market share. Despite every effort by the SSEs to improve quality, there are still challenges in the area of product standardization, inadequate access to international partners, inefficient quality control mechanism and low international experience in marketing. These factors impede international market expansion. Due to these challenges most of the domestic firms do not export their produce, with the exception of companies owned by foreign partners.

Recently about 17% of the domestic firms can export their output (Aryeetey *et al.*, 1994)

2.4.6 Legal Challenges

Though, organizational transformations have been enhanced there is still the need to improve on the activities of the SSEs. High start-up cost for SSEs, including registration and licensing procedures can cause unnecessary burdens on SSEs (Louknaan, 2010). The unbearable cost of legal claims and prolonged court proceedings thwart the activities of SSEs. The cumbersome processes in business registration are key issues that affect SSEs (Abor, 2006).

In view of this, there is a legal blind spot as a result of anti-trust. The legislation always favours the bigger firms whilst lack of protection for the smaller firms limits Small Scale food processor's access to foreign technologies. Also, the legal environment promises greater improvement of small scale firms but the implementation of the legislative instrument has been obscured in favour of large firms which generate large volumes of tax revenues for the government. Legal requirements in support of business registration and licensing also pose a challenge for small scale owners. For instance business owners away from Accra who wish to register and license their businesses would have to travel to Accra in order to have their businesses registered or licensed.

2.4.7 Lack of Entrepreneurial and Business Management Skills

Entrepreneurial and business management skills are the key areas in developing SSEs. According to Abor, (2006) lack of managerial skills in the small scale food processors has adverse effects on the quality of products. Moreover, inadequate support services for the local processors hamper production, especially fruit juice producers. Although there have been training and advisory services for SSEs, there is still a wide gap on small scale food producers and as SSEs sector as a whole. The local manufacturers must blend what they produce locally with innovative ideas to project what is being produced internationally, this can be achieved through better entrepreneurial development with well-equipped inputs and skilled personnel's.

2.4.8 Institutional challenges

However, more of the entrepreneurs even though have associations have not been up and doing in competing with the international market (Boapeah, 2006). According to the report, interdependence among SSEs is very minimal. The Union leaders who are the mouth piece for SSFPIs in policy-making processes have had limited roles as compared to those at the larger processing companies. In addition to this, the vibrant economics of coordinated arrangements in processing and sales among SSEs have not been widely explored (Osei, 2000).

Fruit juice producers in Ghana do not have any association as can be said of the other producers like tomato sellers association, yam sellers association and among others. The inability of this has resulted in the producers' failure to enforce any collective decision in the interest of the producers.

2.5 PROCESSING OF FRUITS INTO JUICE

Fruits and vegetables are used up as fresh, slightly processed, and processed forms such as canned, frozen, dried, preserves and fermented products. Codex Alimentarius (2007) reported that fruits can be processed into different forms, namely fruit juices, cuts-fruits, dried or dehydrated fruits and fruit salads. The most commonly manufactured product is fruit and vegetables juice.

According to the International Fresh- Cut Produce Association (IFPA), fresh cut fruits and vegetables are those peeled, trimmed or 100% usable cut product which is packed to give consumers high nutrition, aroma and convenience while still maintaining its freshness Codex Aliminantariu (2007), defines fruit juice as extracted juice from natural fruits with little or no additives for consumption. The juice may be unfermented or fermentable obtained by a mechanical process and preserved exclusively by physical means.

The manufacturing process of fruits which includes cuts and juices involves many steps and different sub-processes. Targeting the market will ensure variations in processing methods. Local sellers, who sell to the large market, generally keep produce at an optimum temperature without deterioration. Also, Supermarkets, that sell to large consumers display fresh cut produce under favourable temperature and under hygienic conditions on daily basis. Big processors, who also target supermarkets and the food service sector, often include chemical treatment as a processing step to ensure longer shelf-life of their product (James and Rolle, 2010).

2.7 PHYSICOCHEMICAL CHANGES IN FRUIT JUICE DURING STORAGE

Generally there are various physicochemical and biological changes of processed fruit products which may lead to changes in flavor, color, aroma and texture. (Singh, 2010). Physical characteristics of fruits such as moisture content, fruit weight, texture, delayed ripening and physical damage to the fruit greatly affect the chemical compositions of the fruit such as soluble sugars, pH, Vitamin C, phenols content and titratable acidity (Gorney, 2001). Hence biological influence in soluble sugars, phenols, sugars and vitamin c levels in fruit juices are very vital since they are used as basic quality index.

(Gorney, 2001).

2.7.1 Changes in Vitamin C content during storage

Vitamin C content of pineapple is dependent on factors such as the cultivar, stage of maturity, conditions of storage and the part of fruit. Its content in fresh pineapples ranges from about 20 to 34.44 mg/100 ml of juice (Ngoddy and Ihekoronye, 2011).The vitamin C content in processed fruits readily changed chemically to dehydroscobic acid in basic solution whilst it is stable acidic medium. The oxidation pathway of vitamin c breakdown is the key reaction pathway for vitamin c lost in fruits during storage, (Singh, 2010) Breakdown of vitamin level result in aerobic and anaerobic patyway. Breakdown of vitamin C in aerobic channel takes place during processing whilst the anaerobic breakdown of vitamin is during storage. Moreover, rate of breakdown ascorbic and citric acids are affected temperature, PH, time of storage and activity of water (Ngoddy and Ihekoranye, 2011).

According to Gorney (2001), a long chain ascorbic molecule is formed from oxides and traced element that is, copper (II) oxides and iron (III) oxides. This long complex compound break down to form a charge unit(ascorbic radical anion)This then reacts with the oxides to give the dehydroscorbic acid(DHAA).Vitamin C degradation is caused when oxygen is absent. The rate of breakdown is caused when PH is less than 3 or 4 and therefore responsible for loss of vitamin C in packed cut fresh fruits and vegetables

2.7.2 Changes in total soluble sugars (Brix) during storage

Total soluble sugars (Brix) in fruits and vegetables has been ascribed by some authors as having an increasing trend whiles others also report of them of having a decreasing trend during storage. The increase in soluble solids during storage may not necessary reflect in sucrose, glucose and fructose but rather may result in release of soluble components from insoluble material in the fruits while a reduction in TSS in fruits and vegetables is as a result of a reduction in carbohydrates, pectins or proteins hydrolysis and glycosides breakdown at excessive respiration (Gorney, 2001).

According to Agar *et al., (1999)* at high temperature, TSS of fruits and vegetables reduces and an increase in metabolic activities since sugar level also reduce. Moreover, Nunes *et al., (*2008) reported that, there is a decrease of total soluble solids (TSS) over a period of storage time.

2.7.3 Changes in Total Titratable Acidity and pH during Storage

The change in PH of fruits and vegetables is due to the slower rate of metabolic activities and the treatments given to them (Jitareerat et al., 2007).The acid in fruits determines the quality and consumer acceptability.

The change in pH might be due to the effect of treatment on the biochemical condition of the fruit and slower rate of respiration and metabolic activity (Jitareerat *et al*., 2007). A study conducted by Garcia *et al., (*2011),on coated and uncoated fruits indicate that pH and TTA decrease over a period of storage time. Others also have reported that an increase in TTA and a decrease in PH in pineapple and mangoes

2.7.4 Micro Flora Associated with Fresh Juices

Micro flora associated with fresh juice production reduces the quality of the juice.

Microbial contaminants are found in soil, water, on animals or in air (Mohammed, 2007). Food spoilage is mostly caused by microbial growth which results in undesirable change in color, flavor and taste(Singh, 2010).The microorganisms thrives under favourable conditions, a high temperature suppresses growth of microbes while at an optimum temperature,their growth increases

Among microorganisms, yeast and moulds have a competitive advantage over bacteria as they easily cause spoilage in processed fruits at a PH ranging from 2.4-5.0.

According to Ghana Standards Authority (GSA) specifications, yeasts and moulds for preserved fruit and juices are not to exceed $1.5x10^5$ whiles that for unpreserved juices are supposed to be $1.0x10^3$cfu/ml (GSA, 2012).

2.8 FOOD REGULATION AND QUALITY CONTROL

Legislation on food in any nation should be based on the laid down principles and standards globally. In all countries, there are laws and regulations on food which makes the requirements of government to be met by the processors in ensuring that the food is free from any contaminants. These minimum quality standards included in the legislation ensures that, the food are un adulterated and are not intended to deceive the end user with any fraudulent practices .Implementing food laws and regulations is vital since government all over the world are supported in initiating effective modern national food laws and regulations. Team of advisors in consultation with food safety experts provide technical support by instituting legal framework with WTO and Codex requirements with effective guidelines which form a benchmark for food safety.

The initiative adopted by the Food Processing and Manufacturers Association of Ghana (FPMAG), have not been fully achieved considering the state and approach of work adopted by the NBSSI in executing its functions.

The manufacturing industries have adopted a number of international quality standards that provide a basis for implementation and compliance with the requirements. The most common standard is ISO 9002, which refers to the international standard organization

(Olympio and Kumah, 2008). The food processing industry has for many years utilized HACCP (Hazard Analysis and Critical Control Points) as the basis for producing safe food.

2.9 SOURCES OF FRUITS FOR PROCESSING

The producer's major source of fruits for production was from the farmers. The most common fruits for processing in Ghana are Pineapple, Orange and Mango. Most of the companies produce one natural fruit drink from pineapple or Orange while others also produce from mango or Banana.

Ghana has diverse climate and altitude conditions which are conducive to various agricultural activities. There are several lakes and perennial rivers that have great potentials for irrigated agriculture. The groundwater potential of the country is about 3.1 billion cubic meters. Groundwater in the country is generally of good quality and it is frequently used to supply homes and farmsteads. The potentially irrigable land area of the country is estimated at 20 million hectares, out of which only about 0.5% is currently under irrigation (Corbo *et al.*, 2010).S Endowed with favorable weather, altitude, adequate water and availability of suitable soils, the potential to develop horticultural crops, such as fruits, vegetables and root crops is great in Ghana (Boapeah, 1993).

2.10 FRUITS GRADING

Pineapple and orange fruits are graded according to size, weight, colour, etc. Grading by size is the most important method employed by the processing companies to get rid of malformed, immatured and over matured produced during processing (Boapeah, 1993). Producers consider maturity in grading to ensure that, the quality of processed fruits as well as the shelf life are maintained (Kader, 1992).

2.10.1 Advantages of Fruits Grading

1. It helps in buying and selling of the produce since consumers will have trust in what is being produced.
2. It ensures better price at the market.
3. It is done to remove malformed or defect fruits from what is being produced. 4. It ensures equity between the consumers and the producers

2.10.2 Grading Standards

Pineapples and Oranges for processing must be harvested when;

1. Fruits are matured and well formed
2. Fruits are free from defects such as spots, bruises and scratches
3. Fruits have no chemical residues.
4. Fruits have no rots, moulds etc. Kadar (1992)

2.10.3 Ghana Quality Standards for Fruit Juices (Gs 724:2003)

This highlights on fruits hygiene and strict action on growth of microbes. The standard describes juices to be free from total coliforms and yeast and mould growth. According to Ghana Standards Authority (GSA) specifications, yeasts and moulds for preserved fruit and juices are not to exceed $1.5x10^5$ whiles that for unpreserved juices are supposed to be 1.0x103cfu/ml (GSA, 2012).

2.11 SOME QUALITY MANAGEMENT PRACTICES

2.11.1 Refrigeration

Fruits and vegetables undergo various biochemical reactions. The rate of biochemical reactions in fruits and vegetables are linked with temperature and storage period (Gorney, 2010).Hence temperature and storage periods of fruits and vegetables are important at all times in processing. Consumers have expectation that, processed fruit juices must be available at all times throughout the year. To achieve this, there should be an effective system to prevent deterioration of these products. (Brennan, 2006). Refrigeration means a situation where by the temperature of a produce is cooled to a temperature of zero degree Celsius to prevent deterioration. Refrigeration reduces the proliferation of microorganism in food and is the gentlest method of food preservation (Gorney, 2010). However, refrigeration has adverse effects on the taste, texture, and nutritive value Low refrigerating temperatures has been reported to cause damage called ―chilling injury to fruits and vegetables. Chilling injury is a term when fruits and vegetables from tropical and subtropical origin exhibit a physiological dysfunction when exposed to non-freezing temperatures below 12°C (Mahajan, 2013). Hence, the need to have optimum storage conditions for fresh cut and juice (Gorney, 2010). Optimum storage conditions of 7 to12°C are recommended for whole pineapples for 14 to 20 days whiles 5°C to 30°C are for juices and fresh cut products (Paull, 1993).

2.11.2 Packaging

Packaging enables the distribution of processed fruits and vegetables to ensure products quality to the consumer. Packaging prevents physiological and microbiological spoilage of a produce. Modified Atmosphere (MA) and MAP, packaging can reduces the respiration rate of produce and slows the rate of spoilage (James and Rolle, 2010). Packaging material for fruits and vegetables include thermos formed containers with film overwraps and rigid plastic containers. Other packaging films used include perforated thin, low density polyethylene (LDPE), high density polyethylene (HPDE), monolayer polyvinylchloride (PVC) and ethylene vinyl acetate. The main packaging material used for fresh cut and processed products are the plain low and high density polyethylene bags and bottles (James and Rolle, 2010).

2.11.3 Transportation

Deterioration of produce during transport can be minimized by using cold storage transport vehicles. Closed vehicles without refrigeration must be avoided when transporting fresh fruits and vegetables except on very short distances, such as local deliveries from farmers or wholesalers to nearby retailers. Cold storage transport vehicles should be used for transportation processed fruits and vegetables juices to the various market centres. (Kader, 1992). Modified Atmosphere Package (MAP) should be used for safety of the produce during transport. Well packaging of produce with initial wrapping of produce in perforated or non-perforated plastic bags depending on nature of produce prior to packaging would be necessary (Kitinoja and kader,2003).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 INTRODUCTION

The chapter describes the methodology used for the study. It gives details about the sampling techniques, population and the research instruments used in collecting data for the study. It also discusses the data collection methods and data analysis plan.

3.2 STUDY AREA AND SAMPLIMG TECHNIQUES

The study area comprised of Kumasi metropolis (that is Tanoso, Tafo and Bremang) as well as Ejisu, Obuasi, Mampong, Offinso and Konongo municipalities. Tanoso, Tafo, Bremang and Ejisu were chosen as the study areas for the factories of the fruit juice producers while the consumers comprised of Tanoso, Tafo, Bremang Ejisu, Obuasi, Mampong, Offinso and Konongo all in the same region. To avoid bias and improve the

validity and reliability of the study, the simple random sampling technique was employed to select five employees from four (4) pineapple and three (3) orange fruit juice companies from Tanoso-Apatrapa, Tafo, Bremang and Ejisu while two hundred and sixty-five(265) consumers were also randomly selected from Obuasi, Mampong,
Offinso and Konongo where the companies have their open markets.

3.3 THE FIELD SURVEY

Primary data was obtained by interviewing 35 employees from (7) fruit juice companies and two hundred and sixty-five (265) fruit juice consumers from the selected areas.

3.4 QUESTIONNAIRE CONSTRUCTION

Structured questionnaire was used to assess the requisite information required. The data collection covered the following, Biodata of producers/employees of fruit juice companies, fruit juice consumers' perception, producers' handling practices and the challenges of the juice companies

3.4.1 Questionnaire Administration

Interviews using structured questionnaire were administered to purposively selected pineapple and orange fruit juice consumers and producers in the study areas to find out their perceptions about the locally made fruit juice factories, handling practices and the challenges faced by the factories. Interviews and other personal observations were employed to ascertain the conditions under which production was carried out. Structured questionnaires were administered to two hundred and sixty-five (265) pineapple and orange fruit juice consumers and thirty-five (35) employees from seven (7) pineapple and orange fruit juice companies in the selected areas.

3.5 EXPERIMENTAL SITE

The physico-chemical and microbial analysis was carried out at the Biochemistry and Biological Science Laboratories at KNUST, Kumasi Ghana.

3.6 SAMPLE SIZE

A total of forty-two (42) fruit juice samples were collected from the factories and open markets of seven pineapple and orange juice producers. That is four (4) pineapple juice companies and three (3) orange juice companies. This was achieved by collecting twenty-four (24) samples of pineapple juices from the factories and open markets of the four companies and eighteen(18) samples of orange juices from the factories and open markets of the three companies

3.7 SOURCES OF FRUIT JUICE

The pineapple juice were bought from the factories and open markets of four (4) pineapple juice producers across the selected areas whilst the orange juice were also bought from the factories and open markets of three (3) orange juice producers. The areas were Tanoso-Apatrapa, Ejisu, Tafo, Bremang, Offinso, Mampong, Obuasi and Konongo all in Ashanti Region, Ghana.

Harvesting
↓
Field Containers
↓
Transport to packing house
↓
Trimming fruit stalk
↓
Washing/Cleaning/Pre-cooling
↓
Sorting to remove defects
↓
Waxing (applied alone or with fungicide)
↓
Size grading
↓
↓
↓

Packing in container (use of dividers)

Storage (Low temperature)

Load in transit vehicles

Figure 3.1: Flow Diagram of a Postharvest Handling System of Pineapple Fruits The diagram above indicates a flow chart of postharvest handling system of pineapple fruits from the farmer's gate to the factories. After harvesting, the fruits are packed in field containers and transported to the packing houses where they are trimmed, precooled, sorted, waxed, graded and finally loaded to be transported to the factories.

Harvesting
↓
Washing
↓
Sorting
↓
Packing
↓
Cooling
↓
Storage
↓
Transporting

Figure 3.2: Flow Diagram of a Postharvest Handling System of Orange Fruits The flow diagram above indicates postharvest handling system of orange fruits from the farmers to the factories. After harvesting, the fruits are cleaned with water and sorted. They are again packed in containers and finally transported to the various industries for processing.

All the seven (7) pineapple and orange juice factories visited indicated that, they extract the juice from the fruits by crushing, squeezing and straining.

Fresh Fruits → Washing

↓

Crushing

↓

Straining

↓

Boiling/Pasteurization

↓

Adding of ingredients

↓

Bottling/labeling → Cold Storage

↓

Distribution

Figure 3.3: Flow Chart Showing the Steps of Preparation of Pineapple Juice

Delivery of ripped orange fruits

↓

washed, peeled and cut into quarters

↓

Extract juice using manual extractor

↓

filter juice with a mesh strainer and mixed with sugar at 5% of its weight

↓

Heat juice to boiling point for stabilization of the microorganisms liable to induce fermentation

↓

bottle and cape juice while hot

↓

Sterilize juice for 10 minutes

↓

wash bottles, cool, label and store in dry and dark place

Figure 3.4: Flow Chart Showing the Steps of Preparation of Orange Juice at the Processing companies

3.8 ETHICAL CONSIDERATION

A letter was provided to producers and consumers of fruit juice in the study area explaining to them about providing sensitive and confidential information. They were assured of the privacy of their information, and that their identities would not be revealed. It was made to them that, their contributions were voluntary. To further assured them of confidentiality, unmarked self_sealing envelopes were provided to the juice producers for the return of questionnaires.

3.9 PARAMETERS CARRIED OUT

3.9.1 pH

The pH of the fruit juice was measured using pH meter. Thirty grams weight of each fruit juice was poured into a glass cylinder. The pH electrode washed in distilled water was placed in the filtrate for a few minutes to allow the reading to be stable and the pH value recorded for all the fruit juice (AOAC, 1992).

3.9.2 Vitamin C of Fruit Juice

This was determined by using the 2, 6-Dichloroindophenol Titrimetric method and the results recorded as mg/100g of vegetables and fruits (AOAC, 2006).

3.9.3 Determination of Total Titratable Acidity (TTA) of Fruit Juice

25mls of each of the juice was transferred into a 125mls conical flask. Another 25mls of distilled water and four drops of phenolphthalein indicator were added to each of the juice. The solutions were titrated against 0.1M sodium hydroxide until there was a sharp colour change from light yellow to pink. The titre volume of NAOH added in each case was multiplied by the citric acid factor (0.07) to obtain the total titratable acidity (Dadzie and Orchard, 1997).

3.9.4 Determination of Total Soluble Solids (TSS) of Fruit Juice

Total soluble solids of the pineapple, orange and pineapple-orange mix fruit juice were determined by a hand held refractometer (ATAGO Brix=0 to 33%). When a small amount of juice was placed on the prism of the refractometer and the readings were taken and expressed as percentage sugar Brix (Cheour *et al.*, 1991).

3.9.5 Determination of Total Ash of the Juice

25mls of juice was measured into a weighed petri dish. It was evaporated to dryness on water bath and heated for 30 minutes at 500- ^{o} 550C. The charred mass was broken in petri dish. Water was added, filtered through ashless paper and washed thoroughly with water. The contents was dried and heated for 30 minutes at about 525C ^{o} until all the carbon was burnt off. The Filtrate was added and evaporated to dryness and again heated for 15 minutes at 525$_{o}$C. It was then cooled in a desiccator and weighed (weight x) and heated for 5 minutes at 525$_{o}$C and cooled for 1hr in a desiccator. The total ash from the last weight was calculated (AOAC, 2007).

$$\% \text{ By Mass} = \frac{m2 - m3}{mo - m1} \times 100$$

Where M0 = Mass in gm. of dish and test portion
M1 = Mass in gm. of empty dish
M2 = Mass in gm. of dish and acid insoluble ash
M3 = Mass in gm. of empty dish

3.9.6 Determination of Microbial Contamination of the Fruit Juice

This gives a quantitative idea about the presence of microorganisms such as bacteria (*staphylococcus aureus*) as well as yeast and mould in the sample. Sample of fruit juice was immersed in 4% of Clorox for 1 minute. With the aid of sterile forceps, samples of the juice were transferred into sterile distilled water to wash off excess Clorox. The samples were further transferred onto a sterile blotter paper to leave the juice dry and then transferred onto the sterile PDA in Petri dish. Plate was incubated at room temperature until growth occurred. Identification was done by the use of colony and spore characteristics (Magan, 2007).

3.10 DATA ANALYSIS

Data from the field survey was analyzed using SPSS and results presented as pie charts, means, percentages, frequencies and tables. The chemical parameters were also analyzed using IBM version 21 statistical Package for analysis of paired sample t-test and the analysis of variance was carried out with Minitab Version 17 to determine the differences existing among the treatments. Mean separation was done using LSD at 5% significance level. Chi-square analysis was carried out to determine the levels of the challenges from the factories.

CHAPTER FOUR

4.0 RESULTS

4.1 INTRODUCTION

This chapter presents the findings from the survey carried out at the fruit processing companies and on their respective consumers. It also contains findings from the laboratory experiments conducted on the sample fruit juice.

4.2 FIELD SURVEY

A total of four (4) pineapple and three (3) orange juice producing companies were randomly selected and interviewed. Five employees from each company were selected. In addition to this, 265 consumers were also selected and interviewed from the study area as indicated below.

Table 4.1: List of Fruit Juice Companies, their Product and Sample Population

Area/Location	**Company**	**Company Tag**	**Company's products**	**Population**
Tanoso–Apatrapa	Massig	P1	Pineapple juice	50
Bremang	Daavee Ventures	P2	Pineapple Juice	65
Ejisu	Our Ventures	P3	Pineapple Juice	40
Tafo	Yagpa Company Ltd.	P4	Pineapple juice	40
Oduom	First New Age Ltd.	P5	Orange juice	35
Bremang	Golden Rich Ventures	P6	Orange juice	20
Tafo	Yvonne OB Venture	P7	Orange juice	50
Total				**300**

4.3 BIODATA OF RESPONDENTS

Biodata of respondents such as gender, age in years and educational level affects the responses people give to questions. Thus, it was necessary for data to be collected on these demographic variables. This biodata was established to know the nature of the respondents who participated in the study.

4.3.1 Gender Distribution of Respondents

From table 4.1, 68% of the respondents were female while 32% were male. Table 4.2: Gender Distribution of Respondents

Gender	Frequency	Percentage %
Male	95	32
Female	205	68
Total	**300**	**100**

4.3.2 Age Distribution of Respondents

The data obtained indicated that, 50% of the respondents were below the ages of 20. Again, 33% of the respondents were between the ages of 20 and 30. 10% of the respondents were between 30 and 40 years. The number of respondents who were above

40 years was 7%.

Table 4.3: Age Distribution of Respondents

Age	Frequency	Percentage %
Below 20 years	150	50
20 to 30 years	100	33
30 to 40 years	30	10
40 and above	20	7
Total	**300**	**100**

4.3.3 Educational Level of Respondents

The response obtained indicated that 40% of the respondents had SHS/Commercial qualifications. 20%, 17% and 6% of the respondents had basic qualification, diploma and 1st Degree and professional qualification, respectively

Table 4.4: Educational level of Respondents

Educational Background	Frequency	Percentage %
Basic	60	20
SHS / Commercial	120	40
Diploma	50	17
1st and 2nd Degree	50	17
Professional	20	16
Total	**300**	**100**

4.4 PERCEPTION OF FRUIT JUICE CONSUMERS

4.4.1 Purchase of locally made fruit juice

93.33% of consumers purchased locally made fruit juice while 6.67% did not purchase locally made fruit juice.

Table 4.5: Purchase of locally made fruit juice

Response	Frequency	Percentage %
Yes	280	93.33
No	20	6.67
Total	**300**	**100**

4.4.2 Reasons for Purchase of Locally made fruit juice

From table 4.2.1, 51% stated that, they purchased locally made fruit juice based on its taste, 23% also purchased locally made fruit juice based on the package. 20% purchased based on cheap price while the remaining 6% purchased based on its nutritional value. Table 4.6: Reasons for Purchase of Locally made Fruit Juice

Reasons	Frequency	Percentage %
Taste	152	51
Well Packaged	69	23
Cheap Price	61	20
Nutrients	18	6
Total	**300**	**100**

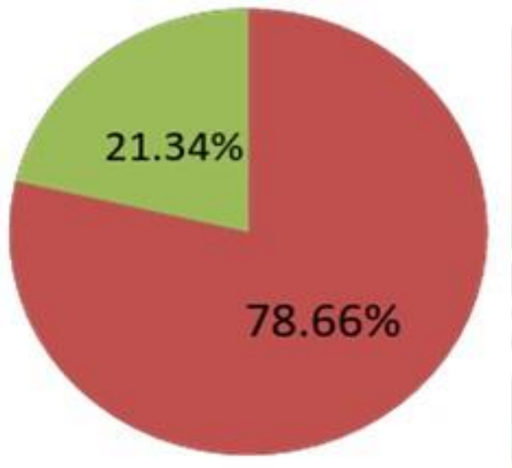

Figure 4.1: Preference of Imported Fruit Juice

78.66% of consumers preferred imported fruit juice while 21.34% did not prefer imported fruit juice.

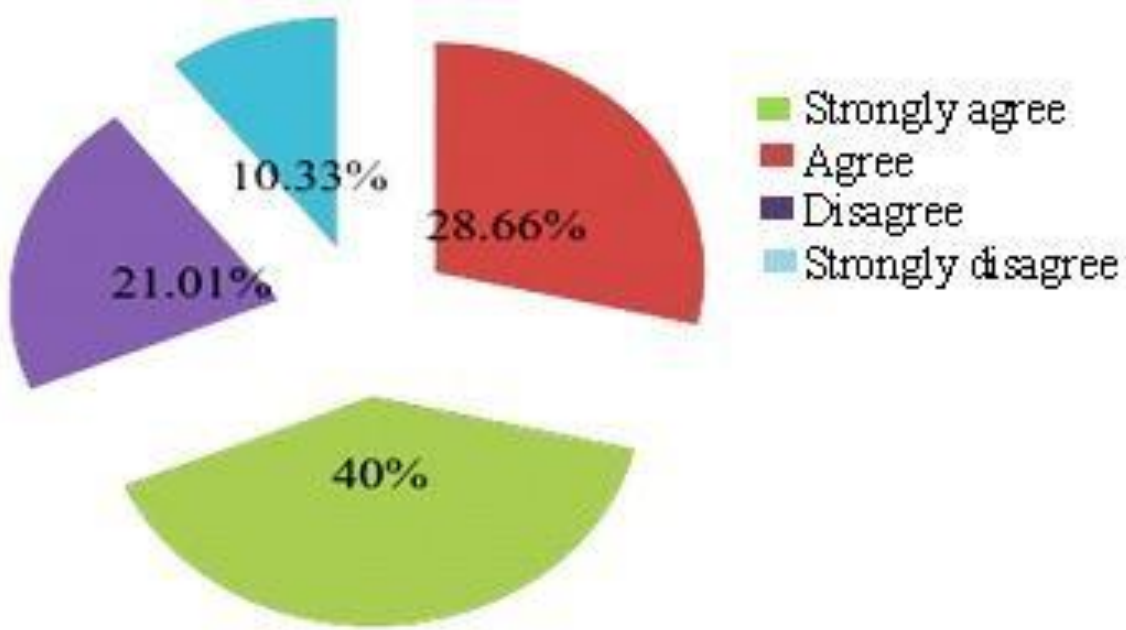

Figure 4.2: Quality of Imported and Locally Made Fruit Juice

From Figure 4.2, 40% of the respondents strongly agreed that imported fruit juice was better than the locally made ones. 28.66% agreed that imported fruit juice was better than the locally made. Another 21.01% disagreed that imported fruit juice were better than the locally made juice while 10.33% strongly disagreed that imported juice was better than the locally made juice.

4.5 FRUIT JUICE PRODUCERS HANDLING PRACTICES

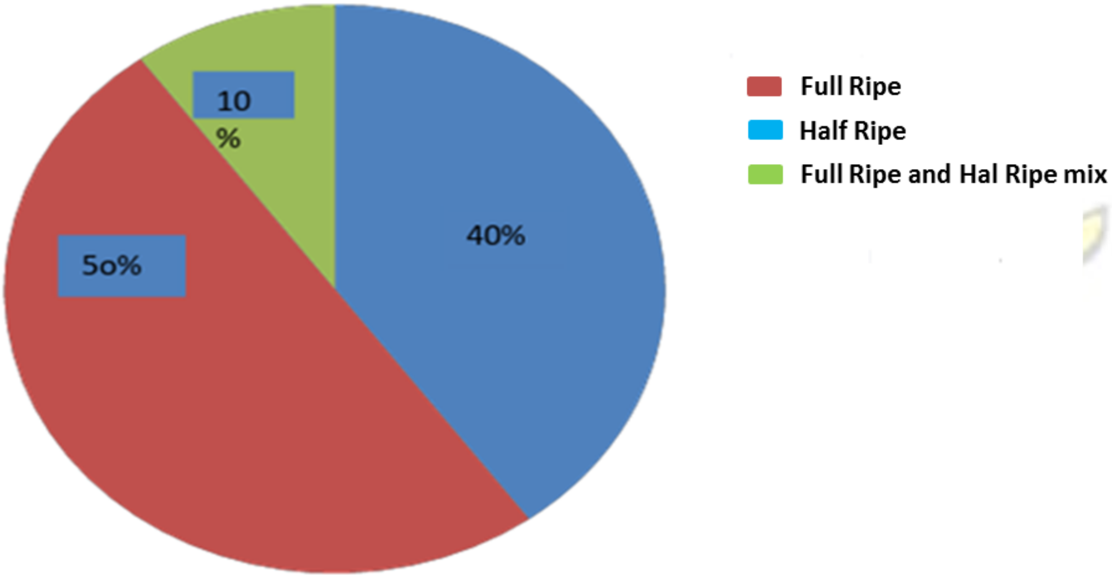

Figure 4.3: Stages of Fruits ripening used for production

50% of the producers used full ripped orange and pineapple fruits only for processing. 40% also used half ripped orange and pineapple fruits for processing, whilst 10% of the producers also used fully and half ripped mix fruits for processing.

4.5.1 Sorting of Fruits before Processing

85.7% of the producers sorted the fruits before processing while 14.3% did not sort fruits before processing.

Table 4.7: Sorting of Fruits before Processing

Response	Frequency	Percentage %
Yes	30	85.7
No	5	14.3
Total	**35**	**100**

4.5.2 Washing of fruits before Processing

All the producers (100%) interviewed indicated that, they washed fruits before processing.

Table 4.8: Washing of fruits before Processing

Response	Frequency	Percentage %
Yes	35	100
No	0	0
Total	**35**	**100**

4.5.3 Use of running water for washing fruits

From table 4.9, only a few (28.6%) of the producers used running water to wash the fruits. More producers (71.4%) did not use running water to wash fruits before processing.

Table 4.9**:** Use of running water for washing fruits

Response	Frequency	Percentage %
Yes	10	28.6
No	25	71.4
Total	**35**	**100**

4.5a ANALYSIS OF THE CHALLENGES OF THE JUICE PRODUCERS

From the analysis, it was revealed that, all the respondents (100%) from three producing companies (1, 2, and 6) indicated finance was a major challenge. 80% from company 3 whilst companies 4 and 5 also recorded 60%. It was again revealed that unstable power supply recorded 100% from companies 3, 6 and 7. Additionally, 80% from company 1 and 2 stated that, power was a challenge. Moreover, 60% of the respondents that were interviewed from companies1, 4, 5 and 6 indicated raw material was a bigger challenge to their factories. Again, 40% from factory 1 stated that, they did not get enough raw materials whilst all (100%) from factory 3 indicated raw material was their major challenge (table 4.10a). The analysis also showed that all respondents (100%) except 1 and 2 did not have cold storage transport vehicles. Furthermore, all the respondents from factory 6 indicated that, they used old processing equipments whilst 60% from factories, P3 and P4 used old equipments for fruit processing.

However, a few (40%) from producer 1 stated they did not get enough raw materials. The analysis also revealed that all the factories (100%) except 1 did not have cold storage transport vehicle. Furthermore, all the respondents from factory 6 indicated that, they used old processing equipments whilst 60% from factory 3 and P4 used old equipments for fruit processing. All the respondents (100%) from factories 5 and 6 did not have quality control officers whilst a few (40%) from P3 and P4 had quality control officers. The respondents also revealed that land tenure system and license acquisition were also challenge. 60% indicated that, they had difficulty in securing land. Another 40% (P3, P5 and P6) indicated that, land tenure system in Ghana was a bigger challenge.

Table 4.10a: Analysis of the Challenges of Fruit Juice Producers

Challenges	Response	P1	P2	P3	P4	P5	P6	P7	Total
Finance	Yes	5 (100%)	2 (40%)	2 (40%)	3 (60%)	3(60%)	5 (100%)	5(100%)	71.4%
	No	0	3(60 %)	3(60 %)	2 (40%)	2 (40%)	0	0	28.6%
Cold storage transport vehicle	Yes	5 (100%)	2 (40%)	2 (40%)	0	0	0	0	25.7%
	No	0	3(60 %)	3(60 %)	5 (100%)	5 (100%)	5 (100%)	5 (100%)	74.3%
Use of old processing equipments	Yes	1 (20%)	2(40%)	3(60%)	3(60%)	2(40%)	5 (100%)	0	86.7%
	No	4 (80%)	3 (60%)	2 (40%)	2 (40%)	3 (60%)	0	5 (100%)	13.3%
Lack of quality control officers	Yes	0	2 (40%)	2 (40%)	3 (60%)	0	5 (100%)	5 (100%)	48.6%
	No	5 (100%)	3(60 %)	3(60 %)	2 (40%)	5 (100%)	0	0	51.4%
Land tenure system	Yes	1 (20%)	3 (60%)	2(40%)	3 (60%)	2(40%)	2(40%)	2(40%)	42.9%
	No	4 (80%)	2 (40%)	3 (60%)	2 (40%)	3 (60%)	3 (60%)	3 (60%)	57.1%
Difficulty in securing license	Yes	1 (20%)	1 (20%)	5 (100%)	3 (60%)	2(40%)	4 (80%)	3 (60%)	54.3%
	No	4 (80%)	4 (80%)	0	2 (40%)	3 (60%)	1 (20%)	2 (40%)	45.7%

Inadequate raw materials	Yes	3 (60%)	2 (40%)	2 (40%)	3 (60%)	3 (60%)	5 (100%)	5 (100%)	65.7%
	No	2 (40%)	3(60 %)	3(60 %)	2 (40%)	2 (40%)	0	0	34.3%

4.5b CHI-SQUARE TEST ANALYSIS OF THE CHALLENGES OF THE JUICE PRODUCERS

The chi-square analysis was used to find the levels of the challenges in the seven factories to be able to assess the effect of the challenges from one factory to another. From table 4.10b, it was revealed that unstable power supply (85.7%) recorded the highest challenge which was not significantly different ($P>0.05$) from the producers. However, cold storage transport vehicles recorded 74.3% which was significantly higher ($P<0.05$) within the producers. Similarly, the use of old equipment (45%) and lack of quality control officers (42.9%) differed significantly ($P<0.05$) from the chi-square analysis. Moreover, inadequate raw materials (62.9%), land tenure system (87.1%) and finance (71.1%) were not significantly different within the factories. Additionally, licensing and business registration was not significantly higher ($P>0.05$) within the factories from the chi-square test.

Table 4.10b: Chi-Square Test Analysis of the Challenges of the Juice Producers

Challenge	Response of Producers		Total	x^2	*d.f*	Asymp. Sig (2-sided)
	Yes (%)	**No (%)**				
Finance	71.1 (27)	22.9 (8)	35	10.046	6	0.0123
Unstable power supply	85.7 (30)	14.3 (5)	35	5.600	6	0.469
Cold storage transport	74.3 (26)	25.7(9)	35	30.812	6	0.000
Use of old processing equipment	45.7 (16)	54.3 (19)	35	12.434	6	0.053
Lack of quality control officer	42.9 (15)	57.1 (20)	35	12.133	6	0.059
Land tenure system	42.9 (15)	57.1 (20)	35	2.333	6	0.887
Difficulty in securing license and business registration	54.3 (19)	45.7 (16)	35	10.822	6	0.094
Inadequate raw materials	62.9 (22)	37.1 (13)	35	4.161	6	0.655

Means separation was done using Lsd at 5% significance level

4.6 CHEMICAL ANALYSIS OF PINEAPPLE JUICE

4.6.1 Analysis of Physicochemical Parameters and Microbial Loads of Pineapple Juice from Factory 1 (P1)

Paired sample t-test was used to determine whether the pH, vitamin C, Total Soluble Solids (TSS), Total Titratable Acidity (TTA), Ash as well as Total Viable Count (TVC/cfu/ml), Yeast and Mould Count (YMC/cfu/ml) and *Staphylococcus aureus* (SC/cfu/ml) of pineapple Juice from factory one (1) was the same as the market. From table 5 the pH of juice from the factory (4.63±0.06) was significantly higher from the market (4.17±0.01), t (2) = 16.386, P<0.05. Similarly, the vitamin C content of juice from the factory (27.05±0.06) was significantly higher than the market (26.36±0.06), t(2) = 21.490, P<0.05. However, the TSS from the factory (11.363±0.01) was not significantly different from the market (11.360±0.01), t (2) = 0.500, P>0.05. Similarly, the TTA from the factory (0.26±0.01) was not significantly different from the market (0.22±0.01), t(2) = 3.464, P>0.05. Additionally, the Ash recorded from the factory (0.65±0.01) was also significantly higher than those from the market (0.62±0.01), t(2) = 8.0, P<0.05.

The paired sample t-test also showed that, the Total Viable Count from the factory ($1.450 \times 10^3 \pm 0.58$) was significantly higher from the market ($1.501 \times 10^3 \pm 1$), t (2) = -76, P<0.05. Similarly, Yeast and Moulds from the factory recorded ($1.007 \times 10^3 \pm 11.55$) which was significantly different from the market ($1.202 \times 10^3 \pm 3.46$), t(2) = -41.857, P<0.05. Additionally, the *Staphylococcus aureus* counts recorded from the factory ($1.9669 \times 10^4 \pm 573.89$) was not significantly different from the market ($2.0333 \times 10^4 \pm 577.35$), t (2) = -1.0, P>0.05.

Table 4.11: Paired Sample T-Test of Physico-Chemical Parameters and Microbial Analysis of Pineapple Juice from Factory 1 (P_1)

Physico-chemical Analysis of Pineapple Juice from Producer 1					
Parameters	**Factory**	**Market**	***t***	***df***	**p-value**
PH	4.63±0.06	4.17±0.01	16.386	2	0.004
VITAMIN C	27.05±0.06	26.36±0.06	21.490	2	0.002
TSS	11.36±0.01	11.360±0.01	0.500	2	0.667
TTA	0.26±0.01	0.22±0.01	3.464	2	0.074
ASH	0.65±0.01	0.62±0.01	8.0	2	0.015

Microbial analysis of Pineapple Juice from Producer 1					
Parameters	**Factory**	**Market**	***t***	***df***	**p-value**
TVC/cfu/ml	1.45 x 10^3±0.58	1.50x10^3±1	-76	2	0.000
YMC/cfu/ml	1.01x10^3 ±11.55	1.20x 10^3±3.46	-41.857	2	0.001
SC/cfu/ml	1.97 x 10^4±573.89	2.03 x 10^4±577.35	-1.0	2	0.423

Means separation was done using Lsd at 5% significance level

TVC/cfu/ml – Total Viable Count in colony forming unit

YMC/cfu/ml – Yeast and Mould Count in colony forming unit

SaC/cfu/ml – *Staphylococcus aureus* Counts in colony forming unit

4.6.2 Analysis of Physicochemical Parameters and Microbial Loads of Pineapple Juice from Factory 2 (P2)

The paired sample t-test showed that the pH content of juice from the factory (4.14±0.05) was not significantly different from the market (4.07±0.03), t (2) =1.866, P>0.05. However, the vitamin C content from the factory (26.60±0.01) was significantly higher than those from market (25.07±0.06), t (2) = 39.714, P<0.05. Again, the TSS from the factory (10.78±0.29) was not significantly different from the market (10.39±0.06), t (2) = 2.029, P>0.05. There was a significant different TTA level from the factory (2.02±0.01) to the market (1.01±0.01), t (2) = 152, P<0.05. Additionally, the Total Ash content of juice from the factory (0.57±0.02) was not significantly different from the market (0.54±0.01), t (2) = 1.437, P>0.05.

The paired sample t-test showed that Total Viable Count from the factory of producer 2 (P2) ($2.001 \times 10^3 \pm 1$) was significantly different from the market ($3.0001 \times 10^5 \pm 2$), t(2)= -89.4002, P<0.05. Similarly, Yeast and Mould as well as *Staphylococcus aureus* counts recorded from the factory ($1.202 \times 10^3 \pm 4$, $3.500 \times 10^3 \pm 100$) were not significantly different from the market ($2.00 \times 10^4 \pm 2$, $4.3 \times 10^5 \pm 26.458$), t(2)= -58.481, -27.841, P<0.05.

Table 4.12: Paired Sample T-Test of Physico-Chemical Parameters and Microbial Analysis of Pineapple Juice from Factory 2 (P_2)

Physico-chemical Analysis of Pineapple Juice from Producer 2					
Parameters	**Factory**	**Market**	***t***	***df***	**p-value**
PH	4.14±0.05	4.07±0.03	1.866	2	0.203
VITAMIN C	26.60±0.01	25.07±0.06	39.714	2	0.001
TSS	10.78±0.29	10.39±0.06	2.029	2	0.180
TTA	2.02±0.01	1.01±0.01	152	2	0.000
ASH	0.57±0.02	0.54±0.01	1.437	2	0.287
Microbial analysis of Pineapple Juice from Producer 2					
Parameters	**Factory**	**Market**	***t***	***df***	**p-value**
TVC/cfu/ml	$2.00 \times 10^3 \pm 1$	$3.00 \text{ X } 10^5 \pm 2$	-89.4002	2	0.000
YMC/cfu/ml	$1.20 \times 10^3 \pm 4$	$2.00 \times 10^4 \pm 2$	-58.48096	2	0.000
SC/cfu/ml	$3.50 \times 10^3 \pm 100$	$4.30 \times 10^5 \pm 26458$	-27.841	2	0.001

Means separation was done using Lsd at 5% significance level

TVC/cfu/ml – Total Viable Count in colony forming unit

YMC/cfu/ml – Yeast and Mould Count in colony forming unit

SaC/cfu/ml – *Staphylococcus aureus* Counts in colony forming unit

4.6.3 Analysis of Physicochemical Parameters and Microbial Loads of Pineapple Juice from Factory 3 (P3)

From the paired sample t-test analysis, the pH content of juice from the factory of producer 4 (4.29±0.04) was significantly higher than market (4.27±0.06), t(2)= 1.732, P>0.05. However, vitamin C content of juice from the factory recorded (25.52±0.01) which was significantly different from the market (24.21±0.01), t(2)= 391, P<0.05.

Similarly, Total Soluble Solids (TSS) content of juice from the factory recorded (11.05±0.01) which was significantly higher from the market (11.78±0.01), t (2) = 63.22, P>0.05. Additionally, the TTA level of juice from the factory (0.14±0.05) was not significantly different from the market (0.14±0.01), t (2) = - 0.105, P>0.05. Total Ash content of juice also recorded (0.56±0.01) from the factory which was not significantly higher from the market (0.570±0.01), t (2)= -1.512, P>0.05.

The paired sample t-test was again used to determine whether the Total Viable Count, Yeast and Mould counts as well *Staphylococcus aureus* counts from factory was the same as the market. From table 4.13, the total viable count from the factory (2.000 x 10^4 1±1.73) was significantly higher from the market (2.5001 x 10^4 ±2.31), t (2) = 2466.15, P<0.05. Similarly, yeast and mould count from the factory (1.501 x 10^3 ±2.89) was significantly different from the market ((2.300 x 10^4 ±0.58), t (2) = -11583.82, P<0.05. Additionally, *Staphylococcus aureus* count (3.25 x 10^2 ±0.58) from the factory, was not significantly different from the market (3.56 x 10^4 ±0.0), t (2) = -105823,

P<0.05.

Table 4.13: Paired Sample T-Test of Physico-Chemical Parameters and Microbial Analysis of Pineapple Juice from Factory 3 (P_3)

Physico-chemical Analysis of Pineapple Juice from Producer 4					
Parameters	**Factory**	**Market**	***T***	***df***	**p-value**
PH	4.29±0.04	4.27±0.06	1.732	2	0.225
VIT	25.52±0.01	24.21±0.01	391	2	0.000
TSS	11.05±0.01	11.78±0.01	-63.22	2	0.000
TTA	0.14±0.05	0.14±0.01	-0.105	2	0.926
ASH	0.56±0.01	0.57±0.01	-1.512	2	0.270

Microbial analysis of Pineapple Juice from Producer 3					
Parameters	**Factory**	**Market**	***T***	***df***	**p-value**
TVC/cfu/ml	(2.00 x 10^4 1±1.73	2.50 x 10^4 ±2.31	-2466.15	2	0.000
YMC/cfu/ml	1.50 x 10^3 ±2.89	2.30 x 10^4 ±0.58	-11583.82	2	0.000
SC/cfu/ml	3.25 x 10^2 ±0.58	3.56 x 10^4 ±0.0	-105823	2	0.000

Means separation was done using Lsd at 5% significance level

TVC/cfu/ml – Total Viable Count in colony forming unit

YMC/cfu/ml – Yeast and Mould Count in colony forming unit

SaC/cfu/ml – *Staphylococcus aureus* Counts in colony forming unit

4.6.4 Analysis of Physicochemical Parameters and Microbial Loads of Pineapple Juice from Factory 4 (P4)

From the paired sample t-test analysis, the pH content of pineapple juice from the factory of producer 4 was (4.31±0.01) which differed significantly from the market (4.11±0.01), t(2)=16.92, P<0.05. Similarly, vitamin C content of the juice recorded 24.90±0.01 from the factory which was significantly different from the market (22.37±0.06), t (265.73, P<0.05. However, the mean TSS of juice from the factory (11.71±0.43) was not significantly different from the market (12.57±0.51), t (2)= -1.74, P>0.05. TTA of juices from the factory (0.21±0.01) and the market (0.21±0.02) were not significantly different from each other, t (2)=-0.23, P>0.05. Total Ash content of the juice recorded (0.53±0.01) from the factory was significantly higher from the market (0.51±0.01), t (2)= 5.00, P<0.05.

The levels of total viable counts in pineapple juices from the factory (2.2000 x 10^4 ±1) and open market (2.4433 x 10^4 ±58) of P7 differed significantly, t(2)= -72.62, P<0.05 (Table 4.14). Similarly, yeast and mould counts of P4 pineapple juice from the factory recorded (1.268 x 10^3 ±59) which was significantly different from the market (2.1000 x 10^4 ±1000), t (2)= -35.96, P<0.05. However, *Staphylococcus aureus* count recorded at the factory

(3.703 x 10^3 ±55) was significantly higher (P<0.038), t (2)= -79.23 than the mean *Staphylococcus aureus* count from the market (4.60 x 10^5 ±10000).

Table 4.14: Paired Sample T-Test of Physico-Chemical Parameters and Microbial Analysis of Pineapple Juice from Factory 4 (P_4)

Physico-chemical Analysis of Pineapple Juice from Producer 4					
Parameters	**Factory**	**Market**	***t***	***df***	**p-value**
PH	4.31±0.01	4.11±0.01	16.92	2	0.003
VITAMIN C	24.90±0.01	22.37±0.06	65.73	2	0.000
TSS	11.71±0.43	12.57±0.51	-1.74	2	0.225
TTA	0.21±0.01	0.21±0.02	-0.23	2	0.840
ASH	0.53±0.01	0.51±0.01	-5.00	2	0.038

Microbial analysis of Pineapple Juice from Producer 4					
Parameters	**Factory**	**Market**	***t***	***df***	**p-value**
TVC/cfu/ml	2.20 x 10^4 ±1	2.44 x 10^4 ±58	-72.62	2	0.001
YMC/cfu/ml	1.27 x 10^3 ±59	2.10 x 10^4 ±1000	-35.96	2	0.000
SC/cfu/ml	3.70 x 10^3 ±55	4.60 x 10^5 ±10000	-79.23	2	0.000

Means separation was done using Lsd at 5% significance level
TVC/cfu/ml – Total Viable Count in colony forming unit
YMC/cfu/ml – Yeast and Mould Count in colony forming unit
SaC/cfu/ml – *Staphylococcus aureus* Counts in colony forming unit

4.7 ANALYSIS OF PHYSICO-CHEMICAL PARAMETERS AND MICROBIAL COUNTS OF ORANGE JUICE FROM FACTORY 5 (P5)

4.7.1 Paired Sample T-Test of Physicochemical Parameters and Microbial Analysis of Orange Juice from Factory 5 (P5)

Paired sample t-test was used to determine whether pH, vitamin C, Total Soluble Solids (TSS), Total Titratable Acidity (TTA) and Total Ash contents of orange juice from the factory of producer 5 were the same as the market. From table 4.15, the pH content of juice from the factory (4.03±0.01) was significantly different from the market (5.51±0.02), t(2)

= -122.589, P<0.05. The vitamin C content of the juice from the factory (24.90±0.44) was significantly higher than from the market (20.92±0.35), t(9.856), P<0.05. Similarly, the TSS of orange juice from the factory (12.51±0.01) was significantly different from the market (10.79±0.01), t (2) = 148.956, P<0.05. Total Ash content of orange juice from the factory recorded 0.66±0.01, and was significantly different from the market (0.64±0.01), t(2) = 7.0, P<0.05. Furthermore, TTA of fruit juice from the factory (1.55±0.01) was significantly higher than the market (1.61±0.01), t
(2) = -7.181, P<0.05.

The paired sample t-test also indicated significant differences in Yeast and Mould and *Staphylococcus aureus* counts of juice from the factory to the market. However, the t-test did not determine significant difference in total viable count of juice from factory (1.2233 x 10^3 ±25.17) to the market (1.2700 x 10^3 ±30.00), t (2) -2.646, P>0.05 (table 4.15)

Table 4.15: Paired Sample T-Test of Physico-Chemical Parameters and Microbial Analysis of Orange Juice from Factory 5 (P_5)

Physico-chemical Analysis of orange Juice of P5					
Parameters	**Factory**	**Market**	***t***	***df***	**p-value**
PH	4.03±0.01	5.51±0.02	-122.589	2	0.000
VIT C	24.90±0.44	20.92±0.35	9.856	2	0.01
TSS	12.51±0.01	10.79±0.01	148.956	2	0.000
TTA	1.55±0.01	1.61±0.01	-7.181	2	0.019
ASH	0.66±0.01	0.64±0.01	7.0	2	0.020

Microbial analysis of orange Juice of P5					
Parameters	**F**	**M**	***t***	***df***	**p-value**
TVC/cfu/ml	1.22 x 10^3 ±25.17	1.27 x 10^3 ±30.00	-2.646	2	0.118
YMC/cfu/ml	1.24 x 10^4 ±109.70	1.32 x 10^4 ±251.66	-7.833	2	0.016
SC/cfu/ml	1.02 x 10^2 ±2.52	1.32 x 10^2 ±12.58	-3.626	2	0.068

Means separation was done using Lsd at 5% significance level
TVC/cfu/ml – Total Viable Count in colony forming unit
YMC/cfu/ml – Yeast and Mould Count in colony forming unit
SaC/cfu/ml – *Staphylococcus aureus* Counts in colony forming unit

4.7.2 Analysis of Physicochemical Parameters and Microbial Loads of Orange Juice from Factory 6 (P6)

From the analysis pH content of juice from the factory was 4.7±0.0 which was significantly higher than the market (4.2±0.0), t (2) = 151.0, P<0.05. Similarly, there were significant differences (P<0.05) in vitamin C and TSS of juice from the factory to the market. However, the t-test also indicated that, TTA of juice from the factory

(1.5±0.0) was not significantly different from the market (1.5±0.0), t (2) = 2.0, P>0.05. The least ash content of orange juice was from the factory (0.5±0.0) of Producer 6 which did not differed from the market (0.6±0.0), t(2) = -0.756, P>0.05.

Moreover, the paired sample t-test also revealed that, total viable count, yeast and moulds as well as *Staphylococcus aureus* counts of all the orange juice sampled from the factory of producer 6 were not significantly higher than the market. However, the highest total viable count was recorded from the market (3.6800 x 10^3) of producer 6 (table

4.16).

Table 4.16: Paired Sample T-Test of Physico-Chemical Parameters and Microbial Analysis of Orange Juice from Factory 6 (P_6)

Physico-chemical Analysis of orange Juice from P6					
Parameters	**Factory**	**Market**	***t***	***df***	**p-value**
PH	4.70±0.0	4.20±0.0	151.0	2	0.000
VIT C	23.00±0.0	22.10±0.0	46	2	0.000
TSS	12.50±0.1	10.80±0.0	31.947	2	0.001
TTA	1.50±0.0	1.50±0.0	2.0	2	0.184
ASH	0.50±0.0	0.60±0.0	-0.756	2	0.529
Microbial analysis of orange Juice from P6					
Parameters	**F**	**M**	***T***	***df***	**p-value**
TVC/cfu/ml	1.50 x 10^4 ±30.0	3.68 x 10^3 ±135377.9	-1.006	2	0.420
YMC/cfu/ml	2.07 x 10^4 ± 8066.6	3.13 x 10^4 ±577.4	-2.208	2	0.158
SC/cfu/ml	1.24 x 10^2 ±3.2	5.36 10^2 ±704.7	-1.01	2	0.419

Means separation was done using Lsd at 5% significance level

TVC/cfu/ml – Total Viable Count in colony forming unit
YMC/cfu/ml – Yeast and Mould Count in colony forming unit
SaC/cfu/ml – *Staphylococcus aureus* Counts in colony forming unit

4.7.3 Analysis of Physicochemical Parameters and Microbial Loads of Orange Juice from Factory 7 (P7)

From the results in table 4.17, the paired sample t-test showed a significant difference in pH content of juice from the factory (4.4±0.2) to the market (3.38±0.32), t(2)= 10.521, P<0.05. However, vitamin C content of juice from the factory (26.4±0.0) was not significantly higher than the market (26.28±0.25), t (2) = 1.073, P>0.05. Total soluble solids (TSS) of juice recorded 11.97±0.0 from the factory which was significantly different from the market (10.04±0.02), t (2) = 580, P<0.05. Similarly, TTA of juice from the factory (0.21±0.0) was significantly higher than the market (0.11±0.01), t (2) = 12.095, P<0.05. Total ash content of juice recorded 0.60±0.01 at the factory and was not significantly different (P>0.05) from the market.

The paired sample t-test also showed that, yeast and mould counts of orange juice from the factory ($2.3666 \times 10^4 \pm 3214.55$) differed significantly from the market ($2.4333 \times 10^5 \pm 5773.5027$), t(2)= -42.450, P<0.05. However, total viable and staphylococcus counts of juice from the factory of P7 were not significantly higher (P>0.05) than the market.

(Table 4.17).

Table 4.17: Paired Sample T-Test of physico-Chemical Parameters and Microbial Analysis of Orange Juice from Factory 7 (P_7)

Physico-chemical Analysis of orange Juice from P7					
Parameters	**Factory**	**Market**	***t***	***df***	**p-value**
PH	4.40±0.2	3.38±0.32	10.521	2	0.009
VIT C	26.40±0.0	26.28±0.25	1.073	2	0.395
TSS	11.97±0.0	10.04±0.02	580	2	0.000
TTA	0.21±0.0	0.11±0.01	12.095	2	0.007

ASH	0.60±0.01	0.61±0.02	-0.500	2	0.667

Microbial analysis of Orange Juice from P7

Parameters	**F**	**M**	***t***	***df***	**p-value**
TVC/cfu/ml	2.3416 x 10^3±2.88675	2.7000 10^3 ± 476.97	-1.297	2	0.324
YMC/cfu/ml	2.3666 x 10^4 ± 3214.55	2.4333 x 10^5 ±5773.5027	-42.450	2	0.001
SC/cfu/ml	1.3200 x 10^3 ±60.82	1.407 x 10^3 ±39	-2.14	2	0.166

Means separation was done using Lsd at 5% significance level

TVC/cfu/ml – Total Viable Count in colony forming unit

YMC/cfu/ml – Yeast and Mould Count in colony forming unit

SaC/cfu/ml – *Staphylococcus aureus* Counts in colony forming unit

4.8 ANALYSIS OF VARIANCE OF PHYSICO-CHEMICAL PARAMETERS OF PINEAPPLEJUICE

Table 4.18 shows the level of pH, Vitamin C, TSS, TTA and Ash of pineapple juice sampled from four producers in the study area. The pH across the different producers were significantly different at p<0.001, F (3) = 72.50. Fisher's multiple comparison test revealed that, level of pH juice from the factories of P3 and P4 were not significantly higher (p<0.05) than the remaining factories. The highest pH of juice was recorded from the factory of P1 (4.63±0.06).

Furthermore, Vitamin C content of juice differed significantly (P<0.001) across the factories with P1, P2, P3 and P4 showing average Vitamin C content of 27.05±0.06, 26.60±0.01, 25.52±0.01, 24.90±0.01. The average of Vitamin C content in the juice was significantly (p<0.05) higher at P1, P2, P3 and the least vitamin C content was recorded from the factory of P4. Similarly TSS content of juice from all the factories differed significantly (P<0.001). However, Fishers multiple comparison test revealed that, TSS of juice from P2 and P3 were significantly higher (p<0.05) than the remaining factories.

TTA of pineapple juice also differed significantly ($P<0.001$) within the factories. However, P1 and P4 were not significantly different ($p>0.05$), but were significantly higher ($p<0.05$) than P2 and P3. The highest TTA of juice was recorded from the factory of P2 (2.02±0.01) and the least TTA of juice was from P3 (0.14±0.05). Additionally the

Ash content of juice was significantly higher ($p<0.001$) within the producers. However, P2 and P3 were not significantly different ($p<0.05$) from each other.

Table 4.18: One-Way Analysis of Variance of Physico-Chemical Parameters of Pineapple Juice Producers

Physico-Chemical Parameters					
Producer Name	PH	VIT C	TSS	TTA	ASH
P1	4.63±0.06 A	27.05±0.06 a	11.36±0.01 ab	0.26±0.01 b	0.65±0.01 a
P2	4.14±0.05 c	26.60±0.01 b	10.78±0.29 c	2.02±0.01 a	0.57±0.02 b
P3	4.29±0.04 b	25.52±0.01 c	11.05±0.01 bc	0.14±0.05 c	0.56±0.01 b
P4	4.31±0.01 b	24.90±0.01 d	11.71±0.43 a	0.21±0.01 b	0.53±0.01 c
Total	4.35±0.19	26.02±0.89	11.22±0.42	0.66±0.82	0.58±0.05
Minimum	4.11	24.89	10.45	0.11	0.52
Maximum	4.67	27.11	12.00	2.03	0.66
F-ratio	72.50	3548.72	7.18	3309.97	42.01
df	3	3	3	3	3
P-value	0.000	0.000	0.012	0.000	0.000
Codex Standard 247 (2005)	3.5-4.5	20-30mg/100ml	9.5-12.0	0.7-1.5	
Means that share the same letters along a column are not significantly different at α = 5% (0.05) significance level by Fisher's LSD multiple comparison test					

4.9 ANALYSIS OF VARIANCE OF MICROBIAL LOADS OF PINEAPPLE JUICE

The Fisher's multiple comparison test also indicated significantly differences ($p<0.001$) in total viable count of juice within the companies. The highest TVC of juice was recorded from the factory of P3 ($2.0001x10^4±2$) and the least was from P2

($1.450x10^3±0.6$). Similarly, yeast and mould counts of juice differed significantly ($p>0.001$) across the factories with the highest count recorded from P3 ($1.502x10^3±2.9$) and the least from P2 ($1.007x10^3$). Moreover, *Staphylococcus aureus* count of juice was significantly higher ($P<0.001$) among the juice companies. However, factories 2 and 4 counts were not significantly higher ($p>0.05$) from each other, according to the Fisher's comparison test. The highest *Staphylococcus aureus* count of juice was recorded from company P2 ($3.500x10^3±100.0$) and the least from P1 ($1.96687x10^5±573.9$)

Table 4.19: One-Way Analysis of Variance of Microbial Loads of Pineapple Juice Producers

Microbial Loads			
Producer Name	TVC/cfu/ml	YMC/cfu/ml	SC/cfu/ml
P1	$1.450x10^3$±0.6 d	$1.007x10^3$±12 d	$1.96687x10^5$±573.9 a
P2	$2.001x10^3$±1.2 c	$1.202x10^3$±4.04 c	$3.500x10^3$±100.0 b
P3	$2.0001x10^4$±2 b	$1.502x10^3$±2.9 a	$3.26x10^2$±0.58 c
P4	$2.2x10^4$±0.6 a	$1.268x10^3$±58.6 b	$3.703x10^2$±55.08 b
Total	$1.1363x10^4$±10095.21	$1.245x10^3$±186.41	$6.799x10^3$±7889.49
Min	$1.450x10^3$	1000	$3.25x10^2$
Max	$2.2001x10^4$	$1.505x10^3$	$2.000x10^5$
F-ratio	$2.99000000x10^8$	$1.39x10^2$	$2.664x10^3$
df	3	3	3
P-value	0.000	0.000	0.000
Codex Standard 247 (2005)	$1.0\text{-}2.0x10^4$cfu/ml	$1.0\text{-}2.5x10^3$cfu/ml	$1.0\text{-}1.5x10^3$cfu/ml

Means that share the same letters along a column are not significantly different at α = 5% (0.05) significance level by Fisher's LSD multiple comparison test

TVC/cfu/ml – Total Viable Count in colony forming unit

YMC/cfu/ml – Yeast and Mould Count in colony forming unit

SaC/cfu/ml – *Staphylococcus aureus* Counts in colony forming unit

4.10 ANALYSIS OF VARIANCE OF PHYSICO-CHEMICAL PARAMETERS OF ORANGE JUICE

From the analysis, the levels of pH, Vitamin C, Total Soluble Solids, Total Titratable Acidity and Ash contents of orange juice were significantly higher ($p>0.001$) across the factories of P5, P6 and P7. Fisher's multiple comparison test indicated significantly differences ($p<0.05$) in pH content of juice. The highest pH content of juice was from P6 (4.68±0.0) and the lowest from the factory of P5 (4.03±0.01). Similarly Vitamin C content also differed significantly ($p>0.001$) among the factories with the highest Vitamin C content of juice from P7 (26.43±0.01) and the lowest from P6 (23.01±0.01).

TSS content of juice from the factories of P5 and P6 were not significantly different ($p>0.05$) from each other but the two were significantly higher ($p<0.05$) from the factory of P7 (11.97±0.10). Additionally, TTA of fruit juice across the three factories also differed significantly ($p>0.001$). The highest TTA of juice was recorded from the factory of P5 (1.55±0.01) and the least was recorded from the factory of P7 (0.22±0.01). Moreover the Ash content of juice was significantly higher ($p<0.05$) among the juice factories. The highest Ash content of juice was recorded from the factory of P5 (0.66±0.01) and the least was from the factory of P6 (0.54±0.01).

Table 4.20: One-Way Analysis of Variance of Physico-Chemical Parameters of Orange Juice Producers.

Producer Name		**PH**	**VIT C**	**TSS**	**TTA**
P5	Mean	4.03±0.01 c	24.90±0.44 b	12.51±0.01 a	1.55±0.01 a
P6	Mean	4.68±0.01 a	23.01±0.01 c	12.50±0.10 a	1.52±0.01 b
P7	Mean	4.38±0.15 b	26.43±0.01 a	11.97±0.10 b	0.22±0.01 c
Total	Mean	4.36±0.29	24.78±1.50	12.33±0.27	1.10±0.66
	Minimum	4.03	23.01	11.96	0.21
	Maximum	4.68	26.44	12.60	1.56
F-ratio		39.26	138.64	84.21	172990
df		2	2	2	2
P-value		0.0000	0.000	0.000	0.000
Codex Standard 247 (2005)		3.2-4.0	> 12.5mg/ml	> 10.5	< 1.35/100ml

Means that share the same letters along a column are not significantly different at α = 5% (0.05) significance level by Fisher's LSD multiple comparison test

4.11 ANALYSIS OF VARIANCE OF MICROBIAL LOADS OF ORANGE JUICE

The Fisher's multiple tests also indicated differences in total viable count, yeast and mould count as well as *Staphylococcus aureus* count of orange juices. However, yeast and mould counts across the companies were not significantly higher ($p<0.05$) $F(2) = 343441.53$ Table 4.21.

The total *Staphylococcus aureus* count of juice from factory of P5 ($1.023 \times 10^2 \pm 2.52$) and P6 ($1.236 \times 10^2 \pm 3.21$) were not significantly higher ($p>0.05$) from the factory of P7 ($1.320 \times 10^3 \pm 60.83$)

Table 4.21: One-Way Analysis of Variance of Microbial Loads of Orange Juice Producers.

Factory Name		**TVC/cfu/ml**	**YMC/cfu/ml**	**SaC/cfu/ml**
P5	Mean	$1.223x10^3$±25.17 c	$1.2436x10^5$±109.70 b	$1.023x10^2$±2.52 b
P6	Mean	$1.503x10^4$±30.00 a	$2.070x10^4$±8066.60 ab	$1.236x10^2$±3.21 b
P7	Mean	$2.341x10^3$±2.89 b	$2.366x10^4$±3214.55 a	$1.320x10^3$±60.83 a
Total	Mean	$3.506x10^3$±6641.46	$1.8934x10^4$±6652.32	$1.193x10^2$±604.34
	Minimum	1200.00	12310.00	100.00
	Maximum	15060.00	30000.00	1360.00
F-ratio		343331.53	4.04	1179.21
df		2	2	2
P-value		0.000	0.077	0.000
Codex Standard 247 (2005)		$1.3x10^3$-$2.0x10^2$/cfu/ml	$2.0x10^3$-$2.5x10^3$cfu/ml	1.0-$2.0x10^2$cfu/ml

Means that share the same letters along a column are not significantly different at α = 5% (0.05) significance level by Fisher's LSD multiple comparison test

TVC/cfu/ml – Total Viable Count in colony forming unit

YMC/cfu/ml – Yeast and Mould Count in colony forming unit

SaC/cfu/ml – *Staphylococcus aureus* Counts in colony forming unit

CHAPTER FIVE

5.0 DISCUSSION

5.1 BIO-DATA OF RESPONDENTS

68% of fruit juice consumers and traders were females whilst 32% were males. This is not surprising because it is in line with what Barker (2006) reported that, urban retail marketing and petty trading are sectors that have long been dominated by women in West Africa and has been the common way for women to earn income.

Fruit juice consumers below the age of twenty (20) years were 50% whilst those above forty (40) years were 7%. This could be due to the fact that below the age of twenty, they may be in basic and second cycle schools and would therefore rely much on fast foods that are ready to eat like fruit juice to avoid time wastage.

The responses from the fruit juice consumers revealed that all of them had some level of formal education. SHS School leavers were 40% followed by JHS leavers 20% and Diploma/First Degree holders being 17% each. The remaining 6% had professional certificates. This implies that, the consumers were enlightened and had knowledge about the nutritional and health benefits of fruit juice.

5.2 PERCEPTION OF FRUIT JUICE CONSUMERS

5.2.1 Purchase of Locally Made Pineapple and Orange Juice

Responses from the stakeholders indicated that, more people consumed pineapple and orange juices produced by the local companies (93.3%) whilst 6.67% did not purchase fruit juice from the local factories. This shows that, fruit and vegetable juices consumption was a popular practice among the natives of the study areas as indicated in table 4.2.0.

5.2.2 Why Consumers Prefer locally made fruit juice

(51%) of the consumers looked out for taste as a preference when purchasing fruit juice whilst 23% also considered the level of packaged. Another 20% of the respondents also purchased fruit from the local factories based on the price. However, nutrient which is an intrinsic characteristic was not commonly considered. This may be due to the fact that, consumers mostly looked out for sweetness or sourness, aroma, flavor etc. as well as light weight, flexible and recyclable package materials for easy transport Achuonjei *et., al (2003)*

5.2.3 Preference of Imported Fruit Juice

From the survey conducted most (78.66%) of the fruit juice consumers preferred imported juice due to its quality. Imported fruit juices made from sugar loaf pineapple have long shelf life and good taste (James and Rolle, 2010).

Even though, not commonly practiced it was observed that some fruit juice producers diluted juices with water to maximize profit.

5.2.4 Comparison of the Quality of Imported and Locally Made Fruit Juice. Quality makes a product what it is. The combination of attributes or characteristics of a product determines its degree of acceptability. 40% of the consumers strongly agreed that, imported fruit juices were better than the locally made juices whilst 28.66% also agreed that, the imported juices were better than the local juices. This may be due to the fact that the imported fruit juices have longer shelf life, no adulterations, high nutritive value and the better package materials. This is in line with the studies conducted by James and Rolle (2010) that Big juice processors include anti-browning treatment and other quality characteristics as a processing steps to ensure longer shelf life of their products. 21.01% of the consumers also disagree that the imported fruit juice were better than the locally made juice.

They preferred fruit juice prepared from the locally cultivated pineapple and orange fruits due to their sweet taste. Another 10.33% strongly disagreed that, the imported fruit juices were better than the locally made juices. To them, locally made pineapple juice from MD2 and sugar loaf varieties were super-sweet and free from any artificial flavor. This confirmed studies conducted by Achuonjei *et al.,* (2003) that, MD2 pineapple variety have good taste and have a long shelf life

5.3 FRUIT JUICE PRODUCERS HANDLING PRACTICES

5.3.1 Stages of Fruit Ripening Used for Juice Production.

Fruits that are riped might have undergone many physiological and chemical changes after harvesting, and these changes determine the quality of the fruit purchased by the consumer (Asare, 2012). The sustainability of the local fruit and vegetable juice companies depend on the available raw materials. Fifty percent (50%) (Figure 4.3.1) of the pineapple and orange juice producers used full riped fruits for processing due to its sweet taste. This confirmed the study conducted by Nakasone and Paul, (2004), that, full ripped fruits converts fruit starch into soluble sugars under the action of phosphorylase enzyme. 40% also used the half ripped orange and pineapple fruits for juice production since they were the types with maximum juice and can be stored for a longer period if processing delayed. Few producers (10%) used full and half ripped mix fruits for juice production since the full ripped fruits were not in abundant to meet their demand.

5.3.2 Sorting Fruits before Processing

Sorting of fruits is very important in fruit processing since it enables separation of some defective fruits which will affect quality. 85.7% of the juice companies indicated that they sorted fruits to get rid of bruised, debris, rotten fruits etc. before processing. This is to ensure that, all fruits that did not have uniform characteristics compared to the rest of the lot, in terms of ripeness, colour, shape and size or which present mechanical or microbiological damage were removed. According to FAO corporate documentary Repository on Quality control for production of juice (2014), Sorting secures homogeneity in processing and ensures quality of products. Few producers (14.3%) did not sort their pineapple and orange fruits before processing and the reason being that once the washed, fruits would be cleaned and free from pathogens. The results revealed high levels of microbial loads from producers 4 and 7 which were above the accepted range, from the codex standard, table 4.19.This might have resulted from poor handling practices like sorting and washing.

5.3.3 Washing of Fruits before Processing

All the juice producers that were interviewed (100%) indicated that, they washed fruits before processing. This is done to ensure good hygiene and to eliminate dirt and any pathogenic infection

5.3.4 Use of Running Water for Washing Fruits

Although washing of fruits was commonly practiced (100%), the use of running water and other chemicals were not commonly done (71.4%). Only a few (28.6%) used sodium hypochlorite to wash the fruits under running to get rid of pathogens before processing

.According to FAO (2014), washing fruits under clean running water by adding sodium hypochlorite that is, 100ml of 10%, solution for every 100 litres of water so that no traces of dirt are left on the fruit surface will ensure quality of the product and maximize profit.

5.4 ANALYSIS OF THE CHALLENGES OF THE JUICE PRODUCERS

From the chi-square test analysis, finance recorded 71.1% which was not significantly different across the producers, x^2= 10.46, df= 6, P>0.05. This indicates that finance was a general challenge across the factories which affect quality. However, non-existence of cold storage transport vehicles and the use of old processing equipments were significantly higher, (P<0.05) within the producers. This indicates that some of the factories were not affected by the challenges and will have a positive relationship on the quality parameters. For instance, producers 2 and5 recorded high vitamin C, TSS and ash contents of juices (table 4.10b) from the factories and the markets due to existence of cold storage transport vehicle and improved processing equipments. This confirms the report of Ngoddy and Ihekoranye (2011) that ascorbic acid of fruit juice is affected by several factors such as temperature, storage time and metal ions. That is those factories (P3 and P4) that did not transport their products in cold storage vehicles will have a decrease in vitamin C, TSS and minerals contents of juices at the market. Also, raw materials, quality control officers, land tenure system and unstable power supply were not significantly different among the producers (P>0.05). This shows that these challenges are general and affect all the companies. However, the paring indicates the levels of effect on each company. The 100% power instability from P3 and P4 decreases TTA, TSS and total mineral contents of juices. This could be due to the fact that, producers will resort to additional power supply which will incur extra cost and that could prevent the addition of the necessary nutritional value.

5.5 ANALYSIS OF PINEAPPLE JUICE

5.5.1 pH of Pineapple Juice

The PH level of fruit juice is the main criteria for assessing the safety of the product. The acidity of the juice helps to prevent the growth of bacteria which may be dangerous to human lives. The highest pH was recorded from the factory of Producer 1 (4.63±0.06) which was significantly higher from factories of Producer 2 (4.14±001) and Producer 5 (4.31±0.01), $t(2)= 16.386$, $P<0.05$. According to Jitaareerate *et al* (2007), PH of fruit and vegetable juices decrease due to the effect of treatment on the biochemical condition of the fruits and vegetables use for processing and slower rate of respiration and metabolic activities. According to the U.S food and Drug Administration Center for Food Safety and Applied Nutrition, (2000) the PH of Pineapple ranges between 3.50-4.40.

PH values observed in this research were within the accepted range for consumption, although PH for P1 was higher which makes it less acidic than the rest. Such Juices would therefore be recommended for consumers desiring less acidic juices.

5.5.2 Vitamin C Content of Pineapple Juice

Vitamin C of pineapple is dependent on factors such as cultivar, stage of maturity, the conditions of storage and the part of fruit. Vitamin C in fresh pineapples ranges from about 20 to 30.44mg/100g of juice Ngoddy and Ihekoranye (2011). Ascorbic acid content of fruit is a useful quality index due to its nutritional benefits. From the paired sample t-test analysis, the vitamin C content of juice from the company (27.05±0.06) of Producer 1 was the highest which was significantly different from the market (26. 36±0.06), $t(2)= 21.490$, $P<0.05$. The high ascorbic acid level from P1 may have an advantage over the P2, P3 and P4 factories and open markets in terms of vitamin C
(Bartholomew *et al.*, 2003).

5.5.3 Total Soluble Solids (TSS) of Pineapple Juice

The soluble solids in the juice are sugars, sucrose, fructose, glucose, citric acids and minerals. Increase in TSS during fruits/vegetables processing is as a result of the transformation of fruit starch into soluble sugars by the action of phosphorylase enzyme (Nakasone and Paull, 2004). The TSS content of juice is known to influence sweetness more than the sugar/Brix Paull (1993). For pineapple juice, TSS content of juice ranges between 10.5-18.0% although little variations can exist (Gorney, 2001). The result from the paired sample t-test indicated that, there were differences ($P<0.05$) between TSS at the factories and the markets. However, TSS from the factory of Producer 6 (11.05 ± 0.01) was significantly different from the market (11.78 ± 0.01), $t(2)= -63.22$, $P<0.05$. This shows that producers handling practices from the factories did not have great quality influence on TSS from their respective markets, although there were changes as the juice moved from factory to market.

5.5.4 Total Titratable Acidity of Pineapple Juice

This is a measure of total acid present in a juice. Predominant organic acids in pineapple juice are malic and citric acids (Saradhuldhat and Paull, 2006). From the results, there was a general decrease in titratable acidity in all the companies. However a significantly higher ($P>0.05$) titratable acidity recorded by producer two (2) at the factory was (2.02 ± 0.01) which was significantly higher than the market (1.01 ± 0.01), $t(2)= 152$, $P<0.05$ as indicated in table 4.12.

5.5.5 Total Ash Content of Pineapple Juice

Ash content determines the total mineral contents in foods. From the paired sample t-test analysis, there were significant differences ($P<0.05$) in total ash content of the juice from the factories to the markets. The highest mean ash value was recorded from the factory of Producer 2 (0.65±0.01) and the least value was recorded from the factory of P7 (0.53±0.01). The change in the level of ash from the factory to the market may be attributed to storage conditions such as heat, light and exposure to air during transport and packaging, Lateef *et al.,* (2007).From the survey producer 7 recorded the highest challenge of cold storage transport vehicle. This may expose such product to excessive heat.

5.5.6 Microbial Analysis of Pineapple Juice

Microbial analysis of fruit juice is a measure of microbial quality of fruit numbers. That is, total viable count greater than 4 log10cfu/ml) is responsible for the spoilage of fruit juices, Gulf standard (2005) and Codex standard (2005). From the results, there were significant differences ($P<0.05$) in viable count, yeast and mould as well as *staphylococcus aureus counts* of pineapple juices from the producers and their markets. This may be due to continual increase in acidity over the period of storage as yeast and moulds thrive well in acidity medium. Though factories juices showed consistent increase in viable and yeast/mould counts, their increases were not significant ($P>0.05$). These insignificant increases were probably due to a comparably slight decrease in acidity over time (Splittstosser, 2012).

The *staphylococcus aureus* count of the pineapple juice ranged from ($1.202 \times 10^3 \pm 4$ – $4.6000 \times 10^5 \pm 1000$) which was relatively lower than the microbial loads (102-105cfu/ml) reported in earlier work of Lateef *et al.,* (2007).From their report, there was no specification set for the proliferation of microbes in fruit juices being served in the market. However, the recommended specifications for fruit juices by the Ghana Standard

Authority is (1.0×10^3cfu/ml) (http://(ghanastandard.org).

The findings raises questions about the wholesomeness of fruit juices on the Ghanaian market.

5.6 ANALYSIS OF ORANGE JUICE

5.6.1 pH of Orange Fruit Juice

From the paired sample t-test analysis, the highest pH (4.7± 0.0) was recorded from the factory of P4 which was significantly different ($P<0.05$) from the market (4.2 ± 0.0). In the all the pH numbers recorded, except P1 there were significant differences from the factory to the market. According to Anon (1992), the pH of orange juice ranges between 3.3-4.9. He re-emphasized that variations exist between varieties, conditions of growing and processing methods. However the low acidity (that is higher pH) of P4 factory orange juice besides its nutrient content makes it a good medium for growth of microorganisms.

5.6.2 Vitamin C content of Orange Juice

The analysis reveals that vitamin C content of orange juice differed significantly ($P<0.05$) among the sources of juice (factory and open market) except producer 5 which recorded insignificant ($P>0.05$) vitamin C content from factory (26.4 ± 0.0) to market (26.28 ± 2.5). These differences in vitamin C content at the factory and open markets might have resulted from poor storage conditions at the market. This is in line with what Ngoddy and Ihekoranye (2011) reported that vitamin C of fruits are readily oxidized and lost during storing of the juice or cut fruit. On the other hand, degradation rate of ascorbic acid in processed fruits is affected by several factors such as temperature, water acidity, PH, storage time and metal ions (Pardio *et al.*, 1994). Therefore producers having good levels of vitamin C content at the factory may give factory products advantage over open market products due to metabolic activities that take place during processing and storage. A decrease in titratable acidity with storage was reported by Bhattarai and Gautam (2006), thus fruits might have utilized the acid through metabolic activities. The decrease in total titratable acidity at the factories also had significant effect on the market storage since shelf life of juices will be reduced.

5.6.3 Total Soluble Solids (TSS) of Orange Juice

The results from the study, table (4.9) indicates that, there were significant differences ($P<0.05$) between TSS factory and open market. The highest TSS value was recorded by producer one (1) factory (12.51 ± 0.0) which was significantly higher ($P<0.05$) than market (10.79 ± 0.0). However there were similar ($P>0.01$). TSS values at factories and markets. This will have a positive influence on taste since TSS has direct impact on sweetness of orange juice (Appiah *et al.,* 2011).

5.6.4 Total Titratable Acidity (TTA) of Orange Juice

The predominant acid in orange juice is citric acid, however, there are small amount of malic and tartaric acid. Total Titratable acidity in orange juice is a weak acid and not completely ionized (Garcia *et al.,* 2011). An increase in pH is associated with a decrease in titratable acidity. From the results, there was general decreases intitratable acidity. The TTA levels from the factory (2.02 ± 0.0) of P3. A decrease in TTA means an increase in PH of juice during storage (Bhattarai and Gautan 2006). This will have positive effect on the taste and its acceptability.

5.6.5 Total Ash content of orange juice

From the t-test analysis, there was a significant difference ash content from P1 factory (0.66 ± 0.01) and market (0.64 ± 0.01), $t(2) = 7.0$, $P<0.05$ (table 4.9). Wardlaw and Insel (1996) reported that, total mineral contents like iron, calcium and vitamin A in fruits and vegetable juices are easily destroyed by heat, exposure to light and air. From the survey all the respondents from p6 and p7 indicated they do not transport their products in cold storage transport vehicles .This might have accounted for a maximum reduction in total minerals at the markets of these producers

5.6.6 Microbial Analysis of Orange Juice

Microbial quality of fruit juices is related to total viable and staphylococcus counts. The Presence of staphylococci in high numbers (SC>3log10cfu/ml) is a health hazard as they cause spoilage of fruit juices and food borne diseases(Gulf Standards,2000 and Codex 2005), From the results, there was significant difference in yeast and mould counts of juices sampled from the factories and markets of P1 and P5. This may increase the growth of total viable count, and yeast and mould, indicating the acidophilic nature of the organisms. The suppressions of microbial growth in P1 could be attributed to the significant increase in the ascorbic acid content in the orange after storage, Mahale *et al.*, (2008).

5.7 ANALYSIS OF VARIANCE OF PHYSICO-CHEMICAL PARAMETERS AND MICROBIAL LOADS OF PINEAPPLE JUICE

The results indicated that, there were significant differences in pH, vitamin C, TSS, TTA, Ash and Microbial loads of pineapple juices among the factories. According to the Codex alimentarius commission (2005), pH of pineapple juice ranges from 3.5-4.5. pH levels depend on the food, variety of the food and the growing conditions such as soil and pH. pH levels observed in these factories were all within the range for consumption except factory 1 (P1) which was higher. This makes it less acidic than the rest. Moreover vitamin C content was significantly higher ($p<0.001$) within all the factories. Vitamin C content ranges from 20-30mg/ml per the Codex standard. This reveals that ascorbic acid across the factories were all within the range for consumption. However, the highest vitamin C content from factory 1 and 2 (P1 and P2) makes them better than the remaining factories. Similarly TSS and TTA levels were significantly higher ($p<0.05$) across the four factories. The standard indicates good levels of TSS from factories 2 and 3. TTA was also better in factory 1, 3 and 4. This shows that there were more citric and malic acids in pineapple juice from factories 1, 3 and 4 (P1, P3 and P4) than factory 2.

(Paull and Saradhuldhet, 2006). TTA level from factory 2 was above the accepted range. This makes the acid contents of the 3 factories better than factory 2. and implies a longer storage life and a possible higher astringency index (Wardy and Saalia, 2009). This may be very useful for juice processors as longer shelf life allows sufficient for handling, storing and selling. The analysis of variance also indicated significant differences ($p<0.001$) in total viable, yeast and mould and Staphylococcus *aureus* counts across all the factories. From the Codex standard (2005) all the factories recorded Staphylococcus *aureus* counts which were higher than the range (Table 4.19). However yeast and moulds contents of juices from factories 1 to 4 (P1 to P4) were within the accepted range. Total viable count of juices from factories 1, 2 and 3 were also within the range. Thus, juices from factories 1, 2 and 3 (P1, P2 and P3) could be recommended for consumers. (Table 4.19).

5.8 ANALYSIS OF VARIANCE OF PHYSIOCOCHEMICAL PARAMETERS AND MICROBIAL LOADS OF ORANGE JUICE

From the analysis there were significant differences ($P<0.05$) in pH, vitamin C, TSS, TTA and total Ash contents among the three orange juice processing companies that is, (P5, P6 and P7). From the codex standard 247 (2005), pH of orange juice ranges from 3.2-4.0.pH levels observed among all the processing companies were within the range for consumption except company four (P4) which recorded pH above the accepted range. This will make the juice from p4 less acidic than P5 and P7.

Moreover, the highest vitamin C level was recorded from P7 (26.43±0.01). This indicates that, ascorbic acid is high in orange Juice. This confirms the studies conducted by Uzeh *et al.*, (2009) that, orange juice is high in citric and ascorbic acids. From the Codex standard, vitamin C levels recorded from the three companies were above the range. This will increase the citric and ascorbic acids in the juice. Furthermore, TSS and TTA levels from processing companies 5 and 6 (P5 and P6) were all within the accepted range for consumption. This will have a positive effect on taste and its acceptability since TSS and TTA levels in orange Juice have impact on taste and storage (Bhattarai and Gautan, 2006). Additionally, fisher's multiple comparison test also indicates differences in total viable and *staphylococcus aureus* counts which were significantly higher ($P<0.05$) than standard 247 (2005). However yeast and mould count did not differed significantly ($P<0.05$) from the processing companies. All the juice from the companies except P5 were above the range for consumption. The suppression of microbial growth in P5 could be attributed to significant increase in the ascorbic, citric and tartaric acids contents in the juice after storage (Mahala *et al.*, 2008).

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

The study sought to assess people's perception, producers handling practices, the challenges as well as to assess the quality of our locally made fruit juice products on the market. A field survey was conducted in five areas of Kumasi Metropolitan Assembly in the Ashanti Region and four municipalities all in the same region.

From the findings:

- Most (93.33%) of the consumers purchase the locally made fruit juice drink.
- Despite the high purchases (93.33%) of locally made fruit juice, consumers (68.66%) believe that, imported fruit and vegetable juices are better than the local ones.
- Only a few (28.6%) of the juice producers wash fruits under running water with sodium hypochlorite solution.
- The findings also indicated that, major challenges like finance, cold storage Transport vehicle, raw materials and quality control officers were commonly associated with those factories producing juices from orange than pineapple producing factories as P6 and P7 recorded 100% challenges in finance, raw materials and cold storage transport vehicles whilst P2 and P3 recorded 40% challenges in finance, raw materials and quality control officers.
- From the paired sample t-test analysis, the levels of pH, Vitamin C, TSS and TTA were higher ($P<0.05$) in the factories of pineapple and orange juice producers than the markets.
- Microbial loads were higher ($P<0.05$) in pineapple and orange juices sampled from the market than those from the factories.
- The analysis of variance also indicated that, juice sampled from producers that produce juice from pineapple have good levels of pH and TTA than those producing orange juice.
- Although, the juices investigated in this study had higher microbial loads than the specifications set for fruit juices in some parts of the world, Codex (2005) as well as the Ghana Standard on fruit juices. Their effect was not significant to pose health hazards to consumers since *Staphylococcus aureus* counts did not exceed the range (SC>3log10cfu/ml-4log10cfu/ml).

6.2 RECOMMENDATIONS

- From the research findings, fruit juices from the market had the highest microbial loads, low levels in vitamin C, Total Soluble Solids (T.S.S) and Total ash content. Thus, I recommend that,
- The food and Drug Authority (FDA) and other supervisory agencies must not only rely on selecting fruit juice samples from the processing companies for their laboratory Analysis but also extend their supervision to the open market. This will enable them know whether products in the open market conforms to the samples the companies present to the Laboratory for the analysis.
- I also recommend that, further studies should be carried out on effects of microbes in the fruit juices on the health conditions of consumers.

REFERENCES

Abor, J. (2006). Small Business Financing Initiatives in Ghana; Problems and Perspective in Management. Vol 4, issue 3.

Achuonjei, P., Boschmas, Happe G., Hoogendoorn, B., Meekma, I., Pilkes, J, and Wardenburg, R. (2003). Ghana Sustainable Horticultural Export Chain. Michigan State University – Michigan. Page 240-248.

Agar, I., Hess-Piece, B., and Kader A.(1999). Postharvest CO2 and Ethylene Production and Quality Maintenance of Fresh Fruits (Kiwi Fruits Slices).*Journal of food science.64 (3):433-440.*

Annon (1992).PH Values of Food Products, *Journal on food science. Eng. 34(3): 98-99*

AOAC (2006).Official Methods of Analysis.15thedition.*Association Official Analytical Chemist,* Washington DC.P.1005.

AOAC (1992).Official Methods of Analysis.5thedition.*Association of official Analytical chemist,* Washington DC.P.1005.

AOAC International, 17th edn,(2007). Official Methods of Analysis,2005;current through revision 2, 2007(on-line). AOAC International, Gaitheisburg, MD

Appiah, F. Kumah, P. and Idun,.I (2006). Effect of Ripening Stages on Composition, Sensory Qualities and Acceptability of Kent Mango (*Mangifera indica L*) Chips. *African Journal of Food, Nutrition and Development 11(5):5096-5109.*

Aryeetey, E.A, Baa-Nuako, T.D, Uggleby, H. and W. F Steel (1994).Supply And Demand for Finance of Small Scale Enterprise in Ghana. Discussion Paper No 251.World Bank, Washing DC

Asare Richard, (2012). Comparative Assessment Fruit Juice from Three Difference Varieties of Pineapple. published MSc (Postharvest Technology). Thesis of KNUST – Kumasi-Ghana PP25.29.

Aworh, C. (1994).The Role of Traditional Food Processing Technologies in West Africa. Department of Food Technology. University of Ibadan, Nigerial.Clorles.aworh@ mail.ui.edu.n.ng

Bartholomew, D.P, Paul R. E, and Rohbach, K.G (2003). The Pineapple: Botany, Production and Uses. ABI Publishing UK PP 253-274

Barker J. M (2006).Understanding Customers, Gain Loyalty in Return Sales and Marketing Management. New York. Vol 158, issue 2, p.30.

Bhattarai, D. R and Gautan, D.M (2006).Effects of Harvesting Method and Calcium on Postharvest Physiology of Tomato. *Nepal Agricultural Resource Journal, Vol17 PP 23-26.*

Boapeah, S.N, (1993).*Small Business Financing Initiatives in Ghana.* M13, G30 University of Stellenbosch PP. 69-74

Boapeah, S.N, (2006). Developing Small Scale Industries in Rural Regions: Business Behavior and Appropriate Promotion Strategies with Reference to Ahanta West District of Ghana. Spring, Dortmund

Brennan, J.G (2006): Food Processing Handbook: 2nd Edition, 2 Vol. Set ISBN: 978 – 3 – 527.

Cheour F. Willemot, C., Arul J., and Makhlouf, D.Y (1991).Postharvest Response of Two Strawberry Cultivars to Folia Application of $CaCl_2$. Alexandria, V.A. EtatsUnis. American Society for Horticultural Sci.: Hort sci. pp 1186-1188.

Codex Alimatarius Commission, (2007). General Requirements (food hygiene), http://www.codexahmantarius.net/web/index.en.jsp.

Codex Alimentarius Commission, (2005).http://www.codexahmantarius.net/web/index.en.jsp.

Corbo, M.R, Campaniello, D. D, Speranz B., and Sinnigalia M.(2010).Fresh Cut Fruits preservation; Current State and Emergency Technology. *International journal of food science and Technology (40);222-241*.

Dadzie, B.K and Orchard, JE (1997).*Routine Postharvest Screening of Banana/Plantain*.

FAO, (2014).Technical Manual on Small Scale Processing Fruits and Vegetables. Chapter 5, page2: Latin America Caribbean's

FAO Corporate Document Repository.(2014). Quality Assurance for Small Scale Rural Food Industries. Available from (http://fao.org/docr).Assessed, 20th June 2016.

Garcia, D.A, Ramos V., Sanchis, M.K, and S. Martin, (2011).Effects of Temperature, PH and Water Activity on Fruits and Vegetables. *Journal on. Food Microbial. 11:139-150*

Ghana Standard Authority,(2012).Catalogue of Ghana Standards, www.gsa.gov.gh

Gisela, B., and Daniel H. (1992).Promoting Purchases of Sustainable Groceries: An Intervention https://www.researchgat.net.

GorneyJ. R. (2001).*Effect of postharvest storage of whole Fruit on Physico-chemical & microbial changes. International food Research journal* 20(1): 953-960. PP.954956.

Gorney J.R,.(2010).A Summary of CA and MA Requirements and Recommendations for Fresh Cut (minimally preserved) Fruits and Vegetables. Postharvest horticultural series No 22,pp 30-36

Gulf standard, (2005).Microbiological Criteria for Food- Stuffs-Part 1.G.C.C Riyadh, Saudi Arabia P7-20.

James and Rolle, (2010)..*Analytical chemistry of Food* Blackie Academic and professional chapman Hall, Bishop Briggs, Glasgow G642NZ.

Jitareerate P., Paumchai S., and Kanlayanarats, F. (2007). Effects of Chitosan on Ripening Enzymatic Activity and Disease Development in Mango *(Mangifera indica L.).Science Journal on Crops and Horticultural 35:211-218.*

Kadar A.A, (1992). Postharvest Biology and Horticultural Crops. University of California. div of agriculture. Pp 15-20

Kayanula, D., and Quartey P (2000).*The Policy Environment for Promoting Small and Medium sized Enterprises in Ghana*. Paper No. 15, IDPM, University of Manchester.

Kitinoja, L. and Kader, A.A. (2003).Small-scale Postharvest Handling Practices-Manual for Horticultural Crops (4th Edition). University of California Davis, California, USA.

Lateef, A.J, Oloke, E.B, Kana E. P, and Guegium, K. K. (2004). The Microbiological Quality of Ice Used to Cool Drinks and Food in South West Nigeria*: Internet Journal of Food Safety 8:39-43.*

Louknaan,, J., (2010).Promoting Micro and Small Industries for Local Development in Ghana. The case of Mamprusi District, unpublished (Development planning and Land Economy). Thesis of KNUST Kumasi Ghana

Magan, N. (2007) *Postharvest Control Strategies: Minimizing Mycotoxin in The Food*. Pub-med. PP.131-139.

Mahajan, P.V., Caleb, O. J, and Singh, Z. (2013.: Postharvest Treatments of fresh produce. *Journal on Fruits* *www.ncbi.nih.gov.PMC 4006172*.

Mahala, D.P., Khade, R. G., and Vaidya V.K, (2008). Microbiological Analysis of Street Vendored Fruit Juice from Mumbai City, *Indian International Journal of Food Safety10:31-34*.

Mohammed-Aylar, S., Somarin, S.J, and Azimi J. (2007).Effects of stages of Ripening on Mechanical Damage in Tomato Fruits. *American Eurasian Journal Agriculture & Environmental Science. 9(3):297-302.*

Mohammed, S. R(2007).Handbook of Preservation. second edition CRC press, Taylor and Francis group, Boca Ration London. pp 23-205

Nakasone, H.R., and Paull R.E, (2004).Tropical Fruits. CAB International, 198 mesidan avenue New York, U.S.A. pages 274-293.

Ngoddy, P.O, Ihekoronye, I.A (2011). Integrated Food Science and Technology for Tropics. Macmillan publication, London PP 70-204

Nunes, M.N, Brecht, J. K, and Morcus, A.M (2008). Physical and Chemical Quality Characteristics of Straw Berries After Storage: Postharvest Biology & Technology. 6:17-28.

Olympio, N.S and Kumah, P. (2008). Hort 575: Quality control of Horticultural crop, KNUST. Institute of Distance Learning University press. PP 2 – 20

Oppong Moses, (2014).Micro and Small Scale Enterprise Development in Ghana. *European Journal of Accounting, Auditing and Finance Research, Vol 2 No. 6 PP 84-97.Pardio Sedas (2009)*

Osei Boateng, (2000).*The Informal Sector in Ghana. Journal of Management Studies university Ghana*.209, vol. 12.

Pardio, S., Waliszewski K., and Garcia M. (1994).Ascorbic Acid and Loss and Sensory Changes in Intermediate Moisture in pineapple During Storage at 30-40^{o}C, *International Journal of Food Science and Technology, (29), -557.*

Parker, J.D., Taylor, G.J and Bagby, R. (1995).*Small Industries Financing Initiatives: Business Perspective.org* PPME

Paull RE (1993).Pineapple and Papaya. Biochemistry of Fruit Ripening. Chapman and Hall. London PP 291-323.Practical Action Technical Brief

Saradhuldhat, P. and Paul, R.E (2006). Pineapple Organic Acid Metabolism and Accumulation During Fruit Development Horticultural Science, 112(3), 297-303 http://dx.doi.org/10.1016/J.scienta.2006.12.103.1

Singh, R. (2010).Phenylpropanoid Metabolism in Ripening Fruits, Food Science and Food Saftey. Vol 9 PP 398 – 416.

Splittstosser Don. F, (2012).Microbiology of Food Manual of Methods of Analysis of Foods. LAB Manual 14

UNIDO, (2004).General Review Study of Small and Medium Enterprise (SME).RT2004-016-00, Technical final Report – UNIDO. University of Munich, Germany PP 27-30.

USAID *Policy framework* (2011).http://www.usaid.gov. 2001-2005

U.S. Food and Drug Administration Center for Food Safety and Applied Nutrition.(2000). Available from June 2000 (http://www.ridusa.com).Assessed 10th June, 2012.

Uzeh RE, Alade FA, Bankole M (2009. The quality Pre-packed mixed vegetables salad in Retail outlets in Lagos, Nigeria Afi J. ford sci 3(9): 270-272. WHO (20012) food safety & food borne illness fact sheet. 237-P7

Wardlaw, G.M, and Insel, P.M (1996).Perspective in Nutrition (3rd Edition). Mosby Publication Inc. USA, Pp 399-440

Wardy W. and Saalia F.K. (2009). A comparison of Some physico-chemical and Sensory Attributes of Three pineapple (*Ananas comosus*) Varieties Grown in Ghana. Navis Publication,,pp 334-358

APPENDIX

QUESTIONNAIRE FOR PRODUCERS

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

(KNUST)

COLLEGE OF AGRICULTURE AND NATURAL RESOURCES

FACULTY OF AGRICULTURE

DEPARTMENT OF HORTICULTURE

POST HARVEST TECHNOLOGY

The purpose of this questionnaire is to gather data for a study on"(THE EFFECT OF POSTHARVEST QUALITY MANAGEMENT PRACTICES ON SMALL SCALE INDUSTRIES IN GHANA. A CASE STUDY OF FRUIT JUICE PRODUCERS IN ASHANTI REGION OF GHANA)"

Data collected would be used solely for academic purpose and respondents are assured of the confidentiality of information provided.

A. PERSONAL INFORMATION

1) Gender: Male [ ] Female [ ]

2) Age Group: Below 20[ ] 20-30 [ ] 30-40 [ ] 40 and above [ ]

3) Level of education

Basic [ ] SHS/ Commercial [ ] Diploma [ ] 1st and/or 2nd Degree [ ] Professional [ ]

4) What type of fruit juice do you produce?

Orange juice [ ] Pineapple fruits [ ]

5) Do you produce any other products other than fruit juice Yes [ ] No [ ]

6) If yes, name the others ……………………………………………….

7) Do you have people who assist you in the fruit juice production? Yes [ ] No [ ]
8) If yes how many do you have ………………………..

9) Do you have a business plan for your business? Yes [ ] No [ ]

10) If yes, do you follow the plan? Yes [ ] No [ ]

11) What are your sources of income? ………………………………….

12) Are you a member of any trade association? Yes [ ] No [ ]

13) If yes, name it ……………………………………………….

B. JUICE MAKING AND POSTHARVEST ACTIVITIES

1) Where do you get your fruits and other ingredients from ………………..

2) What ripening stage do you buy your fruits? half ripe [ ], full ripe[ ] Full and ripped [ ]

3) Do you sort the fruits before purchasing? Yes [ ] No [ ]

4) If yes, what parameters do you look out for? bruises [ ] decay[ ] size[ ] shape[ ] colour[ ]

5) Do you wash the fruits before using them? Yes [ ] No [ ]

6) If yes, do you use running water? Yes [ ] No [ ]

7) Do you buy fruits for processing in bulk? Yes [ ] No [ ]

8) If yes, how do you store them ……………………………….

9) How do you sell the fruit juice? …………………

10) How do you package the fruit juice? Juice box [ ] Glass [ ] Plastics [ ]

11) Do you label the fruit juice drink? Yes [ ] No [ ]

12) Do you provide all the necessary information required by the FDA's regulation on labeling? Yes [ ] No [ ]

13) How do you price the fruit juice drink? cost of production [ ] imaginary pricing [] based on current market price [ ], size of packaging unit [ ]

14) What is the average price of the fruit juice you produce …………

15) How often do people buy the fruit juice drink ………………………

16) Do consumers complain about the product? Yes [ ] No [ ]

17) Do you keep records on your business, Yes [ ] No [ ]

C. FOOD REGULATION AND QUALITY CONTROL

Please, kindly rate the following statements by ticking yes or no

1) Are you aware we have food laws in Ghana? Yes [ ] No [ ]

2) Is your business registered? Yes [ ] No [ ]

3) It is difficult registering and licensing business in Ghana. Yes [ ] No [ ]

4) Have you obtained a health certificate for your business? Yes [ ] No [ ]

5) Is your food production process been supervised by an agent of the regulatory bodies? Yes [ ] No [ ]

6) What certification do you have? HACCP [ ] ISO [ ] F-MARK [ ]

7) Do you have any plans to implement food fortification to enhance nutritional value of your product? Yes [ ] No [ ]

8) If no what are some constraints in this regard?

…..………………………………………………………………………………………

……………………………………………………………………………………………

9) Do you have a quality control lab on site? Yes [ ] No [ ]

10) Do you contract analysis to other labs? Yes [ ] No [ ]

11) Have you implemented an internal control system in your company to identify risk for corrective actions? Yes [ ] No [ ]

12) If yes do you have a permanent risk officer to take care of all risk identified? Yes [ ] No [ ]

D. CHALLENGES OF FRUIT JUICE PRODUCERS

1) Which of the following challenges affect your factory most? Multiple answers are allowed.

   a) Finance [ ]

   b) Unstable power supply [ ]

   c) Lack of quality control officers [ ]

   d) Inadequate raw materials [ ]

   e) Difficulty in securing license [ ]

   f) Non existence of cold storage transport vehicle [ ]

   g) Use of old processing equipments [ ]

2) How do the challenges affect your business?

3) Do you have future plans to overcome the above challenges?

4) Do you produce throughout the year, if "No", why?

5) How long does it take to transport processed juice to the wholesale/ retail stores and by what means?

QUESTIONNAIRE FOR CONSUMERS

Gender Male [ ] Female ( )

Age Group. Below 20[ ] 20-30 [ ] 30-40 [ ] 40 and above [ ]

Level of education Basic ( ) SHS/ Commercial ( ) Diploma ( ) 1st and/or 2nd Degree ( ) Professional ( ) Others ( )

Do you buy locally processed fruits juice? Yes [ ] No [ ]

If yes, why……………………………………………………

Do you buy imported processed fruit juice? Yes [ ] No [ ]

If yes, why……………………………………………………
What do you look out for when purchasing fruit juice………………

Where did you buy the most recent one? open market [ ], restaurant [ ], supermarket[ ], someone bought it for you [ ] others [ ]

10) How expensive was the fruit juice you bought? …………………….

11) What was the price of the fruit juice? ……………………………….

12) How satisfied are you with the fruit juice, very satisfied [ ], satisfied [ ], not satisfied [ ], others [ ]

13) Was the fruit juice you bought packaged, Yes [ ] No [ ]

14) If yes what was the package? Paper [ ], Glass bottle [ ], Plastic bottle (), others [ ]

15) Was the package labeled, Yes [ ] No [ ]

16) If yes, did the label contain the necessary information Yes [ ] No [ ]

17)Which of the following information did you find on the label, date of manufacturing [ ], date of expiring [ ], Nutritional content [ ], ingredients [ ] others [ ]

18) Fruit juice products in Ghana are produced under sanitary conditions. Yes [ ] No [ ]

19) Foreign processed fruit juice is better in terms of quality than locally processed fruit juices? Strongly agree [ ], agree [ ], disagree [ ], strongly disagree [ ], don't know [ ]

20) Fruit juice drink is convenient and can help alleviate postharvest losses in Ghana, Yes [ ] No [ ]

21) If yes, why ……………………………………

22) Would you recommend fruit juice to anybody who has not taken the product before Yes [ ] No [ ]

23) If yes, why ……………………………………………………

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	10.046[a]	6	.123
Likelihood Ratio	12.434	6	.053
Linear-by-Linear Association	3.935	1	.047
N of Valid Cases	35		

Paired Samples Test P1

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	PH_F - PH_M	.46667	.04933	.02848	.34413	.58921	16.386	2	.004
Pair 2	VIT_C_F - Vitamin C_M	.68333	.05508	.03180	.54652	.82015	21.490	2	.002
Pair 3	TSS_F - TSS_M	.00333	.01155	.00667	-.02535	.03202	.500	2	.667
Pair 4	TTA_F - TTA_M	.04000	.02000	.01155	-.00968	.08968	3.464	2	.074
Pair 5	ASH_F - Ash_M	.02667	.00577	.00333	.01232	.04101	8.000	2	.015

Pair 6	TVC_F - TVC_M	-50.66667	1.15470	.66667	-53.53510	-47.79823	-76.000	2	.000
Pair 7	YM_F - YM_M	-195.33333	8.08290	4.66667	-215.41238	-175.25429	-41.857	2	.001
Pair 8	SA_F - SA_M	-664.66667	1151.23644	664.66667	-3524.49651	2195.16318	-1.000	2	.423

Paired Samples Statistics p1

		Mean	N	Std. Deviation	Std. Error Mean
	PH_F	4.6333	3	.05508	.03180
Pair 1	PH_M			.00577	
	VIT_C_F	4.1667	3	.05508	.00333
	Vitamin C_M	27.0467	3	.05508	.03180
Pair 2	TSS_F	26.3633	3	.00577	.03180
	TSS_M	11.3633	3	.01000	.00333
	TTA_F			.01000	
Pair 3	TTA_M			.01000	
	ASH_F	11.3600	3	.01000	.00577
	Ash_M	.2600	3	.00577	.00577
Pair 4	TVC_F			.57735	
	TVC_M			1.00000	
	YM_F	.2200	3	11.54701	.00577
	YM_M	.6500	3	3.46410	.00577
Pair 5	SA_F	.6233	3	573.88617	.00333
	SA_M	1450.3333	3	577.35027	.33333
Pair 6					
		1501.0000	3		.57735
		1006.6667	3		6.66667
Pair 7		1202.0000	3		2.00000

Pair 8	19668.6667	3		331.33333
	20333.3333	3		333.33333

Paired Samples Test 1

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	PH_F - PH_M	-1.47333	.02082	.01202	-1.52504	-1.42162	-122.589	2	.000
Pair 2	VIT_C_F - Vitamin C_M	3.98333	.70002	.40416	2.24438	5.72229	9.856	2	.010
Pair 3	TSS_F - TSS_M	1.72000	.02000	.01155	1.67032	1.76968	148.956	2	.000
Pair 4	TTA_F - TTA_M	-.06333	.01528	.00882	-.10128	-.02539	-7.181	2	.019
Pair 5	ASH_F - Ash_M	.02333	.00577	.00333	.00899	.03768	7.000	2	.020
Pair 6	TVC_F - TVC_M	-46.66667	30.55050	17.63834	-122.55833	29.22499	-2.646	2	.118
Pair 7	YM_F - YM_M	-796.66667	176.16280	101.70764	-1234.27933	-359.05400	-7.833	2	.016
Pair 8	SA_F - SA_M	-29.33333	14.01190	8.08977	-64.14082	5.47416	-3.626	2	.068

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PH_F	4.0333	3	.00577	.00333
	PH_M				
	VIT_C_F	5.5067	3	.01528	.00882
	Vitamin C_M				
Pair 2	TSS_F	24.9000	3	.43589	.25166
	TSS_M				
	TTA_F	20.9167	3	.34933	.20169
	TTA_M				

Pair 3	ASH_F	12.5100	3	.01000	.00577
	Ash_M				
	TVC_F	10.7900	3	.01000	.00577
	TVC_M	1.5500	3	.01000	.00577
Pair 4	YM_F				
	YM_M				
	SA_F	1.6133	3	.00577	.00333
	SA_M	.6633	3	.00577	.00333
Pair 5					
		.6400	3	.01000	.00577
		1223.3333	3	25.16611	14.52966
Pair 6					
		1270.0000	3	30.00000	17.32051
		12436.6667	3	109.69655	63.33333
Pair 7					
		13233.3333	3	251.66115	145.29663
		102.3333	3	2.51661	1.45297
Pair 8					
		131.6667	3	12.58306	7.26483

Paired Samples Test P2

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	PH_F - PH_M	.07333	.06807	.03930	-.09576	.24243	1.866	2	.203
Pair 2	VIT_C_F - Vitamin C_M	1.52667	.06658	.03844	1.36126	1.69207	39.714	2	.001
Pair 3	TSS_F - TSS_M	.38667	.33005	.19055	-.43322	1.20656	2.029	2	.180

Pair 4	TTA_F - TTA_M	1.01333	.01155	.00667	.98465	1.04202	152.000	2	.000
Pair 5	ASH_F - Ash_M	.02667	.03215	.01856	-.05319	.10652	1.437	2	.287
Pair 6	TVC_F - TVC_M	-298000.66667	.57735	.33333	-298002.10088	-297999.23245	-894002.000	2	.000
Pair 7	YM_F - YM_M	-18799.00000	5.56776	3.21455	-18812.83109	-18785.16891	-5848.096	2	.000
Pair 8	SA_F - SA_M	-426500.00000	26533.18677	15318.94252	-492412.08986	-360587.91014	-27.841	2	.001

Paired Samples Statistics p2

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PH_F	4.1433	3	.04933	.02848
	PH_M	4.0700	3	.02646	.01528
Pair 2	VIT_C_F	26.6000	3	.01000	.00577
	Vitamin C_M	25.0733	3	.06429	.03712
Pair 3	TSS_F	10.7767	3	.28572	.16496
	TSS_M	10.3900	3	.06083	.03512
Pair 4	TTA_F TTA_M	2.0200	3	.01000	.00577
		1.0067	3	.00577	.00333
Pair 5	ASH_F Ash_M	.5667	3	.02309	.01333
		.5400	3	.01000	.00577
Pair 6	TVC_F TVC_M	2000.6667	3	1.15470	.66667
		300001.3333	3	1.52753	.88192
Pair 7	YM_F YM_M	1202.3333	3	4.04145	2.33333
		20001.3333	3	2.30940	1.33333
Pair 8	SA_F	3500.0000	3	100.00000	57.73503
	SA_M	430000.0000	3	26457.51311	15275.25232

Paired Samples Test P3

	Paired Differences					t	df	Sig. (2tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			

Pair 1	PH_F - PH_M	.02000	.02000	.01155	-.02968	.06968	1.732	2	.225
Pair 2	VIT_C_F - Vitamin C_M	1.30333	.00577	.00333	1.28899	1.31768	391.000	2	.000
Pair 3	TSS_F - TSS_M	-.73000	.02000	.01155	-.77968	-.68032	-63.220	2	.000
Pair 4	TTA_F - TTA_M	-.00333	.05508	.03180	-.14015	.13348	-.105	2	.926
Pair 5	ASH_F - Ash_M	-.01333	.01528	.00882	-.05128	.02461	-1.512	2	.270
Pair 6	TVC_F - TVC_M	-5000.33333	3.51188	2.02759	-5009.05734	-4991.60933	-2466.149	2	.000
Pair 7	YM_F - YM_M	-21498.66667	3.21455	1.85592	-21506.65205	-21490.68128	-11583.824	2	.000
Pair 8	SA_F - SA_M	-35274.33333	.57735	.33333	-35275.76755	-35272.89912	-105823.000	2	.000

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PH_F	4.2933	3	.03786	.02186
	PH_M	4.2733	3	.05508	.03180
	VIT_C_F	25.5167	3	.00577	.00333
Pair 2	Vitamin C_M	24.2133	3	.00577	.00333
	TSS_F	11.0500	3	.01000	.00577
Pair 3	TSS_M			.01000	
	TTA_F	11.7800	3	.05196	.00577
	TTA_M	.1400	3	.00577	.03000
Pair 4	ASH_F	.1433	3	.00577	.00333
	Ash_M	.5567	3	.01000	.00333
Pair 5	TVC_F	.5700	3	1.73205	.00577
	TVC_M	20001.0000	3	2.30940	1.00000
	YM_F	25001.3333	3	2.88675	1.33333
Pair 6	YM_M	1501.6667	3	.57735	1.66667
	SA_F	23000.3333	3	.57735	.33333
Pair 7					

Pair 8		325.6667	3		.33333
	SA_M	35600.0000	3	.00000	.00000

Paired Samples Test P4

		Paired Differences					t	df	Sig. (2tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	PH_F - PH_M	.20333	.02082	.01202	.15162	.25504	16.918	2	.003
Pair 2	VIT_C_F - Vitamin C_M	2.52667	.06658	.03844	2.36126	2.69207	65.727	2	.000
Pair 3	TSS_F - TSS_M	-.86333	.86095	.49707	-3.00205	1.27538	-1.737	2	.225
Pair 4	TTA_F - TTA_M	.00000	.02000	.01155	-.04968	.04968	-.229	2	.840
Pair 5	ASH_F - Ash_M	.01667	.00577	.00333	.00232	.03101	5.000	2	.038
Pair 6	TVC_F - TVC_M	-2433.00000	58.02586	33.50124	-2577.14422	-2288.85578	-72.624	2	.000
Pair 7	YM_F - YM_M	-19732.33333	950.49268	548.76720	-22093.48804	-17371.17862	-35.958	2	.001
Pair 8	SA_F - SA_M	-456296.66667	9975.12072	5759.13863	-481076.24022	-431517.09311	-79.230	2	.000

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PH_F	4.3133	3	.01155	.00667
	PH_M	4.1100	3	.01000	.00577
Pair 2	VIT_C_F	24.9000	3	.01000	.00577
	Vitamin C_M	22.3733	3	.05686	.03283
Pair 3	TSS_F	11.7067	3	.43247	.24969
	TSS_M	12.5700	3	.51293	.29614

Pair 4	TTA_F	.2100	3	.01000	.00577
	TTA_M	.2100	3	.01000	.00577
Pair 5	ASH_F	.5300	3	.01000	.00577
	Ash_M	.5133	3	.00577	.00333
Pair 6	TVC_F	22000.3333	3	.57735	.33333
	TVC_M	24433.3333	3	57.73503	33.33333
	YM_F	1267.6667	3	58.62025	33.84442
Pair 7	YM_M	21000.0000	3	1000.00000	577.35027
	SA_F	3703.3333	3	55.07571	31.79797
Pair 8	SA_M				
		460000.0000	3	10000.00000	5773.50269

Paired Samples Test 5

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	PH_F - PH_M	-1.47333	.02082	.01202	-1.52504	-1.42162	-122.589	2	.000
Pair 2	VIT_C_F - Vitamin C_M	3.98333	.70002	.40416	2.24438	5.72229	9.856	2	.010
Pair 3	TSS_F - TSS_M	1.72000	.02000	.01155	1.67032	1.76968	148.956	2	.000
Pair 4	TTA_F - TTA_M	-.06333	.01528	.00882	-.10128	-.02539	-7.181	2	.019
Pair 5	ASH_F - Ash_M	.02333	.00577	.00333	.00899	.03768	7.000	2	.020
Pair 6	TVC_F - TVC_M	-46.66667	30.55050	17.63834	-122.55833	29.22499	-2.646	2	.118
Pair 7	YM_F - YM_M	-796.66667	176.16280	101.70764	-1234.27933	-359.05400	-7.833	2	.016
Pair 8	SA_F - SA_M	-29.33333	14.01190	8.08977	-64.14082	5.47416	-3.626	2	.068

Paired Samples Statistics p5

		Mean	N	Std. Deviation	Std. Error Mean
	PH_F	4.0333	3	.00577	.00333
Pair 1	PH_M				
		5.5067	3	.01528	.00882
	VIT_C_F	24.9000	3	.43589	.25166
	Vitamin C_M				
Pair 2		20.9167	3	.34933	.20169
	TSS_F	12.5100	3	.01000	.00577
	TSS_M			.01000	
Pair 3	TTA_F			.01000	
	TTA_M	10.7900	3	.00577	.00577
	ASH_F	1.5500	3	.00577	.00577
	Ash_M				
Pair 4		1.6133	3	.01000	.00333
	TVC_F	.6633	3	25.16611	.00333
	TVC_M	.6400	3	30.00000	.00577
Pair 5	YM_F	1223.3333	3	109.69655	14.52966
	YM_M	1270.0000	3	251.66115	17.32051
Pair 6	SA_F	12436.6667	3	2.51661	63.33333
	SA_M	13233.3333	3		145.29663
Pair 7					
Pair 8		102.3333	3		1.45297
		131.6667	3	12.58306	7.26483

Paired Samples Test P6

	Paired Differences					t	df	Sig. (2tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			

Pair 1	PH_F - PH_M	.50333	.00577	.00333	.48899	.51768	151.000	2	.000
Pair 2	VIT_C_F - Vitamin C_M	.92000	.03464	.02000	.83395	1.00605	46.000	2	.000
Pair 3	TSS_F - TSS_M	1.66000	.09000	.05196	1.43643	1.88357	31.947	2	.001
Pair 4	TTA_F - TTA_M	.01333	.01155	.00667	-.01535	.04202	2.000	2	.184
Pair 5	ASH_F - Ash_M	-.00667	.01528	.00882	-.04461	.03128	-.756	2	.529
Pair 6	TVC_F - TVC_M	-78650.00000	135403.87033	78175.46098	-415011.86060	257711.86060	-1.006	2	.420
Pair 7	YM_F - YM_M	-10633.33333	8342.86122	4816.75317	-31358.14951	10091.48285	-2.208	2	.158
Pair 8	SA_F - SA_M	-412.66667	707.83214	408.66707	-2171.01917	1345.68584	-1.010	2	.419

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
	PH_F	4.6767	3	.00577	.00333
Pair 1	PH_M				
	VIT_C_F	4.1733	3	.00577	.00333
	Vitamin C_M	23.0133	3	.00577	.00333
Pair 2	TSS_F	22.0933	3	.03786	.02186
	TSS_M	12.5000	3	.10000	.05774
	TTA_F	10.8400	3	.01000	.00577
Pair 3	TTA_M			.01000	
	ASH_F			.01528	
Pair 4	Ash_M	1.5200	3	.00577	.00577
	TVC_F	1.5067	3	.01000	.00882
Pair 5	TVC_M	.5433	3	30.00000	.00333
	YM_F	.5500	3	135377.94207	.00577
	YM_M	15030.0000	3	8066.59780	17.32051
Pair 6	SA_F	93680.0000	3	577.35027	78160.49130
	SA_M	20700.0000	3	3.21455	4657.25241
Pair 7		31333.3333	3		333.33333
Pair 8		123.6667	3		1.85592

	536.3333	3	704.65618	406.83344

Paired Samples Test P7

		Paired Differences					t	df	Sig. (2tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	PH_F - PH_M	1.00000	.16462	.09504	.59106	1.40894	10.521	2	.009
Pair 2	VIT_C_F - Vitamin C_M	.14667	.23671	.13667	-.44136	.73470	1.073 580.000	2	.395
Pair 3	TSS_F - TSS_M	1.93333	.00577	.00333	1.91899	1.94768		2	.000
Pair 4	TTA_F - TTA_M	.10667	.01528	.00882	.06872	.14461	12.095	2	.007
Pair 5	ASH_F - Ash_M	-.00333	.01155	.00667	-.03202	.02535	-.500	2	.667
Pair 6	TVC_F - TVC_M	-358.33333	478.54815	276.28990	-1547.11284	830.44618	-1.297	2	.324
Pair 7	YM_F - YM_M	-219666.66667	8962.88644	5174.72490	-241931.71088	-197401.62246	-42.450	2	.001
Pair 8	SA_F - SA_M	-87.00000	70.40597	40.64890	-261.89811	87.89811	-2.140	2	.166

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PH_F	4.3800	3	.15395	.08888
	PH_M	3.3800	3	.31575	.18230
Pair 2	VIT_C_F	26.4300	3	.01000	.00577
	Vitamin C_M	26.2833	3	.24542	.14170
Pair 3	TSS_F	11.9700	3	.01000	.00577
	TSS_M	10.0367	3	.01528	.00882
Pair 4	TTA_F	.2200	3	.01000	.00577
	TTA_M	.1133	3	.00577	.00333

Pair 5	ASH_F	.6033	3	.00577	.00333
	Ash_M	.6067	3	.01528	.00882
Pair 6	TVC_F	2341.6667	3	2.88675	1.66667
	TVC_M	2700.0000	3	476.96960	275.37853
Pair 7	YM_F	23666.6667	3	3214.55025	1855.92145
	YM_M	243333.3333	3	5773.50269	3333.33333
Pair 8	SA_F	1320.0000	3	60.82763	35.11885
	SA_M	1407.0000	3	39.96248	23.07235

ANALYSIS OF VARIANCE OF PINEAPPLE PRODUCERS

One-way ANOVA: pH

Method

Null hypothesis	All means are equal
Alternative hypothesis	At least one mean is different
Significance level	α = 0.05

Equal variances were assumed for the analysis.

Factor Information

Factor	Levels	Values
Name of producer	4	P1, P2, P3, P4

Analysis of Variance

Source	DF	Adj SS	AdjMS	F-Value	P-Value
Name of producer	3	0.38242	0.127475	72.50	0.000
Error	8	0.01407	0.001758		
Total	11	0.39649			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.0419325	96.45%	95.12%	92.02%

Means

Name of producer	N	Mean	StDev	95% CI
P1	3	4.6333	0.0551	(4.5775, 4.6892)
P2	3	4.1433	0.0493	(4.0875, 4.1992)
P3	3	4.2933	0.0379	(4.2375, 4.3492)
P4	3	4.31333	0.01155	(4.25751, 4.36916)

Pooled StDev = 0.0419325

Fisher Pairwise Comparisons

Grouping Information Using the Fisher LSD Method and 95% Confidence

Name of producer	N	Mean	Grouping
P1	3	4.6333	A
P2	3	4.31333	B
P3	3	4.2933	B
P4	3	4.1433	C

Means that do not share a letter are significantly different.

One-way ANOVA: Vitamin C

Method

Null hypothesis	All means are equal
Alternative hypothesis	At least one mean is different
Significance level	α = 0.05

Equal variances were assumed for the analysis.

Factor Information

Factor	Levels	Values
Name of producer	4	P1, P2, P3, P4

Analysis of Variance

Source	DF	Adj SS	AdjMS	F-Value	P-Value
Name of producer	3	8.69436	2.89812	3548.72	0.000
Error	8	0.00653	0.00082		
Total	11	8.70089			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.0285774	99.92%	99.90%	99.83%

```
Means
 Name
of
producer  N     Mean   StDev        95% CI P1
3  27.0467  0.0551  (27.0086, 27.0847)
P2        3  26.6000  0.0100  (26.5620, 26.6380)
P3        3  25.5167  0.0058  (25.4786, 25.5547)
P4        3  24.9000  0.0100  (24.8620, 24.9380)

Pooled StDev = 0.0285774
```

Fisher Pairwise Comparisons

```
Grouping Information Using the Fisher LSD Method and 95%
Confidence
 Name
of
producer  N     Mean  Grouping P4
3  27.0467  A
P1        3  26.6000    B
P3        3  25.5167      C
P2        3  24.9000        D

Means that do not share a letter are significantly
different.
```

One-way ANOVA: TSS

```
Method

Null hypothesis         All means are equal
Alternative hypothesis  At least one mean is different
Significance level      α = 0.05

Equal variances were assumed for the analysis.


Factor Information
```

```
Factor              Levels  Values
Name of producer         4  P1, P2, P3, P4
```

Analysis of Variance

```
Source            DF  Adj SS   Adj MS  F-Value  P-Value
Name of producer   3  1.4483  0.48276     7.18    0.012
Error              8  0.5376  0.06720
Total             11  1.9859
```

Model Summary

```
 S         R-sqR-sq(adj)  R-sq(pred)
0.259230  72.93%     62.78%      39.09%
```

```
Means
 Name
of
producer  N      Mean   StDev        95% CI P1
3   11.3633  0.0058  (11.0182, 11.7085)
P2        3    10.777   0.286   (10.432,  11.122)
P3        3   11.0500  0.0100  (10.7049, 11.3951)
P4        3    11.707   0.432   (11.362,  12.052)

Pooled StDev = 0.259230
```

Fisher Pairwise Comparisons

Grouping Information Using the Fisher LSD Method and 95% Confidence

```
 Name
of
producer  N      Mean  Grouping P4
3    11.707  A
P1        3   11.3633  A B
P3        3   11.0500    B C
P2        3    10.777      C
```

Means that do not share a letter are significantly different.

One-way ANOVA: TTA

Method

Null hypothesis	All means are equal
Alternative hypothesis	At least one mean is different
Significance level	α = 0.05

Equal variances were assumed for the analysis.

Factor Information

Factor	Levels	Values
Name of producer	4	P1, P2, P3, P4

Analysis of Variance

Source	DF	Adj SS	AdjMS	F-Value	P-Value Name
of producer	3	7.44742	2.48247	3309.97	0.000
Error	8	0.00600	0.00075		
Total	11	7.45342			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.0273861	99.92%	99.89%	99.82%

Means

```
 Name
of
producer  N      Mean    StDev         95% CI P2
3   0.26000  0.01000  (0.22354, 0.29646)
P3        3   2.02000  0.01000  (1.98354, 2.05646)
P6        3    0.1400   0.0520  (0.1035,  0.1765)
```

```
P7        3   0.21000  0.01000  (0.17354, 0.24646)

Pooled StDev = 0.0273861
```

Fisher Pairwise Comparisons

```
Grouping Information Using the Fisher LSD Method and 95%
Confidence
 Name
of
producer  N     Mean  Grouping P2
3   2.02000  A
P1        3   0.26000    B
P4        3   0.21000    B
P3        3    0.1400     C

Means that do not share a letter are significantly
different.
```

One-way ANOVA: ASH

```
Method

Null hypothesis         All means are equal
Alternative hypothesis  At least one mean is different
Significance level      α = 0.05

Equal variances were assumed for the analysis.


Factor Information

Factor                    Levels   Values
Name of producer        4  P1,  P2, P3, P4


Analysis of Variance

Source             DF    Adj SS    AdjMS  F-Value  P-Value
Name of producer    3  0.024158  0.008053    42.01    0.000
Error               8  0.001533  0.000192
```

```
Total              11  0.025692


Model Summary

   S      R-sq       R-sq(adj)  R-sq(pred)
0.0138444  94.03%     91.79%      86.57%
Means
 Name
of
producer  N     Mean     StDev        95% CI P1
3  0.65000  0.01000  (0.63157, 0.66843)
P2        3   0.5667   0.0231  ( 0.5482,  0.5851)
P3        3  0.55667  0.00577  (0.53823, 0.57510)
P4        3  0.53000  0.01000  (0.51157, 0.54843)

Pooled StDev = 0.0138444
```

Fisher Pairwise Comparisons

```
Grouping Information Using the Fisher LSD Method and 95%
Confidence
 Name
of
producer  N     Mean  Grouping P1
3   0.65000  A
P2        3    0.5667    B
P3        3   0.55667    B
P4        3   0.53000      C

Means that do not share a letter are significantly
different.
```

One-way ANOVA: TVC

```
Method

Null hypothesis         All means are equal
Alternative hypothesis  At least one mean is different
Significance level      α = 0.05

Equal variances were assumed for the analysis.
```

Factor Information

Factor   Levels   Values
Name of producer   4 P1,   P2, P3, P4

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	PValue
Name of producer	3	1121046451	373682150	2.98946E+08	0.000
Error	8	10	1		
Total	11	1121046461			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
1.11803	100.00%	100.00%	100.00%

Means

Name of producer	N	Mean	StDev	95% CI
P1	3	1450.33	0.58	(1448.84, 1451.82)
P2	3	2000.67	1.15	(1999.18, 2002.16)
P3	3	20001.0	1.7	(19999.5, 20002.5)
P4	3	22000.3	0.6	(21998.8, 22001.8)

Pooled StDev = 1.11803

Fisher Pairwise Comparisons

Grouping Information Using the Fisher LSD Method and 95% Confidence

Name of producer	N	Mean	Grouping
P4	3	22000.3	A

P3	3	20001.0	B
P2	3	2000.67	C
P1	3	1450.33	D

Means that do not share a letter are significantly different.

One-way ANOVA: YMC

Method

Null hypothesis	All means are equal
Alternative hypothesis	At least one mean is different
Significance level	α = 0.05

Equal variances were assumed for the analysis.

Factor Information

Factor	Levels	Values
Name of producer	4	P1, P2, P3, P4

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Name of producer	3	375042	125014	139.12	0.000
Error	8	7189	899		
Total	11	382231			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
29.9764	98.12%	97.41%	95.77%

Means
Name
of

```
producer  N     Mean  StDev        95% CI P1
3  1006.67  11.55  ( 966.76, 1046.58)
P2        3  1202.33   4.04  (1162.42, 1242.24)
P3        3  1501.67   2.89  (1461.76, 1541.58)
P4        3   1267.7   58.6  ( 1227.8,  1307.6)

Pooled StDev = 29.9764
```


Fisher Pairwise Comparisons

```
Grouping Information Using the Fisher LSD Method and 95%
Confidence
 Name
of
producer  N     Mean  Grouping P6
3  1501.67  A
P7        3   1267.7    B
P3        3  1202.33      C
P2        3  1006.67        D

Means that do not share a letter are significantly
different.
```

One-way ANOVA: STAPHYLOCOCCUS COUNT

```
Method

Null hypothesis         All means are equal
Alternative hypothesis  At least one mean is different
Significance level      α = 0.05

Equal variances were assumed for the analysis.


Factor Information

Factor             Levels  Values
Name of producer        4  P1, P2, P3, P4


Analysis of Variance
```

Source	DF	Adj SS	AdjMS	F-Value	P-Value
Name of producer	3	683996751	227998917	2663.70	0.000
Error	8	684758	85595		
Total	11	684681509			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
292.566	99.90%	99.86%	99.77%

Means

Name of producer	N	Mean	StDev	95% CI
P1 3	19669	574	(19279,	20058)
P2	3	3500.0	100.0	(3110.5, 3889.5)
P3	3	325.667	0.577	(-63.847, 715.181)
P4	3	3703.3	55.1	(3313.8, 4092.8)

Pooled StDev = 292.566

Fisher Pairwise Comparisons

Grouping Information Using the Fisher LSD Method and 95% Confidence

Name of producer	N	Mean	Grouping
P1 3	19669	A	
P4	3	3703.3	B
P2	3	3500.0	B
P3	3	325.667	C

Means that do not share a letter are significantly different.

ANALYSIS OF VARIANCE FOR ORANGE JUICE PRODUCERS

One-way ANOVA: pH

Method

Null hypothesis All means are equal

```
Alternative hypothesis  At least one mean is different
Significance level      α = 0.05

Equal variances were assumed for the analysis.


Factor Information

Factor             Levels  Values
Name of producer        3  P5, P6, P7


Analysis of Variance

Source             DF   Adj SS    AdjMS  F-Value  P-Value
Name of producer    2  0.62207  0.311033    39.26    0.000
Error               6  0.04753  0.007922
Total               8  0.66960


Model Summary
S     R-sqR-sq(adj)  R-sq(pred)
0.0890069  92.90%     90.53%      84.03%


Means
 Name
of
producer  N     Mean    StDev         95% CI P5
3  4.03333  0.00577  (3.90759, 4.15908)
P6        3  4.67667  0.00577  (4.55092, 4.80241)
P7        3   4.3800   0.1539  ( 4.2543,  4.5057)

Pooled StDev = 0.0890069
```

Tukey Pairwise Comparisons

```
Grouping Information Using the  Fisher LSD and 95%
Confidence
 Name
of
producer  N     Mean  Grouping P6
3  4.67667  A
P7        3   4.3800    B
P5        3  4.03333   C
```

Means that do not share a letter are significantly differen

One-way ANOVA: Vitamin C

Method

Null hypothesis	All means are equal
Alternative hypothesis	At least one mean is different
Significance level	α = 0.05

Equal variances were assumed for the analysis.

Factor Information

Factor	Levels	Values
Name of producer	3	P5, P6, P7

Analysis of Variance

Source	DF	Adj SS	AdjMS	F-Value	P-Value
Name of producer	2	17.5740	8.78701	138.64	0.000
Error	6	0.3803	0.06338		
Total	8	17.9543			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.251749	97.88%	97.18%	95.23%

Means

Name of producer	N	Mean	StDev	95% CI
P5	3	24.900	0.436	(24.544, 25.256)
P6	3	23.0133	0.0058	(22.6577, 23.3690)
P7	3	26.4300	0.0100	(26.0743, 26.7857)

Pooled StDev = 0.251749

Tukey Pairwise Comparisons

Grouping Information Using the Fisher LSD and 95% Confidence

Name of producer	N	Mean	Grouping
P7	3	26.4300	A
P5	3	24.900	B
P6	3	23.0133	C

Means that do not share a letter are significantly different

One-way ANOVA: TSS

Method

Null hypothesis	All means are equal
Alternative hypothesis	At least one mean is different
Significance level	α = 0.05

Equal variances were assumed for the analysis.

Factor Information

Factor	Levels	Values
Name of producer	3	P5, P6, P7

Analysis of Variance

Source	DF	Adj SS	AdjMS	F-Value	P-Value
Name of producer	2	0.57260	0.286300	84.21	0.000
Error	6	0.02040	0.003400		
Total	8	0.59300			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.0583095	96.56%	95.41%	92.26%

Means

```
 Name
of
producer  N     Mean   StDev        95% CI P5
3  12.5100  0.0100  (12.4276, 12.5924)
P6        3  12.5000  0.1000  (12.4176, 12.5824)
P7        3  11.9700  0.0100  (11.8876, 12.0524)

Pooled StDev = 0.0583095
```

Tukey Pairwise Comparisons

```
Grouping Information Using the  Fisher LSD and 95%
Confidence
 Name
of
producer  N     Mean  Grouping
P5        3  12.5100  A
P6        3  12.5000  A
P7        3  11.9700B

Means that do not share a letter are significantly
different.
```

One-way ANOVA: TTA

```
Method

Null hypothesis         All means are equal
Alternative hypothesis  At least one mean is different
Significance level      α = 0.05

Equal variances were assumed for the analysis.


Factor Information

Factor            Levels  Values
Name of producer       3  P5, P6, P7

Analysis of Variance

Source            DF   Adj SS   Adj MS   F-Value  P-Value
```

Name of producer	2	3.45980	1.72990	17299.00	0.000
Error	6	0.00060	0.00010		
Total	8	3.46040			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.01	99.98%	99.98%	99.96%

Means

Name of producer	N	Mean	StDev	95% CI
P5	3	1.55000	0.01000	(1.53587, 1.56413)
P6	3	1.52000	0.01000	(1.50587, 1.53413)
P7	3	0.22000	0.01000	(0.20587, 0.23413)

Pooled StDev = 0.01

Tukey Pairwise Comparisons

Grouping Information Using the Fisher LSD and 95% Confidence

Name of producer	N	Mean	Grouping
P5	3	1.55000	A
P6	3	1.52000	B
P7	3	0.22000	C

Means that do not share a letter are significantly different

One-way ANOVA: ASH

Method

Null hypothesis All means are equal

Alternative hypothesis At least one mean is different
Significance level   α = 0.05

Equal variances were assumed for the analysis.

Factor Information

Factor	Levels	Values
Name of producer	3	P5, P6, P7

Analysis of Variance

Source	DF	Adj SS	AdjMS	F-Value	P-Value
Name of producer	2	0.021600	0.010800	324.00	0.000
Error	6	0.000200	0.000033		
Total	8	0.021800			

Model Summary

S	R-sqR-sq(adj)	R-sq(pred)	
0.0057735	99.08%	98.78%	97.94%

Means
Name
of
producer N   Mean   StDev   95% CI P5
3 0.66333 0.00577 (0.65518, 0.67149)
P6   3 0.54333 0.00577 (0.53518, 0.55149)
P7   3 0.60333 0.00577 (0.59518, 0.61149)

Pooled StDev = 0.00577350

Tukey Pairwise Comparisons

Grouping Information Using the Fisher LSD and 95% Confidence
Name
of
producer N   Mean Grouping P5
3 0.66333 A
P7   3 0.60333   B

P6 3 0.54333C

Means that do not share a letter are significantly dif

One-way ANOVA: TVC

Method

Null hypothesis	All means are equal
Alternative hypothesis	At least one mean is different
Significance level	α = 0.05

Equal variances were assumed for the analysis.

Factor Information

Factor	Levels	Values
Name of producer	3	P5, P6, P7

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	PValue
Name of producer	2	352868517	176434258	343331.53	0.000
Error	6	3083	514		
Total	8	352871600			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
22.6691	100.00%	100.00%	100.00%

Means

Name of producer	N	Mean	StDev	95% CI
P5	3	1223.3	25.2	(1191.3, 1255.4)
P6	3	15030.0	30.0	(14998.0, 15062.0)
P7	3	2341.67	2.89	(2309.64, 2373.69)

Pooled StDev = 22.6691

Tukey Pairwise Comparisons

Grouping Information Using the Fisher LSD and 95% Confidence

Name of producer	N	Mean	Grouping
P6	3	15030.0	A
P7	3	2341.67	B
P5	3	1223.3	C

Means that do not share a letter are significantly different

One-way ANOVA: YEAST AND MOULD COUNT

Method

Null hypothesis	All means are equal
Alternative hypothesis	At least one mean is different
Significance level	α = 0.05

Equal variances were assumed for the analysis.

Factor Information

Factor	Levels	Values
Name of producer	3	P5, P6, P7

Analysis of Variance

Source	DF	Adj SS	AdjMS	F-Value	P-Value
Name of producer	2	203196689	101598344	4.04	0.077
Error	6	150830733	25138456		
Total	8	354027422			

Model Summary

S R-sq R-sq(adj) R-sq(pred)

```
5013.83  57.40%     43.19%       4.14%


Means
 Name
of
producer  N     Mean  StDev        95% CI P5
3  12436.7  109.7  (5353.5, 19519.8)
P6        3    20700   8067  ( 13617,   27783)
P7        3    23667   3215  ( 16584,   30750)

Pooled StDev = 5013.83
```

Fisher Pairwise Comparisons

```
Grouping Information Using the Fisher LSD Method and 95%
Confidence
 Name
of
producer  N     Mean  Grouping P5
3    23667  A
P4        3    20700  A B
P1        3  12436.7    B

Means that do not share a letter are significantly different
```

One-way ANOVA: STAPHYLOCOCCUS COUNT

```
Method

Null hypothesis         All means are equal
Alternative hypothesis  At least one mean is different
Significance level      α = 0.05

Equal variances were assumed for the analysis.


Factor Information

Factor              Levels  Values
Name of producer         3  P5, P6, P7


Analysis of Variance
```

```
Source              DF   Adj SS   AdjMS  F-Value  P-Value Name
of producer   2  2914381  1457190  1176.21    0.000
Error               6     7433    1239
Total               8  2921814
```

```
Model Summary

      S    R-sqR-sq(adj)  R-sq(pred)
35.1979  99.75%     99.66%      99.43%
```

```
Means
 Name
of
producer  N    Mean  StDev       95% CI P5
3  102.33   2.52  ( 52.61, 152.06)
P6        3  123.67   3.21  ( 73.94, 173.39)
P7        3  1320.0   60.8  (1270.3, 1369.7)

Pooled StDev = 35.1979
```

Fisher Pairwise Comparisons

```
Grouping Information Using the Fisher LSD Method and 95%
Confidence
 Name
of
producer  N    Mean  Grouping P7
3  1320.0A
P6        3  123.67    B
P5        3  102.33    B

Means that do not share a letter are significantly
different.
```