COMPLIANCE OF SMALL AND MEDIUM SCALE PINEAPPLE PROCESSING ENTERPRISES WITH NATIONAL AND INTERNATIONAL STANDARDS IN RWANDA

BY

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EXTENDED ABSTRACT

Small and Medium Scale Enterprises (SMEs) processing fruits play an important role in the national economic development of Rwanda. Although these SMEs have received assistance from the government, they still face many constraints that hinder their development. For example, their access to both local and export markets is limited due to poor quality of their products. A study was conducted using a cross-sectional study design, to assess the compliance of the food SMEs with national and international food quality standards.

A total of 16 small and 11 medium scale pineapple processing enterprises in the country were surveyed through interviews with enterprise managers using a structured questionnaire and face-to-face methods. Results revealed that there existed 27 pineapple processing enterprises, where 16 were small scale managed by women and 11 medium scale managed by men. The mean number of employees ranged between 7 (± 4.37) and 15 (± 6.68) for small and medium scale enterprises, respectively. Capital investment was estimated at less than US$10 000 and above US$25 000 for small and medium processing enterprises, respectively. Pineapple wine and ready-to-drink juices were the most popular products produced, sold locally and to neighbouring countries. Lack of entrepreneurial skills, high cost of water, electricity, high transport cost, limited knowledge and technical skills and inaccessibility to packaging materials and processing equipment were the major constraints identified that the food SMEs faced. Results on Good Manufacturing Practices (GMP) and Good Hygienic Practices (GHP) showed a lack of compliance with the standard requirements in the majority of both enterprise categories. None of the visited enterprises had clear criteria of the delivery procedure of raw pineapples and none had a signed contract with the suppliers, which led to uncontrolled primary production. The plant layout and design of both small and medium enterprises were characterised by insufficient number of working rooms and there was crisscrossing in the production line of 81.8 and 87.5% for medium and small enterprises, respectively. The clean and unclean sectors were only separated at 63.6% and 31.2% of the medium and small enterprises, respectively. Generally, the status of all enterprise categories, their surrounding areas and equipment were classified as unsatisfactory. The majority of enterprises did not have temperature and time control systems and for both enterprise categories, there was no clear plan for waste disposal and pest control. The findings of physico-chemical properties of products stored over a period of 12 months for pineapple syrups and jams and two months for nectars showed that all syrups, jams and nectars had pH ranging from 3-5, the normal pH range for fruit products. The levels of titratable acidity of all products were below the maximum limit of 1.35% set by Codex Alimetarius Commission standards (CAC), East African Standards (EAS) and Rwandan Standards (RS). Similarly, their levels of ethanol were less than 0.3% as recommended by the same standard bodies .

Syrups and jams were stable for most of the evaluated physico-chemical parameters (pH, total titratable acidity, moisture, ash, fibre, total soluble solids) up to six months of storage. However, significant changes were observed from the ninth month of storage. Nectars were stable up to the end of the second month of storage, which was in agreement with indicated expiry date by most of the enterprises. There was a significant ($p<0.05$) decrease of sucrose and increase of reducing sugars in syrup and jam samples, from six month of storage. The levels of sucrose content ranged from 9.36 to 12.91%; 6.24 to 13.48% and 0.36 to 5.98% in syrups, jams and nectars, respectively at the initial storage time. The products were free from microbial contamination throughout the storage period. The sensory analysis findings showed that syrups were equally liked as the reference syrup and nectar, but jams were disliked by panelists while nectars were acceptable up to the end of the first month of storage. As the storage period increased, the mean scores for the colour and aroma preference decreased significantly ($p<0.05$). Results for heavy metal contamination showed that the mean levels ranged from 0.63 to 2.97 mg/l for zinc, 0.95 to 1.92 mg/l for iron, 0.74 to 3.50 mg/l for copper and 2.3 to 7.9 mg/l for aluminium, for syrups and nectars. They were within the acceptable recommended maximum standard values of 5 mg/l for zinc; 15 mg/l for iron; 5 mg/l for copper and 8 mg/l for aluminium in syrups and nectars. However, the levels of lead and cadmium were above the permissible values set by Codex Alimentarius Commission in these products. They ranged from 0.25-1.74 mg/l for lead and 0.21-1.23 mg/kg for cadmium. In jams, copper (2.04-6.33 mg/kg), zinc (0.82-3.55 mg/kg) and cadmium (0.31-1.46 mg/kg) concentration levels were also above the permissible values of 0.03 mg/kg for copper, 0.05 mg/kg for zinc and 0.01mg/kg for cadmium.

Based on the present findings, a shelf life of six months for syrups and jams and one month for nectars processed in hygienic environment using food grade processing equipment is recomemnded for export market. However, the source of copper, zinc, lead and cadmium contamination should be traced in order to produce safe products. Processing enterprises need technical and financial support to overcome some of the constraints and be able to produce quality products that are acceptable in the local and export market.

LIST OF PUBLICATIONS

i. Mukantwali, C., Laswai, H., Tiisekwa, B., Wiehler, S. (2012). Issues Affecting Small- and Medium Scale Pineapple Processing Enterprises in Rwanda: A Cross-sectional Study. *BANWA* 9 (1&2): 97 - 118.

ii. Mukantwali, C., Laswai, H., Tiisekwa, B., Wiehler, S. (2013). Good Manufacturing and Hygienic Practices at Small and Medium Scale Pineapple Processing Enterprises in Rwanda. *Food Science and Quality Management* (13): 15 - 30.

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iv. Mukantwali, C., Laswai, H., Tiisekwa, B., Wiehler, S. (2014). Microbial and Heavy Metal Contamination of Pineapple Products Processed by Small and Medium Scale Processing Enterprises in Rwanda. *African Journal of Biotechnology* 13 (39): 3977 - 3984.

v. Mukantwali, C., Laswai, H., Tiisekwa, B., Wiehler, S. Evaluation of the Storage Stability of Processed Pineapple Products by Small and Medium Scale Processing Enterprises in Rwanda. *Submitted to African Journal of Biotechnology.*

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DECLARATION

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

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I dedicate this work to my late father, Mihanda Télésphore; mother, Maso Espérance and grand-mother, Mushikazi Marcie for raising me in such unforgettable loving environment.

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LIST OF ABREVIATIONS

AAS	Atomic Absorption Spectrophotometer
ANOVA	Analysis of Variance
AOAC	Association of Official Analytical Chemists
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
AWARD	African Women in Agriculture Research and Development
BNR	Banque Nationale du Rwanda
BP	Banque Populaire du Rwanda
BRALIRWA	Brasseries et Limonaderies du Rwanda
BRD	Banque Rwandaise de Developement
CAC	Codex Alimentarius Commission
CCP	Critical Control Points
CEC	Commission of European Communities
CFU	Colony Forming Unit
CIRAD	Centre de coopération Internationale en Recherche Agronomique pour le Développement
CODEXSTAN	Codex Standard
CTA	Centre Technique de Coopération Agricole
EAS	East African Standards
ENs	European Standards
EU	European Union
EWSA	Electricity, Water and Sanitation Authority
FAO	Food and Agriculture Organization
GAP	Good Agricultural Practices

GDP	Gross Domestic Product
GHP	Good Hygienic Practices
GMP	Good Manufacturing Practices
HACCP	Hazard Analysis and Critical Control Points
IFU	International Fruit juice Union
ISO	International Organization for Standardization
ISHS	International Society for Horticultural Science
kW	Kilowatt
KIST	Kigali Institute of Science and Technology
LADAMET	Laboratory of Analysis of Foodstuff, Drugs, Water and Toxins
MINECOFIN	Ministry of Finance and Economic Planning
MINICOM	Ministry of Trade and Industry
NMKL	Nordic Committee on Food Analysis
MSSD	Markets and Structural Studies Division
NAEB	National Agricultural Export Development Board
PET	Polyethylene Terephtalate
RAB	Rwanda Agriculture Board
RCA	Rwanda Cooperative Agency
RHODA	Rwanda Horticulture Development Authority
rpm	revolution per minute
RRA	Rwanda Revenue Authority
RS	Rwanda Standard
SD	Standard Deviation
SMAC	Sorbitol McConkey Agar
SMEs	Small and Medium Enterprises

SPSS	Statistical Product and Service Solutions
SUA	Sokoine University of Agriculture
TSS	Total Soluble Solids
TTA	Total Titratable Acidity
UK	United Kingdom
UNCTAD	United Nations Conference on Trade And Development
UNESCO	United Nations Educational Scientific and Cultural Organization
UR	University of Rwanda
USA	United States of America
UV	Ultrat Violet
WBCSD	World Business Council for Sustainable Development

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Pineapple [*Ananas comosus* (L.) Merrill.] is a tropical fruit of the family *Bromeliaceae* originating from South America and is now grown in various parts of the world (Ikeyi Adachukwu *et al*., 2013; Samson, 1980). The United Nations Conference on Trade And Development (UNCTAD) points out that pineapple is the second fruit harvest of importance after bananas (UNCTAD, 2012). It contributes over 20% of the total world production of tropical fruits. Most of the pineapples harvested are consumed as fresh fruits in the countries of production. The leading producers of pineapples worldwide are Brazil, Thailand, the Philippines, Costa Rica, and China (UNCTAD, 2012). Ninety percent of the world demand of fresh pineapple fruits is in twelve countries, namely, the United States, France, Japan, Belgium, Italy, Germany, Canada, Spain, England, Korea, the Netherlands and Singapore (International Society for Horticultural Science, 2014). Rwanda Horticulture Development Authority (RHODA) has shown that in Rwanda, pineapple is an important horticultural crop and it is grown mainly in the Northern and Southern Provinces (RHODA, 2008). In 2008, the total country pineapple production was estimated at 31 329 tonnes (RHODA, 2008) while 43 000 tonnes were imported from neighbouring countries which produce more pineapple fruits when compared to Rwanda (Austin *et al.*, 2009). For examples, Kenya is ranked among the top ten pineapple producing countries worldwide while the production in Tnzania is estimated at 215 000 tonnes per year (Fresh Plaza, 2013). In Rwanda, the export market for fresh pineapple does not exist due to high cost of transport and this circumstance has created possibilities for pineapple fruit to be locally processed thereby making processed products available on the local market (Austin *et al.*, 2009). However, for two big fruit processing companies in Rwanda (Inyange and

Urwibutso), processed pineapple syrups, nectars, jam and pulp have found a market in the region and in Europe (Austin *et al.*, 2009). Inyange processes pineapple into concentrate to supply Regional, Middle East and European markets. This implies that if the capacity for small and medium scale pineapple processing enterprises is enhanced, they could have an opportunity to penetrate the export market.

1.2 Situation Analysis of Small and Medium Scale Enterprises in Developing Countries

Small and Medium scale Enterprises (SMEs) play an important role in the economies of developing countries (Rodriguez *et al.*, 2007; WBCSD), 2004; Wignaraja, 2003; Randinelli and Kasarda, 1992). Many have considered SMEs as a critical factor in the ongoing growth of market economies and in contributing to the creation of jobs throughout the world (Ardic *et al.*, 2011; Zorpas, 2010; Beck and Demirgüç-Kunt, 2006; WBCSD, 2004). Small and Medium Scale Enterprises have been acknowledged for their flexibility to quickly absorb technological innovations, and today, they occupy a significant position in industrial activities (WBCSD, 2004). Todate, SMEs contribute to about 3% of Gross Domestic Product (GDP) of developing countries with some countries like India where SMEs contribute 8% of India's GDP, generating 45% of manufacturer output and 40% of export (Ardic *et al.*, 2011; Tampy, 2010). In contrast, in developed countries, they contribute 13% of GDP (Ardic *et al.*, 2011). In Sub-Saharan African countries, SMEs contribute less than 20% of GDP (Fjose *et al.*, 2010). The global crisis of 2008 to 2009 has led to an increased interest in the role of SMEs in job creation and economic growth (Ardic *et al.*, 2011). SMEs have other numerous advantages, such as stimulation of unskilled entrepreneurs, possibility of development on decentralized basis in rural and semi-urban areas to meet local demand, provision of linkages to agricultural and rural activities, use of simple technology, use of local human resources and the creation of middle class of self-employed entrepreneurs (Steel and Webster, 1991).

SMEs provide most of the jobs in Africa, while they account for the majority of industrial units (Fjose *et al*., 2010). In Sub-Saharan Africa, 60% of the labour force is found among small and medium scale food processing enterprises (Mhazo *et al*., 2012). Though numerous advantages of SMEs are evidenced, they still face many constraints including difficulties to obtain loans from commercial banks, especially long-term loans and this is not only the case of developing countries but also for some SMEs in developed countries (Ardic *et al*., 2011; Kaivanto and Stoneman, 2007). Beck and Demirgüç-Kunt (2006) have given some reasons leading SMEs to not having easy access to financial support. Those reasons include having difficulties to provide creditworthiness, small cash flows, inadequate credit history, high risk premiums, underdeveloped bank borrower relationships and high transaction costs. In Africa, lack of SMEs transparency and underdeveloped financial systems are the main obstacles to SMEs development in addition to the known macro-economic instability of developing countries (Ardic *et al*., 2011; Fjose *et al.*, 2010; Rocha *et al*., 2010).

For small scale food processing enterprises in developing countries, in addition to limited access to financial support, they face many other challenges hindering their development. These challenges include lack of access to capital for investment and operation; limited technology choice for entrepreneurs; poorly developed technical and managerial skills among entrepreneurs and limited access to technical and market information (Ardic *et al*., 2011). These constraints are common to small scale food processing enterprises in developing countries and are considered as the cause of the enterprises' weakness in terms of price, quality and delivery performance (Minten *et al*., 2009; Markelova *et al*., 2009;

Nankani *et al*., 2005; Mhazo *et al*., 2005; Wignaraja, 2003; Sleuwaegen and Goedhuys, 2002; Dietz *et al*., 2000; Zapharullah *et al*., 1998). For example, Rwanda Government has availed a development bank (Banque Rwandaise de Development (BRD) for processing SMEs to get financial assistance. However, only a few SMEs benefit from this service due to limited information on how to access the fund (Ministry of Trade and Industry, 2010). This is evidenced by Ardic *et al*. (2011) who found that SMEs lending volume in Sub-Saharan Africa, Middle East, North Africa and South Asia account only for 1.7% while it accounts for 90% in China and for 3% in Europe.

Considering the proven importance of SMEs including food processing ones to the economic development of several countries around the world, there is a need for empowering them by assisting in overcoming some of the constraints such as access to bank loans, having in place appropriate infrastructure and accessing market information.

1.3 Compliance of Small and Medium Scale Fruit Processing Enterprises with International Quality Standards

Food quality and safety take on greater scope as the global food supply rises (WHO, 2013). However, it is well established that food borne diseases can damage trade and tourism and lead to loss of earnings and unemployment (da Cruz *et al*., 2006). Thus, effective food hygiene control intended for human consumption is of paramount in order to prevent the consequences of food borne diseases, spoilage and injury on human health and economies (da Cruz *et al*., 2006). Hence the sale of food products which is not of the nature of quality demanded at the market should be avoided (CAC), 2005).

According to Burlingame and Pineiro (2005), food quality include parameters such as organoleptic characteristics, physical, functional properties, nutrient content and consumer protection from fraud, while food safety is more related to the content of various food chemical and microbiological characteristics. For this to happen, food hygiene practices have been translated into a guideline, aiming at establishing processing, handling, transport and distribution procedures that are apt to prevent deterioration due to growth of spoilage pathogens on foodstuff, contamination and recall procedures, maintenance and sanitation, personnel hygiene and training of personnel (CAC, 2005; Will and Guenther, 2007). Thus, the WHO (2013), has recognised need of controlling the premises where food is being processed, stored, handled and or sold. The World Health Organization and Food and Agriculture Organization (WHO/FAO) international conference on nutrition has also recognised the access to nutritional, adequate and safe food as the right of each individual and pointed out that many people suffer from communicable and non-communicable diseases caused by contaminated food and water (WHO, 2013). Therefore, for small scale food processors in developing countries, it is still a challenge to comply with the requirements of the international standards (WHO, 2013). van der Vorst (2000) has given a number of specific characteristics that influence quality assurance in food production processes. They include:

(a) Quality variation between different producers and between different lots of produce, due to climatic conditions, biological variations and variations with regards to seasonality and production

(b) Post harvest food product perishability.

(c) Uncertain production yields due to weather conditions and quality variation within and between lots.

(d) Limited access to storage and transportation facilities such as freezing and cooling facilities.

Generally, it has been observed that in many food industries especially of developing countries, batches are mixed and that cross-contamination is a general problem (Trienekens and Zuurbier, 2008). Additionally, most food industries have many sources of raw materials and this has been found to hinder the achievement of quality assurance due to lack of traceability of the source of raw material for a given lot of food product in a food processing enterprise (Trienekens and Zuurbier, 2008). In contrast, it was found that in industrialised countries, most of the food processing companies comply with international quality standards. However, in few of these countries, the compliance with standards by small food businesses is still questionable for some enterprises (Eves and Darvisi, 2005, Walker *et al*., 2003). For example, a number of barriers that prevent regulatory compliance within SMEs were found in United Kingdom (UK) and Portugal SMEs (Yapp and Fairman, 2006; Eves and Darvisi, 2005). Those barriers included (a) lack of money: SMEs focus on immediate survival rather than potential benefits resulting from the long-term; (b) lack of time (c) lack of experience; (d) limited access to appropriate information; (e) lack of support. SMEs perceived that support was biased towards larger companies and that it was too broad to be useful to them; (f) lack of interest with SMEs focusing on business survival rather than compliance with regulations; (g) lack of knowledge with SMEs having poor awareness of the relevance of legislation.

Though the non-compliance is observed in some small scale food enterprises in developed countries, the situation is more challenging in developing countries including African countries where most of the small food processing companies do not comply with the requirements of the export market of western countries. Lack of enabling environment (institutional and infrastructural facilities), lack of skilled personnel and laboratory facilities are among the major barriers, which make the effective quality management difficult at small scale level in developing countries (WHO, 2013; Trienekens and

Zuurbier, 2008; Eves and Dervisi, 2005). It was observed that for example in countries like Nigeria, Rwanda, Tanzania, Uganda and Zimbabwe, small scale fruit processors and food processors in general are still facing the problems of inadequate food product quality and non-compliance to good hygienic practices in food processing enterprises and thus they tend to process only for the local market (Mhazo *et al.*, 2012; Ojinnaka, 2011; Austin *et al.*, 2009; Byanyima, 2004; Dietz *et al*., 2000). This is a very big challenge to these SMEs because research has shown that one of the measures of success of industrial districts in Europe has been the success in accessing export markets (Humphrey, 2003). However, the situation is much better for small scale fish processors in Uganda and fruit processors in Kenya which are recognised to comply with the European Union (EU) market requirements (Mwangi *et al*., 2014).

Since developing countries are becoming more integrated in the global food market due to increase in consumer demands in developed countries, they should adopt the required quality and safety standards and regulations in these markets. They need to have in place control of production, trade, distribution in order to guarantee the traceability of their products and operate in a cost-effective way so as to compete at global market. This can be accomplished through training and technical support in appropriate product quality assurance for small scale processors (Dietz *et al*., 2000).

1.4 Local and Export Marketing Requirements for Processed Pineapple Products

Processed pineapple products such as pineapple juice concentrate, dried and canned pineapple and pineapple pulp are among the most important tropical fruit products exported especially to United States of America (USA), the Netherlands, Italy, France and Spain (Kilcher and Ringo, 2009). Recent data of the World Trade Organisation showed that two thirds of the pineapples traded on the international market are processed (Bathan and

Lantican, 2009). Thailand, The Philippines and Kenya are recognized to be the most exporters of the pineapple juice concentrate (Kilcher and Ringo, 2009). According to Bathan and Lantican (2009), for processed pineapple products to be accepted at the export market, small and medium scale pineapple processors need to adhere to set guidelines for processing, preservation, packaging, labelling, analysis, Good Manufacturing Practices (GMP) and other importation and exportation guidelines as stipulated in Codex Alimentarius Commission, East African and Rwandan standards (CAC, 1981, 2005, 2009; Rwanda Standard (RS, 2003).

Research has shown that end product testing alone is unable to assure safe food production and hence quality assurance procedures in the food production chain have been established for the elimination or reduction of the identified hazard to an acceptable level (Walker *et al*., 2002). Consequently, FAO also advised food processing enterprises to shift from the emphasis on regulation and control of end products to preventive measures in order to control the introduction of food hazards along the entire food chain (FAO, 2003). This requires adoption of Good Agricultural Practices (GAP), Good Hygienic Practices (GHP) and Good Manufacturing Practices (GMP) in primary production, post-harvest treatment, processing and handling to reduce the risk of microbiological and chemical contamination and to retain optimal quality (Ojinnaka, 2011). According to FAO (2003), control of food processing operations should be based on the Hazard Analysis and Critical Control Point (HACCP) system in food processing plants. HACCP intends to identify, prevent, control and then monitor the most critical points in a food production system with the GMP prerequisites in place (FAO, 2003).

In addition, a whole food chain approach would recognise that, responsibility for supplying safe and nutrious food lies into the hands of all those involved in food production but the government should play the primary role of providing leadership on the implementation of food safety assurance system (CAC, 2006). Responsibility also extends to the end consumer, who needs to be educated on how to hygienically handle food and store it according to the storage conditions during the whole shelf life period. FAO (2003) pointed out that such approach would permit greater traceability of food products and can easily facilitate the withdrawal of contaminated food products from the markets. To achieve this, Codex Alimentarius Commission has given guidelines related to general principles of food hygiene in food industries and SMEs are required to comply with these guidelines (RS, 2003; CAC, 1997).

Beside the requirements on hygienic practices through the value chain required to ensure quality and safe food product, Codex Alimentarius Commission has given physical, biological and chemical quality requirements to be considered for the fruit products including pineapple juices and jams for acceptance at the export market and by the consumers. Specific definitions with regards to juices and jams were clearly detailed by Codex Alimentarius Commission (2005) for the purpose of harmonisation: (a) *Fruit juice* is defined a fruit juice as: " the unfermented but fermentable liquid obtained from the edible part of sound, appropriately mature and fresh fruit or of fruit maintained in sound condition by suitable means including post-harvest surface treatments applied in accordance with the applicable provisions of the Codex Alimentarius Commission". The same body has indicated that the fruit should be subjected to suitable processing techniques that results into maintaining the essential physical, chemical, organoleptical and nutritional characteristics as well as aroma and flavour compounds of the fruit from which the juice is obtained. (b) *Single strength juice:* is defined as "juice that is obtained by simple juice extractions" (CAC, 2001). (c) *Fruit nectar:* is defined as "the unfermented but fermentable product obtained by adding water with or without the addition of sugars, honey and/or syrups and/or food additive sweeteners" (CAC, 2005). It is stated that aromatic substances and volatile flavour compounds of the nectar must be recovered from the same kind of fruit and be obtained by suitable physical means. (d) *Fruit jam*: is defined as: "a product obtained by boiling and concentrating to a suitable consistency, a mixture of clean, sound prepared fruit and sugar with or without potable water, organic fruit acids, artificial colouring matter and pectin and packed in hermetically sealed containers at a temperature which will ensure preservation" (RS, 2008).

Based on the above definitons, different standard bodies have given a number of quality parameters and their methods of analysis to be tested in fruit juices and jams (including pineapple products) in order to ensure their authenticity (CAC, 2005; CAC, 2001; RS, 2005; RS, 2004; EAS 2000 a, b, c, d, e, f, g, h, i, j; AOAC, 1995). Those parameters include for example, alcohol (International Fruit juice Union (IFU method n^{o}.66: 1996)); or Association of Analytical Chemists (AOAC 940.26), sugar (AOAC, 1995); glucose, fructose and saccharose (European Standards :EN 12630) or IFU method n^{o} 67:1996 or Nordic Committee on Food Analysis (NMKL 148:1993); sucrose (EN 12146:1996 or IFU method n^{o} 7A:2000), pH (EN 1132:1994/1996 or IFU method no11:1989 or International Standards Organization (ISO 1842:1991), soluble solids (EN 1245:1996 or AOAC 983.17 or ISO 2173:2003). In addition, the standards indicated that pineapple juice and jam should have the characteristics colour, aroma and flavour of pineapple juice and jam (RS, 2008; RS, 2005). Apart from physico-chemical and sensorial properties to consider for a quality pineapple juice and jam, the standard bodies have indicated that pineapple juice should be free from pathogenic microorganisms (total viable counts, *Escherichia coli, Staphylococcus aureus, Salmonella* spp and yeast and moulds). They should also be tested for heavy metal contamination (arsenic, lead, copper, zinc, iron, tin, sulphur dioxide and pesticide residues (RS, 2005; International Commission on Microbiological Specifications for Foods, 1986).

Considering the many quality requirements of fruit products to enter the export market, it is clear that small scale pineapple processing enterprises in developing countries like Rwanda, are still having a long way to go to comply with these requirements and they need a close assistance from public and private institutions.

1.5 Hygienic Food Processing Plant Layout and Design Requirements

Increasing consumer demand for fresh foods has led to the development of processing and preservation methods that have minimal impact on the nutritional or sensorial properties of foods (Moerman, 2010). Since the use of mild preservation technologies primarily results in pasteurized products, hygienic processing equipment and a hygienic process environment are needed to prevent microbial, chemical and physical contamination from affecting the quality of processed food products while preventing product exposure to sources of several contaminanats (Will and Guenther, 2007). Preventing product contamination may therefore occur not only at the equipment level but also at the factory level. Thus, the facility infrastructure can be so designed and constructed that it cannot contaminate food products, whether directly or indirectly (Moerman, 2010).

Food processing plant design must therefore integrate processing and packaging (Marouris and Saravacos, 2003). The layout and design of a food processing plant must be adapted to the hygienic requirements of a given process, packaging or storage area (CAC, 2003). A complete fruit processing design in compliance with the hygienic standards has to have separation of dry and wet processing areas, pasteurised and non-pasteurised products and a clear zone of hygienic and non- hygienic areas. This required clear separation of different zones, helps avoid any cross-contamination between the products and environment (Marouris and Saravacos, 2003). The interior of the plant must be designed so that the flow of material, personnel, air and waste can proceed in the right direction (CAC, 2003;

Marouris and Saravacos, 2003). As they become incorporated into food products, raw materials and ingredients should move from the dirty to the clean areas (Will and Guenther, 2007). However, the flow of food waste and discarded outer packaging materials should be in the opposite direction. In order to meet a possible increase of processing activities within the food plant in the future, the building and its food processing support systems should be designed so they can either be expanded, or another building can be added (Clark,1998).

(i) Food Processing Plant Utilities

The principal plant utilities in a food plant include process water, process steam, electric power for motors, lighting and fuel (Clark, 1998).

(a) Process water is required for washing the raw materials and for various cooling operations. In fruit and vegetable processing plants, water may be used for transportation of the raw materials from receiving to processing areas. Total water requirement in fruit and vegetable processing may range from 5 to 15 m^3/ ton of raw material.

(b) Steam boilers are needed in most food processing plants to provide process steam, used mainly in various operations, such as heating of process vessels, evaporators and dryers, sterilization, blanching, and peeling. A medium size food plant (80 tons/day raw material) may require a boiler producing about 10 tons/h of steam at 18 bar pressur.

(c) Electrical power in food processing plants is needed for running the motors of the processing, control, and service equipment, for industrial heating, and for illumination. For a medium size food plant processing, about 100 tons/day raw materials, the power requirement may be of the order of 500 kilowatt (kW). A standby power generator of about 200 kW is recommended for emergency operation of the main plant, in case of power failure or breakdown.

(d) Plant effluents consisting mainly of wastewater, but including solids and gas wastes require special handling and treatments to comply with the local laws and regulations. Food plants should be designed and operated so that a minimum pollution is caused to the environment.

In addition, food processing plants are required to take into consideration the following parameters as far as hygiene is concerned: sanitation and maintenance of the processing plant, cleanliness of the working rooms, working surfaces and processing equipment, drainage and waste disposal, insect and pest control and personal hygienic facilities (CAC, 2003; Clark, 1998).

1.6 Hazard Analysis Critical Control Point requirements

Hazard Analysis and Critical Control point (HACCP) is a management system in which food safety is addressed through the analysis and control of microbiological, chemical and physical hazards from raw material production, procurement and handling to the manufacturing, distribution and consumption of finished products, to reduce the risk of food borne illness (Scott and Stevenson, 2006). The system was first developped and used by the Pillsbury Company in the late 1950′s to provide safe food for America’s space program (Scott and Stevenson, 2006). The HACCP system is recommended in food processing industries because it is a system of preventive controls that is the most effective and efficient to assure that food products are safe. The application of HACCP is based on technical and scientific principles. HACCP consists of seven steps used to monitor food as it flows through the establishment, whether it is a food processing plant or food service operation (Cusato *et al.,* 2012). The seven steps of the HACCP system address the analysis and control of biological, chemical and physical hazards.Those steps are: (a) Conduct a hazard analysis, (b) Determine Critical Control Points (CCP), (c) Establish critical limits, (d) Establish monitoring procedures, (e) Establish corrective actions, (f) Establish verification procedures, (g) Establish record keeping and documentation procedures. Todate, the HACCP system is recognised as an important tool in the reduction of foodborne diseases, and it is a global reference in terms of food safety control. It is recommended by the World Health Organization, the International Commission on Microbiological Specifi cations for Foods, the Codex Alimentarius Commission, and food regulatory agencies in various countries (Cusato *et al.,* 2012). However, before the application of HACCP principles, some prerequisite programs, such as good manufacturing practices and cleaning procedures, should be established in order to ensure basic hygiene conditions in the processing plant (Will and Guenther, 2007; CAC, 2003; Wallace and Williams, 2001). These prerequisite programs, if correctly implemented, will determine the principles for correct handling of foodstuffs, making HACCP more efficient and easy to manage (Wallace and Williams, 2001).

1.7 Rationale for Setting Food Standards

Foodborne diseases are a serious public health problem globally and the WHO estiamates that worldwide foodborne and waterborne diarrhoeal diseases taken together kill about 2.2 million people every year (Food Standards Agency, 2011). To cope with this global public health problem, international, national and private standard bodies were created in order to protect the health and safety of consumers and make a positive contribution to longer term public health objectives (FAO, 2010). The main objective of the Food Standards bodies is therefore to protect public health from risks which may arise in connection with the consumption of food (including risks caused by the way in which it is produced or supplied) and otherwise to protect the interests of consumers in relation to food (Food Standards Agency, 2011). Those standard bodies include, Codex Alimentarius Commission which is a series of international standards for food and agricultural products that help to ensure fair trade and consumer protection internationally and International Standards Organization (ISO). Therefore, according to the standards, food safety is a strict requirements in all aspects of food process design. These standards bodies recommend that potential hazards should be considered at the design and specification of processing equipment and food plant (Wallace and Williams, 2001). In addition, GMP and HACCP should be considered at the design stage.

1.8 Storage Stability of Processed Fruit Juice and Jam Products for Export Marketing

Plant-based foods are exposed to processing techniques in order to increase their palatability and to prolong their shelf life while maintaining their original sensorial, biophysico-chemical and nutritional properties during their expected shelf life (Vidhya and Narain, 2010; Rattanathanalerk *et al*., 2005). Therefore, to achieve a balance between food quality and safety, processors are required to optimise conventional processing techniques currently being applied in food industries. However, this optimisation of processing techniques is still a challenge to small scale processing enterprises, especially in developing countries that do not have in place appropriate processing equipment and knowledge (Austin *et al.*, 2009). Several researches on the storage stability of fruit products have shown that it is possible for even pineapple processing enterprises at small scale level to improve on their processing techniques so as to increase the shelf life of the processed products. A study conducted by Obeta and Ugwuanyi (1997) has shown that pineapple fruit juice inoculated with ascospores of *Neosartorya* spp and stored for 64 days containing sodium benzoate as preserving agent and 30% of sucrose at room temperature did not show any sign of microbial spoilage during the storage period.

Similar observations were made by Walking-Ribeiro *et al*. (2009) who found that pasteurised orange juice was microbiologically safe and they did not record any significant changes with regard to sensory properties over the storage period of six months. The juice was still acceptable by panelists even at the end of six months of storage. Similar results were reported by Ume *et al.* (2001, 1999) during an evaluation of the pasteurisation effect on sensory characteristics of the soursop puree during a storage period of four months. The soursop juice stored in a high density polyethylene bottle at ambient temperature of 28^{o} to 38^{o}C showed no significant changes over the storage period of four months, for colour, flavour, odour, consistency and overall acceptability. In addition, there was no significant microbial growth either total plate count, yeasts or moulds and there was no *Escherichia coli*. The stability over the storage duration was attributed to a low pH (3-4), which is a normal pH value for fruit products. Sindhu *et al.* (1984) observed also a stable pH value in tomato and papaya juice during the storage of three months. There was also no pH changes and changes in titratable acidity in mango juice stored at room temperature (Sindhu *et al.*, 1988). Though most of the studies on the storage stability of fruit juices including pineapple juice have reported none or minor changes of the products during the storage period, it is important to note that heating processes can affect the quality of fruit juices through pigment destruction and non-enzymatic browning reactions and this was the case observed by Rattanathanalerk *et al*. (2005) who reported colour degradation of thermally heated pineapple juices. Oey *et al.*(2008) and Espachs-Bamoso *et al*. (2003) proposed the use of high hydrostatic pressure and high intensity pulsed electric fields respectively in order to produce quality fruit juices with none or minor physico-chemical changes though these technologies are still of limited accessibility for small scale processing enterprises in developing countries.

Jam is more of a concentrated fruit processing that has thick consistency (Vidhya and Narain, 2010). It is rich in flavour, because its preparation requires ripe fruits, which have developed full flavour and it has an advantage of being prepared through a single operation (Vidhya and Narain, 2010). Jam is manufactured as one of the important fruit byproducts in industries and its preparartion is based on the high solids, high acid principle (Manay and Shadaksharaswamy, 2005). The processing of fruit jam is one of the value addition strategies to the fruit and vegetables products in order to minimise their high post-harvest losses and to utilise the surplus during off season. To maximise their utilisation and availability to the market, these products have to stay stable in the shelves with regards to chemical, sensorial and microbiological characteristics. Singh *et al*. (2009) while assessing the effect of storage time on quality changes of fruit jams including pineapple jams, have found that total titratable acidity (0.64-1.16%) decreased significantly during storage time of 30-60 days but no significant changes were observed in total soluble solids (TSS) during storage for all jams (73 and 72 % at 30 and 60 days of storage, respectively). Reducing sugars (6.5 and 14.5% at 30 and 60 days, respectively) in this study increased in pineapple jam while there were no significant changes of total sugars (42.90 and 39.10) in pineapple jams at 30 and 60 days, respectively. Microbiologically, pineapple jam was free throughout the storage period. Similar trends in fruit jams were observed by Vidhya and Narain (2011) who found that processed jam and fruit bar of *Limonia acidissima* fruit stored for 90 days retained most of their quality characteristics during storage. There was a decrease in acid content of jam but no significant changes were observed in TSS, pH, pectin and ash value during storage with was an increase in total sugars and reducing sugars. The products were microbiologically safe at the end of 90 days of storage with a decrease in overall acceptability. In contrast, Reddy and Chikkasubbana (2009), noted an increase in pH, TSS, total sugars and reducing sugars and a decrease in acidity, crude protein, fibre,tannins, non reducing sugars and ascorbic acid during 90 days of storage of *amla* jam while Aiona and Adetokunbo (1991) did not observe any changes in tropical fruit jams over the storage period. In their study, the values of physico-chemical constituents were within the expected limits for jams (TSS: 68.6 to 68.9; reducing sugars: 35.6 to 40.6; pH: 2.80 to 3.40) and the products were acceptable with regards to sensory properties throughout the entire storage period.

The existing knowledge on the possibility of processing fruit products that can remain stable during their storage lead to a conclusion that fruit processing technology is still one of the important strategies to reduce high post-harvest losses of fruit and vegetables experienced by most of the African countries (Fellows, 2004).

Basing on the above review on the storage stability of pineapple juices and jams, it is possible that SMEs produce acceptable and stable jams using classical pasteurisation processes. In several studies that assessed the effect of storage on juice and jam stability, packaging material, preservative agents and temperature at which the product was processed and kept were the key parameters taken into considerations. Thus, SMEs wanting to process pineapple products should also consider these important aspects for them to come up with quality products acceptable at the export market.

1.9 Problem Statement and Justification

Rwanda is a country where 90% of the population live in the rural area and earn their living from agricultural activities, which contributed 42% to Rwanda GDP in year 2006 (World Stats, 2010). The farming system is subsistence. In order to assure sustainability in development, the government encourages transformation of the agricultural sector from subsistence to a profitable market-oriented business by diversifying and promoting horticultural crops and processed products (RHODA, 2008). To achieve this target, the government has identified pineapple fruit as one of the priority horticultural crops because pineapple has a potential to grow in all agro-ecological zones throughout the year. Its production was estimated at 31 329 metric tonnes in 2008 and was expected to rise to 112 000 tonnes in 2012 (Kilcher and Ringo, 2009; RHODA, 2009). The Southern and Northern provinces accounted for 86% of the total pineapple production in 2008 (RHODA, 2008).

Beside the increase in pineapple production, the government also considers the improvement in pineapple fruit processing technologies as a key intervention measure aimed at development of the subsector. Thus, the number of SMEs has recently grown due to the encouragement and assistance by the government and non-government institutions. These enterprises are expected to contribute to the economy of the country as it has been the case in other developing and even some developed countries. However, if pineapple processing enterprises wish to penetrate external markets in Europe, the United States, and elsewhere in Africa and Asia, they need to be concerned with the quality of their products in relation to stipulated international quality requirements. A 2008 survey revealed that less than 10% of horticultural products from Rwanda are processed. These statistics imply that 8,182 out of the 9,611 metric tonnes of pineapples produced remain unprocessed (Kilcher and Ringo, 2009). Similar observations have been reported in most African countries, whereby post-harvest losses of fruits and vegetables are estimated at 40–80% due to inadequate post-harvest handling and processing (Fellows, 2004).

A survey conducted by RHODA (2008) recorded 13 medium fruit processors and about 30 small processors (RHODA, 2008) (Annex 1). A study by Austin *et al*. (2009) elaborated a range of products, notably fruit pulp, juice concentrate, fruit wine and jams that were processed. Some of these products, especially those from the two modern industries, such as Inyange and Urwibutso, are exported. It has been reported that dried and frozen fruit products are not produced due to lack of capabilities in terms of technology and infrastructure (Austin *et al*., 2009). Although there are few enterprises that have conducted fruit drying trials, the dried products have been reported to be of poor quality (Austin *et al*., 2009). In general, the fruit processing industry capacity in Rwanda is considered to be underexploited and the unused capacities of processing facilities was estimated at 85% in 2008 due to a high tax of 39% levied on sugar that is commonly used as one of the raw materials during fruit processing (Austin *et al.,* 2009). This low development of food processing industries is known as a characteristic for developing countries (Obeta and Ugwuanyi, 1997).

Lack of solid long term relationship between producers and processors and lack of proper assessment of the market are suggested to be among the factors that cause underutilisation of the capacity for small and medium scale processing industries (Kilcher and Ringo, 2009). Other constraints include lack of proper processing equipment including basic laboratory facilities, lack of skilled technicians in food processing, limited information on Good Agricultural Practices (GAP), Good Manufacturing Practices (GMP) and Hazard Analysis of Critical Control Points (HACCP) at farm and enterprise levels. Others include limited information on the international market quality requirements, quality standards of food products and lack of attention to product presentation and packaging materials (Nankani *et al*., 2005).

The non-compliance with the set quality standards leads to production of low quality products that can not penetrate export markets and thus rendering them being sold in local markets. None of the study reporting on food processing subsector dealt with aspects of compliance with the standards. For that reason, taking into consideration an increase of small and medium scale pineapple fruit processors in Rwanda and their proven potentiality to increase income, improve livelihoods and create employment for rural population, it is necessary to conduct an in-depth study to identify specific challenges in the pineapple processing industry that hinder them from accessing the export market so that it can form a basis for intervention.

Currently, there is no detailed information on the reasons or gaps explaining failure of locally processed pineapple fruit products to enter export market. The present study therefore, aims at assessing the level of compliance of small and medium scale pineapple processing enterprises with set national, regional and international standards with regards to pineapple processing. The information and knowledge that will be generated from this study will be used to recommend appropriate processing technologies and hygiene consideration for the processed products to meet the export market requirements. It is thus expected that the adoption of the recommendations from the present study by small and medium scale fruit processing enterprises and development institutions will improve the quality of processed pineapple products. They will in turn open up product market opportunities and increase earnings for small and medium scale processors. At the same time, it will improve food and nutrition security and livelihood in general for those involved in the value chain.

1.10 Objectives

1.10.1 Overall objective

To assess the extent of compliance of small and medium scale pineapple processing enterprises in Rwanda with National, Regional and International Standards.

1.10.2 Specific objectives

The specific objectives were:

(a) To conduct situation analysis of small and medium scale pineapple processing enterprises in Rwanda

(b) To assess premises and plant layout design compliance with the recommended national, regional and international Good Manufacturing and Hygienic Practices.

(c) To assess conformity of physico-chemical and microbiological quality of selected processed pineapple products to existing Rwandan, East African and Codex Alimentarius Commission (CAC) Standards.

(d) To determine if there are quality changes (physico-chemical, microbiological and sensorial) of pineapple products during storage.

1.11 Organisation of the Thesis

The thesis is organised in three chapters. It starts with introductory chapter, which highlights the key issues regarding the status of small and medium scale pineapple processing enterprises in Rwanda and studies conducted elsewhere, which have been done in relation to SMEs. This introductory chapter contains also the overall theme of the thesis. The chapter ends with a description of the methodology used to collect and analyse data. Chapter two presents four published papers and two manuscripts (ready for publication) resulting from this study. The first paper addresses the issues of the first specific objective while the second specific objective is addressed by the second and third paper. The results covering specific objectives three and four have been combined and presented in papers four, five and six. The third chapter draws the overall conclusions of the study and later recommendations are made for improving SMEs sector in Rwanda.

1.12 Materials and Methods

1.12.1 Study design

The present study was a cross-sectional study design. It examined what was happening at small and medium scale pineapple processing enterprise level at a particular point in time. In addition, a time series experimental design was used to evaluate physico-chemical and microbiological properties of the processed pineapple products (syrups, jams, nectars) over the storage time.

1.12.2 Selection of the study population

A census survey was conducted in Rwanda because the number of pineapple processing enterprises was small enough to be covered by the survey (16 small and 11 medium pineapple processing enterprises). According to Kothari (2004), by using census survey, sampling error is eliminated and desirable precision is achieved.

1.12.3 Location of the study

The survey in this study was conducted accross Rwanda with pineapple processing enterprises located in the northern, southern, western and eastern provinces of the country. Physico-chemical properties in pineapple products were determined at the Laboratory of Analysis of Foodstuff, Drugs, Water and Toxins (LADAMET) of the Faculty of Medicine at the University of Rwanda (UR). Microbiological analyses were completed at LADAMET and UMR Qualisud-CIRAD-Montpellier-France while sensory evaluation was completed at Kigali Institute of Science and Technology (KIST) in Food Science and Technology Department with second year 2012/13 students.

1.12.4 Data collection

1.12.4.1 Survey and interview

A structured questionnaire with closed and open-ended questions and observations of the general status of the processing plants were used to collect data among processors, using face-to-face interviews with the Managing Directors of the enterprises (Annex 2). Prior to the proper survey, the questionnaire was pretested with five directors of small scale passion fruit processing enterprises because all the pineapple enterprises were part of the study population and it was no longer allowed to conduct a pretesting of the questionnaire with them. The questionnaire was then validated and amended appropriately after the pretesting so that every interviewee understood it and gave clear answers without confusion. To collect data on Good Manuafacturing Practices and Good Hygienic Practices, a Hazard Analysis Critical Control Point audit grid was used .

The collected information included the following:

(a) socio-economic data of the study population including: age, gender, education background of the respondent, date at which the enterprise started, number of employees and education background of employees.

(b) pineapple processing operations data including: source of raw material, storage conditions of raw material, washing, peeling, slicing, juice extraction, pasteurisation, preservation, filling, labelling, storage duration and physico-chemical and microbiological evaluation of processed products.

(c) hygiene and sanitation practices data (source of water and access to it, presence of washing rooms, cleaning of the processing plant and hands, disinfection of the processing plant and processing equipment);

(d) data on premises and plant layout design with emphasis on separation of hot zone and cold zone, no crisscrossing of the production lines, separation of clean sector and unclean sector, compliance with the onward flow principle, floor grids and U-bends to collect waste water, ventilation devices ensuring steam and smoke elimination and waste handling and disposal. An updated list of pineapple fruit processing enterprises was gathered at National Agricultural Export Development Board (Appendix 2).

1.12.4.2 Quality evaluation of stored pineapple products

The most commonly processed pineapple products collected included pineapple syrups, nectars and jams. All ten processing enterprises producing these products were visited and samples were taken from the processing sites by the researcher in October 2012. Samples were kept at room temperature (21^{o} to 25^{0}C) for further analysis throughout the storage period of 12 months. They were then subjected to sensory evaluation, important chemical analyses (pH, total titratable acidity (TTA), total soluble solids (TSS), sucrose, reducing sugars, total sugars, ash, fibre, alcohol and heavy metals (zinc, iron, copper, aluminium, lead and cadmium). Microbiological analysis (yeasts and moulds, total plate counts, faecal coliforms, total coliforms, *Escherichia coli*, *Salmonell*a, *Shigella* and *Staphylococcus aureus*) as per International Organization for Standardization (ISO) requirements were also done. Similar bio-chemical and sensorial analyses were repeated every three months and before the indicated expiry date (for each product).

The sensory characteristics of the samples were compared to the ones of an exported pineapple syrup and nectar manufactured by Inyange Food Processing Industries located in Kigali (Rwanda) and an imported pineapple jam manufactured by Premier Food Industries (Kenya) which were considered as the reference samples.

All analyses were completed following the standard methods of analysis described in individual paper in this thesis.

1.12.4.3 Physico-chemical analysis of pineapple products

The following are the parameters analysed: pH, TTA, TSS, sucrose, reducing sugars, total sugars, ash, fibre, alcohol and heavy metals (zinc, iron, copper, alminium, lead, cadmium). Heavy metals were analysed using Atomic Absorption Spectrophometer (AAS) (Perkin-Elmer, model 200) and samples were prepared following the instructions of the AAS manufacturer (Perkin-Elmer Corporation, 1996) and the wet digestion method of Association of Official Analytical Chemists (1995). The remaining parameters were analysed following the methods of analysis as described by Codex Alimentarius Commission and Rwanda Bureau of Standards (CAC, 2005; RS, 2005; RS, 2004).

1.12.4.4 Microbial load determination in the pineapple products

This analysis involved general hygienic parameters and pathogens, which are the most common indicators of general standards of food hygiene (Al-Jedah and Robinson, 2002). The microbiological safety of pineapple processed products was evaluated following the methods of analysis given by Rwanda Bureau of Standard (2005) by determining the total colony counts (ISO 4833:2003) for: total coliforms (ISO 4832:1991), *Escherichia coli* (ISO 16649-2:2001), *Salmonella* (ISO 6579:2002), *Staphylococcus aureus* **(**ISO 6888-1:1999) and yeasts and moulds (ISO 7954:1987).

1.12.4.5 Sensory evaluation

Sampled products were evaluated for taste, flavour, colour, consistency, spreadability, sweetness and overall acceptability (Codex Alimentarius Commission, 1981). Fourty eight panelists composed of 2012/13 second year students from Kigali Institute of Science and

Technology (KIST) evaluated the samples using a seven point hedonic scale as described by Resurreccion (1998) and Larmond (1977) (Annex 3).

1.12.5 Data analysis

Quantitative data collected from pineapple small and medium scale processing enterprises were summarized, coded and entered into Microsoft Excel (2010) sheet and descriptive statistics (means, medians, and frequencies) were computed using Statistical Product and Service Solutions (SPSS) (version 16.0) and Genstat 14th ed. Physico-chemical and microbiological data were compared with national, regional and international standards while sensory evaluation data were compared to the references samples. They were analysed by Analysis of Variance (ANOVA) and mean separations were completed by Tukey's Honest Multiple Range test at $p < 0.05$.

CHAPTER TWO

PAPER ONE

Issues Affecting Small- and Medium-Scale Pineapple Processing Enterprises in Rwanda: A Cross-sectional Study

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PAPER TWO

Good Manufacturing and Hygienic Practices at Small and Medium Scale Pineapple Processing Enterprises in Rwanda

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PAPER THREE

Could Good Hygienic Practices reduce the Microbial Population on Pineapple Fruits?

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PAPER FOUR

Microbial and Heavy Metal Contamination of Pineapple Products Processed by Small and Medium Scale Processing Enterprises in Rwanda

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PAPER FIVE

Evaluation of the Storage Stability of Pineapple Products Processed by Small and Medium Scale Processing Enterprises in Rwanda

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Evaluation of the Storage Stability of Pineapple Products Processed by Small and Medium Scale Processing Enterprises in Rwanda

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Abstract

This study aimed at evaluating the effect of storage time on the stability of pineapple products processed by small and medium scale processing enterprises (SMEs) in Rwanda stored at ambient (21^{o} to 25°C) temperatures. Physico-chemical quality characteristics (pH, moisture, fibre, ash, total soluble solids, titratable acidity, sucrose, reducing sugars, total sugars and ethanol) of the sample products were analysed. Changes in the quality were monitored at three and one months interval for syrups, jams and nectars, respectively. Results showed that for nectars, most of the parameters evaluated were stable up to only two months of storage. All nectars, syrups and jams had a pH ranging from 3-5, the normal pH range for fruit products. The levels of titratable acidity of all products were below the maximum limit of 1.35% set by Codex Alimentarius Commission (CAC) Standards. Similarly, their levels of ethanol were less than the maximum of 0.3% recommended by Codex Alimentarius Commission standards. Syrups and jams were stable for most of the parameters up to six months of storage. There was a significant ($p<0.05$) decrease of sucrose and increase of reducing sugars in syrup and jam samples, specifically from six months of storage. Products from some enterprises exhibited sugar values higher than the maximum recommended by Rwandan, East African and CAC standards. The studied products exhibited significant variations in most of the studied parameters over the storage period with most of the samples not complying with the standards including sugar levels. Processors, therefore, need to be trained on proper fruit processing and the standard requirements for pineapple fruit products.

Key words: Pineapple products, storage stability, physico-chemical properties

Rwanda

Introduction

Products from tropical fruits have increasingly gained global importance due to their characteristic exotic taste, aroma and colour (Abbo et al., 2006; Bicas et al., 2011). Many products such as juices, jams, jellies, marmalades and alcoholic beverages are currently produced from various tropical fruits. These include orange, papaya, pineapple, banana, guava and watermelon. Pineapple, being one of the exotic tropical fruits is recognised for its very pleasant sub-acid, aroma and juicy flesh. Both fresh and processed, pineapple products are source of several nutrients beneficial to human health and are found in retail shops, stores and supermarkets around the world (Chia et al., 2005).

In Rwanda, pineapple producers have aggressively targeted the export market of the fresh fruit (RHODA, 2008). Small scale processors have benefitted from increased production by adding value to the fruit through processing it into different products including juices, jams, wines and dried slices (Austin et al., 2009). Nevertheless, the processed products tend to be of sub-standard making it difficult for the processors to reach the export market. Consequently, the products are locally commercialised (Mukantwali et al., 2012). For these products to reach the export market, they need to comply with national, regional and international fruit product standards (CAC, 2009; RS, 2008; CAC, 2005a,b ; EAS, 2000; CAC, 1981).

The quality of a packaged fruit product is a function of the physico-chemical characteristics such as sugars, pH, acidity, fibre, moisture, alcohol, total soluble solids and other chemical constituents as well as organoleptic properties (Ewaidah et al., 1988). In addition, fruit products are highly prone to microbial deterioration if not adequately processed and stored (Osuntogum and Aboaba, 2004). A large number of lactic acid bacteria, coliforms, yeasts and moulds cause spoilage because they are able to ferment carbohydrates and produce undesirable changes such as production of acids, alcohols and diacetyls, which negatively alter chemical and organoleptic properties of the food products (Tribst et al., 2009). Such changes render the products fail to meet standards acceptable to the export market and can cause food related health problems. So far the effect of storage time on the quality characteristics of pineapple nectars, syrups and jams commonly processed by small scale processors in Rwanda has not been studied. The aim of the present study was therefore to evaluate the effect of storage time on physico-chemical characteristics of the pineapple products (nectars, syrups and jams) processed by small and medium enterprises while taking into consideration the requirements of the local, regional and international standards. The findings from this study will be a basis of recommendations on how to produce better shelf-stable marketable pineapple products in Rwanda.

Materials and methods

Sampling

Random sampling technique was used to obtain bottled pineapple nectars, syrups and packaged jam samples at each pineapple processing enterprise involved in the study. Samples, 62 bottles of 500 ml for syrups, 62 pots of jams and 62 bottles of nectars were collected from each enterprise and coded. Table 1 shows the abbreviations of samples used whith their respective codes. For example, s_1 meant syrup number one that is collected from the small enterprise number one and N_4 meant nectar number four that is collected from the medium enterprise number four. The 10 enterprises were scattered accross the country and not located at the same place. Jams were collected from only six enterprises, which were processing jams in addition to syrups and nectars.

Table1: Abbreviations of samples used in this study.

Syrup samples	Enterprise processing syrups	Nectar samples	Enterprise processin g nectars	Jam samples	Enterprise processing jams
S_1	Small	N_1	Small	J_1	Small
S_2	Medium	N_2	Medium	J_2	Medium
S_3	Small	N_3	Small	J_3	Small
S_4	Medium	N_4	Medium	J_4	Medium
S_5	Medium	N_5	Small	J_5	Medium
S_6	Small	N_6	Small	J_6	Medium
S_7	Medium	N_7	Medium		
S_8	Small	N_8	Small		
S_9	Small	N_9	Medium		
S_{10}	Medium	N_{10}	Medium		

Samples were transported in paper cartons and kept at room temperature ranging from 21^0 to 25^0C in the Southern province of Rwanda, Huye district for subsequent analysis.

Physico-chemical characteristics determinations

Chemical and physico-chemical characteristics of the products were determined by Official Methods of Analysis of the Association of Analytical Chemists (AOAC, 1995).Total soluble solids were determined by using portable refractometer (ref.8145, 0320v, France); pH by potentiometric method, titratable acidity was determined by dissolving a known weight of sample in distilled water and then titrated against 0.1 N NaOH using phenolphthalein as indicator and expressing the results as percent citric acid. Moisture, dietary fibre and ash contents were determined using the approved Official Methods of Analysis (AOAC, 1995). Total sugars, reducing sugars and sucrose were determined according to Luff-Schoorl method (EAS, 2000) and ethanol by densimetric method (AOAC, 1995).

For analysis, one bottle was randomly selected each month for nectars, and every three months for syrups and jams. All determinations were carried out in triplicates and the mean values were reported. All laboratory analyses were conducted at the Laboratory of Analysis of Foodstuff, Drugs, Water and Toxics (LADAMET) of the Faculty of Medicine at the University of Rwanda (UR) from October 2012 to October 2013. Chemicals and reagents were supplied by Merck company, France.

Statistical analysis

Data obtained from the study were analyzed by Genstat statistical software 14^{th} edition (VSN International Ltd, UK). Analysis of variance (ANOVA) was performed to determine significant differences between the main factors. Means were separated by Tukey's Honest Significant Difference at $p<0.05$. Data were expressed as Mean±SD and presented in tabular and graphical forms.

Results and Discussion

Chemical characteristics of the pineapple products

pH

The results of pH changes in pineapple syrups during 12 months of storage are shown in Fig.1A. There was a significant ($p<0.05$) decrease in pH values for samples coded (S_1, S_2, S_5 and S_6) and significant increase for S_3, S_4 and S_8 samples up to 12 months of storage. There was no observed significant ($p>0.05$) change in pH values for samples coded S_7, S_9 and S_{10}. The highest and lowest pH values were 3.7 and 2.7.

For jams, it was observed that, the products remained stable as the storage time went up to 12 months of storage. The pH values in all five jam samples did not change significantly ($p>0.05$) except for J_6 where it decreased significantly ($p<0.05$) from 3.73 to 3.51 up to 12 months of storage (Fig.1B). pH ranged from 3.0 to 4.4 over storage time. In the case of nectars, there were no significant ($p>0.05$) changes in pH values for the majority (60%) of nectars except for N_4, N_5 and N_9 where it decreased significantly at two months of storage while it increased significantly for N_3. The pH range was 2.2 to 4.6 (Fig.1C). The highest and lowest pH values of 4.4 and lowest value of 2.2 were respectively observed in nectars as depicted in Fig.1C.

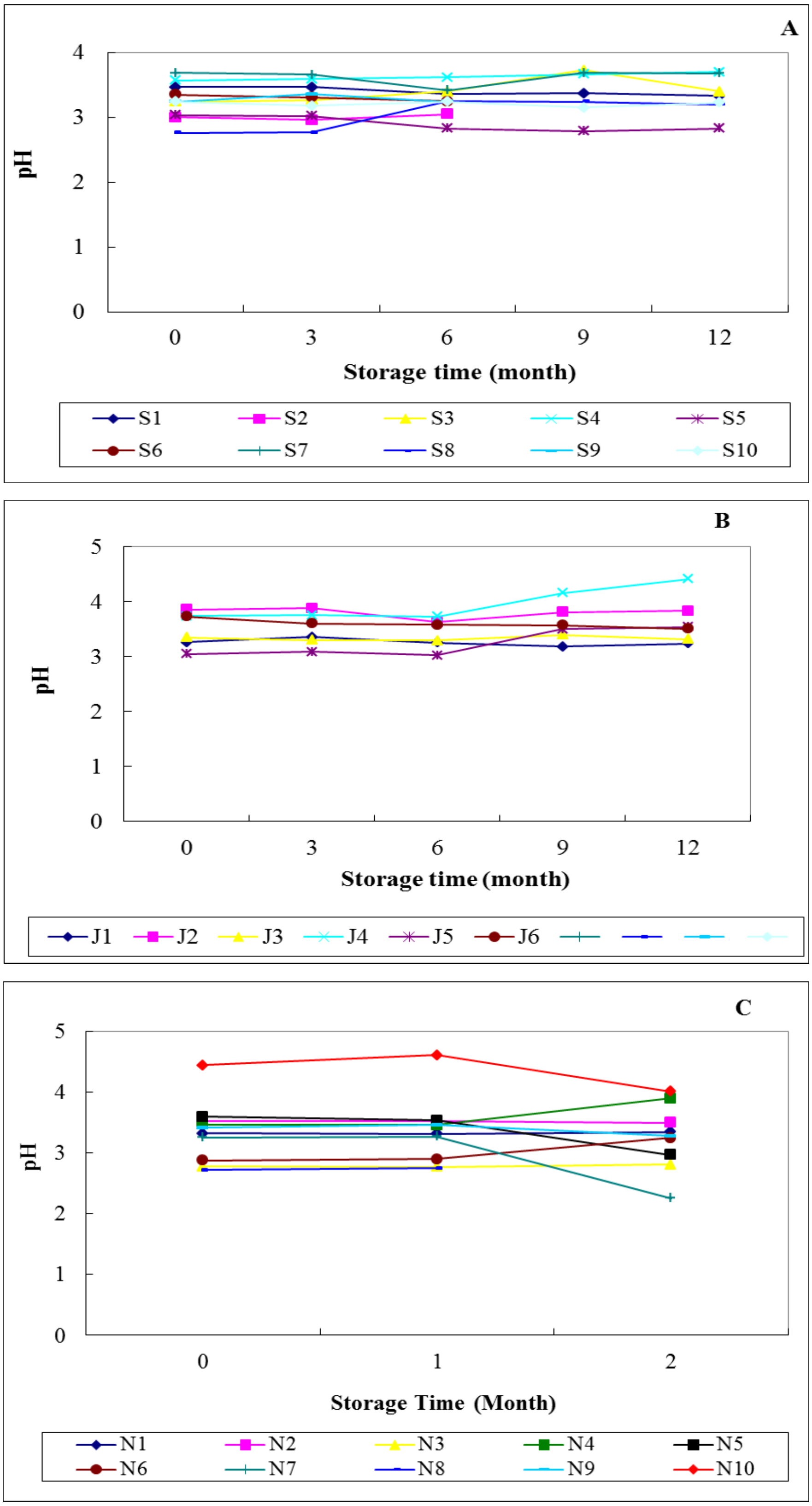


Figure 1: Variation of pH values of pineapple syrups (A), jams (B) and nectars (C) at different storage times

The majority of the samples had a normal pH ranges approaching an estimated pH value of 3.6 of the natural pineapple fruit reported by Nirmara and Reddy (2011) and Camara et al. (1995) and were within the range of 3 to 4 for pineapple products (Tasnim et al., 2010; United States Food and Drug Administration, 2007). Few samples had a pH less than 3.0. This was expected as pineapple fruit pH is known to vary with growing location, harvest time, fruit maturity and other factors, which affect the fruit (Bartolome et al.,1995). The low pH nature of the sampled products was due to the acidic nature of the pineapple fruit used. Fasoyiro et al. (2005) have reported similar pH increase in roselle fruit-flavoured drinks stored at ambient temperature. The authors have suggested that the increase in pH could be due to the decomposition of fermentable substrates especially the carbohydrates in the pineapple fruits and sugars added thereby increasing the acidity. Similar changes may have also taken place in this study for some products resulting in an increased pH. The increase in pH of some products in this study corroborates with a significant increase of pH in untreated and irradiated pineapple juice stored for 13 weeks reported by Chia et al. (2012). These researchers stated that the pH increase can be related to the decrease in the total soluble solids.

Insignificant changes in pH values as observed in some products in this study were similarly reported in pasteurised pineapple juice during storage period of 13 weeks (Chia et al., 2012), heated orange juice stored at 22^{0}C for 13 weeks (Yeom et al., 2000) and canned orange juice stored for one year at 24^{o}C (Camara et al., 1995). For some products, there was a pH decrease and similar findings were reported by Jan and Masih (2012) during the storage stability study of pineapple juice blend with carrot and orange juice. pH is one of the important quality parameters that describe the stability of bioactive compounds in fruit juices (Sanchez-Moreno et al., 2006), it is therefore noted in this study that, pineapple syrups, nectars and jams had expected pH values for fruit and juice products during the storage period. Though there was variations in pH levels throughout the storage period of the studied products, the levels of pH of the samples in this study lead to suggest that pineapple fruits used for processing were of acceptable grade.

Titratable acidity

The results of Total Titratable Acidity (TTA) for syrups (A), jams (B) and nectars (C) are shown in Figure 2. Total titratable acidity values did not change significantly ($p>0.05$) during storage in the majority of the syrups and jams. It changed however significantly ($p<0.05$) in most of the nectars during storage. Titratable acidity ranged from 0.32 to 0.8%; 0.3 to 0.7% and 0.0 to 0.9%, respectively for syrups, jams and nectars after 12 months of storage. It increased significantly ($p<0.05$) up to 12 months of storage for samples coded S_1 and S_8 and it significantly ($p<0.05$) decreased for samples coded S_3 and $S_{7.}$ (Fig. 2A). Total titratable acidity in jams was stable throughout the storage period but there was a significant ($p<0.05$) decrease in samples coded J_5 and J_6. (Fig. 2B). Titratable acidity decreased significantly ($p<0.5$) in nectars coded N_1, N_6, N_7 and N_{10} while it significantly increased for samples coded N_3, N_4 and N_9. There was no significant ($p>0.05$) changes in samples coded N_2, N_5 and N_8 as shown in Fig. 2C.

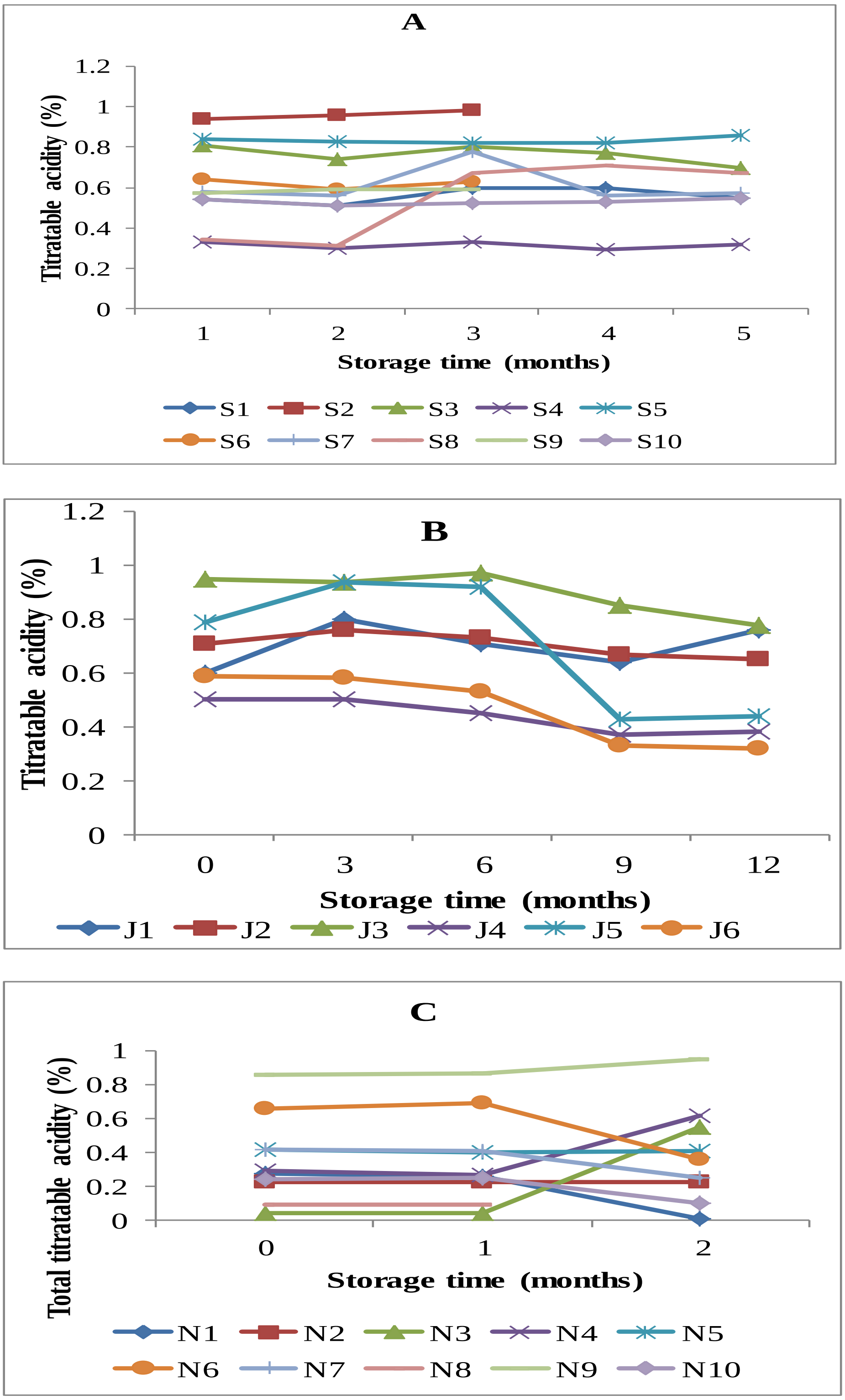


Figure 2: Variation of total titratable acidity values of pineapple Syrups (A), jams (B) and nectars (C) at different storage times

Similar stability in titratable acidity was observed in the thermally pasteurised pineapple juice stored for 13 weeks (Chia et al., 2012) and in grape juice during the storage duration (Buglione and Lozano (2002). The observed significant changes in TTA in some products in the current study were also reported by Ewaidah et al. (1988) in tomato juice stored for one year and Chia et al. *(*2012) in Ultra Violet (UV) irradiated pineapple juice through the storage period of 13 weeks. Those changes in titratable acidity could be attributed to conversion of acid into sugars (Keditsu et al., 2003). Nevertheless, beside the changes on total titratable acidity, the majority of the products complied with the standards with regards to total titratable acidity whose values were below the maximum limit of 1.35 % set by Codex standards for pineapple juice (CAC, 2005b). Therefore, in addition to whatever malpractices that may have been done in the studied samples, TTA values remained close to the values found by Camara et al. (1995) in authentic commercial pineapple juices and nectars, which had legal TTA values.

Moisture

Results for moisture contents in pineapple syrup, jam and nectar are shown in Fig. 3 (A, B and C). The results show that, in syrups (Fig. 3A), moisture was stable up to six months of storage for samples coded S_1, S_2, S_3, S_5, S_8 and S_9 and the significant changes occurred from the ninth month of storage especially for sample $S_{6.}$ The rest of the syrups (S_4, S_7, S_{10}) had stable moisture only up to three months of storage. The moisture ranged from 29.5 to 68.0% during 12 months of storage. Moisture content was stable up to three months and started to significantly ($p<0.05$) either increase or decrease from six months of storage for most of the syrups ranging from 32.63 to 54.66%. Only samples coded S_4 was stable up to 12 months of storage (Fig. 3A). In nectars, the moisture ranged from 79.93 to 95.38% and significant changes ($p<0.05$) started to occur at the second month of storage. All of the nectars had moisture values ranging from 78.45 to 95.36 % (Fig.3 C).

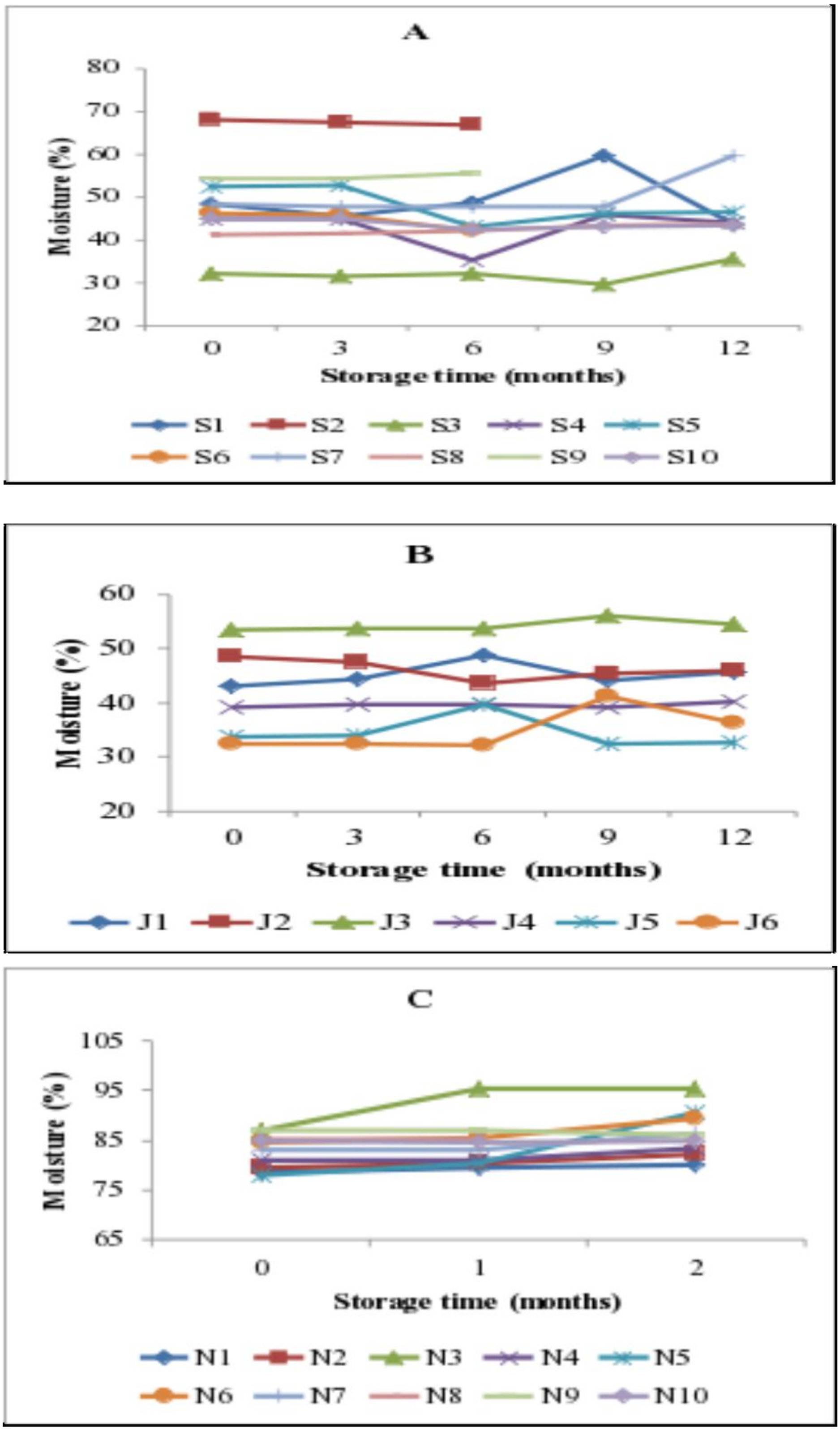


Figure 3: Variation of moisture values of pineapple syrups (A), jams (B) and nectars (C) at different storage times

These values are nomal values for fresh fruit and vegetable juices for which a normal moisture values range from 80-95% (Kirk and Sawyer, 1991). The moisture of jams ranged from 31.06% for samples J_6 to 56.1% for J_3 (Fig.3 B). It was stable for only sample J_4 throughout the entire storage period of 12 months and for samples J_1, J_2 and J_5 a significant decrease ($p<0.05$) was observed from the sixth month of storage while for samples J_3 and J_6 a significant increase was observed from the ninth month. These results show inconsistent changes in moisture for different jam sources over the 12 months of storage period. Moisture is one of the indices used to assess the authenticity of the fruit products. The change in moisture content of some samples could be attributed to either the inappropriate packaging materials (such as packaging not closing tightly), the nature of the packaging material itself in terms of moisture permeability or the change in the structure of the samples (Venir et al., 2007).

Lack of packaging materials has been mentioned as the major constraint in food SMEs business (Mukantwali et al., 2012). From these findings, it is observed that significant variations in moisture content started from six months of storage for syrups and jams and from the end of the first month of storage for nectars. Consequently, based on moisture content criterion it is proposed that syrups and jams be stored up to six months and nectars be stored up to one month. Similarily, Alzamora (1993) have found a storage duration of high moisture fruit products ranging from 4 to 8 months.

Fibre

Results showed that samples had very low fibre levels ranging from 0.008 to 0.07%; 0.14 to 0.40% and 0.024 to 0.040% for syrup, jam and nectar samples, respectively at 12 months of storage. The levels of fibre in the studied samples were lower than 5%, which is the minimum limit set by the Codex and East African and Rwandan standards in pineapple fruit juices (EAS, 2000; CAC, 2005a, RS, 2005; CAC, 2009). The low levels of fibre content noted in the analysed products was expected because, processed fruit products including juices are known to be low fibre content food products (Kelsay et al., 1979). Dietary fibre comes from the portion of plants that is not digested by enzymes in the intestinal tract (Anderson et al., 2010). Part of it, however, may be metabolized by bacteria in the lower gut. Different types of plants vary in their amount and kind of fibre. Fibre includes pectin, gum, mucilage, cellulose, hemicellulose and lignin (Birch and Parker, 1983). Fruits and vegetables are good source of dietary fibre. Research has shown that a high-fibre diet has several benefits including prevention and treatment of constipation, hemorrhoids and diverticulosis as well as decrease of blood cholesterol (Theuwisen and Mensink, 2008). Pineapple processors are advised to process graded pineapple fruit in order to come up with a product of expected values of fibre content.

Ash

Results showed that ash levels were very low in syrups, jams and nectars. The levels ranged from 0.11 to 1.2%; 0.14 to 0.40% and 0.028 to 0.21%, for syrups, jams and nectars, respectively after 12 months of storage for syrups and jams and after two months of storage for nectars. For syrups, ash levels remained stable up to six months, however, significant ($p<0.05$) changes were observed from the ninth month of storage. For jams, ash levels were stable throughout the period of 12 months of storage. Only samples J_4 and J_6 were stable up to six months of storage and significant ($p<0.05$) changes were observed from the ninth month of storage. For most of the nectars, ash levels remained stable up to two months of storage but for sample coded N_6 and N_9, there were significant decreases at the second month of storage. For samples N_2 and N_5, the significant decreases were observed at the end of the first month of storage. Ash levels in a food product represent inorganic residue remaining after destruction of organic matter (Ranganna, 1986). The changes observed in ash content for these few samples were expected as it has been reported that some changes in ash content could occur during storage due to some interactions between constituents (Ranganna, 1986). A similar finding of decrease in ash content for stored soursop juice was observed by Abbo et al. (2006). The stability of ash content in most of the studied products was similar to that reported by Akinyele et al. (1990) who found no significant changes in ash content during the processing and storage duration in pineapples and orange juices. The levels of ash in the studied sample were lower than the expected range of 0.3 to 2% reported in literature for fresh fruits and vegetables (Kirk and Sawyer, 1991). However, similar levels of ash were found by Camara et al. (1995) in authentic pineapple juice concentrate packaged in glass bottles and in pineapple nectars. The very low levels of ash in nectars were obvious because they are only made of 40% of natural pineapple juices (Camara et al., 1995). Ranganna (1986) suggested that the low levels of ash in fruit products could be an indication of the absence of adulterants in the sample products. Accordingly, pineapple products in the current study may be considered as authentic with regards to ash content.

Total soluble solids

Results for total soluble solids in pineapple syrups, jams and nectars are presented in Figure 4. For most of the samples, there was no significant ($p>0.05$) changes in total soluble solids (TSS) levels throughout the storage time except for S_3 where the TSS levels increased significantly from the sixth month of storage (Fig. 4A). The levels ranged from 51 to 65^0 Brix at initial point of storage for syrups. In jams, the TSS levels ranged from 55 to 86^0 Brix at the initial point except in J_3 with the lowest level of 46.33^0 Brix and J_6 with the highest level of 86^0Brix (Fig. 4B). The levels ranged from 14.17 to 20.17^0Brix in nectars at the initial point of storage with the exception of sample N_3 which had the lowest level of 6.1^0Brix (Fig. 4C). However, there was a significant decrease in levels of Brix in N_6 and N_9 at the end of the first month of storage while there was a significant increase of Brix level in N_3 at the end of the first month of storage.

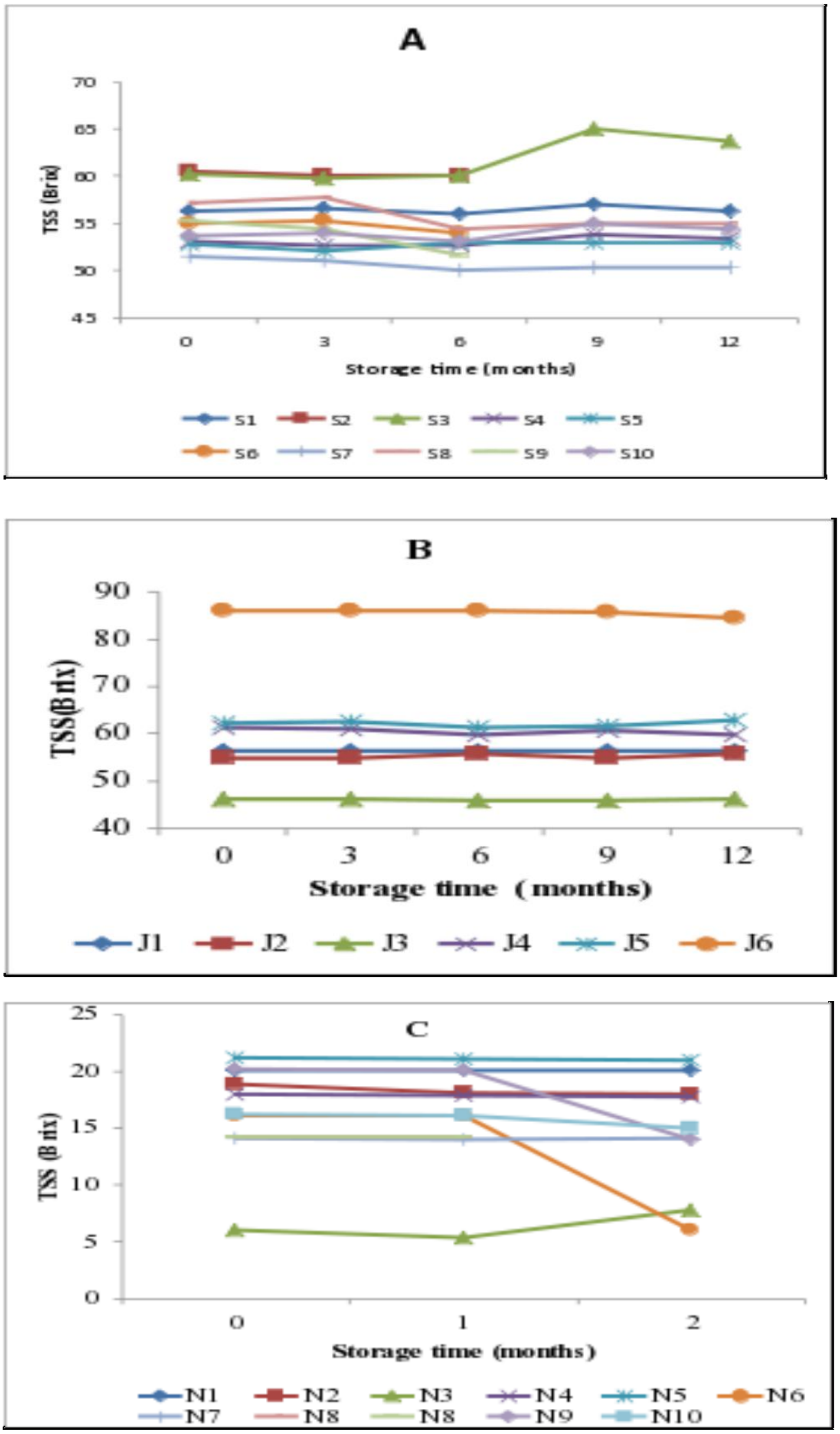


Figure 4: Variation of total soluble solid values of pineapple syrups (A) jams(B) and nectars (C) at different storage times

The amount of total soluble solids has been used as an indicator of fruit product quality and authenticity (Camara et al., 1996). The levels of Brix in the nectars were much higher than the levels in the nectars reported by Camara et al. (1996) which ranged from 11.6 ^{0}Brix to 15.7^{0}Brix. However, Brix levels in nectars were above 12.8 (% v/v), which is the minimum limit in pineapple nectars set by CAC (2005b). Similarly, the Brix levels of syrups S_4, S_5, S_6 and S_{10} in the current study were close to the one of authentic commercial juice concentrate in the same study of Camara et al. (1996). Therefore, most of the syrups and nectars in this study may be qualified as authentic with regards to TSS. However, jam samples coded J_4, J_5 and J_6 were the only ones for which TSS was above 60% as recommended by CAC (2009), probably because they were manufactured by successful and experienced medium enterprises, which have been operating more than five years. The remaining jams were qualified as not acceptable as far as TSS was concerned, may be because most of them were small enterprises with little experience in fruit processing. Consequently, processors need to be informed that the quantity of sugars added to pineapple syrups should not exceed 25 g/kg (RS, 2005) and that for jams, there is a need of having 40% of fruits used as ingredient in the final product (CAC, 2009).

Sucrose

Figure 5 shows the variations of sucrose levels in the syrups, jams and nectars during storage. There was a statistically significant ($p<0.05$) decrease in the sucrose levels during the storage period for jams and syrup samples and a slight decrease started at the end of the first month of storage for nectars. The levels ranged from 9.15% in syrups S_1 to 15.40% in S_4; 6.24% in jam J_3 to 13.48% in J_4 and 0.36% in nectars N_2 to 5.98% in N_2 at the initial storage time. The levels of sucrose in syrups and nectars were much higher than the levels reported by Camara et al. (1995) ranging from 4.13 to 5.51% and 0.21 to 3.58 % for syrups and nectars, respectively.

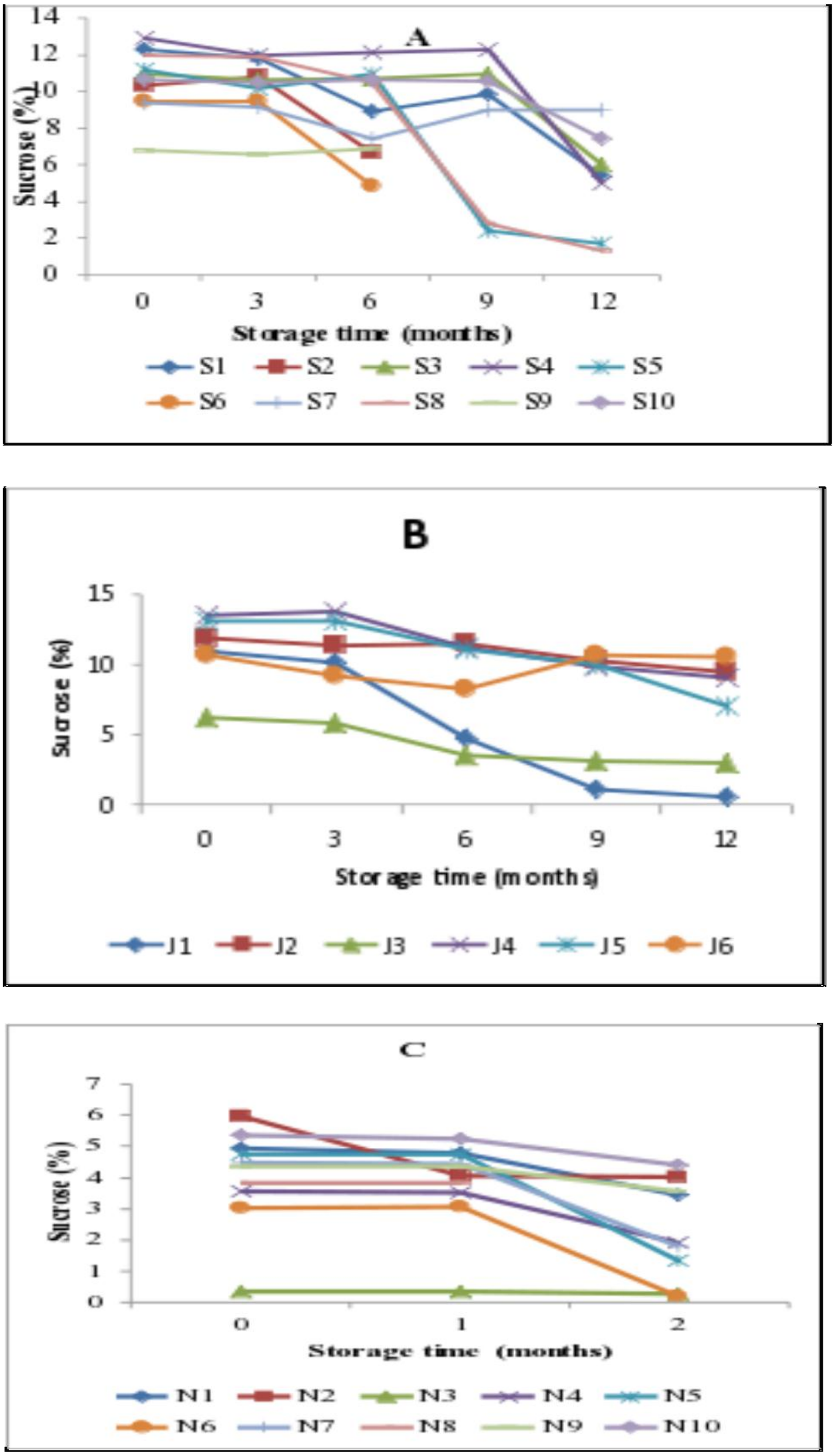


Figure 5: Variation of sucrose values of pineapple syrups (A), jams (B) and nectars (C) at different storage times

There was a sharp decrease in sucrose levels from the end of the third month for syrups and jams, and the first month of storage for nectars. Ewaidah et al. (1988) reported that the decrease in the sucrose content in canned orange juices stored for one year was due to conversion to reducing sugars. In their study, sucrose was still present for the juices stored at 24^0C up to 12 months of storage. Similarly, in the current study, sucrose was still remarkably present in the products stored at a temperature ranging from 21^0 to 25^0C. The storage conditions, such as high temperature have been reported to facilitate the conversion rate of sucrose to reducing sugars and it is suggested that the rate of sucrose hydrolysis is a function of reactants, temperature and acid-catalyst concentration (Babysky et al.,1986).

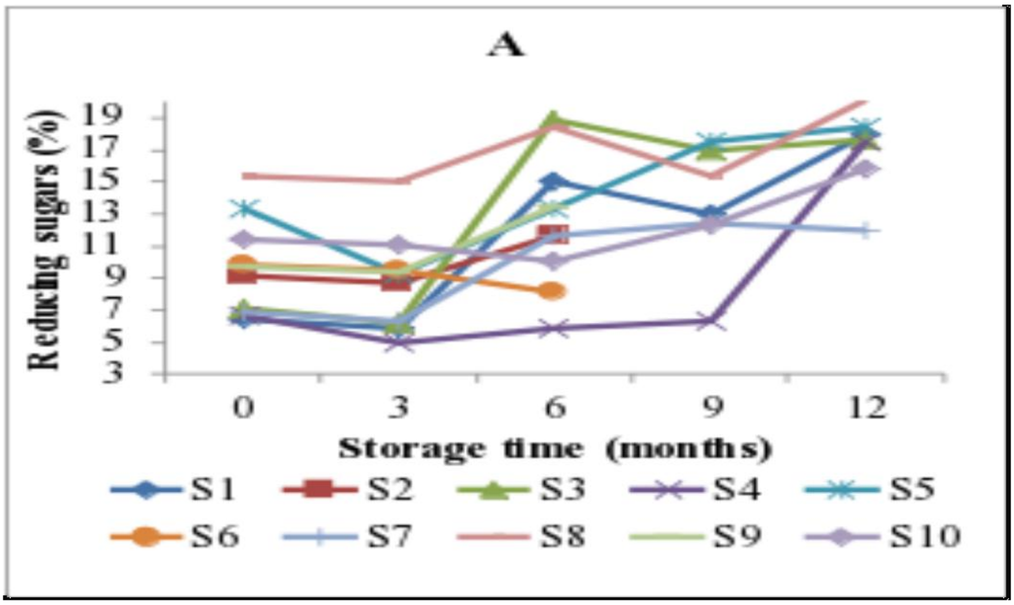
The current results corroborate with the results of Babysky et al. (1986) who reported hydrolysis of sucrose in apple juice concentrate stored for 111 days. However, the levels of sucrose did not significantly change in the nectars as their shelf life did not go beyond two months. The high levels of sucrose found in this study and variation among product sources could be an indication of an improper addition of sugars during processing.

Reducing sugars

Results of reducing sugars changes over 12 months of storage for syrups (A) and jams (B) and over 2 months of storage for nectars (C) are shown in Fig.6. There was a marked increase in reducing sugars for syrups and jams from the end of the third month of storage. Syrup S_9 had the highest level of reducing sugars (20.10%) and S_{10} had the lowest levels (15.59%) at 12 months of storage. The observed differences in reducing sugar contents of the samples were expected because samples came from different pineapple growing locations, which is indicated as one of the key factors contributing to the reducing sugar levels in fruit products in addiidion to the stage of maturity of pineapples to be processed (Tasnim et al., 2010).

For jams, the levels of reducing sugars ranged between 6.6 and 22.00% throughout the storage period. However, the levels did not significantly change in all the nectars. The rate of increase in reducing sugars ranged between 20 and

70% between the beginning and 12 months of storage. These levels were very low ranging between 0.0031% in N_2 to 0.1 % in N_9 at the beginning of storage.



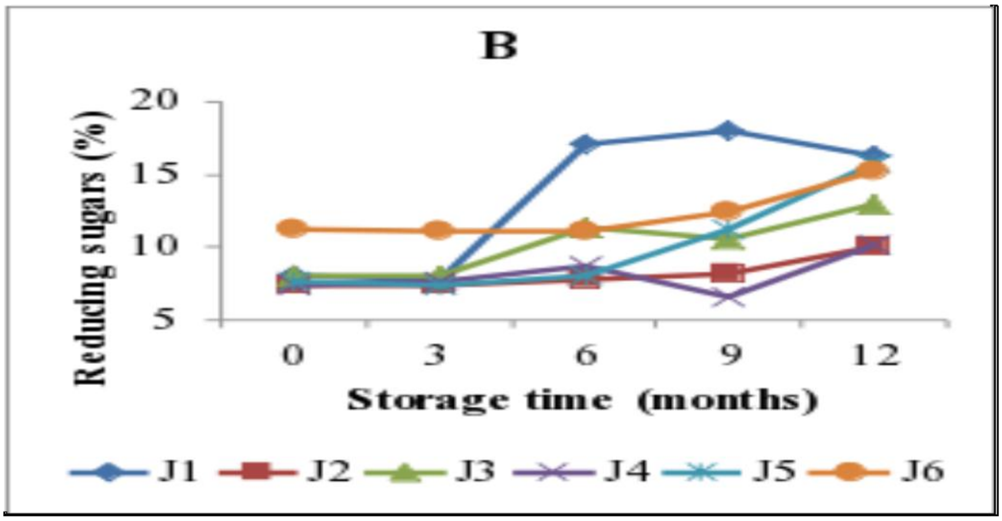


Figure 6: Variation of reducing sugars values of pineapple syrup (A) and jams (B) at different storage times

Similar increase in reducing sugars during the storage were also reported in apple juice by Babsky et al.(1986) and in commercial orange canned nectars by Ewaidah (1988). One of the factors that leads to increased reducing sugars during storage of the juices is the decrease in sucrose which hydrolyses into reducing sugars. It was then observed in this study that the increase in reducing sugar levels starting at the end of the third month of storage and onward followed the same trend of decrease in sucrose. Hence, the rate of conversion of sucrose to reducing sugars could have been affected by storage time, temperature and changes in the chemical constituents of the samples.

For the nectars, sucrose and consequently reducing sugar levels did not change significantly over two months of storage. The coefficient of reducing sugars (predominantly glucose and fructose) over sucrose was close to 1 at the beginning of storage for six out of the ten tested syrups. It ranged from 0.89 to 1.43 for samples coded S_1, S_2, S_3, S_4 and S_5. This coefficient of authenticity was also close to one for only two jam samples coded J_2 and J_6. These jams are the only ones that showed insignificant changes ($p>0.05$) for most of the parameters because they were manufactured by two successful medium enterprises trained by other different agencies in addition to Rwanda Agriculture Board (RAB) and the National Agricultural Export Development Board (NAEB). The coefficient was much less than one for the remaining five syrups, nectars and most of the jam samples. This could be an indication of the addition of much higher sugars in those samples than the recommended amount. Camara et al. (1996) have suggested that the coefficient of fructose plus glucose /sucrose close to one is a reference index of the authenticity of pineapple fruit products. Therefore, the addition of sugar to some syrups, nectars and jams during processing could have been done inappropriately .

Total sugars

Results in Fig.7 showed that total sugars increased in most of the syrups up to 12 months of storage. The levels ranged from 16.41 to 19.30 % in S_7 and 22.95 to 23.70 % in S_{10} at initial point of storage and at 12 months of storage, respectively. The increase in total sugars levels started from the third month of storage (Fig.7A). There were also no significant changes ($p>0.05$) in total sugar content of jams throughout the storage period and the levels ranged from 14.53% in jams J_3 to 24.47% in J_5 at the initial storage time (Fig.7B).

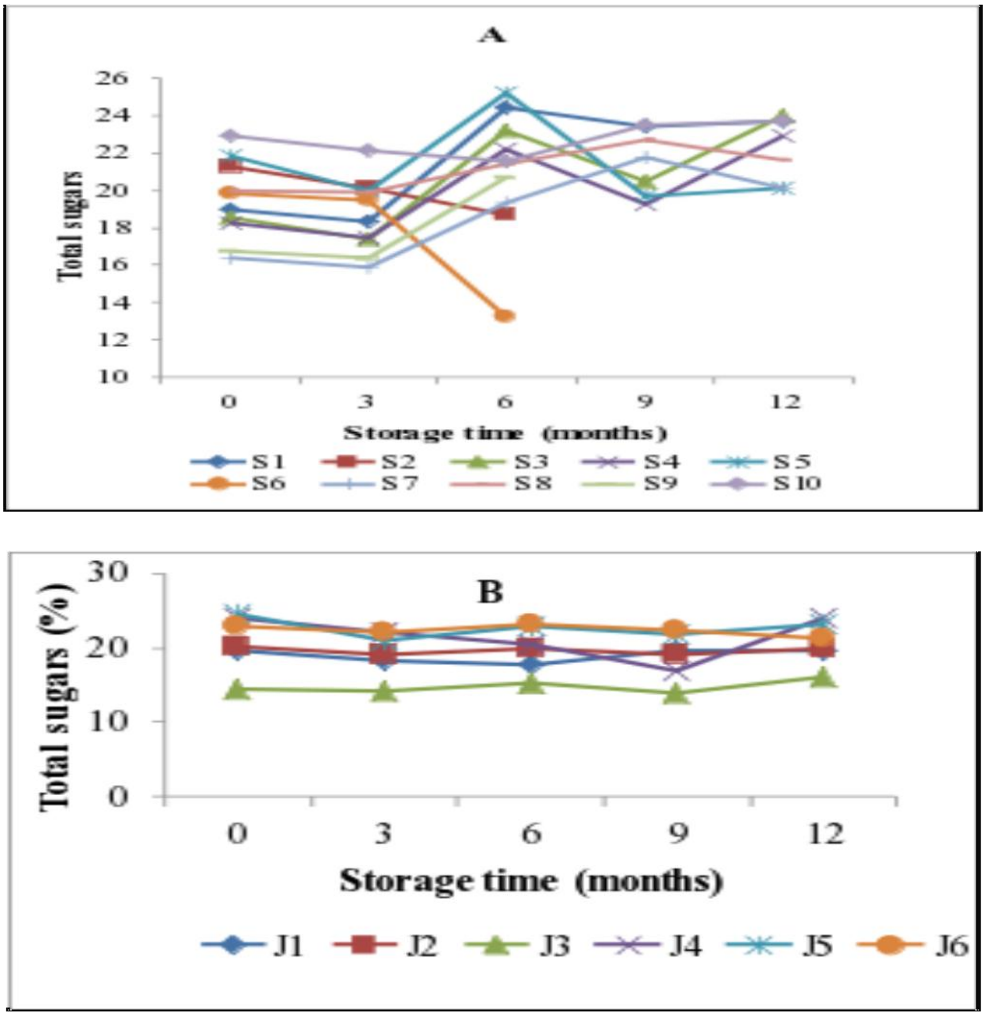


Figure 7: Variation of total sugars values of pineapple syrups (A) and jams (B) at different storage times

The levels of total sugars in nectars were very low ranging from 0.01% in N_3 to 6.25% in N_9 at the initial stage of storage. They did not change significantly up to the end of the storage period for the majority of nectars.

The increase in total sugars during the storage period in this study followed the same trend of increase in reducing sugars over the storage period reported by Chia *et al*. (2012). The non-significant changes in total sugars in nectars could also be justified by the non-significant changes observed in reducing sugars over the storage period. The total sugars in this study were higher than the total sugars reported by Camara et al. (1995). Sugar patterns can be used for detecting an inappropriate admixture of sugar solution or fruit juices (Fügel et al., 2005).

Consequently, it is possible that more sugar was added in the studied products than the maximum permissible levels.

Ethanol

The majority of the samples did not have ethanol throughout the storage period. This is a positive aspect for these processed pineapple products as the Codex standards state that ethanol should not exceed 0.3% (CAC, 2005b). Most of the syrups did not have alcohol throughout the storage period. The levels of alcohol above the recommended level were however detected in four out of 10 syrup samples (S_2, S_3, S_8 and S_9). Alcohol levels ranged from 0.32 to 1.22% in these syrups. There was no detection of alcohol in all nectars up to the second month of storage. The majority of the jam samples had slightly higher levels of ethanol than the recommended amount at six months of storage. Those levels were in the range of 0.3 to 0.33%. There was no alcohol detected in jams coded J_2 and J_6 from the two successful, well trained and well equipped medium fruit processing enterprises. These observations show that there was fermentation going on due to low sugar content in some of the products, improper pasteurisation and contamination.

Conclusions and Recommendations

Results have revealed that the levels of quality parameters for the studied pineapple products vary greatly at all stages of storage indicating absence of non adherence to standards. Results showed that nectars were stable for most of the studied parameters throughout the storage time of two months. The fibre content in these nectars did not comply with the standards. Altough nectars can be stored up to two months of storage, there is a need of selecting good grade pineapple fruits to use during processing so that the fibre levels are increased up to the required standards of 5%. In addition, proper packaging materials should be used in order to achieve an increased shelf life of the product beyond two months of storage. Jams and syrups were stable up to six months of storage for most of the parameters. It is therefore recommended that processors need to indicate an expiry date of six instead of the current 12 months.

However, their shelf life could also be increased by using good grade pineapple fruits as stipulated in the Codex Alimentarius Commission, Rwanda and East African Standards. Processors should adhere to the requirements stipulated in the standards with regards to the addition of sugar in pineapple products. Future research should investigate the effect of packaging materials on the storage stability of pineapple products. Rwanda Bureau of Standards in collaboration with Rwanda Agriculture Board, National Agricultural Export Development Board and Rwanda Cooperative Agency (RCA) should ensure that fruit processors observe required international standards at their processing plants.

Acknowledgements

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PAPER SIX

Evaluation of Influence of Storage time on Organoleptic Properties of Pineapple Products Processed by Small and Medium Scale Enterprises in Rwanda

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Abstract

Pineapple fruit is getting much attention due to its attractive flavour and aroma and nutritional properties**.** Recently, there has been mass production of pineapple fruits in Rwanda and a number of Small and Medium scale Enterprises (SMEs) has started to add value to the fruit by processing it into different products, like syrups, jams and dried slices. However, todate the quality of these products is still questionable and they are only sold locally. To get to the export market, these products have to comply with the international standards. The aim of the present study was therefore to assess the storage stability of the pineapple processed products (stored at room temperature of 21^{o} to 25 ^{o}C) with regards to sensory properties. Fourty eight semi-trained panelists were involved in the study and evaluated syrups and jams at three months intervals and nectars at one month interval using a seven point hedonic scale. Results showed that syrups were equally liked as the reference syrup or superior to it for all the attributes during the storage period of 12 months. The overall acceptability scores ranged from 4.07 to 6.12 at the initial stage and from 4.00 to 5.63 at the end of storage time. However, syrup 1 (S_1) and syrup 8 (S_8), which had deteriorated at 12 months of storage had mean scores of overall acceptability of 1.19 and 3.87, respectively. Syrup 4 (S_4) and syrup 6 (S_6) had highest scores than the remaining ranging from 4.85 to 6.20 and from 5.46 to 6.12 resepectively for overall acceptability. The colour of 50% of the syrups undewent significant ($p<0.05$) degradation as the storage time progressed. Panelists indicated a higher degree of liking the taste of 60% of nectars than the reference nectar with scores ranging from 4.02 to 5.37 at the initial storage time. Similarily, for 80% of nectars, the colour was given high scores ranging from 4.02 to 4.89 at the initial storage time. However, aroma of the nectars was given very low scores ranging from 1.68 to 3.79 at the initial stage of storage. Most of the nectars (80%) were also rated low for overall acceptability at the initial storage time with scores ranging from 2.20 to 3.97. The acceptability of the majority of the nectars decreased tremendously from the second month of storage. Pineapple jams at the initial stage of storage were given low scores compared to the reference jam ranging from 3.16 to 3.60 for 67% of the samples and there was no significant variation in mean scores throughout the storage period for most of the attributes which were given lower score than the reference. Jam 2 (J_2) and jam 6 (J_6) were as liked as the reference jam for all the attributes. These two jams liked as the reference jam behaved differently, probably because they were processed by two medium enterprises which were trained on how to process pineapples by church missionaries in addition to Rwanda Agricuture Board (RAB) and National Agricutural Export Development Board (NAEB). Beside that reason, the hygiene status of these two enterprises was better than the one of the remaining jam processing enterprises. SMEs need to be trained on how to process products that will remain acceptable and stable over the intended storage period. Enterprises should undertake shelf life studies for each product to establish the exact shelf life than what is currently declared on the label without any basis or scientific proof.

Key words: Organoleptic, storage stability, pineapple, enterprises, Rwanda

Introduction

Pineapple fruit (*Ananas comosus* [L] Merrill.) is an edible fruit, which is widely grown in many tropical or subtropical areas including Rwanda. Apart from being consumed fresh, pineapple is also processed into juices, canned and dried pineapple fruit slices, jams and jellies that may be added to dairy products such as yoghurt. Pineapple juices and jams are the most popular fruit products due to their attractive colour, good aroma and sweet-sour mouthfeel. In the last 10 years, the world trade of fresh pineapple fruit and its products has doubled and the pineapple export industry has developed into a complex export supply chain. In Rwanda, pineapple production has increased and it was expected that the production would increase from 30 000 tonnes in 2006 to 120 000 tonnes in 2012 (RHODA, 2008). In order to increase their income, small and medium scale pineapple processors have started value addition processes to the pineapple fruit by transforming the fruit into varied processed products namely juices, jams, wines and dried slices (Austin et al., 2009). For these products to get to the export market, their quality has to meet the international quality requirements including storage stability with regard to sensory properties. It has been proven that consumer acceptance is the ultimate criterion for deciding the quality of a product. Sensory evaluation is required for knowing the consumers' preferences and market acceptability of any food during a given storage period. It is useful for product development and further product improvement since the important factors for a particular market can be identified and improved (Zhang and Litchfield, 1991).

Since the increase in numbers of small scale pineapple processing enterprises, there has been limited information regarding the shelf stability with regards to sensory properties of the products they are producing. Colour, flavour and texture are important quality characteristics of fruits and vegetables and major factors affecting sensory perception and consumer acceptance of foods (Oey et al., 2008). Thus, the objective of this study was to evaluate the storage stability of the processed pineapple syrups, jams and nectars with regards to sensory properties and their compliance to national and international standard requirements.

Materials and methods

Sensory evaluation

Sensory evaluation was carried out on the pineapple nectars, syrups and jams from October 2012 to October 2013. For nectars, this was performed every one month, and every three months for syrups and jams up to 12 month of storage. Assessments were carried out by 48 semi- trained students (34 males and 14 females) aged between 18 and 28 years and selected from the Department of Food Science and Technology, in the Kigali Institute of Science and Technology (KIST), Rwanda. These panelists were employed as a model of generic consumers. Before conducting the evaluation, the aim of the work and the recommended behaviour before and during the test was explained. Samples were placed in individual glass plastic containers and disposable plates for syrups, nectars and jams, respectively. They were then coded with a three-digit random numbers and served in a randomized order to minimize contrast effect (Resurreccion, 1998; Larmond, 1977). The tests were performed under day light conditions. Each panelist received 100 ml of each liquid sample and a small portion of each jam sample (20 g) for testing. Sufficient time between samples was ensured and a set of five samples was allowed for each panelist to evaluate each sample and recover or equilibrate between samples. They were then asked to evaluate one parameter at a time and then proceed to the next. Colour, taste, flavour and overall acceptability were evaluated for the syrups and nectars as was done by Bartolome et al. (1995).

For jams, consistency, spreadability, colour, sweetness and flavour were the parameters evaluated as demanded in Rwanda Standard (2008). The 26 samples of syrups, nectars and jams were evaluated during three consecutive days. In the multiple comparison test, a commercial pineapple syrup and nectar (from Inyange Food Industries manufactured in Rwanda) and a commercial pineapple jam (manufactured by Premier Food Industries, Kenya) tagged R, were used as a reference against which the panelists were asked to compare the colour, taste, aroma, spreadability, sweetness and overall acceptability of the syrups, nectars and jams using a 7 point hedonic scale where 1 = Dislike very much than R, 4 = Equal to R, and 7 = Like very much than R. Table 1 shows the codes that are used in this study in order to distinguish the samples from different enterprises.

Table1: Abbreviations of samples used in this study.

Syrup samples	Enterprise processing syrups	Nectar samples	Enterprise processing nectars	Jam samples	Enterprise processing jams
S_1	Small	N_1	Small	J_1	Small
S_2	Medium	N_2	Medium	J_2	Medium
S_3	Small	N_3	Small	J_3	Small
S_4	Medium	N_4	Medium	J_4	Medium
S_5	Medium	N_5	Small	J_5	Medium
S_6	Small	N_6	Small	J_6	Medium
S_7	Medium	N_7	Medium		
S_8	Small	N_8	Small		
S_9	Small	N_9	Medium		
S_{10}	Medium	N_{10}	Medium		

Statistical data analysis

The sensory evaluation data were analysed by using Genstat statistical software 14th edition (VSN International Ltd, UK). Analysis of variance (ANOVA) was performed to determine significant differences between the means of parameters studied and interaction between the factors. Means were separated by Tukey's Honest Significant Difference at $p<0.05$. Results were expressed as means of 48 evaluations ±SD and presented in tabular and graphical forms generated by MS Excel 2010.

Results and discussion

Sensory properties of pineapple syrups

Taste

Results on the variation of mean scores for taste throughout the storage period are shown in Fig.1. There was a significant difference ($p<0.05$) in the taste of the syrups between the initial and final storage time but the syrups were still accepted by panelists at the end of storage times. Syrup samples coded S_1, S_4, S_6, S_9 and S_{10} (50% of the samples) were scored as liked moderately compared to the reference syrup at the initial stage of storage. Among all the samples, only S_1 and S_8 (20%) of all were disliked very much by the panelists throughout the storage period of 12 months, with their mean scores dropping from dislike slightly (3.87) to dislike very much (1.19) compared to the reference syrup. Based on the taste criterion of the syrups which was still accepted by panelists up to the end of 12 months of storage, it may be concluded that the shelf life of syrups could be 12 months.

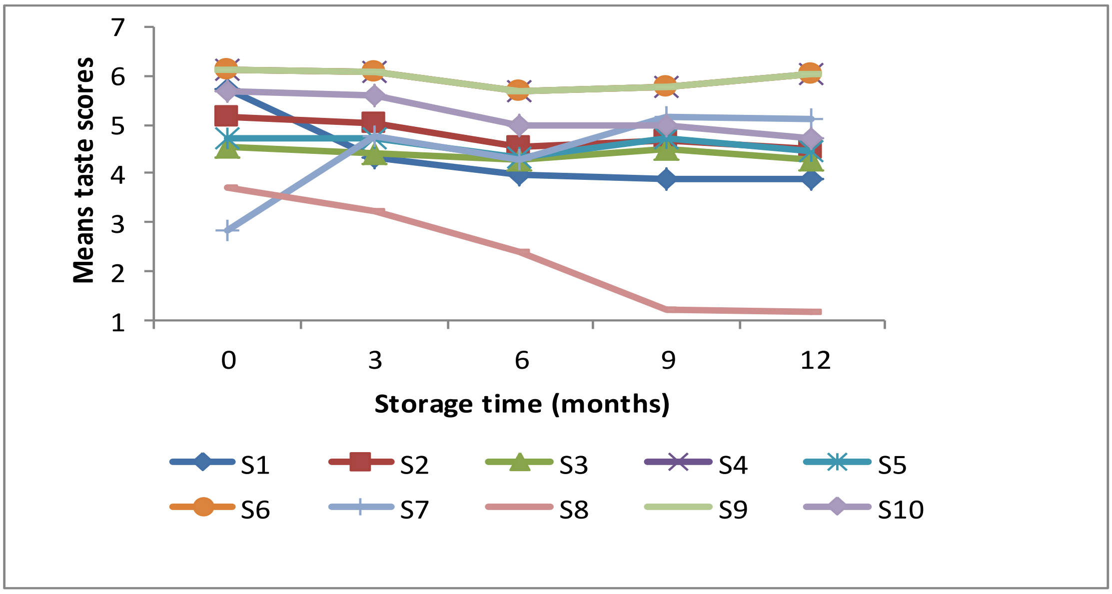

Figure 1: Variation in mean sensory scores of taste during storage of syrups

Aroma

Syrups evaluation results for aroma are given in Figure 2. Most of the syrups (80%) at the beginning of storage were scored above four indicating better than the reference syrup except S_3 and S_5 (20%) that were not liked relative to the reference. There was no significant variation in aroma scores throughout the storage period for the majority (80%) of syrups though slight changes were observed. Only significant changes were observed in S_1, where aroma scores decreased from 4.36 to 2.07 and from 4.07 to 1.97 in S_8 at the beginning and at 12 months of storage, respectively. Samples S_6, S_9 and S_{10} (30% of the samples) were scored as like slightly more compared to the reference (mean score above 5) while S_1, S_2, S_4 and S_8 were given scores as liked equally as the reference syrup.

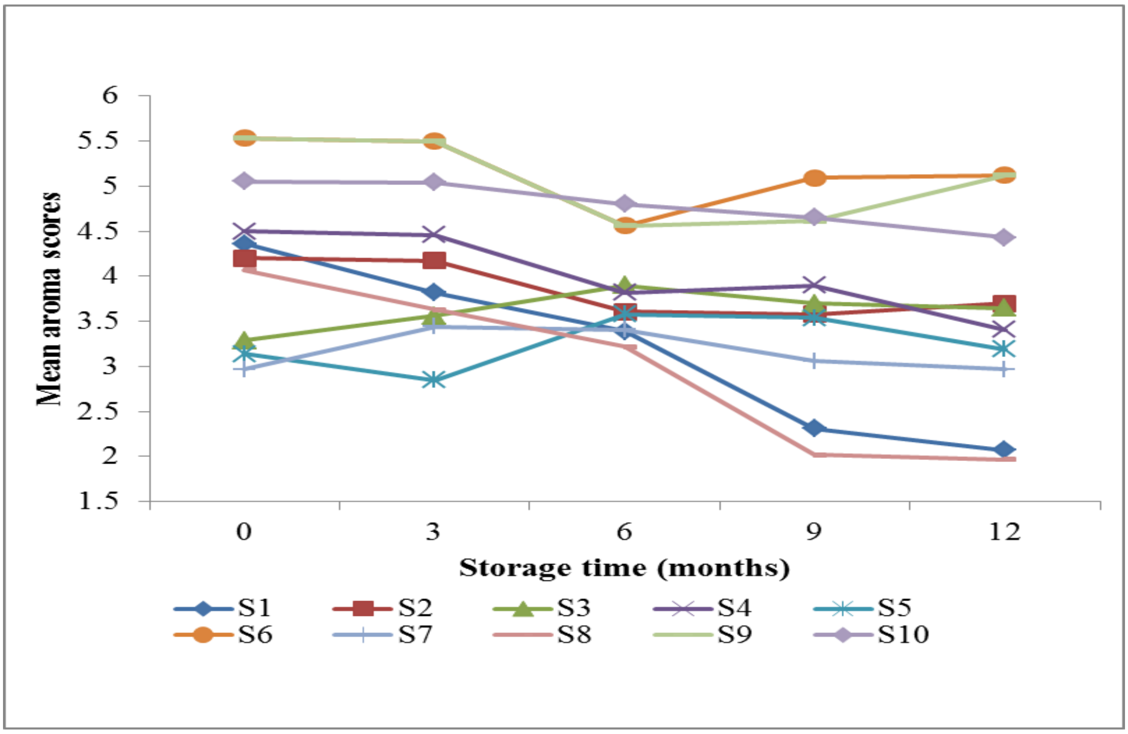

Figure 2: Variation in mean sensory scores of aroma during storage of syrups

The remaining samples (S_3, S_5 and S_7) were scored below five at the beginning of storage. At the end of 12 months of storage, only S_6, S_9 and S_{10} (30%) were equally liked as the reference sample for the aroma. The remaining 70% of syrups were disliked very much.

The present aroma results suggest that only three syrups (S_6, S_9 and S_{10}) can be stored for up to 12 months and still be accepted by consumers while syrups S_2 and S_4 can only be stored for three months and still be accepted by consumers. The remaining syrups S_1, S_3, S_5, S_7 and S_8 were not acceptable with regards to aroma property even at the initial stage of storage. The changes in aroma profile of the syrup samples from different enterprises could be explained by the fact that aroma compound profile depends on the nature (maturity stage, variety, growning location) of the pineapple fruit to be processed and the methods of processing used. As most of these enterprises were trained by different agencies, it is understandable that their methods of processing are not standardized and then affect differently the chemical composition of the final product.

Colour

Figure. 3 shows the variation of mean scores of colour during the 12 months of storage period.

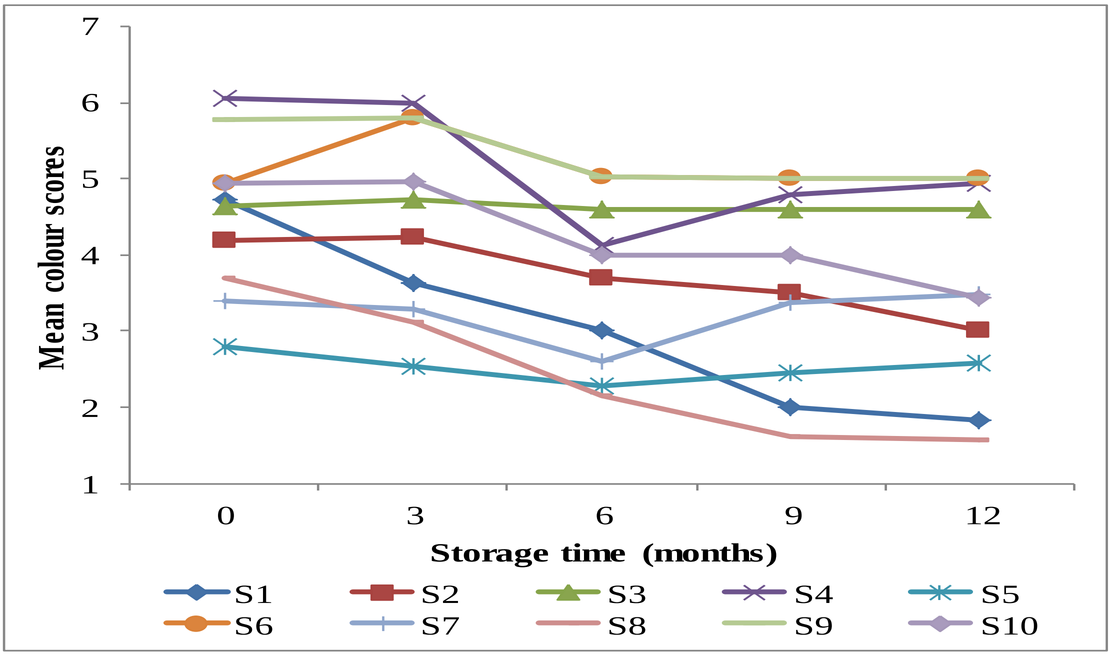

Figure 3: Variation in mean sensory scores of colour during storage of syrups

The results indicated that at the beginning of storage, panelists allocated very low mean scores of 2.80; 3.39 and 3.70 to S_5, S_7 and S_8 (30% of all samples), respectively. The remaining seven syrups (70%) were scored from four (liked as the reference syrup) and above. The colour was stable throughout the storage period for syrups S_3, S_6 and S_9. The remaining syrups (70%) experienced a decrease in mean scores of the colour throughout the storage ranging from 1.82 to 3.48 at the 12th month of storage. Only S_3, S_4 and S_6 (30%) were equally scored as the reference syrup up to 12 months of storage. Based on the colour results, syrups S3, S6 and S9 can be stored for 12 months and still be accepted by the consumers while S2, S4 and S10 can only be stored for six months and still be accepted by the consumers. The remaining syrups (40%) were not accepted even at the initial storage period. The degradation of the colour in the sample products could be due to the permeability to oxygen of PolyEthylene Terephtalate (PET) packagings (used as packaging materials). This is considered as the major factor detrimentally affecting the colour of a fruit product in addition to Maillard reactions, responsible for non-enzymatic browning (Berlinet et al., 2003).

Overall acceptability

Syrups were evaluated for overall acceptability throughout the storage period (Fig 4.). All the syrups were given mean scores above four for overall acceptability at the beginning of storage. This means they were liked to the same or greater extent compared to the reference syrup. It is surprising that even syrups S_1, S_2, S_4, S_6 and S_9 that were lowly ranked in the previously mentioned parameters (taste, colour and aroma) were this time very highly scored and given mean scores ranging from 5.36 to 6.20. As the storage proceeded, syrups S_1, S_2, S_4, S_8 and S_{10} (50%) significantly depreciated making panelists score them significantly ($p<0.05$) lower than the respective scores observed at the beginning of storage. Syrups S_3, S_5, S_6, S_7, S_9 (50%) were stable in terms of overall acceptability throughout the storage period. It was noted that at the end of the 12th month of storage, only three syrups (S_1, S_5, and S_8) (30%) were disliked very much as compared to the reference syrup. The remaining syrups (70%) were very liked by the panelists with scores above four.

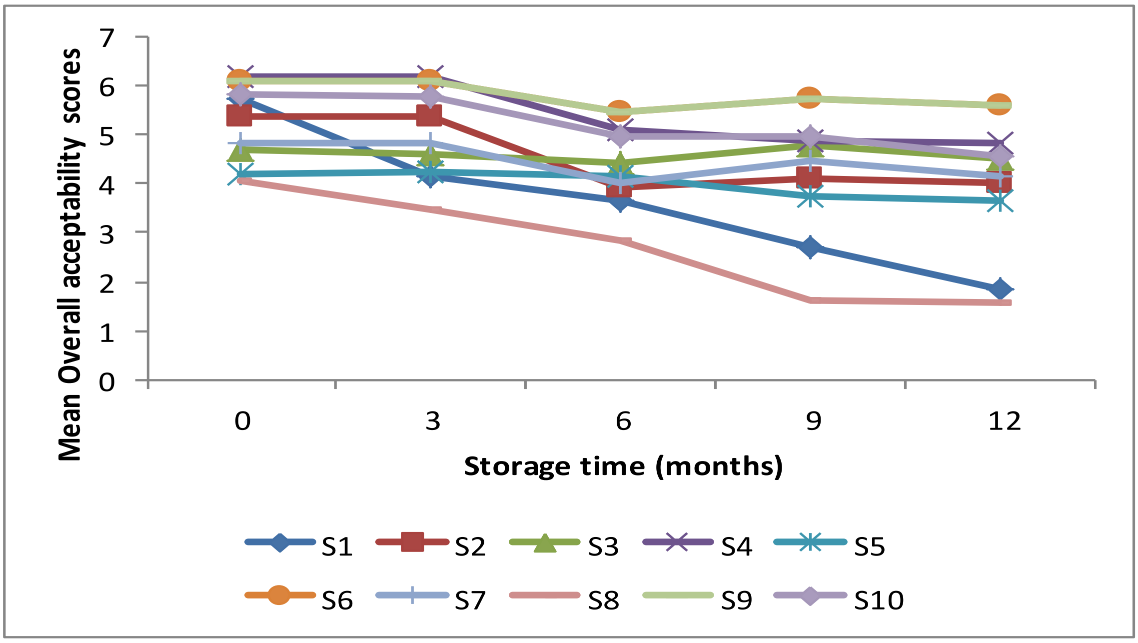

Figure 4: Variation in mean sensory scores of overall acceptability during storage of syrups

The results obtained from this study led to conclusion that most of the syrups processed by SMEs were liked by the panelists when they were compared with the reference syrup throughout the storage period. This was in terms of taste, colour, aroma and overall acceptability, though the scores decreased significantly as the storage period increased. Only few samples (S_1, S_5 and S_8) (30%) were disliked by the panelists at the 12th month of storage while S_4 and S_6 were highly scored (above 6) throughout the storage period. Considering the overall acceptability results, it may be suggested that syrups S_2, S_3, S_4, S_6, S_7, S_9 and S_{10} can be stored at room temperature in Rwanda for 12 months and still be accepted by consumers while the remaining S_1 and S_5 can be stored for three and six months, respectively and still be accepted by consumers. The processing techniques of syrup S_8 could be improved by the concerned enterprises for its acceptability throughout the storage time.

Sensory properties of nectars

A single factor ANOVA was done to test the effect of storage time on sensory scores of taste, aroma, colour and overall acceptability of the pineapple nectars (Table 2).

Table 2: Mean scores of acceptance tests of pineapple juice nectars as influenced by storage time.

Sample [1]	Month	Taste	Aroma	Colour	Overall acceptability
N_1	0	4.43^a	3.41^a	4.02^b	3.97^a
	1	4.12^a	3.14^a	5.54^a	4.14^a
	2	4.45^a	3.16^a	4.08^b	3.91^a
N_2	0	4.08^a	3.22^a	4.16^a	3.82^a
	1	3.55^b	2.75^b	3.90^a	3.31^b
	2	1.81^c	2.34^c	2.56^b	2.59^c
N_3	0	4.16^a	3.35^a	4.81^a	3.91^a
	1	3.72^a	3.12^a	4.39^a	3.64^a
	2	1.00^b	1.00^b	1.00^b	1.00^b
N_4	0	4.02^a	3.35^a	4.35^a	4.02^a
	1	3.25^{ab}	2.47^b	3.06^a	2.62^b
	2	2.54^b	2.16^b	2.62^b	2.27^b
N_5	0	5.37^a	3.79^a	4.89^a	4.79^a
	1	3.91^b	3.62^a	4.50^a	4.70^a
	2	1.00^b	4.14^a	4.47^a	3.83^b
N_6	0	4.16^a	3.35^a	4.81^a	3.91^a
	1	3.22^b	2.97^a	4.41^a	3.70^a
	2	1.00^c	1.00^b	1.00^b	1.00^b
N_7	0	2.79^a	2.60^a	3.52^a	3.33^a
	1	2.54^a	2.12^b	3.29^a	3.14^{ab}
	2	2.12^a	1.68^b	2.29^b	2.52^b
N_8	0	3.50^a	3.45^a	4.14^a	3.33^a
	1	3.43^a	1.81^b	2.25^a	1.95^b
	2	1.00^b	1.85^b	2.06^b	1.68^b
N_9	0	3.54^a	3.21^a	4.70^a	3.43^{ab}
	1	3.54^a	3.22^a	4.77^a	3.54^a
	2	1.00^b	2.72^a	2.37^b	2.66^b
N_{10}	0	2.22^a	1.68^a	2.80^a	2.20^a
	1	2.85^a	1.83^a	2.81^a	2.28^a
	2	1.00^b	1.16^a	2.04^b	2.12^a

[1]N1-N10 represents jams from different producers. Means bearing different superscript letters within a sample in a column are significantly different ($p<0.05$). Values are means of 48 evaluations±SD.

There was no significant variation for taste during storage time for N_1 and N_7. Significant decrease ($p<0.05$) in mean scores of taste between the beginning and the second month of storage were observed for nectars N_3, N_4, N_8, N_9 and N_{10} (50%). The remaining nectars varied significantly in taste just at the end of the second month of storage. Majority of nectars were liked than the reference sample and N_5 scored even higher than the reference sample (5.37) while N_{10} was given very low score (2.22) at the initial storage time. Majority (90 %) of nectars were disliked compared to the reference sample at the end of the second month of storage except N_1, which was still liked up to the end of the second month of storage. The behaviour of N_1 which differed from other nectars with regards to taste during the storage period could not be explained because it was produced by a small enterprise with inadequate hygiene practices and processing equipment.

Nectars were given low mean scores for aroma, ranging from 1.68 for N_{10} to 3.79 for N_5 throughout the storage period. Nectars N_1, N_5, N_9 and N_{10} were stable up to the second month of storage while N_2, N_4, N_7, N_8 had mean scores significantly decreasing from the first month of storage ($p<0.05$). Based on the aroma results it can be concluded that the studied nectars were not liked by the panelists from the beginning of the storage time. Therefore, there is a need for processors in collaboration with researchers to come up with a processing technology that can keep the pineapple aroma for these nectars throughout the storage period.

Panelists liked the colour of eight nectars (80% of the enterprises) to the same extent as the reference nectar at the beginning of the storage time. The highest mean score was 4.89 and the lowest 2.80 for N_5 and $N_{10,}$ respectively. There was a significant difference in mean scores given to colour for most of the nectars throughout the storage period ($p<0.05$). The mean scores started to decrease significantly from the beginning of the second month of storage ($p<0.05$), with the exception of N_5, where the colour remained stable throughout the storage period probably because this nectar was manufactured by a small scale enterprise that was trained by church missionaries on how to process fruit juices.

From the findings of changes in colour for nectars over storage time, it is recommended that these products be stored for only one month except nectar N_5 which can be stored for two months and still keep its acceptable colour.

Results for overall acceptability for nectars showed that mean scores of overall acceptability were also low ranging from 2.20 to 4.02 for N_{10} and N_4 and respectively at the beginning of storage and from 1.00 to 3.97 for N_3 and $N_{1,}$ respectively at the end of the storage period. Nectars N_1 and N_5 scored higher than the remaining nectars throughout the storage period and N_{10} scored the lowest. Basing on the overall acceptability of the studied nectars, N_1, N_2, N_3, N_4, N_5 and N_6 (60%) were the nectars with acceptability close to the reference though there was a decrease in mean scores as the storage time progressed. It is noted that nectars were given mean scores close to the reference nectar only at the end of the first month of storage. From these observations, the shelf life of nectars could be fixed at only one month. Small-scale pineapple processors should improve their processing technology so as to extend the shelf life. Consideration of the proper packaging materials that could have impacted on the quality of the nectars should be made.

The aroma of syrups was scored as good as the reference syrup and was stable throughout the storage period. This shows that the processing techniques and the storage time did not have much effect on 4-hydroxy-2, 5-dimethyl-3 (2H)-furanone, methy-2-methylbutanoate and ethyl-2-methylbutanoate volatility, which are known to be the most important contributors to pineapple fruit aroma (Tokitomo et al., 2005). However, the case was different for nectars for which aroma was given a very low score during the entire storage period. This could be due to the processing techniques used which could have impacted the volatile and non-volatile compounds responsible for the aroma in pineapple fruit. The trend in overall acceptability over storage duration followed the trend of the taste of the syrups and nectars. It is therefore possible that the parameter taste is the most important determinant of acceptability of the product for the panelists.

Similar degradation of sensory properties during storage was observed by Polydera et al. (2005) in a kinetic study of post processing of fresh navel orange juice though pasteurised juice in their study was still acceptable at the end of the storage period. Adeola and Aworh (2013) reported similar observation while Akhtar et al. (2010) reported a significant decline in mean scores of all attributes during storage of mango pulp but the pulp was still acceptable by the panelists at the end of storage. Similarly, in the study of Gurrieri et al. (2000), Sicilian prickly juice was less appreciated in terms of sensory properties during storage compared to the standard juice but the researchers believed that by optimising processing conditions through means of various technological treatments, it is possible to produce an acceptable juice. In contrast, de Sousa et al. (2010) developed acceptable mixed tropical fruit nectar with no significant changes in overall acceptability and flavor throughout the storage period of six months. Thus, from the present findings, SMEs need to be assisted on how to appropriately process and package their products in order for them to produce acceptable pineapple products that could have a longer shelf life.

Sensory properties of pineapple jams

Jams were evaluated for sweetness, aroma, colour, spreadability and overall acceptability in comparison with the reference jam. Results of the sensory properties of pineapple jams over the storage period are shown in Table 3.

Table 3: Mean scores of the acceptance tests of the pineapple jams as influenced by storage time.

Sample[1]	Month	Sweetness	Aroma	Colour	Spreadability	Overall acceptability
J_1	0	2.86^{a}	3.07^{a}	3.18^{a}	2.86^{a}	3.51^{a}
	3	1.65^{c}	2.88^{a}	1.90^{bc}	1.65^{c}	2.04^{b}
	6	1.79^{a}	2.41^{a}	1.90^{bc}	1.79^{bc}	2.04^{b}
	9	2.58^{a}	2.46^{a}	2.48^{b}	2.58^{a}	2.55^{b}
	12	2.37^{a}	2.39^{a}	1.81^{c}	2.86^{a}	2.27^{b}
J_2	0	4.39^{a}	3.95^{a}	4.72^{a}	4.02^{a}	4.62^{a}
	3	3.58^{ab}	2.46^{c}	4.68^{a}	3.04^{bc}	2.83^{b}
	6	3.55^{ab}	2.76^{c}	2.11^{cd}	3.00^{bc}	2.32^{b}
	9	4.00^{a}	3.34^{ab}	2.97^{b}	3.86^{ab}	3.81^{a}
	12	4.34^{a}	3.39^{a}	2.55^{bc}	4.39^{a}	3.88^{a}
J_3	0	3.16^{a}	2.85^{a}	3.27^{a}	3.58^{a}	3.16^{a}
	3	3.46^{a}	3.30^{a}	3.37^{a}	3.55^{a}	3.46^{a}
	6	3.62^{a}	3.23^{a}	3.25^{a}	3.62^{a}	3.62^{a}
	9	3.44^{a}	3.51^{a}	3.76^{a}	3.72^{a}	3.44^{a}
	12	3.26^{a}	3.23^{a}	3.35^{a}	3.92^{a}	3.26^{a}
J_4	0	3.86^{a}	3.07^{a}	3.18^{a}	2.86^{a}	3.51^{a}
	3	3.88^{a}	3.32^{a}	2.93^{a}	2.69^{a}	3.07^{a}
	6	3.93^{a}	3.18^{a}	2.76^{a}	2.46^{a}	3.04^{a}
	9	3.53^{a}	3.25^{a}	3.27^{a}	3.16^{a}	3.44^{a}
	12	3.72^{a}	3.20^{a}	2.86^{a}	2.86^{a}	3.51^{a}
J_5	0	3.80^{ab}	3.40^{a}	3.27^{a}	3.70^{a}	3.60^{a}
	3	3.81^{ab}	3.46^{a}	2.90^{ab}	3.74^{a}	3.62^{a}
	6	3.65^{ab}	3.55^{a}	3.37^{a}	3.44^{a}	3.67^{a}
	9	4.00^{ab}	3.50^{a}	3.18^{ab}	3.41^{a}	3.72^{a}
	12	4.07^{a}	3.55^{a}	2.41^{b}	3.07^{a}	3.32^{a}
J_6	0	4.81a	4.23a	4.16a	3.95a	4.18^{a}
	3	4.41a	4.16a	3.86ab	3.81a	3.86^{a}
	6	4.41a	3.27b	2.95c	3.20a	3.69^{a}
	9	4.04a	3.60ab	3.51bc	3.67a	3.90^{a}
	12	4.76a	3.58ab	3.25bc	3.76a	4.14^{a}

[1] J_1-J_6 represent jams from different processors. Means bearing different superscript letters within a sample in a column are significantly different ($p<0.05$)Values are means of 48 evaluations±SD.

Panelists gave low mean scores to jams with regards to sweetness. The scores ranged from 2.86 to 4.81 for jam samples coded J_1 and J_6, respectively at the beginning of storage. There was no significant variation in sweetness for most of the jams throughout the storage period. Jams J_2 and J_6 had the highest mean scores (4.39 and 4.81, respectively). The remaining jams were scored as dislike very much to dislike slightly. Similarly, aroma scores were very low for all jams (less than 4) with J_3 scoring 2.83 and J_6 scoring 4.23. There was no significant variation in mean scores throughout the storage period for all jams except J_6, where significant variations were observed from six months of storage ($p<0.05$). Jam samples compared to the reference jam were given very low scores by the panelists, ranging from 3.18 in J_1 and J_4 to 4.72 in J_2 at the beginning of storage. As the storage time progressed, the colour degraded significantly for most of the jams ($p<0.05$), with the exception of J_3 and J_4 (33.3% of all samples) where the colour was stable throughout the storage duration. The spreadability of the jam samples was also given very low mean scores by the panelists, ranging from 2.86 for J_1 and J_4 to 4.02 for J_2 at the beginning of storage and showing significant variation in spreadability of all jams during the entire storage period.

All the jam samples scored very low for overall acceptability, which ranged from 3.51 for J_1 and J_4 to 4.62 for J_2. There was no significant variation in overall acceptability for jam samples throughout the storage duration with the exception of J_1 and J_2 that recorded significant difference between the initial mean scores and the mean scores at the third month of storage (Table 2). Sample J_2 and J_6 (33%) scored higher mean scores (4.62 and 4.18, respectively) than the remaining, which were given a mean score of less than 4. The observed different behaviour of the two jam samples (J_2 and J_6) could not be explained because the processing techniques used by most of the enterprises were the same and even the packaging material of plastic containers used were the same.

Basing on these findings, four out of six jams (67%) processed by small scale processors did not have appropriate pineapple sweetness, aroma, colour, spreadability and overall acceptability according to the panelists. Only J_2 and J_6 (33%) were comparable to the reference jam throughout the storage period of 12 months. Contrary to this finding, Jena (2013) reported an acceptable passion fruit jam up to six months of storage when packaged in glass jar. Similarly, Mohamad et al. (2012) reported an acceptable jam made of watermelon with pineapple flavor. Ajenifujah-Solebo and Iona (2011) found also an acceptable black-plum jam with regards to the sensory characteristics of taste, aroma, colour, spreadability and overall acceptability. This shows that the surveyed SMEs can produce an acceptable pineapple jam if they improve the processing techniques while taking into consideration the use of quality pineapple fruits and appropriate packaging materials.

Conclusions and Recommendations

The study has shown that the products within a given category are not standardised. They exhibited different levels of preference. The present study has also shown that processed pineapple products such as syrups, nectars and jams by small and medium scale processing enterprises in Rwanda were given lower scores, therefore less liked by the KIST panelists compared to the reference products. For all the sensory attributes, the scores were on the lower side within the ranges of disliked very much to disliked silightly for nectars and jams throughout the storage period of two months for nectars and 12 months for jams. Only 33% of the jams were given a mean score comparable to the reference jam. However, 70% of syrups were scored either comparable or superior to the reference syrup throughout the storage period, for all the sensory attributes. This shows that pineapple processing enterprises need to be assisted to improve processing techniques so that quality and shelf stable products are produced and accepted at the local as well as export market. More research is needed to establish and standardise processing techniques and packaging materials that can conserve the quality of these products during storage. Once improvements have been made, consumer acceptability tests using a larger heterogeneous population is recommended.

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CHAPTER THREE

GENERAL CONCLUSIONS AND RECOMMENDATIONS

3.1 Conclusions

This study has established the status in production, safety and quality of processed pineapple products by SMEs. The study lead to conclude that SMEs, though receiving assistance from the government, they still face numerous constraints that hinder their development and their presence at the export market. Such constraints include limited access to modern processing equipment and proper packaging materials, limited access to raw materials, high cost of water and electricity and high transportation cost. Others include limited knowledge and skills of human resources and many heavy rules and regulations sector, limited access to finance, advice, information and reliable markets. Once these constraints are properly dealt with, these SMEs could grow and create employment opportunities while contributing to the overall economic development of the country.

Due to their small scale nature, it was observed that it is difficult for these enterprises to comply with the Good Manufacturing and Hygienic Practices stipulated in the Rwanda Bureau of Standards and Codex Alimentarius Commission standards. It is therefore concluded that the processing enterprises do not have proper food processing plants in terms of layout, plant design and equipment appropriate for food processing as stipulated in the Codex food hygiene guidelines. The studied SMEs had inadequate facilities such as regular clean water supply and electricity as well as washing and changing rooms for workers. Having inadequate food processing facilities is a risk factor for the processed food products with regards to safety. However, the microbial analysis has showed that the processed products were free from microorganisms. This could probably be due to use of chlorinated water, low pH, high sugar content and cooking of the product. As it was shown, the microbial population of pineapple wash water was significantly reduced after chlorination and reduced sligthly yeasts population as well as total plate counts. Therefore, it is important to use recommended levels of food grade disinfectants and pressurised potable water in food processing industries in order to reduce microbial contamination levels to the set maximum limits in the food products. SMEs are therefore required to seek the information from Rwanda Bureau of Standards, regarding plant layout design, equipment and other required facilities for them to process quality products acceptable at local and export market. Failing to do this, will restrict the availabilty of their products neither at the local market nor at the export market.

This study has revealed that the levels of metal contamination such as copper, iron, zinc levels in syrups, nectars and lead in jams were within the permissible limits set by the Rwanda Bureau of Standards. However, the levels were above the permissible limits for lead in most of the analysed syrups and nectars. Similarly, the levels of cadmium were high in most of the analysed products. High levels of lead and cadmium in some samples could probably limit the chance of pineapple products processed by SMEs to be commercialised and get to the export market. Efforts geared towards addressing the observed challenges faced by small and medium pineapple processing enterprises would help in improving the fruit processing technologies leading to production of well accepted products at the export market. Sources of these high levels and measures to reduce them call for immediate intervention.

The physico-chemical parameters of the pineapple syrups, jams and nectars changed significantly after the sixth month of storage and for nectars, the changes were observed after the first month of storage. This indicated that after six months of storage; syrups and jams were not chemically stable but nectars were only stable up to one month of storage. It has also been established that products with unstable levels of different physico-chemical parameters throughout the storage period lacked standardisation. Sensory evaluation studies have shown that syrups were appreciated by the panelists throughout the storage period but nectars and jams were not accepted by the panelists throughout this same period. The fact that these studied products were not stable up to the indicated expiry date with regards to physico-chemical and sensorial properties implies that these SMEs need to revise their processing techniques through training in order to come up with shelf stable products with a well known life span.

3.2 Recommendations

This study has revealed that food SMEs especially for pineapple processing have several challenges that need to be addressed, for them to contribute to economic development in Rwanda. To overcome these constraints, government policies, regulations and procedures, as well as institutions and other aspects of business environment in an integrated manner, need to operate in favuor of SME development. The following are the major areas that need improvement in the sector:

(a) Small and medium scale fruit processing enterprises need to be strengthened. This will help reduce heavy losses experienced by fruit producers and ensure product availability on the market. To encourage uptake of recommened practices, entrepreneurs need to be exposed to available technologies on fruit processing and preservation and be furnished with information on the range of products that can be manufactured. This would be done through intensive and continuing training.

(b) For the short term, the government can assist the SMEs to purchase processing and packaging equipment by exempting them from value added tax on imported material, and introducing low cost financing to help SMEs. Small and medium enterprises can operate under an umbrella of cooperatives to enable them purchase appropriate processing equipment, which individual enterprises could not possibly afford on their own. However, a long-term solution is to invest in collaborative research between the public and private sector that aims to assist equipment manufacturers to produce quality and affordable fruit processing machines for processors, making it unnecessary to source expensive equipment from outside the country.

(c) The strict enforcement of food safety and hygiene standards should be practiced to protect the welfare of consumers.

(d) These enterprises did not have easy access to infrastructure despite the fact that accessibility to efficient and cost-effective infrastructure was key to SME's. Access to potable water and to food quality testing laboratories should be improved to ensure production of quality pineapple products produced by small and medium pineapple-processing enterprises.

(e) The viability of any business is generally enhanced through proper training, growing financial packages, strategic equipment and ownership arrangements. For this reason, agricultural training institutions and extension services should develop a business model to assist fruit processors in terms of planning, business management skills and finances for them to increase business profits.

(f) Since access to information is key to business success, relavant institutions/offices should develop and avail information to enterprises on technologies and the requirements of the export market.

(g) Women entrepreneurs should be a key focus area for interventions. Since more women are engaged in small scale processing, they need to be trained on managerial skills for them to increase the profit levels of their enterprises. They also need to be encouraged to think about starting bigger businesses by making it easier to access capital from microcredit development institutions available in the country.

(h) Rwanda Bureau of Standards in collaboration with Rwanda Agriculture Board, Rwanda Export Board and Rwanda Cooperative Agency (RCA) should ensure that fruit processors are trained and their capacity built to observe required international standards in order to produce quality products acceptableto the export market.

(i) Further research should be conducted to test effectiveness of disinfectant to other types of pathogenic and non-pathogenic microorganisms on pineapple fruit surfaces in other provinces and their sensitivity to different disinfection practices.

(j) This study did not evalaute the effect of different packaging materials on physico-chemical changes over storage time at different storage temperature. Future research should explore this areas to identify the proper and cost-effective packaging materials for these products.

(k) There were high levels of lead and cadmium in the sampled products. Consequently, more research is needed to establish the actual source of these heavy metal contamination in pineapple processed products and find a way of avoiding these metals in the processed products.

(l).There exists some other Codex standard parameters for pineapple juices and jams that were not assessed in the current study. Future research shoul explore those other parameters in order to avail that necessary information to the SMEs and assist them in taking proper action towards product quality improvement.

(m) The government should plan to have an advisory section equivalent to the extension department to assist food processing activities.

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APPENDICES

Appendix 1: List of Small and Medium Pineapple Processing Enterprises

LIST OF SMALL AND MEDIUM SCALE PINEAPPLE PROCESSORS IN RWANDA				
	WESTERN PROVINCE			
SN	**Processor**	**What processed**	**Contact person**	**Contact address**
1	AGASARO Cooperative M[x]	Juice	Isabelle Uzamukunda	Nyamasheke-Kirimbi: 0788777583
2	CODECAM Cooperative S[xx]	Juices	Niyitanga Phocas	Rutsiro: 0788517671
3	Individual S	Wine	Nshunguyinka Ananaias	Ngororero-Nyange: 07888618740/0788540190
4	Individual S	Juice	Iyamuremye Simon	Karongi-Murundi:0783059709
5	UMWEZI Cooperative S	Juice	Mukabusunyu Adeline	Karengera-Nyamasheke:07883613699
7	APROGEFUGI M	Juice	Uwera Nadine/Nahimana Venuste	Rusizi-Rwimbogo;07888655541/0788525362
	SOUTHERN PROVINCE			
1	AKIWACU WINE M	Wine	Mukantagara Marthe	Huye: 0788683256
2	Individual S	Juice	Ndikumwenayo Reverien Kabubera Beline	Muhanga-Rugendabari:0788254848
3	CODECOMA M	Wine, juice, Jam, dried	UGAMA CSS/Kubwimana Jean Baptiste	Ruhango Kabagari:0788503596/0783479039
4	Individual S	Juice	Ntegeyimana Francois	Muhanga – Shyogwe:0788775550
5	Individual S	Wine	Munyeshuri faustin	Musambira-Kamonyi:0788484574
6	CEARWA S	Juice and wine	Biyitire J.Baptiste	Muhanga-Mushishiro:0783259554
7	COPROCOABU S	Juice	Uwimpuhwe Esron	Muhanga-Kamonyi-Kayenzi:0788822677

8	DUSABANE Cooperative M	Juice,wine	Niyonsaba Cecile	Ruhango Kabagarai:0785270756
9	CODEPRAR S	Juice	Nkerabigwi Joseph	Ruhango-kabagari: 0788417818
10	KOANYA S	Juice	Ndayisenga Peter	Muhanga-Nyamabuye:078835151/0788534179
11	KARU S	Wine	Hakizimana Janier	Muhanga-Kiyumba:0788465603/0788736514
12	Individual S	Juice	Minani Aloys	Muhanga-Rugendabari:0785180481
13	Individual S	Juice,wine	Mukabanda Donatille	Muhanga-Nyamabauye:0788617267
14	Individual S	Juice	Uwayisenga Claudine	Muhanga-Nyamabuye:0783582263
15	NRZRWA M			Muhanga
16	DUSABANE M			Ruhango
17	APODER-GANIRA M			Nyamagabe
	EASTERN PROVINCE			
1	CATAM S	Juice	Nshizirungu Ernest	Ngoma-Mutenderi:078851051
2	Individual S	Juice,wine	Bizimana Ildephonse	Rwamagana-Gishari:0788419500
3	Get together enterprise M	Juice,wine	Mujyambere Vianney	Nyagatare:078849091
4	Individual S	Juice,jam,wine	Mbariyehe Anastase	Ngoma Mutenderi:0783602274
5	Individual S	Wine,juice	Ngendahimana	Ngoma-Mutenderi:0783602274
6	Individual S	Juice	Kamanzi Mushi Gabriel	Ngoma:0788830902
7	COTRAFRUKI M	Juice	Uwamariya Annonciata	Ngoma;0788752924
8	Individual S	Juice	Uwamana Marie Claire	Nyagatare-karama:0788545025
9	Poterie NYANGE S	Wine	Ndinabo Francois	Ngoma-Mugesera:0788578350

10	Individual S	Wine	Africa Alexis	Ngoma:Mugesera:0788578319
11	Individual S	Wine	Abimana martin	Ngoma-Kazo
12	Kirehe Mltipurpose M	Juice		Kirehe
13	Uburyohe M			Kirehe
NOTHERN PROVINCE				
1	COVAFGA S	Juice,wine	Gasana Michel	Gakenke:078217179
2	TANTUMERGO S	Juice	Hagenimana Richard Uwamariya Opporunee	Gakenke:0788619394
3	COTRAFGF S	Juice,wine	Mathieu	Rulindo:0788752386
4	Individual S	Jam,wine	Bisangwa Innocent	Gicumbi-Ruvune:0788607775
5	KOABM M	Juice,jam	Mukarusagara Jeanne d'Arc	Gicumbi-Bwisige:0788828324
	KIGALI PROVINCE			
1	ABATANGANA S	Juice,wine ,jam	Muhawenimana Eric	Nyarugenge-Kimisagara:0788563499
2	GOFTC S	Juice	Munyarurango Alphonsine	Kicukiro-Masaka:0788306668

Source: RHODA (2008)

Appendix 2: Questionnaire for small and medium scale processors

Student names: Christine Mukantwali, FOA, SUA, Morogoro, Tanzania

Supervisors: Prof H. Laswai; Prof B. Tiisekwa, S. Wiehler

The following questionnaire is meant to find out the following:

1. The processing technologies used to process pineapple juices and jam by small and medium scale processors in Rwanda.
2. Good Manufacturing Practices at small and medium scale level
3. The situation analysis of small and medium scale processors

Please make an effort to answer all questions in the questionnaire. I assure you that all the answers will remain anonymous and will be used for this study only.

Section I: Socio-economic data

Name of the respondent:……………………………………………………………

Age category of the respondent: Less than twenty ☐ -30 ☐ -40

☐ 41-50 ☐ Above 50 ☐

Province of the respondent…………………………………………………………...

District of the respondent……………………………………………………………….

Sector of the respondent…………………………………………………………..

Celllular…………………………………………………………………………………

What is your marital status:

(1) Single ☐ (2) Married ☐ (3) Divorced ☐

(4)Widow ☐ (5) Separated ☐

Education level

1. Do you have formal education: Yes/No

2. If yes, ask the following question:

(1) Completed primary school Yes /No

(2) Completed secondary school Yes/No

5) Completed university (Bachelor's degree) Yes/No

(6) Still doing my university studies: Yes/No

Section II: Current status of processing of processed pineapple products

3. Is this processing plant yours? Yes /No

4. If No, which position do you have in this processing plant?

(1)Manager ☐ (2) Laboratory technician ☐ (3) Secretary ☐

(4)Accountant ☐ (5) Supporting staff ☐

(6) other job (specify)…………………………………………………………………...

5. What types of products do you produce here at your plant?

(1) Concentrated pineapple juice ☐ (2) Pineapple ready to drink juice ☐

(3) Dried pineapple ☐ (4) Pineapple jam ☐ (5) Pineapple wine ☐

(6) Others products (specify)…………………………………………………………

6. since when you processing plant exists?

7. Do you have access to electricity? Yes/No

8. Where do you get water you use here in the plant?

(1)RecoRwasco ☐ (2) River ☐ (3) Boreholes ☐

(4) any other sources (specify)……………………………………………………

9. Do you have regular supply of water? Yes/No

10. If No, where do you get water when it is scarce?

(1)Boreholes ☐ (2) River ☐

Any other source (specify)…………………………………………………………

11. Do you have supply of hot water? Yes/No

12. Do you use hot water in your plant? (Yes/No)

13. For what purpose? (1) Cleaning ☐ (2) sterilization ☐

(3) Other (specify)…………………………………………………………………

14. Do you treat water before using it in processing? Yes/No

15. If yes, how do you treat it? Put chlorine ☐ Boil it ☐

Sur eau other treatment (specify)…………………………………………………………

16. How far (in km) is your processing plant from the main road? ………..km

17.Do you think the road linking you to the market is good? Yes/No

18. How many staff do you have in your company ………………………………………

19. State their qualifications and working hours per day

	Primary school education	**Secondary school education**	**University education**	**Training related to the job she/he is doing**	**Working hours per day**	**Permanent/ Temporary**
Manager:						
Secretary:						
Administrative assistant:						
Accountant:						
Technician1:						
Technician2:						
Technician3:						
Technician 4:						
Technician 5:						
Technician 6:						
Support staff1						
Support staff2						
Support staff3						
Support staff4						
Support staff5						
Support staff 6						
Support staff 7						
Support staff 8						
Support staff 9						
Support staff 10						

20. Where do you get the raw materials from?

(1) From the pineapple producers located around the processing plant ☐

(2) From other Districts in this province ☐

(3)From other provinces ☐

Which are those provinces………………………………………………………………

(4) Others sources of pineapples (specify)………………………………………...

21. How long does it take for the raw material to reach your processing plant from the field? ☐

(1) 1hour (2) 2 hours ☐ (3) 3 hours ☐ (4) 4 hours ☐

(5)5 hours ☐ (6) 6 hours ☐ (7)7hours ☐

(8) 1 day (9) Others (please specify) the time in terms of hours or days)……..☐……..

22. Do you do sorting of the raw material before processing? Yes/No

23. If yes, how do you sort it?

(1)Select the enough ripe one for processing ☐ (2) Select big one for processing ☐

(3)Only reject damaged one ☐

(4)Any other characteristic used to sort before processing (specify)

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

24. How do you know that the pineapples are mature enough for harvest and processed?

(1) I look at the colour whether it has turned to yellow/red ☐

(2) I consider the planting period ☐

25. How long can your pineapple be stored before they begin to spoil and become unfit for processing?

(1)1 day ☐ (2) 2 days ☐ (3) 3 days ☐ (4) 4 days ☐

(5) 5 days ☐ (6) 6 days ☐ (7) one week ☐ (8) More than 1 week ☐

26. Do you know the variety of the pineapple you process? Yes/No

27. If yes which variety do you process?

(1) smooth cayenne ☐ (2) any other variety (please specify) (3) Do not know ☐

28. What are the pineapple products you process?

(1) juice ☐ (2) wine ☐ (3) jam ☐ (4) jellies ☐

(5) dried pineapple ☐

Any others (please specify)……………………………………………………

29. Processing technologies used and processing capacity of the company

How do you process concentrated juice?

The respondent will be asked to describe how they produce concentrated pineapple juice. The enumerator will take note of the steps followed during the processing and the ingredients used in a separate note book. For each step, the enumerator will have to note the equipment used

Product	**Processing steps**	**Ingredients used**	**Equipment used**
Juice processing			

Comments (write any observation while the respondent is talking. Get all the possible details

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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………………………………………………………………………

Pineapple juice nectars processing

30. How do you process pineapple jam?

The respondent will be asked to describe how they produce concentrated pineapple juice. The enumerator will take note of the steps followed during the processing and the ingredients used in a separate note book. For each step, the enumerator will have to note the equipment used.

Product	**Processing steps**	**Ingredients used**	**Equipment used**
Juice processing			

Comments (write any observation while the respondents talk. Get all the possible details

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

Pineapple jam processing

31. How do you process pineapple jam?

The respondent will be asked to describe how they produce concentrated pineapple juice. The enumerator will take note of the steps followed during the processing and the ingredients used in a separate note book. For each step, the enumerator will have to note the equipment used.

Product	**Processing steps**	**Ingredients used**	**Equipment used**
Juice processing			

Comments (write any observation while the respondents are talking. Get all the possible details

details

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

Section III: Assessment of Good Manufacturing Practices (plant layout design, equipment, general hygiene practices)

1. Is the processing plant easily cleanable? Yes/No

2. Describe the following (the enumerator will observe)

(1)Is the flow cemented ☐ (2) Tiled ☐ (3) Not cemented /tiled ☐

Are the walls painted? Yes/No

3. How do you score the cleanliness of the processing plant itself?

(1)Very clean ☐ (2) Acceptable ☐ (3) Not satisfactory ☐ (4) Not clean at all ☐

Comments…………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………

4. How do you score the maintenance of the building?

Answer this question) (1) Very clean ☐ (2) Acceptable ☐ (3) Non satisfactory ☐

(4)Not clean at all ☐

Comments…………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………

5. How do you score the maintenance of the equipment?

(1) Very clean ☐ (2) Acceptable ☐ (3) Not satisfactory ☐

(4) Not clean at all ☐

Comments……………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

6. Do you have an RBS certificate? Yes/No

7. If yes, which certificate do you have?

………………………………………………………………………………………

………………………………………………………………………………………

8. When did you obtain it? ……………………………………………………………

9. Are the equipment which is being used cleaned? Yes/No (the enumerator needs to observe and note)

10. How do you score the cleanliness of the equipment?

(1) Very clean ☐ (2) Acceptable ☐ (3) Not satisfactory

(4) not clean at all ☐

Comments……………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………

11. How many time do you clean the processing equipment?

(1)vEveryday ☐ (2) Every two days ☐ (3) Every three days ☐

(4) Every four days ☐ (5) Once a week ☐

12. How many time do you clean the building?

(1)Everyday ☐ (2) Every two days ☐ (3) Every three days ☐

(4)Every four days ☐ (5) Once a week ☐

13. Is the area around the processing room clean? Yes/No (the enumerator will observe this and answer this question)

(1) Very clean ☐ (2) Acceptable ☐ (3) Not satisfactory ☐

Not clean at all ☐

Comments………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

14. Is there a toilet? Yes/No (the enumerator will observe this)

15. If yes, how many rooms of toilet?..

16. If yes what type of toilet is there?

(1)Modern toilet with flowing water ☐

(2) Modern toilet without flowing water ☐

(3)Traditional toilet/pit latrine ☐

17. Where is the toilet located?

(1) Near the processing room ☐ (2) Far from the processing room ☐

18. Is the toilet ventilated? Yes/No

19. If yes, how is it ventilated?

(1) Natural ventilation with open windows ☐

(2) Ventilated with electrical fan ☐

20. Is there a hand washing place? Yes/No

21. Is there soap at that place? Yes/No

22. Is there hot water at that place? Yes/No

23. Is there hand drying system? Yes/No

24. If no, what is used to dry hands?

(1) tissue paper ☐ (2) towel ☐ (3) other (specify) ……………………….

25. Are the workers clean enough? Yes/No (Comment on their cleanliness)

26. Do they wear laboratory coats? Yes/No…….Gloves? Yes/No…… Hat? Yes/No

27. Do they cut their finger nails? Yes/No

28. Is there a changing room for personnel? Yes/No

29. Do they have cleaning chemicals? Yes/No

30. If yes, which chemicals? (write the names of the cleaning chemicals they use)

………………………………………………………………………………………………

………………………………………………………………………………………………

Note anything you observe which you think it describes their cleanliness?

....

....

....

....

31. Has each worker a health insurance card (mutuelle de santé). Yes/No

32. Which material is the processing equipment made of? (The enumerator needs to observe the equipment used for each processing step and make a note whether it is:

(1)Stainless steel ☐ (2) Aluminium ☐ (3) Oxidable material ☐

33. Do you have a reserved area where you clean pineapple fruit? Yes/No

If yes, the enumerator needs to look at around to see whether that place is present) and comment:

34. Does water flow in that place? Yes/No

35. If yes, is hot water flowing there. Yes/No

36. Is cold water flowing there? Yes/No

37. Is the place made as it can be cleaned? Yes/No

Any other comment you think it describes the washing place

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………..

38. Is there a reserved area for only processing? Yes/No

39. Is the access to processing area restricted or controlled? Yes/No

40. If yes, is the entering of processing area via changing facilities? Yes/No

41. Is there a reserved area for only filling, capping and packaging? Yes/No

42. Is there a reserved area for storage of products? Yes/No

43. Is there a reserved area for storage of raw materials? Yes/No

44. Is the temperature and humidity in the storage room controlled? Yes/No

45. Are the walls of the different rooms painted with oily paint? Yes/No

46. Does the plant have a roof? Yes/No

47. Of which material is the roof made?

(1) Glass ☐ (2) wood ☐ (3) other (specify)………………………………...

48. Is the floor free of cracks? Yes/No

49. If yes in which material is the floor made?

(1)Soil ☐ (2) Cement ☐ (3) Modern tales ☐

(4) Other (specify) ☐

…………………………………………………………………………………

…………………………………………………………………………..........................

....

50. Do rooms have drainage that facilitates cleaning water to go out? Yes/No

51. Do you have an outside drainage? Yes/No

52. If yes, is that drainage protected against entry by rodents? Yes/No (the enumerator observes the drainage)

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

53. In which material are working surfaces are made?

(1) Wooden ☐ (2) plastic ☐ (3) Aluminium metal ☐

4) Other (specify)…………..

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

54. Is there a storage place for (the enumerator observes the store and state its conditions):

(1)Raw pineapple ☐ (2) end product ☐

55. Is the storage room enlighten enough? Yes/No

56. How do you score the cleanliness of the storage rooms answer this question)

(1) Very clean ☐ (2) Acceptable ☐ (3) Not satisfactory ☐

(4) Not clean at all ☐

Comments

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………

57. Do you dispose a product delivery notebook? Yes/No

58. Do you dispose costumer purchase notebook? Yes/No

59. Do you do dispose the status of the product stock Yes/No

60. Do you dispose a pest and insect control system? Yes/No

61. If yes, how do you do it?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

62. Is there a washing instruction near the wash stands? Yes/No

63. Do you control the cleanliness of the premises and equipment? Yes/No

64. If yes, how much time a week do you do it?

Once a week ☐ twice a week ☐ three times a week ☐

Four times a week ☐ five times a week ☐ six times a week ☐

Every day ☐

65. Do you dispose a plan for training the staff of your company? Yes/No

66. When you receive raw pineapple fruit, do you get information from the supplier on the quality of the pineapple brought to you? Yes/No

67. If yes, which information do you get?...

....

....

68. Do you have contract with your supplier of the quality of pineapple they have to bring you? Yes/No

69. Of which materials are the windows made?

(1)Wooden ☐ (2) screen ☐ (3) metal ☐

(4) Other (specify) ☐

70. Of which materials are the doors made?

(1)Wooden ☐ (2) screen ☐ (3) metal ☐ (4) other (specify)

71. Is there a ventilation system in place? Yes/No

72. Do they have a container for waste? Yes/No

73. If yes, is that container cleanable? Yes/No

74. Is that container covered? Yes/No

75. Of which material the dustbin (container for waste) is made?

(1)Plastic ☐ (2) Metal ☐

(3)Any other material (specify)...

76. Do you have a system of disposing the waste? Yes/No

77. How is the waste disposed (describe the ways they use to take waste away from the processing plant and where are the waste taken)

………………………………………………………………………………………………

………………………………………………………………………………………………

78. If yes, how far is placed the container in (meters)? From the processing plant...

79. How do you wash the containers of your products?

(1) Machine wash ☐ (2) use hands ☐

(3)Other

(specify)…………………………………………………..…………………

80. Which cleaning products do you use for washing?

(1)Water and soap ☐

(2)Water and disinfectant (specify the disinfectant used) ☐

(3)Any other means used to wash containers……………………………………

<u>Checklist for the labeling of the product</u>

Take one product ready to sell from the producer and note the following

a. Labeling for pineapple concentrated juice

Labelling	**Yes=1**	**No=2**
Does the label shows different types of ingredients in descending order of weight		
Does the label has the words: best before or sell by		
Does the location of the manufacturer appears on the label		
Does the name of the producer appear at the label		
Does the address of the producer appears		
Is the net weight indicated at the label		
Is the information on the label readable		
Is the content of the food indicated on the label		
Does the name of the product appears		
Is the net weight of the product in the package indicated		
Is there instruction on how to use/prepare the product		
Is the storage information /instruction after opening available at the label		
Do you have a certificate for the product from RBS		

b. Labeling for pineapple juice nectar

Labelling	**Yes=1**	**No=2**
Does the label shows different types of ingredients in descending order of weight		
Does the label has the words: best before or sell by		
Does the location of the manufacturer appears on the label		
Does the name of the producer appear at the label		
Does the address of the producer appears		
Is the net weight indicated at the label		
Is the information on the label readable		
Is the content of the food indicated on the label		
Does the name of the product appears		
Is the net weight of the product in the package indicated		
Is there instruction on how to use/prepare the product		
Is the storage information /instruction after opening available at the label		
Do you have a certificate for the product from RBS		

C. Labeling for pineapple jam

Labelling	**Yes=1**	**No=2**
Does the label shows different types of ingredients in descending order of weight		
Does the label has the words: best before or sell by		
Does the location of the manufacturer appears on the label		
Does the name of the producer appear at the label		
Does the address of the producer appears		
Is the net weight indicated at the label		
Is the information on the label readable		
Is the content of the food indicated on the label		
Does the name of the product appears		
Is the net weight of the product in the package indicated		
Is there instruction on how to use/prepare the product		
Is the storage information /instruction after opening available at the label		
Do you have a certificate for the product from RBS		

Section IV: Situational analysis of pineapple processing business performance at small and medium scale processors

Source of raw material

1. Who supply you raw pineapples?

……………………………………………………………………………………………………

2. What weight of pineapples do you buy in a week/month?

……………………………kg/tonnes…………………………………………….month (kg/tonnes)

3. What weight of pineapples do you process in a week?

…………………………Kg/tonnes………………………month (kg/tonnes)

4. What is the unit price of raw pineapples?………………………………..RFWS/Kg

5. When do you receive plenty of pineapples during the year?

(a)January ☐ (b) February ☐ (c) March ☐ (d) April ☐

(e) May ☐ (f) June ☐ (g) July ☐ (h) August ☐

(i) September ☐ (j) October ☐

(k) November ☐ (l) December ☐

6. What is the price of 1kg during that period of plenty?...

7. When do you experience scarcity of pineapple fruits to process?

(a)January ☐ (b) February ☐ (c) March ☐ April ☐

(e) May ☐

(f)June ☐ (g) July ☐ (h) August ☐

(i) September ☐ (j) October ☐ (k) November ☐

(l) December ☐

8. What is the price of 1kg of pineapple during the scarce period?

....

9. Do you manage your cash flow to make funds available for buying pineapple fruit to process throughout the year? Yes/No

State the reasons for your answer

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

10. Do you have a regular supply of raw pineapples? Yes/No

11. Do you have a contract with the supplier of raw pineapple? Yes/No

12. Production

How many kg of pineapples do you process?	**Day**	**Week**	**Month**	**Year**
Juices concentrate				
Juice nectars				
Jam				

How many litres/kg do you produce?	**Day**	**Week**	**Month**	**Year**
Juices concentrate				
Juice nectars				
Jam				

13. Selling of processed pineapple juices and jam

Product	**Major market destination**	**Means of transport**	**Distance to Destination (Km, time)**	**Volume of product traded per (week , month)**	**When is the high demand (months) and how much is demanded (quantity)**	**How much do you supply quantity (units)**
Juices concentrate						
Juice nectars						
Jam						

14. Why did you prefer to process pineapple (tick where appropriate)?

(1) It is an easy crop to grow ☐ (2) it is abundant in our area ☐

(3) the processing technology is easy ☐

(4) the processing equipment is easy to find ☐

(5) it is more profitable to process than other fruits ☐

(6) others (specify)……………………………………………………………

15. Have you received any technical training on how to process pineapple products?

Yes/No

16. If yes, what products have you been trained on?

(1)Pineapple juice ☐ (2) Pineapple wine ☐ (3) Pineapple jam ☐

(4)Pineapple jellies ☐ (5) Dried pineapples ☐

(6) Any others (please specify)

17. If yes, who trained you (1) RAB ☐ (2) KIST ☐ (3) UR? ☐

(4)ISAE ☐ (5) Umbrella of fruit processors ☐

(6) Rwanda Bureau of Standards ☐

(7)Others (please specify) …………………………………………………………

18. If yes, what information did they give?

Information on techniques of pineapple processing on:

(1) juice ☐ (2) jam ☐ (3) drying of pineapple ☐

(4) Pineapple wine processing ☐

(5)Other information on processing (specify the information)

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………..

(6)Information on hygiene and sanitation in a food processing industry ☐

(7)Information on national standards for fruit products processing ☐

19. How do you know that your product is of good quality?

(1) Test by the mouth the product for its sweetness ☐ (2)

Have a small laboratory with equipment to look at basic quality parameters ☐

20. Which quality parameters do you test? (1) Brix ☐ (2) Moisture content ☐

(3)Any other parameter

(specify)……………………………………………………………………………

21. We always take our sample to a laboratory ☐

(1)Which laboratory?

22. Of recent, do you know which of the pineapple products have an increasing demand at the market (tick?)

(1)Dried pineapple slices ☐ (2) pineapple wine ☐ (3) pineapple jam ☐

(4) pineapple concentrated juice ☐ (5) pineapples ready to drink juice ☐

23. How did you acquire processing equipment you are using?

(1) Bought from Kigali supermarket ☐

Which types of equipment have you bought in Kigali supermarket?

....

....

....

....

(2) Manufacturers located in Rwanda fabricated for us ☐

(Specify the name of the manufacturer and the names of equipment bought in Rwanda)……………………………………………………………………………………

…………………………………………………………………………………..

(3) Manufacturers located outside Rwanda have fabricated them for us ☐

(Specify the name of the country and the name of the manufacturer and equipment)

………………………………………………………………………………………

(4)Any other sources (specify)……………………………………………………

24.What are the constraints you face in pineapple processing in your unit?...

....

....

25. Do you have information on any other place where you can sell your products? Yes/No.

If yes, what are that other places where you can sell your products?

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………

26. How did you get the information on other places you can sell your products

Source of information	**Tick where appropriate**
Friend	1
National Export Board (NAEB)	2
Rwanda Agriculture Bocard (RAB)	3

Rwanda Cooperative Agency (RCA)	4
Rwanda Horticulture Organization (RHIO)	5
Other (specify)	6

27. Have you ever experienced losses of your products (juices/jam) because you missed the market for it? Yes/No?

28. When was it?...month/year

29. Why do you think your product was not bought at that time?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………...………………………

30. Do you have information on export market requirements? Yes/No

If yes, which information do you have?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………………

31. Who gave you that information?

Source of information	**Tick where appropriate**
Friend	1
National Export Board (NAEB)	2
Rwanda Agriculture Board (RAB)	3

Rwanda Cooperative Agency (RCA)	4
Rwanda Horticulture Organisation (RHIO)	5
Other (specify)	6

32. Do you intend to take your products to those external markets? Yes/No

33. If yes, where do you plan to take your products?

……

……………………………………………………………………………………………………….

34. If No, state the reasons

……

……

……

………………………………………………………………………………………………

35. Who are your competitors in the country?

……

……

……

………………………………………………………………………………………………

36. What is the capacity of a bottle of juice/jam and what is the price of one unit

Capacity	**Juice concentrate**	**Price in RFWS**	**Juice nectars**	**Price in RFWS**	**Jam**	**Price in RFWS**
500ml						
1 litre						
1.5 liters						
2 liters						
Others						

37. What is the potential of business with respect to juices and jam being processed and sold

Product	**Advantages**	**Prospects**	**Constraints**
Juice concentrate			
Juice nectars			
Jam			

38. Do you make profit from your business? Yes/No

39. If No give the reasons

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

………………………………………………………………………………………

40. How much do you earn per month/year from the trade/ Rwandan

Francs……………………………………………………………………………………

41. What are the existing rules and regulations that affect your

business?………………………………………………………………………………

…………………………………………………………………………………………………

b.………………………………………………………………………………………………

c.………………………………………………………………………………………………

d.………………………………………………………………………………………………

42. Are existing rules and regulations fair? Yes/No. Give the reasons of your answer

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

43. Have you ever received a credit from any institution? Yes/No

44. If yes What Institution

....

....

45.If yes, how much have you received………………………….RFWS

46 If yes what was the interest rate you paid………………………RFWS

47. If No, what were the reasons of not getting the loan?

……………………………………………………………………………………………

……………………………………………………………………………………………

48. What type of packaging material are you using and where do you get it?

Packaging material	**Source**	**Unit price (FRWS)**
1. Plastic		
2. Glass		
3. Other (specify)		

49. Do you face any of the following constraints in your business?

HACCP Audit Grid: Assessment of the implementation of pre-requisites **sa=satisfactory, acceptable=ac ns=non satisfactory, ab=absence**						
Item	**Assessment criteria**	**Documents associated to these criteria (to be inspected and verified)**	sa	ac	ns	ab
1	**Buildings**					
1.1	*Conformity of the premises: general organization:*					
1.1.1	Conformity of the establishment immediate surroundings	Plan of the establishment showing: (1) drinking water supply……………………… .... (2) waste water drain off………………………….. .... Plan of the showing: (1) Identification of rooms……………………… .... (2) position of workstations and the equipment. (3) position of cloakroom and toilets……………................ .... (4) location of inputs/outputs of flows (staff, products …………………………… (5) flowchart of flows (staff, products, raw materials, waste) ……………………………..				
1.1.2	Compliance with the onward flow principle					
1.1.3	Separation of clean sector and unclean sector					
1.1.4	No crisscross of the production lines					
1.1.5	Separation of hot zone and cold zone					
1.2	*Conformity of the premises: construction:*	Explanatory leaflet of materials used and techniques of constructions employed…………				
1.2.1	floor covering: smooth, light coloured, washable, resistant					
1.2.3	floor and walls joined by round gorge assemblages					
	floor grids and U-bends to collect waste water					
1.2.5	ventilation devices ensuring steam and smoke elimination					
1.2.6	lighting bright and neutral in colour					

1.3	*Conformity of the premises: equipment and furniture*	Explanatory leaflet of the equipment (machines)				
1.3.1	materials: inalterable and easy to clean					
1.3.2	furniture: smooth, washable, resistant					
1.3.3	work surfaces: smooth, washable, resistant					
1.4	*Lawful or normative conformity*	Documents attesting of: (1) national approval………………………….. (2) foreign country importation approval……. (3) certification of voluntary setting in conformity with specific food safety standards..				
1.5	*Maintenance of buildings and equipment*	Daybook of technical mending of buildings and equipment				

item	Assessment criteria	Documents associated to these criteria (to be inspected and verified)	sa	ac	ns	ab
2	**Supplies**					
2.1	Contractual relationship with the suppliers	Contracts past with suppliers……………………………… Criteria of acceptance of batches……………………………… Planed corrective actions for any case of loss of control…………………………………………..				
2.2	Raw materials specifications	Cards of specifications of raw materials Composition... Microbiological standards.. Residues Iimit content…………………………. Conditioning (type, volume, weight)………… . Preserving conditions…………………………. . Lifespan…………………………………………… Organization of stock turnover……………….. .				
2.3	Checking of deliveries	Recording cards of control of deliveries……… . temperature of delivered products intact conditionings compliance with consumption deadlines labelling compliance with official food safety marking rules……………………… Cleanliness of the delivery vehicle…………….				
2.4	Water supply	Analysis or certificate of water portability………………………………………….				

Item	Assessment criteria	Documents associated to these criteria (to be inspected and verified)	sa	ac	ns	ab
3	Implementation of systems of traceability					
3.1	System of upstream traceability	Specimen of simulation test of upstream traceability: • Recordings relating to upstream traceability: .... • delivery control cards.......................... • listing of raw materials stock				
3.2	System of downstream traceability	Specimen of simulation test of downstream traceability: • Recordings relating to downstream traceability .... • Customers purchase orders………………………………… • Listing of finished product stocks customers invoices…………………..				

Item	Assessment criteria	Documents associated to these criteria (to be inspected and verified)	sa	ac	ns	ab
4	**Pest control**					
4.1	Implementation of a pest control plan	Pest control plan…………………..				
4.1.1	Management of the outdoor dustbins, absence of waste on the ground	Insect control plan…………………				
4.1.2	management of materials and equipment outdoor storage	Intervention forms of the pest control company (department)……………………….				

Item	Assessment criteria	Documents associated to these criteria (to be inspected and verified)	sa	ac	ns	ab
5	**Control of staff originated contaminations**					
5.1	Medical follow-up of the staff members	Individual health certificates of food handling ability………………….				
5.2	Plan of staff training	Time table and contents of training activities……………….				
5.3	Clothing hygiene:	Staff member's vocational training certificate……………...				
5.3.1	standard work clothing supplied by the company	In house management procedure of clothing. or washing supplier contract………………..				
5.3.2	washing of clothing by the company or under its responsibility					
5.3.3	management of clean and dirty clothing					
5.3.4	lockers with 2 compartments					
5.3.5	boots/shoes washstands in conformity with standards					
5.4	Compliance with GHP and GMP	Specific approved GHP and GMP guide of the production sector or…………………….. In house manual of the GHP and GMP of the company………………				

Item	**Assessment criteria**	**Documents associated to these criteria (to be inspected and verified)**	sa	ac	ns	ab
6	**Hands and premises cleaning**					
6.1	Hands					
6.1.1	washstands in conformity with standards or regulations	Posting of washing hands instructions near the wash stands…………………………				
6.1.2	washing hands procedures					
6.2	Premises	Sum of written cleaning procedures comprised in "cleaning plan"………………………… Check-grids of good execution of cleaning tasks………………………… Weekly check-grid of visual cleanliness of equipment surfaces…………………….. Reports of microbiological controls of surfaces………………………				
6.2.1	enforcement of a cleaning plan					
6.2.2	microbiological Control of effectiveness of cleaning					

sa: satisfactory; acceptable; ns: not satisfactory; ab:absent

Any other constraints

……………………………………………………………………………………………………

……………………………………………………………………………………………………

Major constraints	**Yes**	**No**
Lack of raw material		
Raw material of poor quality		
High cost of raw material		
High transport cost of raw material		
Limited access to information on export market requirements		
Limited knowledge on how to process quality products		
Lack of proper packaging material		
Inadequate transport infrastructure		
High cost of power and water for processing		
Lack of capital to acquire modern equipment		
Lack of entrepreneurial training		

Appendix 3: Sensory Evaluation Form

Name...

Date...

Age..Gender........................Male....................Female..........

You are receiving samples of pineappoles juices/jam to comparefor colour, taste, aroma and overall acceptability. You have been given a reference sample, marked R, with which you are to compare each sample. Evaluate each parameter against the reference , nice colour than the reference, or overall good than the reference. Then mark the amount of difference that exists.

Dislike very much R=1; Dislike moderately than R=2 Dislike Slightly than R=3; Equal to R=4; Like sligtly than R ; Like moderately than =6; Like very much than R=7.

Colour

	148	914	432
Dislike very much than R			
Dislike moderately than R			
Dislike Slightly than R			
Equal to R			
Like slightly than R			
Like moderately than R			
Like very much than R			

Amount of difference

	148	914	432
None			
Slight			
Moderate			
Extreme			

Comments:

....

....

....

Aroma

	148	914	432
Dislike very much than R			
Dislike moderately than R			
Dislike Slightly than R			
Equal to R			
Like slightly than R			
Like moderately than R			
Like very much than R			

Amount of difference

	148	914	432
None			
Slight			
Moderate			
Extreme			

Comments:

....

....

....

Sweetness

	148	914	432
Dislike very much than R			
Dislike moderately than R			
Dislike Slightly than R			
Equal to R			
Like slightly than R			
Like moderately than R			
Like very much than R			

Amount of difference

	148	914	432
None			
Slight			
Moderate			
Extreme			

Comments:

....

....

Spreadability

	148	914	432
Dislike very much than R			
Dislike moderately than R			
Dislike Slightly than R			
Equal to R			
Like slightly than R			
Like moderately than R			
Like very much than R			

Amount of difference

	148	914	432
None			
Slight			
Moderate			
Extreme			

Comments:

....

....

Overall acceptability

	148	914	432
Dislike very much than R			
Dislike moderately than R			
Dislike Slightly than R			
Equal to R			
Like slightly than R			
Like moderately than R			
Like very much than R			

Amount of difference

	148	914	432
None			
Slight			
Moderate			
Extreme			

Comments:

....

....

....

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