UNIVERSITY OF EDUCATION, WINNEBA COLLEGE

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PHYSICOCHEMICAL PROPERTIES AND SENSORY EVALUATION OF PINEAPPLE-PREKESE WINE

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DEDICATION

This project is dedicated to my dear Father Most Rev. Joseph Afrifah Agyekum, Bishop of the Catholic Diocese of Koforidua and Rev. Fr. Richard Kwabena Dordunu, the Parish Priest of Saint Theresa Catholic Church, Effiduase-Koforidua for their prayers and support.

DECLARATION

Candidate's Declaration

I, Felicia Elorm Dugbazah hereby declare that this dissertation is the result of my own original work and that no part of it has been presented for another degree in this university or elsewhere.

Signature: ………………………………….. Date:………………………….

Supervisor's Declaration

I hereby declare that the preparation and presentation of this dissertation were supervised in accordance with the guidelines on supervision of dissertation bid down by the University of Education, Winneba

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ABSTRACT

The increasing interests in the search for locally produced fruits that are readily available and cheap enough for wine making is gradually gaining momentum. This quest informed the decision to develop wine from pineapple and *prekese*. The study aimed at examining the consumer preferences of wine produced from pineapple and *prekese*, physiochemical properties of pineapple *prekese* wine, evaluation of the variations in the ratios of *prekese* extract to pineapple juice on sensory acceptability of the wine. The study adopted experimental research design. The experiment was handled as a two by five (2x5) factorial design. A total of 230 research participants (200 consumers and 30 sensory evaluators) were sampled for the study. Sensory assessment was done by the use of a 5-point hedonic scale, ranging from like very much to dislike very much. Means, standard deviations, correlation, and multivariate analysis of variance were employed to analyse the data. Various ratios of pineapple and *prekese* compositions were subjected to fermentation processes. The average generation of alcohol in the wine following fermentation was 11.6%. The sensory evaluators preferred 50% pineapple and 50% *prekese* formulation (1.60±0.83) in terms of its aroma (1.47±0.64), appearance (1.47±0.52), taste (1.27±0.59), and colour (1.93±0.96). The critical lexicons generated by the evaluators were fruity, citrus, herbal, flavour, sweetness, alcohol, and dark. The evaluators scored the wine 16 on the scale. This implies that the wine produced from pineapple and *prekese* was rated as a standard wine. The rating of the pineapple *prekese* wine as a standard wine suggests that it could survive commercialisation based on its sensory attributes. The study recommended that production of pineapple *prekese* wine should maintain its texture, flavour, appearance, herbal nature and fruity aroma to continue to attract consumers to the wine.

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FRI-CSIR	Research Institute of the Centre for Scientific and Industrial Research
MLF	Malo Lactic Fermentation
RPM	Revolutions Per Minute

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Wine is an alcoholic drink processed from fermented juices of grapes and other fruits whose chemical composition enables them to ferment without addition of acids, enzymes, sugar or other nutrients (Awe, Eniola & Kayode-Ishola, 2013). According to Bindon, Varela, Kennedy, Holt & Herderich (2013), wine processing is an ancient trade and it is now a very viable commercial enterprise (Bobai, Mohammed, Emmanuel & Ugboko, 2017). Although grapes are the main raw material for wine production, Balamaze & Wambete (2017) indicated that there is increased interest in the search for other local fruits such as apple, peach, apricot, mango, orange, and palm sap that are of lower costs and are available readily for wine production in regions where grapes are not readily available. Thus, efforts have been made to use tropical fruits to produce various types of wine for varied reasons, including adding value to other fruits, reducing cost of wine production, developing different tastes of wine, developing local tastes of wines, and obtaining different nutrition from wine.

Moreover, Swami, Thakor & Divate (2014) posited that two or more these fruits can be combined to make mixed fruit wine. For example, Ogodo, Ugbogu, Agwaranze & Ezeonu (2018) reported of mixed fruit wines produced from banana, watermelon and pawpaw using *Saccharomyces cerevisiae* obtained from palm wine. In addition, Febianti & Komang (2017) explained that wines have been produced at home with various fruits that includes banana, apple, orange, watermelon, cashew, plum, guava, cucumber, strawberry, cherries and pawpaw using *S. cerevisiae,* which transforms the sugar contained in the substrate to alcohol, organic acids, esters other products (Butnariu & Butu, 2019). The fruits undergo a period of ageing and fermentation to generate the alcohol content. Thus, fruit wines are undistilled alcoholic beverages and usually named after the fruit. Nonetheless, Bobai et al. (2017) reported that in all cases, physicochemical analysis of the final output should be conducted to ensure that the wine is safe for human consumption, appealing to people, and have good and quality taste. As a result, Otegbayo, Akwa and Tanimola (2020) suggested the need to measure right quantities of raw materials, control temperature and timing for various activities and reactions, and monitor various steps in the wine preparation processes to ensure that the final output meets the needs and tastes of people, while remaining safe for human consumption.

According to Awe et al. (2013), the physicochemical properties that wine producers should measure to ascertain the safety of wines for human consumption should include, the pH, alcohol content, vitamin C content, titratable acidity, and total soluble solids. Thus, Swami et al. (2014) indicated that adequate information about wines should be generated to inform consumers' choices and preferences. Bindon et al. (2013) reported that the oxygen content of the must at the beginning of the fermentation, speed of fermentation and the temperature are important considerations in winemaking. These elements to a large extent influence the taste, acidity and alcohol content to be generated in the final output. Establishing critical controls enables the producer to maintain standards in the production of wine for commercial production (Balamaze & Wambete, 2017). In other words, the various parameters should be maintained within the acceptable standards for the production fruit wine. Thus, the pH should be within 3.5, while alcohol content should range between 5 and 13% (Ogodo et al., 2018).

Balamaze & Wambete (2017) posited that part of the process of getting fruit wines approved is to subject them to sensory evaluation. Sensory evaluation allows for critical stakeholders, who are experts in wine to pass their judgements on various aspects and attributes of the wine. The judges pass their judgement on the quality of taste, alcohol content, colour of the wine, and aroma, among others. According to Bobai et al. (2017), sensory evaluation is imperative to enhance the commercial production of fruit wine. This is because the sensory evaluators pass judgement on various compositions of the wine to determine the most appropriate or best composition to inform the producer on the commercialisation of the wine. As a result, Butnariu & Butu (2019), expressed that the selection of the sensory evaluators should be scientifically done to ensure that persons who are experienced in the area and well connected to wine production and consumption should be engaged to ensure fair and objective assessments. According to Otegbayo et al. (2020), various categories of sensory evaluators to ascertain the extent to which the wine appeals to the senses of different categories of persons. The final judgement gives indication to the producer about the categories of persons in the society that the wine should be targeted at based on the sensory evaluation scores.

In the production of fruit wine, Febianti & Komang (2017) indicated that the selection of the fruit is imperative to appeal to particular groups of people. Accordingly, Ogodo et al. (2018) suggested that there should be adequate justification for the selection of particular fruits in the production of wine. The focus of this study is produced wine from *Tetrapleura tetraptera* (*prekese*) and *Ananas cosmosus* (pineapple).

In many countries, including Ghana, pineapple is processed and sold by roadside as snack. Pineapple chunks are used in desserts such as fruit salad, and in some savory dishes such as pizza and cake topping. Pineapple is incorporated in yoghurt, sweets, jam and ice cream. Pineapple juice is served as beverage and also as a major ingredient in such cocktails as the pina colada. Pineapples contain adequate quantities of sugar which makes it appropriate for making wine (Williams et al., 2017). *Prekese* is a tropical fruit largely used as aroma in the preparation of local foods. *Prekese* is considered as highly nutritional among the people of Ghana and used to spice soups. Some people also consume *prekese* in the form of herbal medicine. This study seeks to expand the commercial value of such important fruits in the tropical region through the production of pineapple-*prekese* wine.

1.2 Statement of the problem

Pineapple is a globally traded crop and it is a well-known nutritious fruit cultivated in many tropical countries, including Ghana. It is a good source of minerals and vitamins (A, C and E) for humans. Williams et al. (2017) indicated that pineapple cultivated by about 2% of all Ghanaian households. Due to its requirement for high labour, pineapple cultivation plays an important role in employment creation as well as improving incomes. Gaveh (2016) reported that the commercial production of pineapple is the most developed horticultural sector of the Ghana's economy and pineapple exports accounted for 40 percent of the all horticultural exports of Ghana. This was partly attributed to the increased demand for fresh pineapples in the European Union (EU). From 1994 to 2004, the pineapple industry in Ghana grew at a cumulative yearly rate of 172%, which resulted in the growth of its European Union market share from 2 to 10% between 1999 and 2004 (Gaveh, 2016).

However, change in regulations and the shift in demand internationally had a serious impact on the growth of the pineapple market after 2004. Thus, Ghanaian share reduced and maintained only 4% of EU market share. Gaveh (2016) posited that a fall in the Ghanaian market share of pineapple in the EU had contributed to increasing post-harvest losses of the fruit, ranging between 15 and 20 % (53-75 tons). There have therefore been calls to increase the domestic demand through fresh consumption and addition of value to pineapple to sustain the growth of the industry (Williams et al., 2017).

According to the GAIN report (2019), Ghana imported $26.6 million worth of wine in 2013. Ghana's total consumption of wine in 2017 was 11.7 million liters. With a population of about 30 million, the estimated per capita wine consumption is 0.4 liters which is very high. Hence, the quest to develop wine from pineapple is in direct response to these calls to increase local productive capacities to meet the high production levels and help to reduce the high post-harvest losses resulting from market accessibility challenges.

Tetrapleura tetraptera, locally known as *prekese* in Ghana is a deciduous tree native to Ghana and many tropical African countries. *Prekese* is reported to have many nutritional and medicinal properties (Adesina, Iwalewa & Imoh, 2016). The medicinal properties are can be traced to presence of bio-active substances (alkaloids, tannins, saponins, flavonoids, phenols, flavonoids and glycosides) that are vital for health (Akin-Idowu, Ibitoye, Ademoyegun & Adeniyi, 2011). For instance, *prekese* fruit is known to have anti-inflammatory, anti-arthritis and anti-diabetic properties (Adadi & Kanwugu, 2020).

Adesina et al. (2016) also explained *prekese* is used to control schistosomiasis, a chronic parasitic disease caused by blood flukes (trematode worms). The nutritional properties of *prekese* are due to vital food micronutrients, including zinc and iron that are contained in the dry fruit (Akin-Idowu et al., 2011). Irrespective of all the nutritional and medical properties, Adadi and Kanwugu (2020) posited that the *prekese* is a highly underutilised fruit. This study seeks to create an avenue to add value to the fruit through the production of wine. This is expected to change *prekese* from a household fruit to a commercial one. Hence, the quest to produce wine from *prekese* and pineapple is expected to add extra value to locally produced fruits.

1.3 Main objectives

The main objective of the study was to develop pineapple-*prekese* wine.

1.3.1 Specific Objectives

1. Assess consumer preferences of locally produced wine from pineapple and *prekese*
2. Determine the physicochemical properties of pineapple-*prekese* wine
3. Evaluate the variations in the ratios of *prekese* extract to pineapple juice on sensory acceptability of the wine.

1.4 Significance of the Study

Using pineapple and *prekese* for wine production will generate income for farmers, create employment and deal with the post-harvest losses that occur during the glut in Ghana. The findings of this study will also help policy makers to make informed decisions with regards to adding value to pineapple and *prekese*.

1.5 Scope of the study

The study encompasses the production of wine from pineapple and *prekese* and the evaluation of its physicochemical properties, sensory properties of the wine produced will also be determined.

1.6 Limitation of the study

A consumer sensory was not done to validate the most preferred formulation due to resource and time constraints.

1.7 Organisation of the study

The organization of the study involves five main chapters. Chapter one presents the background information of the research topic, defining the statement of the problem, stating the objectives of the study and research questions that the project seeks to answer, the methodology which outlines the method employed in carrying out the research, highlight the significance of the study, describing the scope of the study and presenting the organization of the study. Chapter two reviews the literature. In this section of the research literature materials of other authors are discussed and reviewed. This includes newsletters, magazines, textbooks, reports etc. Chapter three discusses the research methodology adopted for the study and relevant justifications. It outlines the methods employed to collect both the secondary and primary data and how results was analyzed. The methodology includes the research design, population of the study, sampling techniques and sample size, data collection approach (primary and secondary data), research instrument (questionnaires/interview) and administration of the research instrument. Chapter four presents the analysis of the data, interpretation and discussion of the results. Chapter five is the final chapter of the study and it presents summary of findings, conclusions and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.1 Pineapple

Pineapple (*Ananas Comosus*), belongs to *Bromeliaceous* family which consists of about 2,000 types mainly epiphytic and a lot of them strikingly ornamental. Pineapple varies in colour from yellow to almost white (Morton, 1987). It is a perennial herbaceous crop with not less than 30 trough-shaped and pointed leaves, which grow to about 30 cm long, covering its thick stem. Water is driven onto the stem by the shape of the plant and the water is then taken in by the axils. The plant grows to around 1.0 to 1.5m. The pineapple fruit has a good sugar level which makes it appropriate for wine production (Adaikan and Ganesan, 2004). Pineapple is a very important fruit, accounting for more than 20 % of the world's production of tropical fruits (COVECA, 2002). More than 70% of the pineapple produced is consumed freshly in the producer countries particularly those in Africa including Ghana. The origin of pineapple can be traced to Paraguay and Amazon basin of Brazil where it was domesticated. The pineapple fruit is the only brome-land fruit is widely cultivated. It can be cultivated as an ornamental, especially from the leafy tops. Pineapple can be or canned or juiced or eaten fresh. The fruit has high amounts of essential mineral such as manganese and vitamin c. Pineapple has a protein digesting enzyme known as bromeliad which can help digestion after meal high in protein.

2.2 Varieties of pineapple

The varieties vary according to size, colour shape, and many more (Edible, 2019). Pineapple varieties exist in some physical (weight, shape size and colour texture), physicochemical (pH, acidity, titratable and soluble solids), chemical (organic acids and soluble sugars), biochemical characteristics (peroxidase activity, total dietary fibre and soluble protein) and sensorial properties (appearance, odour, firmness, flavour, colour and acceptability) (Sam Valley Farms, 2013).

Plate 2.1: MD2

Plate 2.3 SMOOTH CAYANNE

Plate 2.2: QUEEN

Plate 2.4: SUGAR LOAF

Plate 2.1 – 2. 4: Varieties of Pineapple

Source: Sam Valley Farms (2013)

The MD2 pineapple has cylindrical fruits with medium to large sizes (1.3-2.5 kg). The fruits are coloured intense yellow. The pulp is sweet, clear, yellowish in colour, compact and with acidity and lower fibre, although its vitamin C content can be as much as four times more than normal varieties. Its sugar content (15-17 Brix) and ascorbic acid content are high but it has lower total acid content than the "Smooth Cayenne" pineapple. As compared to other varieties, MD2 pineapple has post-harvest shelf life of 30 days which is nine more than the average and it can remain fresh after 2 weeks in cold storage. It was originally cultivated in Costa Rica and it is currently the standard variety for many of large scale pineapple farmers around the world.

The *Queen Victoria pineapple* fruit has a full yellow colour when ripe. The fruit is small with a weight 0.5-1 kg. The pulp is sweet (14 to 18 Brix) and crispy with an excellent flavour and long shelf life. This variety forms about 2.5% of pineapple exports from Ghana

Smooth Cayenne pineapple has a pale yellow, juicy and soft flesh with sugar of 13-19 Brix. It is appropriate for fresh processing because of its fruits large (1.5-2.5 kg).

Sugar Loaf pineapple has a conical fruit shape. The fruit is sweet with little acidity and the flesh is pale in colour. The size of the fruit may range from 0.5-1.5 kg. Cultivation is concentrated in the Mfantseman area of the Central Region of Ghana. Most of the fruits consumed locally.

2.3 Description of *Tetrapleura Tetraptera* (*Prekese*) Tree

Prekese is a member of the family Mimosaceae, and is widely cultivated in Tropical Africa (Keay, 1998) and grows wildly in West Africa. In Nigeria, it is mainly found in the southern parts where it grows in rainforest, secondary forest, fringing forests and derived savannah where relative humidity and rainfall and are relatively high (Jimoh, 2005). According to Aladesanmi, (2007), the *prekese* tree is hardy, single stemmed, perennial and about 30m tall. The fruits borne by tree are four-winged and woody shelled. It has a fleshy pulp and small brownish-black seeds with distinctive fragrance.

Plate 2.5: *Tetrapluera tetraptera* tree

Plate 2.6: *Tetrapluera tetraptera* Seeds

The fragrance emanates from the vital oil contents of the fruit and it also serves as insect repellent. The fruits are dark red-brown when fully ripe but green when tender. The dry fruit has a pleasant aroma (Aladesanmi, 2007). Keay, (1989) noted that the flowers are densely crowded in spike and are pinkish-cream turning to orange. Blay (2001) mentioned that each pod may contain between ten and fifteen seeds. The pods do not split open, the seeds are therefore released after the pods are rotten. The process takes between three and four weeks Keay (1989).

Table 2.1: Soil condition necessary for the growth of *tetrapluera tetraptera.*

Chemical / Mineral Composition	Percentage
pH	4.1 – 5.2%
Nitrogen	0.06 – 0.35%
Phosphorus	2.5 – 43.5%
Carbon content	1.03 – 2.36%
Magnesium	0.32 – 3.9%

(Adakwa – Aduasah et al*.,* 2000)

2.4 Varieties of *Tetrapleura Tetraptera (Prekese)*

The varieties are: *Tetrapleura thonningii* and *Adenanthera tetraptera* (Hutchinson & Dalziel, 1998). One other known variety of *prekese* in Ghana is *T – chevalier*. The significance of this variety regarding its application as a spice or medicine unknown. There are two varieties or types which farmers have separated into, 'female' and 'male' types. The 'female' branches at a height of around 1.3m and it bears fruits heavily. The 'male' branches at a higher height of around 1.7-2m, although it is fruity, due to its straightness and form it does not bear heavily (Adarkwa – Aduasah et al., 2000).

2.5 Chemical, Medicinal, Nutritional Properties of *Prekese*

Okwu, (2003) on the chemical evaluation, flavouring, nutritional and properties of *prekese* indicated that the spice contain crude lipid (4.98% - 20.36%), crude protein, (7.44% - 17.50%), and food energy (234.42 – 379.48g/Cal), they also indicated that it contains significant quantities of minerals such as iron, potassium, phosphorous, zinc and calcium.

Phytochemical investigations also indicate the presence of saponins, tannins, phenolic substances, alkaloids, flavonoids and steroids which could be to be responsible for its varied pharmacological and biological properties. Phytochemicals is identified as anticonvulsants, toxic, antimicrobial, molluscidal, insecticidal and antimicrobial.

The chemical composition of *prekese* was analysed by Akin-Idowu et al*.,* (2011). The composition (approximate %) based on dry weight was sugar (3.29 to 39.63); ash (3.17 to 3.48); starch (7.56 to 29.10); and crude protein (5.13 to 8.65); The content of mineral (mg/kg) based on dry weight was Cu (4.00 to 12.54); Zn (5.35 to 25.16); Fe (29.69 to 65.06); Mg (392.35 to 2951.28) ;); Na (119.48 to 2364.93) Mn (16.23 to 178.91; Ca (1348.63 to 13839.86); B (1.14 to 6.23); and K (8631.09 to 14881.00); The contents of starch, sugar, Mn, Zn, Mg, Cu, Na, Ca and K differ in different parts of the fruit ($p < 0 .05$).

The phytochemicals content (mg/100 g) based on dry weight were saponin (60.80 to 953.40); flavonoid (10.30 to 410.75); tannin (135.50 to 1097.50); polyphenol (38.05 to 2907.15); and phytate (1021.00 to 5170.00). Generally, as compared to other common spices, the phytochemical constituents in the *prekese* fruit was high. This indicates the potential use of *prekese* as a good source of phytochemicals in local African medicine (Akin-Idowu et al*.,* 2011).

The nutritional content of freshly harvested matured fruits in Southern Nigeria was also analysed by Dosunmu (1997) and he found that the content of crude protein was quite small in the seeds (0.51%) and fleshy mesocarp (2.21%) while there was no crude protein in the woody mesocarp. The seeds and fruits had high proportions of some macro-elements including magnesium, potassium, phosphorus and iron, but low sodium content. The nutritional quality of the dry fruit of *prekese* also was analysed by Essien et al. (2002). The fruit shell, seed and fruit pulp contained quantities of nutrients including minerals, protein and lipids, that were higher or comparable to that of some well-known spices such as onion, red pepper, curry and ginger. The quantity crude fibre in the shell of the fruit was significant and therefore an important nutrition source.

The powdered dry fruit is used in soap making to improve the antimicrobial functions and to increase the hardness and foaming of the soaps (Adebayo et al., 2000). The fruit is known to contain caffeic acid which works as HIV replication inhibitor and also control inflammatory and antitumor characteristic (Adesina, 1982).

The prekese fruit is often used in traditional African medicine to control and manage many of diseases such as arthritis, diabetes mellitus, epilepsy hypertension, schistosomiasis, asthma inflammatory conditions. Ojewole and Adesina (1999) said that the plant has a lot of traditional medicinal uses mainly in the control of convulsion, inflammation, leprosy and rheumatic pains.

2.6 Suitability of *Prekese* for Making Wine Making

It was observed by Kyei and Allman (2001) that in the western part of Africa the *prekese* plant is used as medicine, spice and as dietary supplements because of its richness in vitamins. In southern Nigeria, *prekese* it is used to prepare pepper soup and it is believed that the aroma drives away snakes in cold weather (Abii & Amarachi, 2007). In eastern Nigeria, the fruits are used to prepare soups for women who had just delivered to prevent postpartum contraction. The fruits also contain caffeic acid, cinnamic acids and carbohydrates (Adesina, 1982). The latter two of these components are common in most spices. The common food usage and attributes of *prekese* showed people in West Africa were used to its medicinal properties and aroma. These could help in the commercially viable production of wine from *prekese* as the consumers were aware of some of the benefits of the *prekese* fruit. In addition, the high sugar content of the fruit could help fermentation and enable the formation of alcohols to produce the wine. This was important since the alcohol content of wines is important in increasing their commercial use.

2.7 Fermentation

Fermentation is a process of whereby energy is extracted from the oxidation of carbohydrates and such organic substances by the use of endogenous electron acceptors. Pyruvate, an organic substance is usually used. Pyruvate is converted into carbon dioxide and ethanol during the fermentation of alcoholic, usually carried out by yeasts. The process of fermentation is simply serving nutrients and sugars in solution to yeast, which in turn produces alcohol and carbon dioxide. This process continues until either the quantity of yeast cannot support the proportion of alcohol in the drink or all the sugar is used up (Garrison, 1993). According to Anon (2005), different yeasts have different tolerance levels generally yields different results.

Sophisticated tools and equipment are needed for fermentation or to store the fermented product. Fermentation can done inside wine barrels, in open wooden vats, in stainless steel containers, and inside wine bottles as done in the processing of many sparkling wines (Wikipedia, 2010; Robinson, 2006; Kunze, 2004). Fermentation is an energy efficient and a cheap method for the preservation of perishable products including fruit juice (FAO, 2002). Rapid deterioration of harvested fruits may occur if appropriate storage and facilities for processing are not available, particularly in tropical countries where the humid weather conditions accelerate the rate of decomposition (FAO, 2010). Though there are other preservation methods for fresh fruits such as freezing, canning, drying and pickling, some of these methods are not appropriate for use by small-scale producers in poor countries.

Fermentation is a viable method for new products development with modified sensory physicochemical properties especially nutritional and flavour qualities. Alcohol, lactic and acetic fermentations are significant for quality in the production process (Swami et al., 2016). Alcoholic fermentation is the main method for preparing drinks in which a major ingredient is alcohol. Alcoholic beverages/drinks are drinks that contain ethanol. Alcoholic drinks are divided into three broad groups for the purposes of regulation and taxation. The three groups are wines, beers and spirits. Spirits are distilled drinks and the group includes gin, rum, whisk and vodka. Beer is produced from the fermentation of yeast and malted cereal starch, particularly rye, barley, wheat, corn, or a mixture of grains in most cases with the addition of hops. Its alcohol content is between 4 and 8% and its energy level varies from 28 to 73 kcal per 100 ml. Production of distilled alcoholic drinks are done by the distillation of ethanol through the fermentation of grains, fruits or vegetables. They are produced from sugarcane juice, molasses, mash of potatoes and cereals, and the malt of rye and barley. Distilled alcoholic beverages have alcohol contents ranging between 40 and 60 per cent (Swami et al., 2016).

2.7.1 Fermentation of Fruit into Wine

According to Robinson (2006), the wine fermentation process is the catalyst function that converts fruits into alcoholic drinks. Fermentation of wine has two well defined stages: Aerobic and anaerobic (also known as primary and secondary) fermentations (Berry, 1996; Jacobs, 2001). These stages of fermentation involve a complicated multistage chemical transformation of glucose to ethanol in yeasts. Reactions at aerobic fermentation stage include those of glycolysis, pyruvate, respiratory (electron transfer) chain and tricarboxylic acid cycle leading to the transformation of glucose to H^2O and CO^2. The anaerobic fermentation stage on the other hand involves glycolysis, alcohol dehydrogenase and pyruvate decarboxylase complex, which transforms glucose to CO^2 and ethanol (Garrett and Grisham, 1999; Nelson and Cox, 2000). Primary fermentations are vigorous chemical reactions that generate huge amounts of gases. A secondary fermentation is however slow and quiet reaction and is it hardly noticeable as it nears the end (Berry, 1996; Jacobs, 2001).

In the production of cashew wine, the apples are sliced into small pieces to increase the rate of extraction of the juice when ground in a juice press. To remove wild yeast, the juice is sterilised in a stainless steel vessel at a temperature of 85ºC (Wimalsiri et al., 1971). Either potassium metabisulphite or sodium is added to the sieved juice to eliminate or hinder the growth of any unwanted organisms like moulds, wild yeasts, acetic acid and bacteria. Wine yeast is then added and the wine stirred adequately and permitted to ferment for fourteen days (Au Du, 2010). When fermentation is ended, impurities in the wine are removed by racking. The wine may be further clarified by the use of fining agents like pectin, casein or gelatine. After racking, the wine may be filtered using a filter-aid like a fuller’s earth. Pasteurisation of wine then done under a controlled temperature of 50ºC –

60°C. The alcohol content of the wine vaporises at temperatures between 75 and 78°C (Au Du, 2010). The wine is stored in wooden tanks and allowed to age. The wine should be allowed to age for at least six months. The wine may be clarified again prior to bottling. Oxidation and other reactions occur during ageing and the maturing of wines in bottles leading to the formation of small amounts of aldehydes and esters, which in combination with the acids and tannin already existing enrich the wine's aroma, taste and preservative qualities (Wimalsiri et al, 1971).

Date wines are well known in North Africa and in Sudan (Dirar, 1992). There are several types of date wine and each is produced using a varied method. “Dakhai” is prepared by putting dates a clean pot made from earthenware. Between two and four volumes of boiling water are added to each volume of dates. It is sealed for three days after is it allowed to cool. A lot of hot water is added and the pot is then sealed again for between seven and ten days. In preparing “El madfuna”, the earthenware pots are buried in the ground. “Bentimerse” is prepared from a blend of sorghum and dates.

There are three methods of making sparkling wines. Carbonating the wines under pressure is the cheapest method, however, the sparkles of these sparkling wines unfortunately disappear quickly, and they therefore regarded to be of inferior quality to the sparkling wines made by the traditional means of secondary fermentation. In the traditional method of making sparkling wine, a particular type of wine yeast (S. *cerevisiaevar. ellipsoideus*), which is a champagne yeast is added to wine that has already been artificially sweetened. The CO^2 generated by the fermentation of the added sugar provides the sparkle. In the technique originally used for making champagne, which is still currently used widely, the secondary fermentation are done in pressure resistant bottles, but in the early part of nineteenth century a technique for fermenting wines in closed vessels was employed, this being a lot cheaper than the use of bottles (Rose, 1961; Van Rooyen, et al., 1982).

2.7.2 Effect of pH on Wine Fermentation and Wine Quality

According to Fleet (1998), pH directly affects the stability of wines. This may be because at a pH close to neutral (7.0), moulds including some yeasts and other microbes have increased rates of activity for fermentation and for deterioration of wine, whereas a pH less than 3.5 destroy many micro-organisms and supports only few of the microbes for fermentation. The optimum pH for many micro-organisms is close to the neutral pH of 7.0. Yeasts and moulds and often tolerate low pH and hence support the deterioration of foods with low pH. The pH measures the concentration of hydrogen ions (H+) in acid solutions that include wines, grape juice and pineapple juice or in the converse, the hydroxyl ions (OH-) concentration alkaline solutions such as lye. A pH unit can be expressed as the negative logarithm of the concentration of H+ and it is measured by a pH meter (Lacroux et al., 2008). The smaller the pH value, the greater the concentration of H+ ions, the greater the level of acidity, hence there exist an inverse relationship between increasing H+ ions concentration and decreasing pH value. The conventional method of fermenting wine entails extracting juice from fruits and altering the pH to 4.0 by the use of sodium bicarbonate and adding yeast nutrient For example, in the fermentation of fruit juices, decrease in soluble solids from pH of 7.4 to between 3.5 and 4.0 are possible in worm fermentation (Steinkraus, 1992).

2.7.3 Effects of Sugar Content on Fermentation

According to Keller (2010), the most important substrate for fermenting fruit juice into alcohol is sugar; though, other food commodities including fats and protein and can be decomposed by several micro-organism in instances where sugar is not adequate. In the presence of sugar, cells of yeast continue the process of fermentation till the growth of yeast is by inhibited other factors (Dickinson, 1999). Although, sugar is very significant for fermentation, a higher concentration of sugar curtails the growth of microbes (FAO, 2010). For instance, in the fermentation of agave juices, the soluble solids should be lowered to 6%, which is the optimum from between 25 and 30%. The sucrose content consequently falls to 1% from 15% (Steinkraus, 1992). Yeasts, however, can tolerate higher concentrations of sugar and grow fairly well in solutions of about 40% sugar content.

2.8 Brewer's Yeast

Brewer's yeasts are in common use in breweries and wine making enterprise. These yeasts are micro-organisms and are responsible for fermenting wines and beers (Keller, 2010). The sugars extracted from grains and fruits are metabolised by yeasts producing carbon dioxide and alcohol, and then transforming the fruits into wine and grains into beer respectively. Yeasts also affect the flavour and character of the product (Ostergaard et al., 2000). The Saccharomyces types are the dominant species of yeast employed in fermenting alcoholic drinks. For example, to produce beer the ale yeast (Saccharomyces cerevisae) and lager yeast (Saccharomyces uvarum) are employed (Dittmer and Desmond, 2005), whereas in wine (Saccharomyces cerevisiaevarellipsoideus and (Saccharomyces cerevisae) might be utilized (Keller, 2010). The diversity of wine is due in part uses of different types of yeasts used in wine making, among even the same variety of fruits (Robinson, 2006). In generally, yeast removes protein naturally during clearing or fining. Also dry yeast is applied to remove copper sulphate, ethyl acetate, browning, copper sulphate, oxidation, and excess oak that occurs in cloudy wine (Rotter, 2008). Dosages of 240-1000 mg/l are commonly recommended

2.9 Wine Production

Wine is an alcoholic drink produced generally from fermented juices of fruits (Okafor, 2007). Wines can be made from fruits with adequate sugar levels and the final wine produced is usually named after the fruit. The fruit and strain of yeast used in the process is dictated by the type of wine to be produced (Amerine and Kunkee, 2005). Preservatives used in wine production include potassium sorbate, sulphur dioxide, sorbic acid and metabisulphides (Idise and Izuagbe, 1988). High amounts of preservatives cause off odours in wines and can induce some systemic disorders such as gastrointestinal disturbances in allergic persons and breathing problems in asthmatic patients. In many subtropical countries including Angola, wine drinking has become a habit in recently mainly due to the realization that moderate wine consumption is healthy and promotes food digestion (Ferrieres, 2004).

Fruit wines usually produced from grapes but can also be produced from other fruits including banana, peaches, apricots, plums, elderberry, pineapple, etc. which are nutritive, tasty and stimulates mildly. The fruits fermented and aged. The alcohol content of fruit wines range from 5 and 13 percent. Wine is nutritious with a good flavour and like fresh fruit, wine can be transported and stored under the prevailing conditions. A lot of the food nutrients contained in the fruit are maintained in wine. Fruit wines contain between 2 and 3% sugar and between 8 and 11% alcohol. The energy values range from 70 to 90 kcal per 100 mL (Swami et al., 2016).

2.9.1 Effects of Acid on Fermentation and Wine Quality

Acid is indicated to have direct effect on wine quality, but wine's acid composition is due tartaric acid, citric acid, and smaller quantities of lactic acid several other acids. The acid levels in wine fruit juices can be ascertained through titration (Amerine, and Ough, 1980; Gallander, et al., 1987; Iland, et al., 2000; Lacroux et al., 2008).

In comparison to mineral acids such as hydrochloric and sulphuric which are strong, fruit acids are weak acids. Strong acids produce their hydrogen ion (H+) constituent almost fully in solution, weak acids dissociate just about 1% of their H+. Therefore, solutions of weak acid such as that of fruit wine have a lot more H+ than hydroxyl ions (OH-). As the concentration of H+ rises, the solution becomes less favourable for most micro-organisms associated with the deterioration of acidic foods and wine. However, some yeasts and moulds that are necessary for the fermentation of fruit juice into wine are often acid tolerant and are hence very crucial to the making of dry wine (Mountney and Gould, 1988). Reduction in acidity increases the pH values and facilitate the growth of spoilage organisms like L. oenos (Fleet, 1998).

2.9.2 Development of Aroma in Wines

Aroma is a significant factor in quality assurance and quality control of wines. Aroma results from complicated balance of more than 800 volatile compounds in varying ranges of concentrations, and with different polarities and volatilities. The aroma and flavour substances are released through the nascent in the fruit (released only by milling), and substances produced by enzymatic interactions during milling, fermentation and aging (Swiegers et al., 2005). The wine acquires the aroma during aging. The aroma is formed as a result of complex modifications which results from different phenomena, such as hydrolytic reactions, esterification, redox reactions, carbon dioxide elimination, spontaneous clarification, continuous and slow flow of oxygen through the pores of the wood and the transfer of aromatic substances and tannins from the wood into the wine.

Qualitatively, esters are the highest constituents of wines. Esters are either straight chain (aliphatic) or cyclic (phenolic) in structure. Quantitatively, glycerol and ethanol are the largest constituents of alcohols contained in wine, followed by diols, higher alcohols and esters.

2.9.3 Alcohol Content of Wines

Alcohol contributes to body, intensity, texture and sweetness in fruit wines. Ethanol contributes to wine sensory properties through the enhancement of wine fullness and its effects on the concentrations of several wine volatiles and contribution to sweetness (Guth and Sies, 2002). At higher levels, alcohol suppresses the aromas of fruits on the nose by secluding molecules of the aroma and prevents them from being released into the air. Although, alcohol is tasteless, it can overpower the palate, inhibiting recognition of nuances in wine by suppressing flavours. At levels of 15% and above in wines, alcohol can cause a burning sensation in the nose and cause a sense of bitterness and severe heat on the finish (Anonymous, 2010c).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Research Design

A 2 X 5 factorial experimental design was used for the study. The factors used for the experimental design were the composition (pineapple and *prekese*), and five (5) formulations. These were the parameters adopted in the production of the various pineapple and *prekese* wine. These factors were used to produce five different types of pineapple *prekese* wine, which were later subjected to sensorial evaluation and physicochemical analysis.

3.2 Consumer Survey

Prior to the wine formulation process, a survey was conducted in the Accra Metropolis to assess consumers' preference for local and imported wine. The Accra Metropolis was selected because it hosts the capital city of Ghana, which attracts different categories of both local and international people to the city. The city also has a cross section of the affluent and middle-class people who are perceived to be regular consumers and connoisseurs of wine. The selection of the Accra Metropolis therefore ensured that varied views were expressed about wine.

Two hundred (200) wine customers from the following 10 shopping malls, restaurants and hotels which were purposefully selected because they serve wine and have large clientele: Accra Mall, West Hills Mall, Marina Mall, Golden Tulip Hotel, Alisa Hotel, Airport West Hotel, Afrikiko Restaurant, Mamma Mia Restaurant, Santoku Restaurant, and the Venue Restaurant. Twenty (20) respondents were selected accidentally from each of 10 shopping malls, restaurants and hotels to obtain a total of 200 respondents. Information generated during survey included wine consumption in a month, preferred alcoholic content and colour of wine, and their acceptance to pineapple-*prekese* wine. The information was obtained through a structured questionnaire which were administered to the respondents.

3.3 Wine Formulation

3.3.1 Sources of Raw Materials

Pineapples were obtained from Branqus farms located at Otomena near Samsam-Odumase, off the Nwasam Amasaman road, Ghana. The sugar loaf and smooth cayenne varieties were selected for the study because sugar loaf has a high brix as compared to the other varieties such as MD2. The smooth cayenne has a comparably high juice content that makes it suitable for processing. The index used to determine the maturity level was the brix, the determining factor was that, the total soluble solids content in the flesh of the fruit should be at least 12˚ Brix (twelve Brix degrees). The *prekese* was obtained from CSIR- Forestry Research Institute of Ghana, (FORIG) located at Femesua, Kumasi. Sugar and Brewer's yeast were bought from Shoprite, Accra. Reagents were obtained from Food Research Institute (CSIR-FRI) chemistry laboratory in Accra.

3.3.2 Preparation of *Prekese* Powder

The *prekese* fruit pods were sorted to ensure that the selected pods were not damaged and free from insect infestation. The fruits were washed in 10% salt solution to kill all possible germs and bacteria present on it and sun-dried for 10 days (It was dried every morning at 9:00am to 4:30 pm every evening). The soft part of the fruit was roughly cut using a stainless- steel knife. The pods were also split open to remove the seeds from the pods. The fruit and the seeds were then oven dried at 60ºC for one hour using the master chef gas cooker (model number MC-461C). This was done to ensure that the fruit achieved a moisture of 12% or below. The fruit and the seeds were milled into powder form, sieved and stored in an air-tight container. Figure 3.1 shows a flowchart of the method and preparation of *prekese.*

***Plate 3.1: (a) Preparation of *prekese* powder (b) Extraction of prekese juice**

Prekese
↓
Sorting
↓
Sun drying (10 days)
↓
Cutting
↓
Milling
↓
Sieving
↓
Storage (Container)

Figure 3.1: Flowchart of the Method and Preparation of *Prekese*

3.3.3 Extraction of the *Prekese* Extract (Aqueous)

Five hundred (500) grams of *prekese* powder was soaked in 2.5 litres of water in a container. It was then allowed to stand at room temperature (28ºC) for 24hours at 210 revolutions per minute (RPM) with frequent agitation with the aid of a Shaker. The mixture was then strained using a muslin cloth to get the extract. The extract was then pasteurized at 75ºC for 15 minutes and cool at ambient temperature. This method of extraction was used because the laboratory where the extraction was carried out had the equipment and resources, unlike the other methods which were difficult and laborious.

3.3.4 Preparation of the Pineapple Juice

Twelve (12) pieces of freshly ripe un-bruised pineapple (6 of each of 2 varieties) with a total weight 14.4kg were washed in 10% salt solution and rinsed in order to make the fruits free from any germs. After washing, the pineapples weighed 14.2kg. The fruits were then peeled and cut into chunks. The fruits weighed 8.85kg after peeling. The fruit juice was extracted using fruit extractor Model Number NJ-2000 by Samra Yo Industrial Ltd. The juice was strained using a muslin cloth and then pasteurized at 75°C for 15 minutes and cooled at ambient temperature. Figure 3.2 presents flowchart of method for preparing the sugar loaf and smooth cayenne pineapple juice.

Plate 3.2: (a) Weighing of pineapple (b) Washing of pineapple

(a) (b)

Plate 3.3: (a) Peeling of pineapple and (b) measuring the volume of pineapple juice

Ripe unbruised pineapple fruits

↓

Washed in 10% salt solution

↓

Rinsed

↓

Cut into pieces

↓

Extracted using fruit extractor

↓

Pasteurisation of the pineapple juice (75ºC) for 15 minutes

↓

Cooling at Ambient temperature

Figure 3.2: Flowchart of the Method for Preparing Pineapple Juice

3.3.5 Fermentation of Must (Pineapple and *Prekese*)

After the pineapple and *prekese* must preparation, five types of wines were produced from their extracts. The different types were based on different compositions of the pineapple and prekese contents. The aim was to give varied options for evaluators to ascertain the most preferred formulation in terms of its sensorial properties. Prior to the preparation of the five formulations of the pineapple and *prekese* wine, a purely pineapple wine was produced to serve as a control. Details of the compositions of the five formulations are presented in Table 3.1.

Table 3.1: Compositions of the various formulations of pineapple and prekese must

	Composition	
Formulation	**Pineapple**	***Prekese***
Control	100%	0%
Formulation 1	90%	10%
Formulation 2	80%	20%
Formulation 3	70%	30%
Formulation 4	60%	40%
Formulation 5	50%	50%

Generally, the wine was prepared by mixing the pasteurized pineapple juice and *prekese* extract in the right proportions. Sugar (quantity was calculated using the Pearson square method) was added to the pineapple juice and *prekese* extract mixture to adjust the soluble solids level to 18.5˚ Brix. Sodium metabisulphite was added to prevent the growth of bacteria. The mixture was then brought to a temperature of 40˚C and inoculated with the yeast. The mixture was agitated for a minute by stirring for even distribution of the yeast. The mixture was then poured into a sterilized glass bottle and closed. The mixture was kept at ambient temperature for 14 days. The soluble solids, pH, and alcohol content were monitored periodically during the fermentation. On the 7th day of the fermentation, the supernatant was decanted to remove impurities. The mixture was then allowed to continue with the fermentation for 7 more days.

The control formulation was produced from 100% pineapple juice. Thus, 900ml of pineapple juice with 106.4g of sugar 4g brewer's yeast and 0.4g of sodium metabisulphite

(100% pineapple wine) was used for the production of the control formulation. Formulation 1 was produced 840ml of pineapple juice with 60ml of *prekese* extract, 106.4g of sugar, 4g brewer's yeast and 0.4g of sodium metabisulphite (pineapple 90%, *prekese* 10%). Formulation 2 was produced from 780ml of pineapple juice with 120ml of *prekese* extract. Thus, 106.4g sugar, 4g brewer's yeast and 0.4g sodium metabisulphite (80% pineapple juice 20% *prekese*). In reference to Formulation 3, 720ml of pineapple juice with 180ml of *prekese* extract, 106.4g sugar 4g brewer's yeast x 0.4g sodium – metabisulphite (70% pineapple juice, 30% *prekese*) was used in the production. Formulation 4 was produced from 60% pineapple juice and 40% *prekese* aqueous extract (600 ml of pineapple juice and 300ml of *prekese*). Formulation 5 was also produced from 50% pineapple juice and 50% *prekese* aqueous extract (450 ml of pineapple juice and 450ml of *prekese*) respectively. In all, nine hundred millimetres (0.9000L) of each formulation was prepared.

Table 3.2: Formulations of pineapple and prekese wine

Formulation	**Content**				
	Pineapple (ml)	***Prekese* (ml)**	**Sugar (g)**	**Yeast (g)**	**Sodium metabisulphite (g)**
Control	900	0	106.4	4	0.4
1	840	60	106.4	4	0.4
2	780	120	106.4	4	0.4
3	720	180	106.4	4	0.4
4	600	300	106.4	4	0.4
5	450	450	106.4	4	0.4

3.4 Physiochemical Analysis

This section discusses the physiochemical analysis of the wine produced. The aim was to establish the physicochemical properties of the pineapple-*prekese* wine produced. The section is organised under the determination of titratable acidity, determination of pH, determination of total soluble solids, and alcohol content.

3.4.1 Determination of titratable acidity

The method described by Amerine and Ough (1980) for titratable acidity was modified by using a 10 ml sample in 100 ml distilled water instead of 5ml sample in 200 ml of distilled water. Titratable acidity was determined by the use of a 0.1 N NaOH and phenolphthalein indicator. A 250 ml beaker was filled with 100ml distilled water and a few drops of phenolphthalein indicator was added and mixed. The mixture was titrated to a pale pink colour. Degassing of the wine was then done by allowing the wine sample to stand in an ultrasonic water bath for 10 minutes to remove carbon dioxide gas. Degassed wine sample (10ml) was measured into the mixture and titrated against 0.1 N NaOH to a pale pink colour which persisted for at least 30 seconds.

3.4.2 Determination of pH

The digital bench top pH meter (Orion 2 star pH meter, Hanna Instruments, USA) equipped with an electrode was used in the determination. The electrode was washed in distilled water. It was then placed into the wine sample. The pH reading was read from the lead display screen of the pH meter (AOAC, 1990).

3.4.3 Determination of Total Soluble Solids

A hand-held refractometer (REF-103, 0-32° Brix) was used. The refractometer was standardized by placing a drop of distilled water on the prism. The refractometer was placed such that it allowed entry of sunlight into the prism. The eye-piece was used to observe the standardization after adjusting the coarse and fine adjustment properly. The process was repeated for each sample and the appropriate correction factors made depending on the temperature of the sample (AOAC, 1990).

3.4.4 Alcohol Content

The alcohol content was obtained using the difference in potential alcohol method by the aid of hydrometer. With this method, a hydrometer reading was taken when yeast was added to the wine must. This test gave an indication about how much alcohol the wine can have if all the sugars are fermented. Another alcohol reading was taken with hydrometer following the completion of the fermentation. The difference between the two readings produced the alcohol content of the pineapple-*prekese* wine.

3.5 Sensory Evaluation

Wines were evaluated by a panel of 30 judges who were very familiar with wines. The judges were made up of 27 males, 3 females, and ages between 23 to 58 years and are food scientists and food technologists of FRI-CSIR, Accra, Ghana for the sensory evaluation. Since such judges had been used by the Institute to certify so many wines over the years, their judgements and choices were considered very critical to the general acceptability of the wine among the populace.

Wines from the various formulations were evaluated based on colour, aroma, appearance and overall acceptability (based on overall mean value). The assessment was done by the use of a 5-point hedonic scale, where 1 represented like very much, 2 represented like moderately, 3 represented neither like nor dislike, 4 represented dislike moderately, 5 represented dislike very much. The wines were placed in plain wine bottles and stored at room temperature. The wines were sent to the sensory laboratory one hour prior to testing to enable the wine adjust to the environment. Samples of wine (30 ml each) were served in clear disposable plastic cups. The wines were coded using three-digit random numbers and served in no particular order. Judges were instructed to chew cream cracker biscuits and rinse their mouths with water between the tasting of different wine samples.

3.6 Data Analysis

Each experiment was performed in triplicate and the results expressed as the mean ± standard deviation. The data obtained were analysed statistically using SPSS version 22. Multivariate analysis of variance, correlation and descriptive statistics were employed to analyse the data. An error margin of five per cent was used for all inferential analysis.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Background Characteristics of Consumers

As indicated in Figure 4.1, the majority (60.5%) of the consumers were males, while 39.5% were females. Males were more associated with alcoholic beverages than females as espoused by Wilsnack et al. (2010) that alcohol consumption is consistently more prevalent among men than women.

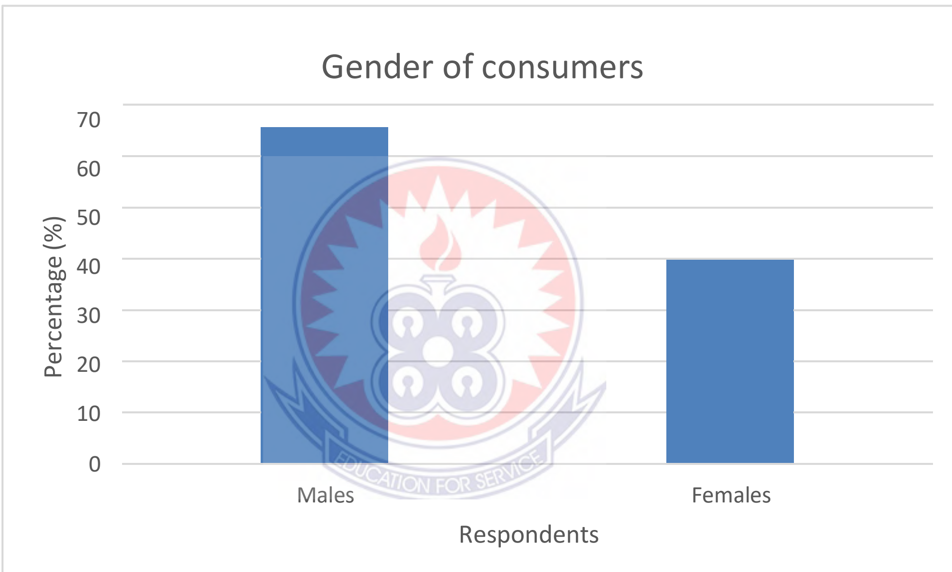

Figure 4.1: Gender of consumers

Table 4.1 shows that 9.5% of the consumers were aged between 20 and 29 years, 36% were within 30 and 39 years of age, while 26.5% were within 40 and 49 years of age. The results showed that alcoholic wines were appealing to people from varied age cohorts. This is important for the new wine development as it has wide potential market base with respect to the age categories of persons attracted to wines. The mean age of the consumers was 39.2 years.

Table 4.1: Age characteristics of consumers

Age group (in years)	Frequency	Percentage
20 – 29	19	9.5
30 – 39	72	36.0
40 – 49	53	26.5
50 – 59	31	15.5
60 and above	25	12.5
Total	**200**	**100**

The consumers were asked to indicate their levels of education. The results are presented in Figure 4.2.

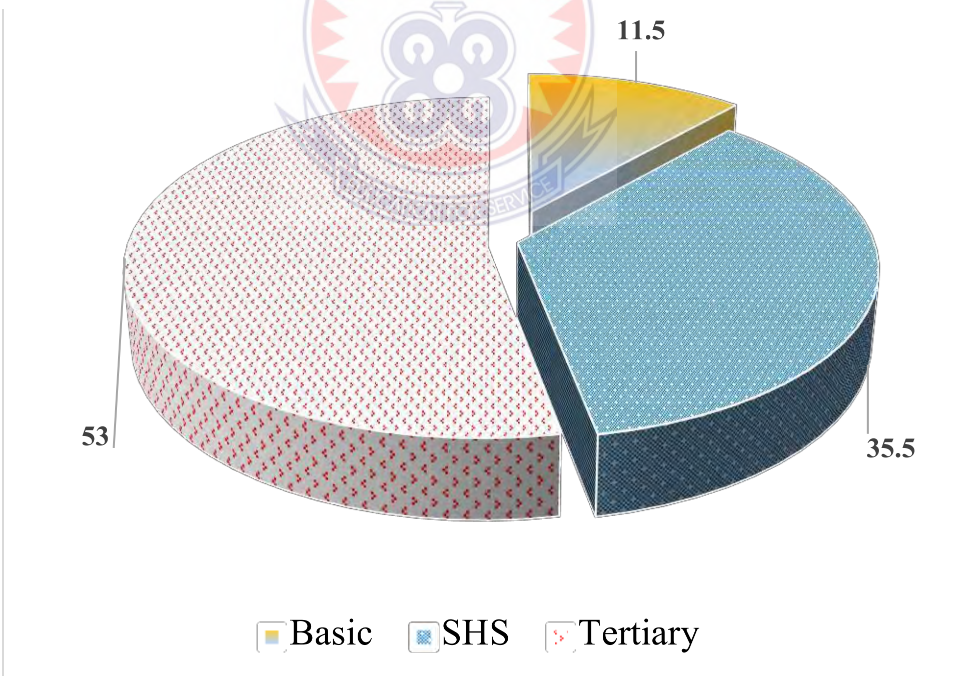

Figure 4.2: Level of education of consumers

Figure 4.2 shows that a little over half (53%) of the consumers had attained tertiary education, 35.5% had senior high school (SHS) education as their highest level of educational attainment, while 11.5% had attained basic level of education. The results showed that people's affinity to wines increased as they attained higher levels of education.

Another issue considered under the background characteristics of consumers was average monthly income. This was important because consumers' capacity to consume alcoholic wine partly depends on their income levels. The results are illustrated in Table 4.2.

Table 4.2: Average monthly income of consumers

Monthly income (GH₵)	Frequency	Percentage
1000 and below	5	2.5
1001 – 2000	13	6.5
2001 – 3000	24	12.0
3001 – 4000	71	35.5
4001 – 5000	58	29.0
Above 5000	29	14.5
Total	**200**	**100.0**

Table 4.2 shows that, a majority of the respondents earned GH₵3000 and above. Consumer monthly consumption of alcoholic wines ranged from 3 to 10 bottles. On the average, each respondent consumed about four bottles of alcoholic wines in a month. This indicates that alcoholic consumption amongst the respondent is high.

Table 4.3: Average monthly expenditure on wines

Monthly income (GH₵)	Frequency	Percentage
100 and below	57	28.5
101 – 200	61	30.5
201 – 300	33	16.5
301 – 400	28	14.0
401 – 500	13	6.5
Above 500	8	4.0
Total	**200**	**100.0**

From Table 4.3, majority of the respondents (59%) of the consumers spent an average of GH₵200 and below on wines, whilst 36.5% spent over GH₵200. The mean monthly expenditure on wines among the respondents was GH₵203.8.

The respondents were requested to indicate their most preferred colour of wine. The results are presented in Figure 4.3. It shows that 37% of the consumers most preferred red wines, 20.5% most preferred white wine, whereas 18.5% and 17.5% most preferred chocolate and rose wines, respectively. The results showed that the consumers had varied preference with respect to the colour of wines.

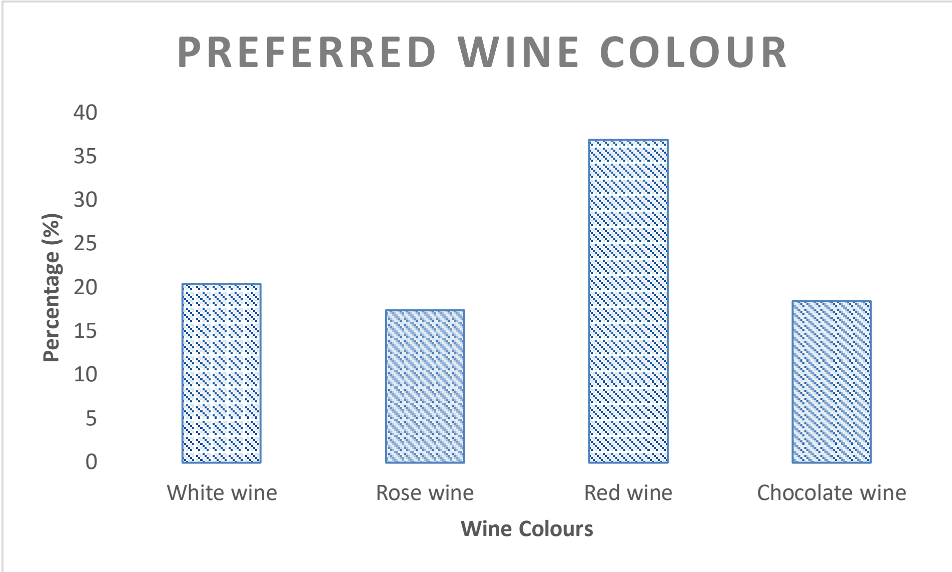

Figure 4.3: Most preferred wine colour

Table 4.4 presents the results of the analysis of the elements that attracted consumers to choose particular wines. It indicates that 42.5% of the consumers strongly agreed that they were attracted by the taste of wine in their choice, whereas the majority (57.5%) agreed. The results showed that all (100%) the wine consumers were attracted by the taste for their selection. The implication is that the acceptability of the taste of wine could help attract more consumers. In other words, acceptability of the taste of pineapple-*prekese* wine could contribute significantly in its commercialisation drive. The Table further showed that the majority (78.5%) of the consumers strongly agreed and agreed that they were attracted by the colour of wines. In addition, all (100%) the consumers indicated that they were attracted by the alcoholic content of wines in their choice making process.

Table 4.4: Elements attracting consumers to choose particular wines

Elements	Strongly Agree (%)	Agree (%)	Disagree (%)	Strongly disagree (%)	Mean
Taste	85 (42.5)	115 (57.5)	-	-	100
Colour	66 (33.0)	91 (45.5)	27 (13.5)	16 (8.0)	50
Alcoholic content	79 (39.5)	121 (60.5)	-	-	100
Ingredients	28 (14.0)	83 (41.5)	72 (36.0)	17 (8.5)	50
Country of origin	33 (16.5)	75 (37.5)	62 (31.0)	30 (15.0)	50
Packaging	57 (28.5)	94 (47.0)	49 (24.5)	-	66.67
Brand	45 (22.5)	88 (44.0)	53 (26.5)	14 (7.0)	50

Results from Table 4.4 further showed that the majority (55.5%) of the consumers were attracted to wines by the ingredients of the wine. This suggests that consumers are likely to be attracted to pineapple-*prekese* wine if they have knowledge about the health benefits of the ingredients of the wine. Another issue was the country of origin, which a little over half (54%) of the consumers agreed to be attracted by the country of origin to the consumers. The study found that the consumers had high regard for wines from Italy, Spain and South Africa. It was also found that about three-quarters (75.5%) of the consumers were attracted by the packaging of wines, while 24.5% disagreed. The implication is that the packaging of the pineapple-*prekese* wine will critically influence the extent of attraction from consumers. In addition, Table 4.4 showed that the majority (66.5%) of the consumers strongly agreed and agreed that they were attracted to wines based on their brands.

4.2 Consumer Preferences of Wine Produced from *Prekese* and Pineapple

The first research objective sought to examine the consumer preferences of wine produced from pineapple and *prekese*. This was imperative to ascertain the likely level of acceptability of the pineapple-*prekese* wine by consumers on the market. Findings from this section provided an opportunity for some of the elements to be incorporated into the wine production to enhance the possible commercialisation of the wine. From the study, the majority (92%) of the consumers reported that they consume *prekese*, whereas 8% indicated they did not consume *prekese*. However, about half (50.5%) of the consumers who did not consume *prekese* were ready to consume it when used for wines. This was because some of the consumers indicated that their non-consumption of *prekese* was not based on medical reasons but due to its unavailability in the restaurants they visited, and their poor knowledge in the use of *prekese* in food. This was important as it could provide a critical potential market base for the new wine development from *prekese*. The consumers were further asked to indicate their willingness to drink wine from *prekese*. The results are presented in Figure 4.3.

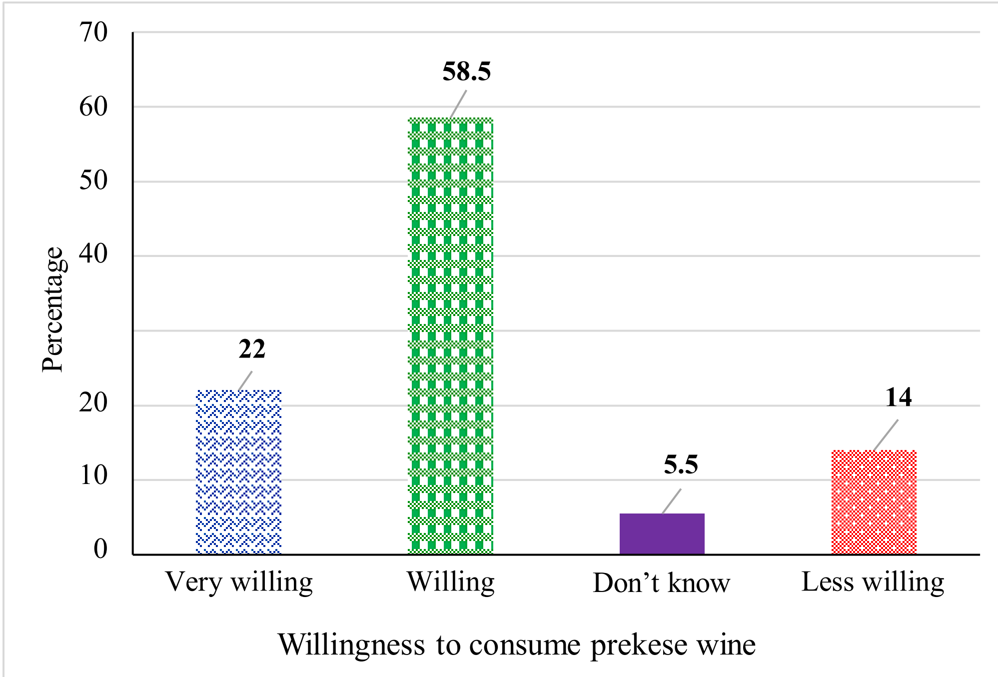

Figure 4.4: Willingness of consumers to drink wine from *prekese*

From Figure 4.4, 22% of the consumers were very willing to drink wine from *prekese,* 58.5% were willing, while 14% were less willing. As indicated by the results 80.5% of the consumers were willing to drink wine made from *prekese*. This is a major boost for the development wine from *prekese* as Skotti, Kalli, Lappa and Bouchagier (2018) posited that the potential commercial viability of wine production from particular principal ingredients is quintessential to promote and sustain newly developed wines on the market.

The consumers were asked to provide reasons for their level of willingness to drink wine from *prekese*. Table 4.5 presented the results.

Table 4.5: Reasons for level of willingness to drink wine from *prekese*

Reasons	Frequency	Percentage
Local taste	78	39.0
Medicinal properties	133	66.5
Good aroma	61	30.5
Unpleasant aroma	19	9.5
Unusual taste	27	13.5
Prefers foreign wines	32	16.0

Table 4.5 shows that 39% of the consumers were willing to drink wine made from *prekese* because of the unique local taste, 66.5% were willing to drink *prekese* wine because of the medicinal properties it possesses, while 30.5% were willing to consume *prekese* wine because of good aroma. Since taste play a critical role in the attraction of consumers to particular wines (see Table 4.4), the willingness of the consumers to drink wine from *prekese* because of its unique taste is imperative for the acceptability of the *prekese* wine to sustain its production. The results indicate that the majority of the consumers were very much particular about the medicinal properties of the wine and as such were willing to drink wine made from prekese. The implication is that the commercialisation of such wine could capitalise on the medicinal properties to sustain operations. According to Skotti et al. (2018), the commercial viability of newly developed wine partly depends on some uniqueness in terms taste or ingredients from existing ones. The perceived unique medicinal properties of *prekese* could therefore become the point of attraction to the large scale production of the wine. Table 4.5 further showed that 9.5% of the consumers were

not willing to drink wine from *prekese* because of bad aroma, 13.5% were unwilling because of unusual taste, while 16% were unwilling because they were more used to foreign wines.

Another issue considered under the section was the expected level of alcoholic content from *prekese* wine. This was essential as all the sampled consumers reported alcoholic content of wines as one of the elements that attracted them to choose particular wines. Table 4.6 shows the results.

Table 4.6: Expected level of alcohol content from *prekese* wine

Alcoholic content (%)	Frequency	Percentage
1 – 3	7	3.5
4 – 7	34	17.0
8 – 11	47	23.5
12 – 15	83	41.5
16 – 19	21	10.5
Above 19	8	4.0
Total	**200**	**100.0**

As illustrated in Table 4.6, 41.5% of the consumers expected the level of alcohol content from the *prekese* wine to be within 12-15%, 23.5% were expecting it to be within 8-11%, while 17% and 10.5% expected within 4-7% and 16-19%, respectively. Thus, the consumers had various preferences regarding the alcoholic content of the wine to be produced from pineapple and *prekese*. The mean expected level of alcohol content from the *prekese* wine among consumers was 13.3% with a standard deviation of 4.9. The implication is that producing *prekese*-pineapple wine with alcoholic content within 13.3% (+/- 4.9) could help attract critical number of people to drink such wines.

The consumers were further requested to indicate the places they obtain their wines. The results are presented in Table 4.7. Results showed that all (100%) of the consumers obtained their wines from restaurants, 86% obtained theirs from shopping malls, 52.5 obtained their wines from hotels, while 34.5% imported their wines.

Table 4.7: Places consumers obtain their wines

Places	Frequency	Percentage
Hotels	105	52.5
Shopping malls	172	86.0
Wine shops	133	66.5
Restaurants	200	100.0
Import them	69	34.5

Table 4.7 shows that the consumers obtained wines from variety of sources. The results further showed that the producers of pineapple-*prekese* wine could target consumers at restaurants, shopping malls and hotels to increase sales and consumption.

The study further inquired from the consumers about their most preferred quantity for packaging. This was important to help attract consumers to purchasing the pineapple-*prekese* wine as about three-quarters (75.5%) of the consumers were attracted by packaging in their selection of wines (see Table 4.4). The results are presented in Figure 4.4.

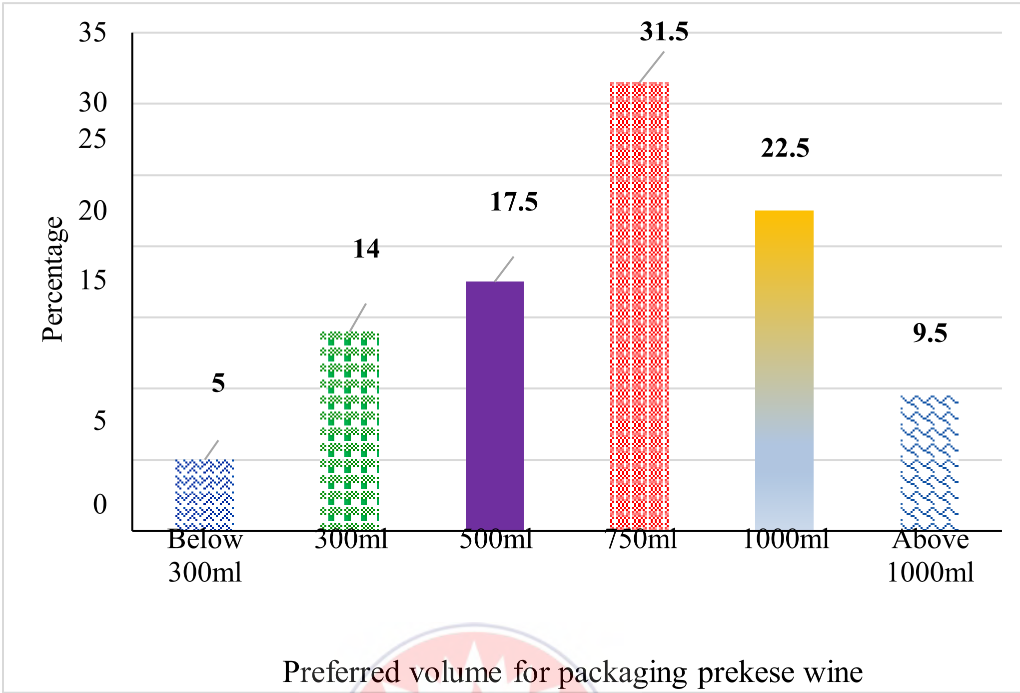

Figure 4.5: Preferred volume for packaging *prekese* wine

Figure 4.5 indicates that 5% of all the consumers preferred packaging *prekese* wine below 300 ml, 31.5% preferred 750 ml, 22.5% preferred 1000 ml, while 17.5% and 9.5% preferred 500 ml and above 1000ml, respectively. The results showed that the consumers had varied preferences for the volume of packaging of the *prekese*-wine. Some of the consumers who preferred below 300ml added that they wanted a pocket size volume to enable them drink small quantities of the wine in their convenient times without attracting unnecessary attention. However, some of the respondents who preferred above 1000ml added that they wanted something they can easily share with friends and colleagues during their weekend interactions. The implication is that the production of pineapple-*prekese* wine should be done in varied volumes of packaging to meeting different interests of the consumers. This is important as it will inform the choices of consumers in various circumstances.

Another issue considered under the section was the amount the consumers were prepared to buy the *prekese* wine. The results are presented in Table 4.8.

Table 4.8: Amount consumers preferred buying the *prekese* wine

Amount (GH₵)	Frequency	Percentage
10 and below	13	6.5
11 – 15	91	45.5
16 – 20	49	24.5
21 – 25	22	11.0
26 – 30	15	7.5
Above 30	10	5.0
Total	**200**	**100.0**

From Table 4.8, 45.5% of the consumers preferred buying a bottle of *prekese* wine for within GH₵11 – 15, 24.5% preferred buying it for GH₵16 – 20, while 11% and 7.5% preferred buying it for GH₵21 – 25, and GH₵26 – 30, respectively. The mean amount the consumers preferred purchasing a bottle of *prekese* wine was GH₵16.7 with a standard deviation of 5.3.

4.3 Physicochemical Properties of Pineapple- *Prekese* Wine

The second research objective sought to examine the physicochemical properties of the pineapple-*prekese* wine. This was imperative as it helps to determine the properties of the wine to inform the choices of consumers.

Further, the determination of the pH was important to establish the appropriate taste and microbial stability of the wine. The alcoholic content determination of the wine was imperative as all the consumers admitted to getting attracted to particular wines because of the alcoholic content (see Table 4.4). The aim was to track the performances of the various properties of the wine. These were based on the assertion of Qi et al. (2017) that ample times should be given for intermittent measurements of the physiochemical properties in a fermentation process. Table 4.9 presents results on the physio-chemical properties of the must before they were subjected to fermentation (Day 0). This was essential to provide a base data to measure the changes in the physical properties during the fermentation process.

Table 4.9: Physicochemical properties of must at Day 0

Sample	Brix	Acidity	pH	% Alcohol
Control	18.6	0.42	3.87	Not detected
Formulation 1	18.6	0.39	3.81	Not detected
Formulation 2	18.6	0.43	3.67	Not detected
Formulation 3	18.6	0.36	4.09	Not detected
Formulation 4	18.6	0.34	4.07	Not detected
Formulation 5	18.6	0.34	4.07	Not detected

Table 4.9 shows that the brix content was constant (18.6^0) in all the formulations prior to fermentation. This implies that fermentation had not begun. According to Jordao, Vilela and Cosme (2015), the brix level in a must ultimately determines the alcohol level a wine could possess at the final stage in the production process. Jordao et al. (2015) posited that a high brix, which is 20^0 and above produces high alcoholic content of above 17% in a wine. The implication is that a brix of 18.6^0 is likely to produce mid-ranged alcoholic content.

The acidity level of the must was also determined. Results from Table 4.9 show some level of fluctuations in the acidity contents of the various formulations. Thus, the acidity level of the control (100% pineapple) was 0.42. The acidity level reduced to 0.39 following 10% addition of *prekese* to 90% pineapple in formulation 1. However, the acidity level increased at formulation 2 to 0.43. The acidity level reduced consistently in the subsequent formulations. From Table 4.9, the pH of the control sample was 3.87 and increased to 4.07 at formulation 5. Thus, the pH reduced to 3.81 on the first formulation, reduced further to 3.67 on formulation 2, but increased to 4.09 on formulation 3.

The study conducted a Pearson's correlation test to examine the statistical relationship between the acidity and pH of the must on Day 0. From the study a correlation of -0.91 indicates the existence of a negative and strong relationship between acidity and pH of the must. The implication is that as the acidity levels of the samples on Day 0 increase, the pH levels decrease. This is concurs with the finding of Jordao et al. (2015) that increased acidity content of wines are associated with decreased pH ratings. A p-value of 0.001 associated with the correlation suggests that there exist a negative and statistically significant correlation between acidity and pH of the must for the various formulations.

No alcohol levels were detected on Day 0 across all the various formulations. This was because both fruits are naturally non-alcoholic and required some processes of fermentation to generate alcohol. This differentiates the production of fruit juices from fruit wine with some alcoholic content. In other words, fruits have to be subjected to fermentation to produce alcohols in wines. This is in agreement with the assertion of Mutiat, Abiodun, Kowalowe and Kayode (2017) that pineapples are naturally non- alcoholic but has have to undergo fermentation to produce some alcohol levels for consumption.

The study also took some measurements on the physio-chemical properties of the wine samples on Day 3. The results are shown in Table 4.10.

Table 4.10: Physicochemical properties of samples at Day 3

Sample	Brix	Acidity	pH	% Alcohol
Control	15.1	0.37	4.00	3.56
Formulation 1	15.4	0.34	3.99	3.41
Formulation 2	16.6	0.37	3.82	2.82
Formulation 3	16.8	0.31	4.09	2.76
Formulation 4	16.4	0.31	4.07	2.51
Formulation 5	15.3	0.30	4.07	3.32

Results from Table 4.10 show that there were some deviations or changes in the brix content following the beginning of the fermentation process across all the formulations.

Thus, the control sample recorded a brix of 15.1^0 and increased steadily from formulation 1 (15.4^0) to formulation 3 (16.8^0) and decreased afterwards continuously to 15.3^0 at formulation 5. The Table further showed that the brix content reduced from the initial 18.6^0 to 15.1^0, 15.4^0, and 16.6^0 respectively for control sample, and formulations 1, 2 and 3.

In reference to the acidity content of the samples following three days of fermentation, Table 4.10 showed that there were fluctuations over the various formulations. While the acidity level reduced between the control sample (0.37) and formulation 1 (0.34), it increased to 0.37 at formulation 2, when the pineapple content was reduced and more *prekese* was added. In addition, the acidity levels reduced across all the various formulation samples between Day 0 and Day 3. For example, the acidity level of the control sample reduced from 0.42 on Day 0 to 0.37 on Day 3, while formulations 4 and 5 reduced from 0.34 to 0.31 and 0.30, respectively. Kodagoda and Marapana (2017) attributed the changes in the acidity content between Day 0 and Day 3 to the fermentation process.

Table 4.10 also showed that the pH levels of the various samples fluctuated across the various formulations. The pH of the control sample was 4.00, reduced to 3.99 and 3.82 for formulations 1 and 2, but increased to 4.09 for formulation 3. It dropped subsequently to 4.07 for formulations 4 and 5. Comparing the pH levels between Day 0 and Day 3 showed that the values increased between the two measuring points across all the formulation samples. In other words, the pH for the control sample increased from 3.87 to 4.00 between Day 0 and Day 3, while those for formulations 1, and 2, increased from 3.81, and 3.67 to 3.99, 3.82, respectively. The pH levels for formulations 4 and 5 remained at 4.07 between the two measuring points.

Table 4.10 further showed the generation of some alcohol content following the subjecting of the samples to fermentation. The alcohol content was highest in the control sample of 3.56%, which reduced consistently between formulations 1 to 4 (3.41%, 2.82%, 2.76% to 2.51%), when the pineapple content was reduced for the addition of *prekese*. The alcohol content however increased to 3.32% between formulations 4 and 5.

Following the measuring of the physio-chemical properties of the samples on Day 3, the study took further measurements on Day 6. The aim was to understand the performance or behaviour of the samples as subjected to the fermentation processes to produce the alcoholic wine. The results are shown in Table 4.11.

Table 4.11: Physicochemical properties of samples at Day 6

Sample	Brix	Acidity	pH	% Alcohol
Control	12.8	0.30	4.05	5.71
Formulation 1	13.0	0.29	4.03	5.64
Formulation 2	13.5	0.30	3.92	3.51
Formulation 3	12.5	0.29	4.19	5.32
Formulation 4	13.0	0.26	4.09	5.44
Formulation 5	13.5	0.27	4.17	5.51

From Table 4.11, the brix level for the control sample was 12.8^0, which increased between formulations 1 and 2 of 13.0^0 and 13.5^0, respectively. The brix content however decreased to 12.5^0 at formulation 3, and increased subsequently 13.0^0 at formulation 4. A comparison between the brix content of Day 3 and Day 6 showed that there was reduction across all the samples. This was attributed to the sugars in the samples fermenting to produce alcohol.

The acidity content of the various samples fluctuated as different combinations of pineapple and *prekese* were mixed. The acidity level in the control sample was 0.30, reduced to 0.29 at formulation 1, and increased to 0.30 at formulation 2. It fluctuated further between formulations 3 and 5. A comparison in the acidity levels between Days 3 and 9 showed reduction across all the samples.

With respect to the pH levels on Day 6, Table 4.11 shows that the control sample recorded 4.05, while formulations 1, 2, 3, 4 and 5 recorded 4.03, 3.92, 4.19, 4.09 and 4.17, respectively. Thus, the pH levels decreased from the control sample through to formulation 2, while appreciating at formulation 3 and reducing subsequently at formulation 4. A comparison of pH levels between Days 3 and 6 showed that the levels dropped across all the samples. This suggested that the pH levels in the pineapple and *prekese* samples decreased as they were subjected to fermentation.

The control sample recorded alcohol content of 5.71% on Day 6, but reduced subsequently between formulations 1 and 2 with 5.64% and 3.51%, and subsequently increased consistently from formulation 3 (5.32%) to formulation 5 (5.51%). A comparison between the recorded alcoholic content of the formulation samples between Days 3 and 6 showed that the alcoholic content increased across all the samples. This showed that the longer the fermentation period, the more alcohol is generated for the wine. This was because Mutiat et al. (2017) posited that it takes time for all the sugars to ferment to produce alcohol in fruit wine preparation process.

Subsequent to the measurements on Day 6, further measurements were made on Day 9 to determine the physio-chemical properties of the samples. The results are illustrated in Table 4.12.

Table 4.12: Physicochemical properties of samples at Day 9

Sample	Brix	Acidity	pH	% Alcohol
Control	10.5	0.25	4.11	8.66
Formulation 1	9.4	0.25	4.11	8.72
Formulation 2	10.5	0.25	4.12	9.20
Formulation 3	10.5	0.24	4.45	8.55
Formulation 4	8.9	0.25	4.15	9.12
Formulation 5	10.2	0.24	4.27	8.45

Results from Table 4.12 show that the brix content for the control sample was 10.5^0, which reduced to 9.4^0 at formulation 1, but increased subsequently to 10.5^0 at formulations 2 and 3. In other words, the brix content in the various formulations fluctuated on Day 9. A comparative analysis of the brix content of the samples between Day 6 and 9 showed that they all reduced over the period. This was because the sugar content in the various formulations were being converted to alcohol as they continued the fermentation processes. This further stress the time element indicated by Mutiat et al. (2017) that sugars in must during wine preparation require time to ferment to generate the needed alcohol levels.

The acidity levels in the various formulations largely remained constant at 0.25 with the exception formulations 3 and 5 which recorded 0.24. Comparing the acidity levels of the samples in Day 9 to those of Day 6 showed that acidity generally reduced. In other words, the acid levels of the formulations reduced as the samples were subjected to long periods of fermentation.

The pH levels of the control formulation and formulation 1 was 4.11 on Day 9, which increased to 4.12 and 4.45 on formulations 2 and 3, respectively. The pH levels for formulations 4 and 5 were respectively 4.15 and 4.27. Comparing the pH levels for Days 9 and 6 showed that they all increased. In other words, the longer the fermentation process of the wine, the more the pH increased. The steadily increase in the pH levels of the various formulations are likely to reduce the sour taste from the acidity in fruits. This is because the study found that there was a negative relationship between the acidity levels and the pH levels of the various formulations.

The alcohol content of the control formulation was 8.66%, while those for formulations 1, 2, 3, 4 and 5 were 8.72%, 9.20%, 8.55%, 9.12% and 8.45%, respectively. The results showed that the level of alcohol generally increased for the formulations that contained *prekese*. The low alcohol level in the control formulation could be attributed to the relatively high brix content, which showed that most of the sugars had not fermented to generate the needed alcoholic content for the wine. Comparing the alcohol content between Days 9 and 6 showed that the levels increased for all the formulations. This was attributed to the increased number of days for fermentation that that allowed the sugars in the samples to ferment to generate more alcohol.

The final measurements on the physio-chemical properties of the wine were taken on Day 14. The measurements on this Day were for the final output to be tested by sensory evaluators to determine the optimum formulation that could be produced for consumers. The results are illustrated in Table 4.13.

Table 4.13: Physicochemical properties of samples at Day 14

Sample	Brix	Acidity	pH	% Alcohol
Control	5.8	0.22	4.25	12.23
Formulation 1	6.0	0.22	4.28	11.46
Formulation 2	6.0	0.22	4.36	11.73
Formulation 3	6.0	0.20	5.02	12.10
Formulation 4	5.6	0.20	4.27	11.32
Formulation 5	8.8	0.20	4.34	10.67

Results from Table 4.13 showed that the control formulation recorded a brix level of 5.8^0 after 14 days of fermentation. Formulations 1, 2 and 3 maintained a brix level of 6.0^0, while formulations 4 and 5 recorded 5.6^0 and 8.8^0, respectively. A comparison between brix levels of Day 14 and Day 9 showed that there was a general reduction across all the formulations. This was due to the longer period for the fermentation process as it allowed more of the sugars to be fermented. The acidity levels of the control formulation were 0.22 for the control formulation and formulations 1 and 2, while formulations 3, 4 and 5 recorded 0.20. Comparing the acidity content of the wine at Day 14 with the formulations at Day 9 showed that there were reductions in all the samples. The pH level for the control formulation was 4.25 at Day 14, while those for formulations 1, 2, 3, 4 and 5 were respectively 4.28, 4.36, 5.02, 4.27 and 4.34. Increases in the pH levels were attributed to the decreases in the acidity levels as they were inversely related. According to Jordao et al. (2017), all wines are acidic and most wines range between 2.5 and 4.5 on the pH scale. The implication is that all the formulations with the exception of formulation 3 fell within the range. A comparison of the pH levels between Days 14 and 9 showed general appreciation of the levels. This was due to the reduction of the acidity levels of the various formulations when fermentation was complete. In other words, there was a negative relationship between acidity levels and pH levels in wine preparation.

At the completion of the fermentation period (Day 14), the control formulation recorded alcohol content of 12.23%, formulation 1 recorded 11.46%, formulation 2 recorded 11.73%, formulation 3 recorded 12.10%, while formulations 4 and 5 recorded 11.32% and 10.67% respectively. The results indicated that there were no clear direction in terms of the increases or decreases in the pineapple and *prekese* contents in the samples and alcohol generation in the wine. A comparison of alcohol content between Days 14 and 9 showed that all the formulations appreciated in their alcohol contents. This was largely due to the length of period for the fermentation and the volume of brix that was subjected to the fermentation processes. According to Kodagoda and Marapana (2017), the brix content in a must largely determines the alcohol content of wines when subjected to fermentation over a period of time. Since this was the final product, the study estimated the extent of change in the physio-chemical properties of the wine as they underwent fermentation. Table 4.15 presents results on the extent of change in the physio-chemical properties of the wine between Day 0 and Day 14.

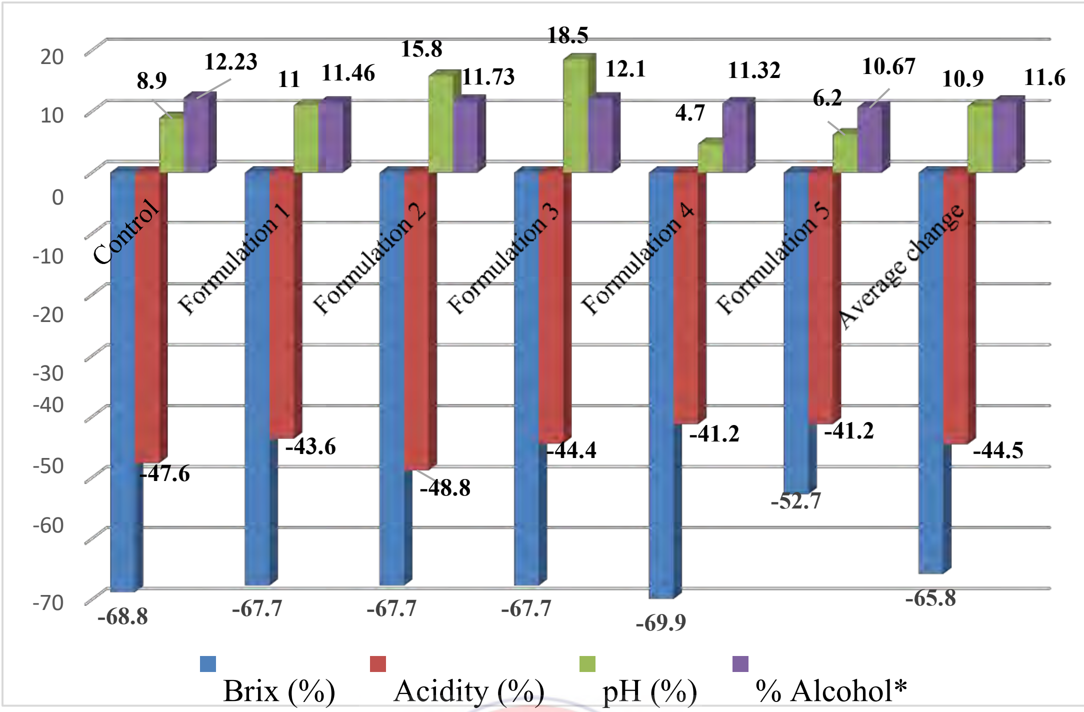

Figure 4.6: Extent of change in the physiochemical properties of the pineapple-*prekese* wine at the end of the fermentation period

Table 4.14: Extent of change in the physio-chemical properties of the pineapple-*prekese* wine at the end of the fermentation period

Sample	Brix (%)	Acidity (%)	pH (%)	% Alcohol*
Control	-68.8	-47.6	8.9	12.23
Formulation 1	-67.7	-43.6	11.0	11.46
Formulation 2	-67.7	-48.8	15.8	11.73
Formulation 3	-67.7	-44.4	18.5	12.10
Formulation 4	-69.9	-41.2	4.7	11.32
Formulation 5	-52.7	-41.2	6.2	10.67
Average change	-65.8	-44.5	10.9	11.6

*no records were detected on Day 0

Table 4.14 shows that the average change in the brix content between Day 0 and Day 14 was 65.8%. It also shows that brix in the control formulation reduced by 68.8% at the end of the fermentation period (Day 14), while the brix in formulations 1, 2, and 3 reduced by 67.7%. In addition, the brix content in formulations 4 and 5 reduced by 69.9% and 52.7% respectively between Day 0 and Day 14, following fermentation. The implication was that the majority of the brix got fermented and converted into alcohol. The results also showed that formulation 4 had the highest reduction in the brix level following the fermentation process, while formulation 5 recorded the least change in the brix content.

The Table shows that the average level of reduction in the acidity level of the wine reduced 44.5% at the fermentation period. The acidity level of the control formulation reduced by 47.6% between Day 0 and Day 14, while the acidity contents of formulations 1, 2, 3, 4, and 5 reduced by 43.6%, 48.8%, 44.4%, and 41.2% respectively. The results showed that formulation 2 had the highest reduction in the acidity content at the end of the fermentation period, while formulations 4 and 5 recorded the least change.

Table 4.14 further shows that the pH levels appreciated between Day 0 and Day 14. The average level of appreciation in the pH of the wine was 10.9% over the fermentation period. The pH level in the control formulation appreciated by 8.9%, while those of formulations 1, 2, 3, 4 and 5 increased by 11%, 15.8%, 18.5%, 4.7% and 6.2%, respectively. The results showed that formulation 3 recorded the maximum change or appreciation in the pH level at the end of the fermentation period, while formulation 5 recorded the least change or increase at Day 14.

The average generation of alcohol in the wine following fermentation was 11.6%. Comparing the average rate of alcohol generation from the *prekese*-pineapple wine with the average expected alcohol content of wine from the consumers of 13.3% (+/- 4.9) showed that the wine was within their expectation in terms of the level of alcohol. This is likely to contribute to attract consumers to choose the *prekese*-pineapple wine to enhance its commercial viability. The results from Table 4.14 further showed that the alcohol content of all the formulations was within the average expected alcohol content of consumers.

Plate 4.1: Wine Developed from pineapple and *prekese*

The study conducted a multivariate analysis of variance to ascertain the statistical significance of the observed changes in the various formulations as they were subjected to fermentation. Table 4.15 illustrate the results.

Table 4.15: Multivariate analysis of variance on the physio-chemical characteristics of the wine

	Brix	Acidity	pH	Alcohol
Chi-square	67.26	76.84	54.25	93.49
Df	5	5	5	5
Asymptotic Sig.	0.001	0.001	0.001	0.001

a. Kruskal Wallis test

b. Grouping variable: formulation types

Table 4.15 shows that all the samples recorded statistical changes in the physiochemical characteristics of the formulations as they underwent fermentation. Thus, p-value (asymptotic sig.) of 0.001 showed that statistically significant differences exist among the physiochemical characteristics (brix, acidity, pH and alcohol) across the formulation groups over the fermentation process. This was because the p-value or asymptotic sig. value of 0.001 was within the error margin of 0.05. The implication is that fermentation processes have critical influence or cause critical changes in physio-chemical properties of pineapple and *prekese* in wine preparation.

The study also performed a correlation matrix among the various physio-chemical properties to ascertain the kinds of behaviours among them. The results are shown in Table 4.16.

Table 4.16: Pearson's correlation matrix among the physio-chemical characteristics of *prekese*-pineapple formulation in wine fermentation process

		Brix	Acidity	pH	Alcohol
	Correlation	1	0.914**	-0.709**	-0.989**
Brix	Sig. (2-tailed)	-	0.001	0.001	0.001
	N	30	30	30	30
	Correlation	0.914**	1	-0.778**	-0.924**
Acidity	Sig. (2-tailed)	0.001	-	0.001	0.001
	N	30	30	30	30
	Correlation	-0.709**	-0.778**	1	0.721**
pH	Sig. (2-tailed)	0.001	0.001	-	0.001
	N	30	30	30	30
	Correlation	-0.989**	-0.924**	0.721**	1
Alcohol	Sig. (2-tailed)	0.001	0.001	0.001	-
	N	30	30	30	30

**correlation is significant at the 0.01 level (2-tailed)

Results from Table 4.16 showed a positive and strong correlation (r = 0.914; p-value = 0.001) between brix and acidity levels in the *prekese*-pineapple wine fermentation process. The implication is that the acidity level of the wine increased as the volumes of brix increased and decreased as that of brix also decreased. It also suggested that consumers' preference for higher acidity level could be obtained from increasing the brix volume in the formulation. A p-value of 0.001 means that there was a statistical significant relationship between brix and acidity. This was because the p-value of 0.001 was within the error margin of 0.05.

The results also indicated a strong negative correlation (r = -0.709; p-value = 0.001) between brix and pH levels in the formulations. The implication is that as the brix levels increased, the pH levels decreased and while the brix levels decreased the pH levels increased. This can be traced to the fermentation of the sugars in the formulations to produce alcohol. A p-value of 0.001 means that there was a statistical significant relationship between brix and pH levels. This was because the p-value of 0.001 was within the error margin of 0.05.

Table 4.16 showed further that strong negative correlation (r = -0.989; p-value = 0.001) exists between brix and alcohol levels in the pineapple-*prekese* formulations. This showed that the alcohol content decreased as the brix volume increased and vice versa. This was due to the fact that the fermentation of the brix was used to generate more alcohols in the wine. The associated p-value of 0.001 means that the relationship was statistically significant. This was because the p-value was within the error margin of 0.05.

There was also strong negative correlation (r = -778; p-value = 0.001) between pH and acidity levels of the pineapple-*prekese* formulations. This means that increased levels of pH were associated with decreased levels of acidity, and vice versa. This was because the acidity in the fruits had to give way for some pH to reduce the sour taste in the wine during the fermentation process. The associated p-value of 0.001 means that the relationship was statistically significant. This was because the p-value was within the acceptable error margin of 0.05.

Further, there was a strong positive correlation (r = 0.721; p-value = 0.001) between pH levels and alcohol volumes in the pineapple-*prekese* formulations. The implication is that increased levels of pH were associated with increased alcohol level and vice versa. The associated p-value of 0.001 means that the relationship was statistically significant. This was because the p-value was within the acceptable error margin of 0.05.

4.4 Evaluation of the variations in the ratios of *prekese* extract to pineapple juice on sensory acceptability of the wine

Table 4.17: Demographic Characteristics of Sensory Evaluators

Sex		Age		Educational Level	
Male (%)	Female (%)	23-40 (%)	40 and above	Tertiary (%)	Secondary (%)
90	10	67	33	100	0

This section was administered to 30 sensory evaluators. The majority (90%) of the sensory evaluators were males, while 10% were females. Further, 67% of the sensory evaluators were aged within 23-40 years, while 33% were 40 years and above. This suggested that all the sensory evaluators were adults and are permitted to drink alcoholic beverages. With respect to the education characteristics of the sensory evaluators, the study found that-all of them (100%) had attained tertiary education qualifications. Table 4.17 presented results on the results of sensory evaluation on pineapple and *prekese* wine on the various variations of pineapple and *prekese*.

Table 4.18: Results of Sensory Evaluation on Pineapple *Prekese* Wine

Sample	Aroma	Appearance	Colour	Taste	Overall Acceptability
Formulation 1	2.67 ± 1.05^{a}	2.40 ± 1.35^{ab}	2.33 ± 1.01^{a}	2.40 ± 0.99^{ab}	2.73 ± 0.88^{ab}
Formulation 2	2.53 ± 1.06^{a}	2.40 ± 1.30^{ab}	2.00 ± 1.00^{ab}	2.47 ± 1.36^{ab}	2.53 ± 1.30^{ab}
Formulation 3	2.07 ± 0.59^{ab}	2.47 ± 1.30^{ab}	2.27 ± 0.96^{ab}	2.67 ± 1.35^{a}	2.73 ± 1.34^{ab}
Formulation 4	2.40 ± 1.30^{ab}	2.60 ± 1.18^{ab}	2.20 ± 1.08^{ab}	2.80 ± 1.32^{a}	3.07 ± 1.28^{a}
Formulation 5	1.47 ± 0.64^{b}	1.47 ± 0.52^{b}	1.93 ± 0.96^{b}	1.27 ± 0.59^{b}	1.60 ± 0.83^{b}
Control	2.53 ± 0.92^{a}	2.80 ± 0.86^{a}	2.80 ± 1.01^{a}	2.73 ± 1.03^{a}	3.08 ± 1.22^{a}

Note: Means across a column with different letters are significantly different at $P\leq0.05$. (1=like very much, 2=like moderately, 3=neither like nor dislike, 4=dislike moderately, 5=dislike very much).

From Table 4.18, the sensory evaluation focused on the aroma, appearance, colour and taste of the pineapple-*prekese* wine across the various variations in the ratios of *prekese* and pineapple juice. The aim was to ascertain the most preferred ratio across the various indices for possible production. The acceptability criteria were in line with the assertion of Chumngoen and Tan (2015) that wine acceptability is a function of a number of elements, including aroma, appearance, colour, taste, branding, and price. However, issues about branding and price are obtained after commercialisation of the wine, which suggests that the basic elements that new wine developers have to be concerned about are aroma, appearance, colour and taste to generate the necessary sensation for the other two elements based on its performance on the market. A five-point hedonic scale (1=like very much, 2=like moderately, 3=neither like nor dislike, 4=dislike moderately, 5=dislike very much) was used to assess the sensory evaluation. The 5-point hedonic scale was employed to interpret the mean and standard deviation values to ascertain the levels of preferences for the various formulations across the various sensory elements.

In reference to the aroma characteristics, the Table shows that the evaluators most preferred Formulation 5 (1.47±0.64) which had 50% pineapple and 50% prekese, followed by Formulation 3 (2.07±0.59) with 70% pineapple and 30% *prekese*, and Formulation 4 (2.40±1.30) with 60% pineapple and 40% *prekese*. The aroma for Formulation 1 (2.67±1.05) with 90% pineapple and 10% *prekese* was the least preferred followed by Formulation 2 (2.53±1.06) 80% pineapple and 20% *prekese*, and the control Formulation (2.53±0.92), which contained 100% pineapple. Thus, formulation 5 was ranked highest in terms of the aroma because its mean of 1.47±0.64 fell within like very much on the scale. Formulation 3 was ranked second because it had the second lowest mean of 2.07±0.59, which suggested that the mean fell within like moderately. On the other hand, although Formula 1 was liked moderately, its mean score of 2.67 was the highest, indicating that its aroma was the least preferred.

The results showed that sensory evaluators generally liked the aroma from all the formulations. This could be attributed to the natural pineapple aroma that overshadowed the wine, gives the various formulations some fruit juice aroma. In other words, the high concentration of pineapple and its strong aroma were considered as natural, which the evaluators were already used to. According to Swami, Thakor and Divate (2014), giving a fruit base to wine production gives it a natural and usual aroma that consumers are mostly use to and sometimes preferred. The Table further showed that the Control Formulation and Formulation 2 recorded the same mean, however, the Control Formulation was ranked higher than Formulation 2. This was due to the higher standard deviation (1.06) of Formulation 2 as against the Control Formulation (0.92). Thus, Pallant (2005) reported that means with the lowest standard deviations are more representative of their distributions and reliable than those with high standard deviations. The Table also showed that statistically, there was a significant difference between Formulation 3 and the other formulation with an error margin of 0.05. In addition, there was a significant statistical difference between Formulation 4 and the other formulations with an error margin of 0.05.

The results further showed that there was no particular order in terms of preferences for the formulations as the ratios for pineapple and *prekese* changed. This could be attributed to the fact that the sensory evaluators were guided by their sense of smell and taste without knowledge on the various compositions of pineapple and *prekese*. This shows some level of objectivity in their assessments as they were purely guided by their natural tastes and preferences without any influence about knowledge on the various ratios of pineapple and *prekese* components in the wine.

Table 4.18also showed results on sensory evaluation about the appearance of the wine across the various formulations. The aim was to determine the most preferred appearance among the various formulations. From the Table, Formulation 5 was ranked as the most preferred in terms of appearance with a mean of 1.93±0.96. This meant that the sensory evaluators liked the appearance of Formulation 5 very much. Formulation 2 was ranked as the second most preferred sample in terms of appearance with a mean of 2.40±1.30 and followed by Formulation 1 with a mean of 2.40±1.35. The Control Formulation was the least preferred sample in terms of appearance with a mean of 2.80±0.86, and followed by formulation 4 with a mean of 2.60±1.18. Apart from the Control Formulation, all the other formulations had their low limits falling within the like very much on the Likert scale. Further, apart from Formulation 5 whose upper limit was still within like very much, all the other formulations had their upper limits falling within neither like nor dislike section of the Likert scale. The implication is that the sensory evaluators generally liked the appearances of all the formulations of the wine. From the Table, both Formulations 1 and 2 recorded the same mean but Formulation 2 was recorded higher than Formulation 1 because Formulation 2 had a lower standard deviation compared to that of Formulation 1. It is also shown from the Table that apart from Formulation 5 and the Control Formulation that did not make significant difference with the others, all the other formulations recorded significant differences in means with the other formulations.

Another sensory element assessed by the evaluators was colour. The aim was to ascertain their most preferred colour. This was important because Swami et al. (2014) indicated that the colour of wines attract consumers and influence their wine choices. From Table 4.17, Formulation 5 was ranked as the most preferred sample with a mean of 1.93±0.96 in terms of the colour of the wine, followed by Formulation 2 with a mean of 2.00±1.00, and then Formulation 4 with a mean of 2.20±1.08. The Control Formulation was the least preferred sample with a mean of 2.80±1.01, followed by Formulation 1 with a mean of 2.33±1.01, and then Formulation 3 with a mean of 2.27±0.96. This suggested that the sensory evaluators generally preferred the colour of Formulation 5 as compared to the other samples. The Table showed that there were significant differences in the means of the colours for Formulations 2, 3 and 4 and the rest of the formulations.

The sensory evaluators were also made to pass their judgements on the taste of the wine across the various ratios of pineapple and *prekese* compositions. This was important because the taste of wine plays an important role in the choice of wine among consumers as well as encouraging repetitive consumption and creating branding for particular wine among certain cohorts of the population (Mutiat et al., 2017). Results from Table 4.17 showed that the taste from Formulation 5 was the most preferred with a mean of 1.27±0.59, followed by Formulation 1 with a mean of 2.40±0.99, and then Formulation 2 with a mean of 2.47±1.36. Formulation 4 was the least preferred sample with a mean of 2.80±1.32, followed by the Control Formulation with a mean of 2.73±1.03, and then Formulation 3 with a mean of 2.67±1.35. The results showed that all the sensory score of taste were liked moderately, except for formulation 1 which was liked very much. The implication is that the sensory evaluators generally liked the tastes of the wines from the various rations of pineapple and *prekese* compositions. The Table further shows that the means for Formulations 1 and 2 were statistically different from the means of the other formulation.

Based on the measurements for the various indices under the sensory evaluation across the various formulations, the study conducted an overall level of acceptability of wine. The aim was to determine the overall preferences of the evaluators on the various formulations of the wine. Results from Table 4.17 showed that Formulation 5 was the most acceptable among the samples with a mean of 1.60±0.83, followed by Formulation 2 with a mean of 2.53±1.30, and then Formulation 1 with a mean of 2.73±0.88. In addition, the Control Formulation was the least acceptable with a mean of 3.08±1.22, followed by Formulation 4 with a mean of 3.07±1.28 and then Formulation 3 with a mean of 2.73±1.34. The results showed that the most preferred sample was Formulation 1 which was liked very much and the least preferred was the control which was neither liked nor disliked. All the other Formulations were liked moderately. The implication is that the wines across the various formulations with different ratios of pineapple and *prekese* compositions were generally acceptable among the sensory evaluators. The ranking of Formulation 5 as the most preferred and acceptable sample of the wine implies that the possible commercialisation of the pineapple-*prekese* wine should be composed of 50% pineapple and 50% *prekese*. With this composition, the consumers are most likely to accept the aroma, appearance, colour and taste of the wine to promote the successful commercialisation of the pineapple-*prekese* wine.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The thesis assessed five different formulations of win produced from different proportions of pineapple and *prekese* by means of sensory and physiochemical analysis. Five different formulations of wine produced from different proportions of pineapple and *prekese* were subjected to sensory and physiochemical analysis. The formulation made up of 50% pineapple and 50% *prekese* was the most preferred. The sensory properties of formulation 5 (50% pineapple and 50% *prekese*) was liked very much based on the five-point hedonic scale. The physiochemical properties of the formulated wines showed the final alcoholic content of the selected wine (formulation 5) following fermentation was 11.2% which could be described as a table wine.

According to Okafor and Ogonna (2018), wine with alcoholic content ranging between 3% and 13% is classified as table wine.

The average generation of alcohol in the wine following fermentation was 11.6%, which was within the expected alcohol content of the wine from consumers of 13.3% (+/- 4.9). This implies that the wine produced from pineapple and *prekese* was rated as a standard wine. The rating of the pineapple-*prekese* wine as a standard wine suggests that it could survive commercialisation based on its sensory attributes. The study concludes that commercial wines with acceptable attributes could be produced from pineapple and *prekese* fruits.

5.2 Recommendations

Based on the major findings of the study, the following recommendations were made for further research.

1. The study recommends that the marketing of pineapple-*prekese* wine should focus more on the medicinal properties of the wine. This is because the majority of the consumers were very much particular about the medicinal properties of the wine and as such were very willing to drink wine made from *prekese*. This could be done by sensitising the populace about the medicinal properties in both fruits and the benefits to the human body. This will encourage more consumers to drink wine from pineapple and *prekese* to derive such nutritional benefits.
2. It is recommended that the producers of the pineapple and *prekese* wine should ensure that it fits into the production of a table wine with its alcoholic content. This is because the consumers envisaged to drink pineapple and *prekese* wine with alcoholic content of 13.3% (+/- 4.9). The implication is that the production of table wine from pineapple and *prekese* could help attract most consumers to consume the wine to promote the sustainability of its commercialisation.
3. The study recommends that the commercialisation of the pineapple and *prekese* wine should target restaurants, shopping malls and hotels as points of sale. This is because the majority of the consumers reported of getting their wines from these locations.
4. The study further suggests that the production of wine from pineapple and *prekese* should take a critical look at the packaging of the product. This is because the majority of the consumers reported that they were attracted to wines through the packaging. As

a result, having an attractive packaging could help attract more consumers from consuming it to promote sales and sustainability of the commercialisation process.

5. The study recommends that the production of pineapple and *prekese* wine should be done through different volumes of packaging to meet the varied needs of consumers. Thus, whereas some of the consumers preferred 1000ml for group activities, others wanted pocket size packages for convenient usage.
6. It is also recommended that the production of pineapple and *prekese* wine should maintain its texture, flavour, appearance, herbal nature and fruity aroma to continue attract consumers to the wine. This was important because these were the descriptors generated by the evaluators during the sensory evaluation.

5.3 Contribution to Knowledge

The thesis assessed five different formulations of wine produced from different proportions of pineapple and prekese by means of sensory and physiochemical analysis. Five different formulations of wine produced from different proportions of pineapple and prekese were subjected to sensory and physiochemical analysis. The formulation made up of 50% pineapple and 50% prekese was the most preferred. The sensory properties of formulation 5 (50% pineapple and 50% prekese) was liked very much based on the five-point hedonic scale. The physiochemical properties of the formulated wines showed that final alcohol content of the selected wine (Formulation 5) following fermentation was 11.2%, which could be described as a table wine.

5.4 Suggestion for Further Studies

The study suggests that further studies should be conducted into the production of wine from *prekese* and other citrus fruits such as oranges and melons for comparison. This study will help to explore the possibility of adding value to other locally-produced fruits to promote their commercialisation.

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APPENDICES

Appendix I: Consumer Survey Questionnaire

Dear Sir/Madam,

This questionnaire is designed to examine the consumer preferences with respect to the production of alcoholic wine from *prekese* and pineapple. The Researcher is a student from University of Education, Winneba -Kumasi and is writing a research work on Production of *Prekese* Wine. I will be pleased if you will complete this questionnaire for the process. Your response will be treated with utmost anonymity and confidentiality. Thank you for your cooperation. In each question choose the alternative that best reflects in your own opinion or experiences. Thank you for your cooperation.

Section A: Background characteristics of respondents

1. Gender:

   [1] Male [2] Female

2. Age (years):

   [1] 20 – 29 [2] 30 – 39 [3] 40 – 49 [4] 50 – 59 [5] 60 and above

3. Level of education:

   [1] Basic [2] SHS [3] Tertiary

4. Average monthly income (GH₵)

   [1] 1000 and below [2] 1001 – 2000 [3] 2001 – 3000 [4] 3001 – 4000 [5] 4001 – 5000 [6] Above 5000

5. How many bottles of wine do you consume in a month? ……………….

6. How much (GH₵) do you spend on wine in a month?

   [1] 50 and below [2] 51 – 100 [3] 101 – 150 [4] 151 – 200 [5] Above 200

7. What is your most preferred colour of wine?

   [1] Red   [2] White   [3] Gray   [4] Orange   [5] Rose   [6] Others ………..

8. What attracts you to choose a particular wine?

Elements	Strongly Agree (%)	Agree (%)	Indifferent (%)	Disagree (%)	Strongly disagree (%)
Taste					
Colour					
Alcoholic content					
Ingredients					
Country of origin					
Packaging					
Brand					

Section B: Consumer Preferences of wine produced from *prekese* and pineapple

9. Do you eat prekese?

   [1] Yes   [2] No

10. How willing are you to drink wine made from prekese?

    [1] Very willing   [2] Willing   [3] Don't know   [4] Less willing   [5] Least willing

11. Please provide reason for your answer above

    [1] Local taste   [2] Medicinal properties   [3] Good aroma   [4] Bad aroma

    [5] Unusual taste   [6] Used to foreign wines   [7] Others …………

12. What level of alcoholic content do you expect from the prekese wine?

 [1] 1 – 3% [2] 4 – 7% [3] 8 – 11% [4] 12 – 15% [5] 16 - 19% [6] Above 19%

13. Where do you obtain your wines?

 [1] Hotels [2] Shopping malls [3] Wine shops [4] Restaurants [5] Others

14. What will be your most preferred quantity for packaging?

 [1] 300ml [2] 500 ml [3] 750 ml [4] 1000 ml [5] Above 1000 ml

15. How much (GH₵) are you prepared to buy your preferred quantity?

 [1] 10 and below [2] 11 – 15 [3] 16 – 20 [4] 21 – 25 [5] 25 – 30 [6] Above 30

Thank you

Appendix II: Sensory Evaluation Form

Dear Sir/Madam,

The Researcher is a student from University of Education, Winneba -Kumasi and is writing a research work on Production of Prekese-Pineapple Wine. I will be pleased if you will complete this questionnaire for the process. Your response will be treated with utmost anonymity and confidentiality. Thank you for your cooperation. In each question choose the alternative that best reflects in your own opinion or experiences. Thank you for your cooperation.

INSTRUCTIONS

In each case, complete the statement[s] or tick [√] the appropriate option.

A. RESPONDENT'S PROFILE

1. Gender
   a. Male [ ] b. Female [ ]

2. What is your highest level of education?
   a. Primary b. Secondary [ ]
   c. University

3. Among which of the age groups will you place yourself
   a. 15 – 18 [ ] b. 19 – 22 [ ]
   c. 23 – 40 [ ] d. 40 and Above [ ]

4. Occupational Status
   a. Employed [ ] b. Unemployed [ ]

B. SENSORY EVALUATION

Quantify the degree of liking or disliking of the product before you and evaluate each given attribute one by one separately. Put a [√] in the box that best describes your opinion of the product. Please try and give the reasons to your opinion under comments after evaluating the various samples.

Please indicate each sample code on top of the table when evaluating.

Sample code:……………………………………………….

SENSORY ATTRIBUTE	**LEVEL OF LIKENESS OF THE PREKESE AND PINEAPPLE WINE PRODUCT**				
	1	**2**	**3**	**4**	**5**
	Like Very Much	Like Much	Neither Like nor Dislike	Dislike Much	Dislike Very Much
Taste					
Colour					
Aroma/Flavour					
Appearance					
Overall Acceptability					

Which of the sample product you most prefer and why?

…………………………………………………………………………………………

…………………………………………………………………………………………

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…………………………………………………………………………………………

Which of sample product do you least prefer and why?

…………………………………………………………………………………………

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