EFFECTS OF TOMATO (*Lycopercison esculentum L.*) PUREE SUBSTITUTION WITH ROSELLE (*Hibiscus sabdariffa L.*) WASTE IN CHILI SAUCE ON THE PHYSICOCHEMICAL CHARACTERISTICS AND THEIR ACCEPTANCE LEVEL

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FACULTY OF AGROTECHNOLOGY AND FOOD SCIENCE
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Lihat Sebelah

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By
Aloha Binti Ngah

Research Report submitted in partial fulfillment of
the requirements for the degree of
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DEPARTMENT OF FOOD SCIENCE
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ENDORSEMENT

The project report entitled **Effects of tomato *(Lycopercison esculentum L.)* puree substitution with Roselle *(Hibiscus sabdariffa L.)* waste in chili sauce on the physicochemical characteristics and their acceptance level** by **Aloha Binti Ngah,** Matric No. **UK17571** has been review and corrections by examiners have been made according to the recommendations by examiners. This report is submitted to the Department of Food Science in partial fulfillment of the requirement of the degree of Bachelor of Food Science (Food Technology), Faculty of Agrotechnology and Food Science, Universiti Malaysia Terengganu.

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(DR NORIZAH MHD SARBON)

DR. NORIZAH MHD. SARBON
Pensyarah
Jabatan Sains Makanan
Fakulti Agroteknologi dan Sains Makanan
Universiti Malaysia Terengganu
21030 Kuala Terengganu

Date: 9/2/2012

DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged.

Signature :

Name : ALOHA BINTI NGAH

Matric No.: UK17571

Date : 09/02/2012

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ABSTRACT

This study was determined the effects of tomato *(Lycopercison esculentum L.)* puree substitution with Roselle *(Hibiscus sabdariffa L.)* waste in chili sauce on the physicochemical properties such as pH, °Brix value, viscosity, color, proximate and ascorbic acid analysis. The pH value obtained for chili sauces were between 3.94-2.65, the range of °Brix value was 30.63-22.7, and the range for viscosity was 9009-15284 cP. The proximate analysis of Roselle waste were conducted before proceed to the production of chili sauce. The Roselle *(Hibiscus sabdariffa L.)* waste contained 92.31% of moisture, 3.60% of carbohydrate, 0.38% of protein, 1.32% of fat and 2.30% of fiber. Five different formulations of chili sauce were produced with percentage of Roselle waste to tomato puree, sample A (0:100), sample B (25:75), sample C (50:50), sample D (75:25) and sample E (100:0). All chili sauce produced was determined on their physical properties. Viscosity for all samples were increased from sample A to sample E meanwhile for pH value, it was decreased for all sample due to the citric and malic acid content in Roselle waste. Color of sample E was darker due to the anthocyanin in Roselle that give brilliant red color to the chili sauces. In addition, sensory evaluation demonstrated that chili sauce from sample B received the highest score in term of color, aroma, taste, viscosity and overall acceptance. Proximate analysis of sample A (control) and sample B (accepted) formulation was also determined. The proximate analysis of both sample shown that sample B had high fat, fiber, carbohydrate, and ash content compared to the sample A. Besides, ascorbic acid analysis obtained Roselle waste had low level of vitamin C compared with vitamin C in fresh Roselle calyces due to the degradation of vitamin C when exposure to heat whereas ascorbic analysis for sample A and sample B, the vitamin C was high in sample B compared to the sample A.

ABSTRAK

Kajian ini adalah untuk menentukan kesan penggantian pati tomato *(Lycopercison esculentum L.)* dengan lebihan Roselle *(Hibiscus sabdariffa L.)* ke atas ciri-ciri fizikal seperti pH, nilai °Brix, kelikatan, warna, komposisi kimia and analisis asid askorbik. Nilai pH yang diperoleh untuk sos cili adalah antara 3.94-2.65, nilai °Brix adalah diantara 30.63-22.7, dan julat untuk kelikatan pula adalah antara 9009-15284 cP. Komposisi kimia untuk lebihan Roselle *(Hibiscus sabdariffa L.)* di analisis sebelum penghasilan sos cili dilakukan. Lebihan Roselle *(Hibiscus sabdariffa L.)* mengandungi kadar kelembapan sebanyak 92.31%, 3.60% karbohidrat, 0.38% untuk kandungan protein, 1.32% untuk kandungan lemak dan mengandungi sebanyak 2.30% kandungan serat. Lima formulasi sos cili yang berbeza telah dihasilkan dengan menggunakan peratusan lebihan Roselle kepada pati tomato, sampel A (0:100), sampel B (25:75), sampel C (50:50), sampel D (75:25) and sampel E (100:0). Kesemua sampel sos cili yang dihasilkan telah ditentukan ciri-ciri fizikalnya. Kepekatan untuk kesemua sampel telah meningkat dari sampel A kepada sampel E manakala untuk nilai pH, ianya telah meurun untuk semua sampel disebabkan oleh kandungan asid citric dan asid malik yang terdapat dalam lebihan Roselle. Nilai untuk warna untuk sampel E mempunyai warna yang lebih gelap dalam sos cili disebabkan oleh kandungan anthocyanin dalam Roselle yang member warna merah gelap kepada sos cili. Tambahan itu, penilaian deria menunjukkan sos cili sampel B mencapai skor tertinggi dari segi warna, rasa, kelikatan dan penerimaan keseluruhan. Analisis komposisi kimia untuk formulasi sampel A (kawalan) dan sampel B (yang diterima) juga ditentukan. Analisi komposisi kimia untuk kedua-dua sampel menunjukkan sampel B mengandungi kandungan lemak, serat, karbohidrat dan abu yang tinggi berbanding dengan sampel A. Di samping itu, analisis kandungan asid askorbik yang diperolehi menunjukkan lebihan Roselle mengandungi kandungan vitamin C yang rendah berbanding dengan kandungan vitamin C dalam kaliks Roselle segar disebabkan oleh penurunan kandungan vitamin C apabila didedahkan kepada haba manakala untuk analisis asid askorbik untuk sampel A dan sampel B, kandungan vitamin C adalah tinggi dalam sampel B berbanding dengan sampel A.

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LIST OF ABBREVIATIONS

g	Gram
mm	Milimeter
mg	Miligram
µg	Mikrogram
cm	Centimeter
˚C	Degree celcius
mL	Mililiter
cP	Centipoise
β	Beta
α	Alpha
rpm	Revolutions per minutes
BC	Before Century
%	Percentage

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CHAPTER 1

INTRODUCTION

1.1 Background of study

Chili sauces are one popular condiment in Malaysia. Chili sauces can act to enhance food's flavor, texture, moisture and appearance. In local market there are some of well known sauce such as tomato sauce, soy sauce, plum sauces and tamarind sauces. Chili sauces also have great demand in exportation and the processing is quite easy. Chili sauces are made of chili with some other ingredients such as salt, sugar and some thickener in certain amounts. Chili sauces also added with tomato puree to make the chili thicker and to avoid sauce become watery. However, due to the slightly decrease of tomato production in Malaysia and high production of Roselle waste from Roselle cordial production, the addition of tomato in chili sauce could be substituted with Roselle waste *(Hibiscus sabdariffa L.)*.

Roselle waste has similarity properties with tomato, so it is suitable to substitute with tomato. Roselle is belongs to *Malvaceae* family and it has brilliant red color and unique flavor make it a valuable food product. Roselle calyces have repeatedly been shown to have positive health effects (Faraji and Tarkhani, 1999; Tseng et al., 1997). Roselle also had greater overall antioxidant (Refaei et al., 2010). In China, it is used to treat hypertension, pyrexia, and liver damage. The fleshy calyces of Roselle flowers have a pleasant acid taste and very attractive red color.

The anthocyanins are responsible for the red color, while the acid taste is due to the presence of some organic acids (Refaei et al., 2010).

1.2 Problem statement

In Roselle cordial production some amounts of Roselle waste has been produced. The Roselle cordial production for 50kg of fresh Roselle will produce 30kg of Roselle waste. So, the Roselle waste was reused as substitute with tomato puree in chili sauce production in order to reduce the amount of Roselle waste. Besides that, the growth of sauces demand and sauces production was increased year by year. Although, the production of chili sauce in market was mixed with tomato puree but the production of tomato in Malaysia was slightly decreased. There was lower quantity in tomato production worth 1,352 metric tons (8.92% decreases) because the production of tomato in 1998 was worth 15,165 metric tons whereas 13,813 metric tons whereas in 1999.

1.3 Significance of study

The substitution of Roselle waste with tomato in chili sauce can reduce the amount of Roselle waste due to the high produce of Roselle waste in cordial Roselle production. Furthermore, Roselle has very attractive color (Refaei et.al, 2010) due to the presence of anthocyanin pigments in the Roselle calyces. The brilliant red color and unique flavor of Roselle make it a valuable food product. So, the color of chili sauce became more attractive. Besides that, the uses of Roselle waste as substitute with tomato in chili sauces can reduce the price and cost of chili sauces production because the price of fresh Roselle calyces is cheaper than tomato.

1.4 Objectives

The objectives of this study are:

1. To reuse the Roselle (*Hibiscus sabdariffa L.*) waste that produced from cordial production.
2. To produce chili sauce by substituted tomato (*Lycopercison esculentum L.*) with Roselle (*Hibiscus sabdariffa L.*) waste.
3. To study the effects on the physicochemical characteristics and the acceptance level of chili sauce with Roselle (*Hibiscus sabdariffa L.*) waste substitution produced.

CHAPTER 2

LITERATURE REVIEW

2.1 Sauce

In Malaysia, sauces are popular food item that act as condiment to enhance food's flavor, texture, moisture, and appearance. In local market some of well known sauce soy sauce, tomato sauce, chili sauce, and plum sauces from various brands. Some imported sauces also available such as salad dressings, cocktail sauces and so on (Faridah and Rokiah, 1997). According to Faridah (2005), sauces from Europe such as pasta sauce or salad dressings have high growth rate, 5 percent per year compare to the 1 % or 2 % per year of Asia sauce such as chili sauce, soy sauce or other fermented sauces. However, the growth industries of sauces have increased from 1.8 % to 1.9 % per year. Sales volume of Asia sauces is higher than Europe sauces because low in market share of Europe sauces. Local demand and export are increases rapidly. World demand on tropical sauce and ethnic sauces are also increase.

Table 2.1: Malaysia retail market size on sauces, dressing and condiment in Malaysia 2003 is valued RM943.7 million

Types of sauces	**RM(million)**	**Percentage (%)**
Tomato puree and paste	5.7	0.60
Bouillion, stock and cubes	16.3	1.73
Herbs and spices	407.2	43.15
Fermented sauces:	119.7	12.68
Chili sauces	72.4	
Oyster sauces	41.4	
Other fermented sauces	5.9	
Soy sauces	115.4	12.23
Pasta sauces	15.5	1.64
Wet sauces	109.4	11.60
ketchup	47.7	5.05

Source: Faridah, 2005

2.1.1 Sauce definition

Sauce is a liquid plus with thickening agent plus and plus with some seasonings (Labensky and Hausse, 1999). According to Farrell (1990), sauces is defined as any hot or cold liquid or semi liquid product other than condiment, which added to food as it is being served, added to acceptance by improving its appearance, aroma, flavor, and texture. It is may or may not include the use of spices or spices extracts.

Besides that, according to Malaysian Food Act (1983) and Food Regulations (1985), sauce or also known as ketchup shall be the product prepared in liquid forms or semi liquid forms with or without the use of spices or spices extracts to enhance a food's flavor, texture, moisture, and appearance. For the purpose of this regulations, sauce included fish sauce, "budu" and "cincalok".

The word "sauces" is originally come from feminine of Latin word 'salus', meaning 'salted'. This derivation is appropriate because salt has been the basic condiment for enhancing or disguising the flavor of many foods (Labensky and Hausse, 1999). According to Faridah (2005), sauce is the mixture of varieties of food ingredients that have been processed as flavor to enhance food's flavor. Sauces can be in liquid, paste or powder. Sauces product in market can be classified into two groups, it is sauce that origin from Europe and sauces from Asia. Sauces chilies is sauces industry main product with new varieties such as Thai chilli sauces, green chili sauces, black pepper flavored chili sauces and chili sauces on tropical fruit.

2.1.2 Role of sauce ingredients

In fact, there are some ingredients used in Roselle waste substitute with tomato in chili sauces. The ingredients are dried chili and Roselle waste as main ingredients. The other ingredients used are salt, sugar, water, garlic, spices and modified cornstarch. All this ingredients give impact on their own characteristics for Roselle waste substitute with tomato in chili sauces.

The amount of water used in sauce production is controlled in order to avoid in appropriate viscosity. Salt is use as seasoning to achieve desirable flavor. It is also can increase the flavor and bring out the flavor of the product. Besides that, sugar is added because it fulfills the degree of sweetness to the sauces. Sugar also can act as preservatives in order to extend the shelf life of the sauces. It preserved the sauces due the lower water activity of microorganism in the sauces (Labensky and Hausse, 1999).

Based on Nora Asikin (2007) have reported that, an acid was needed to react with other ingredients such as salt and also increase the taste and aroma of the sauces. The common acid use is citric acid that contain in citrus fruits. Citric acid is the most versatile and wide use food acidulants. It has been used in food more than 100 years. However, in chili incorporated with Roselle waste sauces, citric acid from citrus fruits is not been added because Roselle has already contain citric acid (Mardiah, 2009). Citric acid is used as flavor enhancer, preservative and antioxidant synergist with ascorbic or erythorbic acid and as pH regulator. It is also contribute to the excellent solubility, extremely low acidity, chelating ability and pleasantly sour taste (Diena et al., 2005). Garlic is used to give flavor and aroma to the sauces. When raw garlic are crushed or chopped, a series of chemical reactions produces their familiar assertive aroma and flavor (Peterson, 1998).

2.2 Chili sauce

According to Malaysian Agricultural Research and Development Institute MARDI (1983), chili sauces are a popular condiment in Malaysia. Chili sauces are made of chili with some other ingredients in certain amount. Since chili sauce can be kept long, it has a wide market demand. Usually chili sauces were distributed through mini market, convenience stores, supermarket, and food premises. Chili sauce can also be found in institutional operations and also have a great demand in exportation. Chili sauces processing is quite easy and can be done in small scale as well as a low production cost.

Malaysian Food Act (1983) and Food Regulations (1985) stated that chili sauces shall be produced from high quality of chili as mentioned in regulations 297 or chili powder with salt, sugar, vinegar with or without other food products. It must contain not less than 5% of fresh chili. It also shall contain not less than 25% of total soluble solid and 0.8% of total acidity that stated as acetic acids. Chili sauces may contain permitted preservatives, permitted colouring substance, permitted flavouring substance and permitted food conditioner. Chilis sauces shall not show any fermentation changes if incubate at 37°C for 15 days. Howard Culture Count shall not more than 50% from counted field.

2.3 Chilies history

Chilies are the world's oldest cultivated plant. According to (Cheifitz, 1994) wild chilies were eaten by the ancient Mexicans from as early as 700BC and cultivated there from around 5200BC. By the time Columbus landed in the Americas in 1942, the chili was known from Mexico to Brazil, and in Chile, Argentina, the West Indies and the Caribbean. Peppers seed were carried to the Spain in 1943 and from there their popularity spread rapidly throughout Europe. Spices is very lucrative and were treasured as a gems during Columbus time and because they not found in Europe explorers of the fifteenth and sixteenth centuries were looking for new sea routes to the East where the home of spices.

Based on Cheifitz (1994), the irony of the Columbus' discovery of the Americas is that he was, in fact looking for the spices islands or East Indies and India, as well as hoping to discover a source of black pepper. In consequence, therefore although the Mexicans called the hot spices they knew by its Nahuatl name, 'chili', Columbus insisted on calling it 'pepper', and on calling the native Americans 'Indians'. It was the Portuguese navigators since Da Gama who took the chili from the New World to the East. In this way, the chili became the mark of many Asian cuisines which is from Thailand, the Sichuan region of China, Malaysia, Singapore and Indonesia to Korea. The Spanish introduces chili to India.

2.4 Chili

Chilies are members of large *solanaceace* family of plant of the genus *capsicum.* Chilies have five species. There are *capsicum annuum*, *capsicum frutescens*, *capsicum Chinese, capsicum pubescens,* and *capsicum baccatum* (Raghavan, 2007). Chili, chile, or chili peppers are the commonly used terms for hot peppers in the United States, Canada, Central America, and Mexico. Chili is the word for the hot chile pepper in Asia, England, and other English-speaking region, while the term capsicum is used for the nonsweet bell peppers. The Food and Agricultural Organization (FAO) refers to the hot varities as chilies. South Americans refer to chile pepper as aji which came from the Arawaks. Hungarians call any Capsicum paprika, but to the world paprika is the ground red powder that provides mostly color with some flavor (Raghavan, 2007).

Chilies add flavor as well as heat to foods. They enchance and provide a background note for other spices and flavorings. Mexican have mastered the knowledge of use of different types of chilies to achieve that characteristics flavor, aroma, mouth feel, color and bite in their foods (Raghavan, 2007). Chilies native to

Central and South America, have been enthusiastically adopted by cooks in Europe, Africa, the Middle East, India and South-east Asia, as well as the America (Gould, 1974). There are the common red, green, and yellow peppers which are rich in vitamin A and C and used as flavouring or simply as vegetables. The word 'chili' comes from the Spanish 'chile' and 'chili' has been use to describe hot peppers since the seventh century (Cheifitz, 1994).

Chilies have chemical effects on our bodies which are some of us enjoying more than others. Once you got over the stage where the slightest hint of chili makes you cry and splutter, you may find that the flavor becomes pleasurable and even addictive. Chilies are rich in vitamin; they stimulate the appetite and cool the body, especially in hot climates, by making the person sweat. The cooling effect also creates a feeling of calm and benignity. To relieve the burning sensation in the mouth, drink yogurt or milk, not water or beer.

2.4.1 Aroma and flavor of chilies

The characteristics pungency of chilies is caused by the presence of capsaicin. Research has indicated that the components of capsaicin (*capsaicinoids*) promote different taste sensations when eaten, giving either a short fiery flavor or lingering hot taste. The hotness is said not to come from the seeds but rather the placenta. This is the pithy white part of the fruits to which the seeds are attached, and it does contain the most capsaicin so removal of both seeds and placenta should reduce the pungency of chilies, if required. The heat of chilies is measured in scoville units, ranging from 0 (for sweet bell peppers) to 30,000 (for habareno). To provide a simple guide, the scale has been reduced to 0-10, with the habaneros having a scorching rating of 10 (Morris and Mackley, 2007).

According to Raghavan (2007), chilies contain 0.2% to 2% capsaicinoids (vanillylamides of monocarboxyl acids), which are responsible for the pungency or bite in capsicum. Heat are varies widely among the different chilies depending on their chain length. Capsaicinoids are mostly found in the white or placenta that runs down the inside of the chili, in the seeds and in the skin. Most of overall heat is due to two capsaicinoids, capsaicin and dihydrocapsaicin. Capsaicin, an alkaloid, accounts for about 50% to 70% of the total capsaicins. It gives the bite but has no odor. The other bite contributing components are 20% to 25% dihydrocapsaicin (DHC), which together with capsaicins provides the fieriest notes from midplate to throat; 7% nordihydrocapsaicin (NDHC), which is fruity and sweet and has least burning sensation; about 1% homodihydrocapsaicin (HDHC), both of which give a numbing and prolonged burn. The degree of heat or pungency of chillies varies based on the varieties, origin, growing conditions, and drying conditions (Raghavan, 2007). Their pungency is influenced by several factors, such as high night temperatures and drought or over watering (Morris and Mackley, 2007). Heat is measured by using organoleptic test or high performance liquid chromatography (HPLC). The capsaicinoids are measured in parts per million and are then converted to Scoville Units. Heat values can vary with the same type of chilies, such as jalapenos or cayennes, based on its origin, breeding, and climatic and growing conditions.

2.4.2 The nutritional value of chilies

Chilies are high in vitamin A and C. Green chilies have double the vitamin C of a regular-sized orange, while red chilies have more vitamin A compare to the carrots. They are low in calories and sodium and contain potassium, phosphorus, magnesium and folic acids (Raghavan, 2007). Based on Cheifitz (1994), there are the common red, green and yellow peppers which are rich in vitamins A and C.

2.4.3 The use of chilies

The chili flavor revolutionized the cooking of tropical countries with bland staple foods, like cassava in South America, West and East Africa; rice in India and South-east Asia; and beans in Mexico and the Southern States of America. Famous Mexican moles, chili con carne and Tex-mex foods make extensive use of chilies. Curries from Thailand and Malaysia, and Indonesia sambals and satays all rely on chilies for their characteristics flavours. Many of Szechuan dishes depend on the chili flavor. Countries which do not use chilies as extensively in everyday dishes also depend on their heat for certain traditional preparation. For example, piquant pasta dishes from Italy use fresh and dried chilies, and prudent use of chilies is made in many pickles, relishes and cooked chutneys of the more Northern European countries (Morris and Mackley, 2007).

Furthermore, Raghavan (2007) said that the ancient Mayans and Aztecs used chilies as food and medicine and in religious rituals and ceremonies. Nowadays, they provide not only heat but also flavor, color, and visual appeal to foods around the world. Caribbean, Mexicans, South America, Mediterranean, Asian Indians and South-east Asians used chilies to add zest or flavor to their cuisine. These ethnic cuisines use chilies as vegetables when fresh and as spices when dried or smoked.

Chilies also made into hot sauces or signature spice blends that are characteristics of a region. The early hot sauces were made by the Cribs and Arawak Indians, who mixed chilies with cassava juice to create coui. Todays, hot chilies are pickled or pureed as table's condiments or sauces all over the Caribbean. The fiery Bajan sauces contains scotch bonnets with other ingredients such as fruits, mustard, garlic, thyme, green onions, and clove. Similarly, Louisiana hot sauce, *sambals* of Indonesia, salsas and moles of Mexico, *goit chu jang* of Korea, *balachuang* in Myanmar, *harrisa* of Tunisia, romesco of Spain and *chaat masala* of India contain chilies as an essential flavoring.

In Asian cooking, dried whole red chilies are fried in hot oil until they turn dark brown. This hot oil is added to Szechwan and Hunan stir fries, and in India, a mixture of chilies and oil is added to spice up many curries and dals. Chilies pair well with garlic, fermented beans, ginger, coconut, shallots, fermented fish or shrimp, galangal, turmeric, sesame oil and fruit sauces. In south-east Asia, Korea, and Szechwan region, they are added to the fermented soybeans and seafood to make fiery hot pastes for many dishes. Dried and fresh chilies are a must in Thai salads and curry pastes, Korean *kimchis*, Indonesian *rendangs*, and Malaysian *sambals*. In India, dried red chilies and fresh green chilies are popularly used. Sri Lankans and South Indians use whole cut chilies abundantly in snacks, chutneys and curries. The black curries of Sri Lanka contain bird peppers and cayenne with toasted spices (Raghavan, 2007).

In Eastern Europe, chilies are not commonly used, except in Hungary. In the Mediterranean regions, the North Africans usually use the hotter chilies, while in Spanish use the mildly hot ones. In Latin America, chilies add heat to land potatoes, yuccas, salsas, ceviches, moles, and condiments. Mexicans, Ecuadorians, Brazilians, and Peruvians use many types of fresh and dried chilies (jalapenos, habaneros, ajis, rocotos, and malaguetas) to create moles, ceviches and salsas. *Ocapa* (potato, peanut, cheese with ajis), stuffed rocotos, *pebre* (with olive oil, cilantro and red chilies), *aji molida* (with fresh chilies, herbs, and onions), *salbutes* (puffed tortillas) topped with a hot sauce of habaneros, lime juice, and onions, and chimmichurri with ajis, cilantro, garlic and lime juice are common application (Raghavan, 2007).

2.5 Chili products

2.5.1 Chili sauces

Tabasco sauce is a North American seasoning made from extremely hot Tabasco or cone chilies, which are mixed with salt and vinegar and then matured in white oak cacks for several years. Many of the islands of the Caribbean have their own style of chili sauce. Most are like Tabasco, made from steeping the chilies in vinegar and all are very hot indeed. Chili sauces are widely used in small quantities as a general seasoning. Tabasco is served with tomato juice and used to flavor Bloody Mary cocktails (Morris and Mackey, 2007).

2.5.2 Chili paste

Readymade chili paste is sold in small jars. However, it is easy to make at home. Simply seed fresh chilies then puree them in a food processor to make a smooth paste. An onion can be added to the processor to add bulk to the paste (Morris and Mackey, 2007).

2.6 Cultivation of chilies

Chilies are a part of the potato, tomato, aurbergine and nightshade family of plants. The chili family is minefield; there are at least 150 different types. The plant, which is bush-like, grows up to about 0.6 meters/2 feet and bears white flowers that produce fruits in a variety of size and shapes. Some chilies look like stout fingers such as the cayenne, others are tiny like bird's eye chilli, which is very tiny, explosive, and often use d in Thai cooking, and some look deceptively like mini sweet peppers. For example, habanero, this is the hottest. The plants grow at altitudes from sea level to 1800 meters/6000 feet in tropics.

Green chilies are immature fruits and red chilies have been allowed to ripen for a further 4 weeks. Ripened chilies can also be orange-yellow, purple, dark brown or black. India is the largest producer and exporter of chilies, with a significant part of the total crop used for home consumption. Travelers in Rajasthan and the south of India marvel at the acres of chilies, lay out to dry like a huge red carpet stretching as far as the eye can see. Thailand, Mexico, Japan, Turkey, Nigeria, Ethiopia, Uganda, Kenya, and Tanzania are also major producers, and they export chilies to other countries around the world. The most common Mexican chilies, used in the cuisine to make fiery salsas, bean, fish and poultry dishes, are fresh green Serrano, jalapeno and poblano chilies (Morris and Mackley, 2007).

2.7 Roselle (*Hibiscus sabdariffa L.*)

Roselle (*Hibiscus sabdariffa L.*) is belongs to *Malvaceae* family same like hibiscus and okra beans. There are more than 300 species of hibiscus around the world (Emmy Hainida et al., 2008). Roselle can be found in almost all countries such as

India, Saudi Arabia, Malaysia, Indonesia, Thailand, Vietnam, Sudan, Egypt, and Mexico (Mat Isa et al., 1985). The origin of *Hibiscus sabdariffa L.* is not fully known, but it is believed to be native of tropical countries such as Africa, West Indies and Central America (Emmy Hainida et al., 2008). It was first introduced to West Indies, and cultivated mainly as an ornamental plant.

Roselle is a new commercial crop in Malaysia, where it was natively brought from India to Malaysia (Amin et al., 2008). Roselle industry in Malaysia has been introduced in 1993 at Terengganu as a trial in order to commercialize Roselle and nowadays, Roselle is planted in Kelantan, Terengganu, Pahang, Johor, Selangor and Sarawak (Musa et al., 2006). It is known by different synonyms and vernacular names such as Roselle (Abu Tarboush et al., 1997; Chewonarin et al., 1999; Tsai, et al., 2002), karkade (Abu Tarboush et al., 1997) and mesta (Rao, 1996). In Malaysia, it is also known as *asam paya*, *asam susur* or *asam kumbang* (Musa et al., 2006).

2.7.1 Ecology of Roselle (*Hibiscus sabdariffa L.*)

Roselle is an annual erect, bushy, herbaceous sub shrub, with smooth or nearly smooth, cylindrical, typically red stems. It can grow to 0.5-3 m in height with a green or red or pale yellow calyx that is edible (Brouk 1975; Purseglove 1986; Morton 1987). The plant takes about 3-4 months to reach the commercial stage of maturity before the flowers are harvested. Roselle plant is suitable for tropical climates with well-distributed rainfall of 1500-2000 mm/year, from sea level to about 600 m in altitude. The plants are tolerates a warmer and more humid climate with night time temperature not below 21°C, and is most susceptible to damage from frost and fog. In addition, it requires a permeable soil, preferably a friable sandy loam with humus;

however, it will adapt to a variety of soils. It can tolerant, and must be keeping weed-free (Robert, 2005).

According to Tindal (1986), the plant has been found to thrive on a wide range of soil conditions. It can perform satisfactorily on relatively infertile soils but for economic purposes, a soil well supplied with organic materials and essential nutrients is essential. It can tolerate relatively high temperature throughout the growing and fruiting periods. The plant requires an optimum rainfall of approximately 45-50 cm distributed over a 90-120 day growing period (Tindal, 1986). Figure 2.1 was shown the Roselle *(Hibiscus sabdariffa L.)* plant.

Figure 2.1: The Roselle *(Hibiscus sabdariffa L.)* plant (Source: Morton, 1987)

2.7.2 Nutritional value of Roselle (*Hibiscus sabdariffa L.*)

Red calyces are the commercially valuable, its contain anthocyanins, vitamin C, B1, B2 and high in B complex. Roselle calyces have repeatedly been shown to have positive health effects (Faraji and Tarkhani, 1999; Tseng et al., 1997). It is commonly used to make jelly, jam, juice, wine, syrup, gelatin, pudding, cake, ice cream and flavors (Refaei et al., 2010). According to Mardiah (2009), the important value in Roselle calyces is the anthocyanins (flavonoid) as an antioxidant. *Cyanidin-3-monoglucoside*, *delphinidin-3-monoglucoside* and *delphinidin* are the types of anthocyanins present in the calyces (Amin et al., 2008). This antocyanin are believed to cure degenerative disease (Mardiah, 2009). The red Roselle calyces also contain antioxidants including flavonoids, gossypetine, hibiscetine and sabdaretine. These antioxidants help bodies fight the harmful molecules known as free radicals, which can cause cell damage leaving the body in a diseased state. By taming free radicals, antioxidants help maintain the body's good health (Anon, 2005).

Besides that, Roselle calyces are also high in calcium, niacin, riboflavin and iron. Iron content 8.98 mg/100g in Roselle calyces. Roselle calyces contain 1.12% of protein, 12% crude fiber, and 21.89 mg/100g of sodium, vitamin C and vitamin A. Roselle calyces have sour taste due to its citric acid and malic acid component. Vitamin C and vitamin A of Roselle calyces is also higher compared to the papaya, apple, guava and lime (Mardiah, 2009). The vitamin A content is 113.46 mg/100 g and vitamin C is 214.68 mg/100 g of Roselle extraction. Roselle contains three times more vitamin C than blackcurrent (*Ribes nigrum L.*) and nine times more than citrus (*Citrus sinensis L.*) fruit (Amin et al., 1996). Table 2.2 show the analysis nutritional value of Roselle calyces in each 100 g.

Table 2.2: Nutritional value of Roselle calyces in each 100 g.

Composition	**Total**
Protein	1.145 g
Fat	2.61 g
Fiber	12.0 g
Ash	6.90 g
Calcium	1.263 mg
Phosphorus	2.73.2 mg
Iron	8.98 mg
Carotene	0.029 mg
Thiamin	0.117 mg
Riboflavin	0.277 mg
Niacin	3.765 mg
Ascorbic acid	6.7 mg

Source: Musa, 2006 (MARDI)

According to Duke and Atchley (1984) reported that every 100 g of fresh calyces contains 2.85 μg vitamin D, 0.04 mg vitamin B1, 0.6 mg vitamin B2, and 0.5 mg vitamin B complex. Furthermore, the others studies also reported that it is good in reducing hypertension (Adegunloye et al., 1996; Onyenekwe et al., 1999). (Duke, 1983) and (Mat Isa et al., 1985) found that 100 g of fresh Roselle calyces contain 84.5% of moisture content. Furthermore, Roselle calyces contain 1.9 g protein, 0.1 g fat, and 12.3 g of carbohydrates, 2.3 g fiber and 1.2 g ash (Duke and Atchley, 1984). It also contains 1.72 mg Ca, 57 mg Fe, 300 μg β-carotene equivalent, and 14 mg ascorbic acid/100 g (Duke, 1983).

2.8 Tomato *(Lycopersicon esculentum L.)*

Tomato is grown throughout the world for its fruit. Tomato is the fourth most commonly consumed fresh produce and the most frequently consumed canned produce in the American diet (Canene et al., 2004). It is also among the ten most important fruits and vegetables in the terms of consumption, with estimated 124.4 million tons of tomato fruits produced every year all over the world (Maul, 1999). More than 80% of processed tomatoes are consumed in the form of tomato juice, paste, puree, sauce and salsa (Oke et al., 2010). The consumption of tomato has increased over the past three decades because of an increased knowledge of the nutritional and processing qualities of tomato and tomato products. Tomatoes contain many bioactive components such as vitamins C, vitamin E and carotenoids. Lycopene, the main carotenoid in tomatoes, is believed to be responsible for the positive health effects associated with increased tomato intake. The characteristic deep-red color of ripe tomato fruits and tomato-based foods is mainly due to lycopene (Shi and Maguer, 2000). Figure 2.2 was shown the tomato *(Lycopersicon esculentum L.)* fruits.

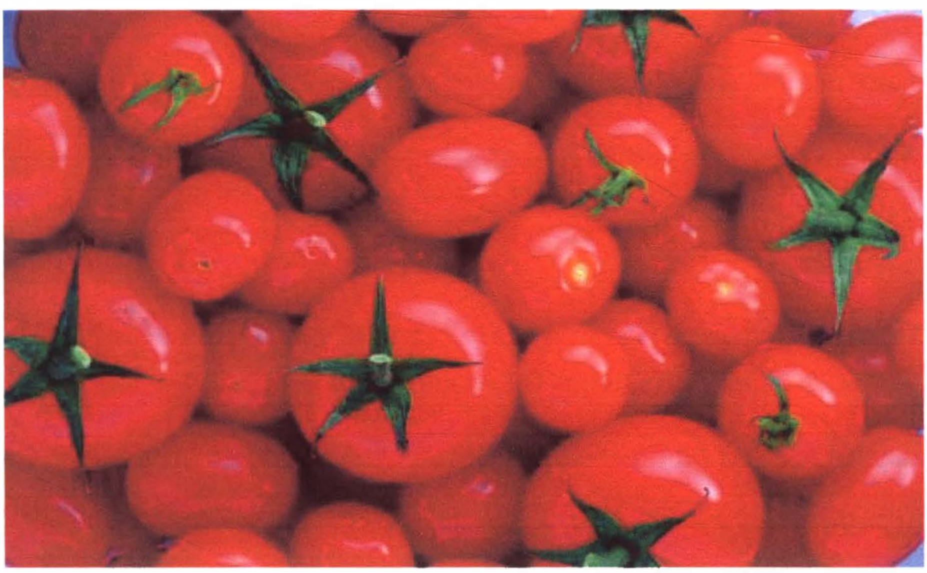

Figure 2.2: The tomato *(Lycopersicon esculentum L.)* fruits (Source: Peterson, 2009)

2.8.1 Nutritional composition of tomato

Tomatoes are composed of 93-95% of water. The remaining constituents include 5-7% inorganic compound, organic acids (citric and malic acid), sugar (glucose, fructose and sucrose), solid insoluble in alcohol (proteins, cellulose, pectin, polysaccharides, carotenoids and lipids) (Derly et al., 1999). The tomato possesses many valuable properties including abundance of potassium although; it is not rich in essential nutrients for human beings (Grierson and Kader, 1986). Potassium is important in the control of the osmotic pressure of the blood, kidney functions and control of heart muscle contractions (Anderson et al., 1998).

Carotenoids are also important to humans because of their nutraceutic property. The carotenoid lycopene is responsible for the red color of the fruit and constituents 75-83% of the total carotenoids. The β carotene pigment is responsible for the yellowish color and represents 3-7% (Gould, 1974). Lycopene is found in great concentrations, but only in restricted number of vegetables. The tomato is the main source of these, containing high amounts, which, however, vary as a function of time of harvest, geographic location and plant genotype. In the human organism the lycopene present in high concentrations in the blood plasma, seemingly an essential fraction, acting as natural defense pathway and acting as an antioxidant and antimutagenic agent.

The content of β carotene determines the activity of vitamin A, which has been cited as important in the prevention of coronary disease and cancer (Abdulnabi et al., 1996). The concentration of β carotene varies considerably among species, cultivars and lineages. Besides vitamin A, the most important vitamins in the constitution of the fruit are vitamin B1 (Thiamine), B2 (riboflavin), B3 (pantothenic acid), B6, niacin, folic acid, biotin, ascorbic acid and α tocopherol. Among these, several studies have reported the importance of vitamin C in the human diet, cited mainly for its antioxidant activity (Abdulnabi et al., 1996). Vitamin E is present exclusively in the seeds and as these eliminated in most of the process to which the fruits are subjected its contribution to human diet becomes irrelevant. Processing also reduces levels of the remaining vitamins.

In addition, among the acid present in the tomato fruit, the main acids are citric and malic, with citric acid being predominant over malic acid (Bertin et al., 2000). Any change in the contents of citric or malic acid will alter the content of titratable acid and will change the degree of acidity of the fruit, altering its flavor. It is important to emphasize that the potassium present in the fruits is positively related to the reduction of maturing disorders and to the increase in acid concentration in the fruits (Ho, 1996).

2.8.2 Tomato products

More that 80% of tomatoes produced are consumed in the form of processed products such as juice, paste, puree, ketchup, sauces and soup (Willcox et al., 2003). Tomato pulp refers to crushed tomatoes either before or after the removal of skins and seeds. Tomato juice refers to juice from the whole crushed tomatoes from which the skins and seeds have been removed and which has been subject to fine screening, as intended for consumption without dilution or concentration. Tomato paste is the product resulting from the concentration of tomato pulp, after the removal of skins and seeds, and contains 24% or more natural tomato soluble solids. Tomato paste that is marketed to the consumer in small packs and sold as condiment, it may also be described as tomato puree. Tomato puree is the term applied to lower concentrations of tomato paste (containing 8-24% natural tomato soluble solids). In any case, the nutritional value of tomato products depends on processing and storage conditions (Shi and Le Maguer, 2000). Nutrient content is also affected by variety and maturity (Willcox et al., 2003). Special concern arises in the case of juice or other tomato beverage products because of the losses of vitamin C (Hayes et al., 1998). Table 2.3 shows the nutritional information for 50 g of tomato paste:

Table 2.3: Nutritional information for 50 g of tomato paste

Composition	**Total**
Calories	18 Kcal
Carbohydrates	2.8 g
Proteins	1.3 g
Total fat	0.2 g
Saturated fats	0.1 g
Sodium	180 mg
Lycopene	13 mg

Source: Edinger and Koff (2006)

2.9 Sensory evaluation

Sensory analysis is a multidisciplinary science that uses human panelists and their senses of sight, smell, taste, touch and hearing to measure the sensory characteristics and acceptability of food products, as well as many other materials. There is no one instrument that can replicate or replace the human response, making the sensory evaluation component of any food study essential. Sensory analysis is applicable to a variety of areas such as product development, product improvement, quality control, storage studies and process development. A sensory panel must he treated as a scientific instrument if it is to produce reliable, valid results. Tests using sensory panels must be conducted under controlled conditions, using appropriate experimental designs, test methods and statistical analyses. Only in this way can sensory analysis produce consistent and reproducible data (Watts, 1989).

CHAPTER 3

MATERIALS AND METHODS

3.1 MATERIALS

3.1.1 Raw materials

Roselle *(Hibiscus sabdariffa L.)* waste has been collected from Natural Nutrition, Rhu Tapai, Lembah Bidong was in frozen form. Roselle *(Hibiscus sabdariffa L.)* waste was stored in freezer at below -18°C. UKMR-1 was species of Roselle *(Hibiscus sabdariffa L.)* waste that was used in chili sauce production. Dried chili and other ingredients such as tomato *(Lycopersicon esculentum L.)* puree, sugar, garlic, salt and modified cornstarch has been purchased at Mydin, Kuala Terengganu. Figure 3.1 was shown the frozen Roselle waste.

Figure 3.1: frozen Roselle waste as raw material

3.2 METHODS

3.2.1 Formulations of tomato puree substitute with Roselle waste in chili sauces

To meet the objectives of this study, the percentage of tomato puree and Roselle waste in chili sauces were changed consecutively in order to determine which one is the most acceptable based on sensory evaluation and the effects on physical and chemical analysis was investigated. According to Faridah (2005), five different formulations of substitute tomato puree with Roselle waste in chili sauces were identified and modified.

The percentage of tomato puree and Roselle waste were changed consecutively which is sample A contains 100% of tomato puree and 0% Roselle waste, sample B consist 75% of tomato puree and 25% of Roselle waste, sample C consist 50% tomato puree and 50% of Roselle waste, 25% of tomato puree and 75% of Roselle waste for sample D and 0% of tomato puree and 100% of Roselle waste. The percentage of other ingredients such as dried chili, sugar, salt, water, garlic and modified cornstarch remain the same for all five formulations. Table 3.1 showed the different formulation for substitution of tomato puree with Roselle waste in chili sauces.

Table 3.1: Five different formulation of tomato puree substitute with Roselle waste in chili sauce.

Ingredients	Sample A		Sample B		Sample C		Sample D		Sample E	
	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)
Dried Chili	60	8	60	8	60	8	60	8	60	8
Tomato puree	**150**	**20**	**112.5**	**15**	**75**	**10**	**37.5**	**5**	**0**	**0**
Roselle waste	**0**	**0**	**37.5**	**5**	**75**	**10**	**112.5**	**15**	**150**	**20**
Sugar	75	10	75	10	75	10	75	10	75	10
Salt	4.5	0.6	4.5	0.6	4.5	0.6	4.5	0.6	4.5	0.6
Water	450	60	450	60	450	60	450	60	450	60
Garlic	6	0.8	6	0.8	6	0.8	6	0.8	6	0.8
Modified cornstarch	4.5	0.6	4.5	0.6	4.5	0.6	4.5	0.6	4.5	0.6
Total	750	100	750	100	750	100	750	100	750	100

Source: Modified from Faridah, 2005 (MARDI)

3.2.2 Production step of tomato puree substitute with Roselle waste in chili sauces.

Firstly, the ingredients to produce chili sauces such as dried chili, tomato puree, Roselle waste, water, sugar, salt, garlic and modified cornstarch were prepared. Roselle waste was thawed and blended prior used. Roselle waste was blended with water in 1:2 (Roselle waste: water), in order to get the same moisture content tomato puree. Dried chili was cleaned and cut into smaller pieces prior to blending. Dried chili was blanched for 10 minutes (90-100°C) (Noryati, 2006). The blanching process will soften the dried chili (Norjimi, 2009). Then, based on the formulation in Table 3.1, the amount of each ingredient was measured correctly. Dried chili, tomato puree, Roselle waste and garlic was blended together until really smooth.

Next, the blended ingredients were poured into saucepan. Water was added and stirred properly. The mixture was heated and cooked until boiled (95°C). After that, salt and sugar was added and stirred well until it achieved at least 30° Brix. When mixture achieved 30° Brix, modified cornstarch was added and the heat was lowered. The sauces was stirred evenly and simmered for 5 minutes. Then, the glass bottle had through pasteurization process (below 100°C) prior sauces are filled into glass bottle. Lastly, the glass bottle that filled with sauces was sealed and stored at ambient temperature. The steps of chili sauces production were shown in Figure 3.2 as following and the final product of chili sauces were shown in Figure 3.3.

The ingredients such as dried chili, tomato puree, Roselle waste, water, sugar, salt, garlic and modified cornstarch were prepared.

⇩

Roselle waste was thawed and blended with water (1:2) prior used. Dried chili was cleaned and cut into smaller pieces. Dried chili was blanched for 10 minutes (90-100°C)

⇩

Dried chili, tomato puree, Roselle waste and garlic was blended together.

Blended ingredients were poured into saucepan. Water was added. The mixture was stirred and boiled (95°C).

Salt and sugar was added and stir well until achieved 30° Brix lowered.

Modified cornstarch was added. The heat was lowered. The sauce was stirred well.

The mixture was simmered for 5 minutes. The glass bottle had through pasteurization process (below 100°C) prior sauces are filled into glass bottle.

The glass bottle was capped and stored at ambient temperature

Figure 3.2: The steps to produce chili sauces

Figure 3.3: The final product of chili sauces that substitute tomato puree with Roselle waste for five different formulations

3.2.3 Experimental design

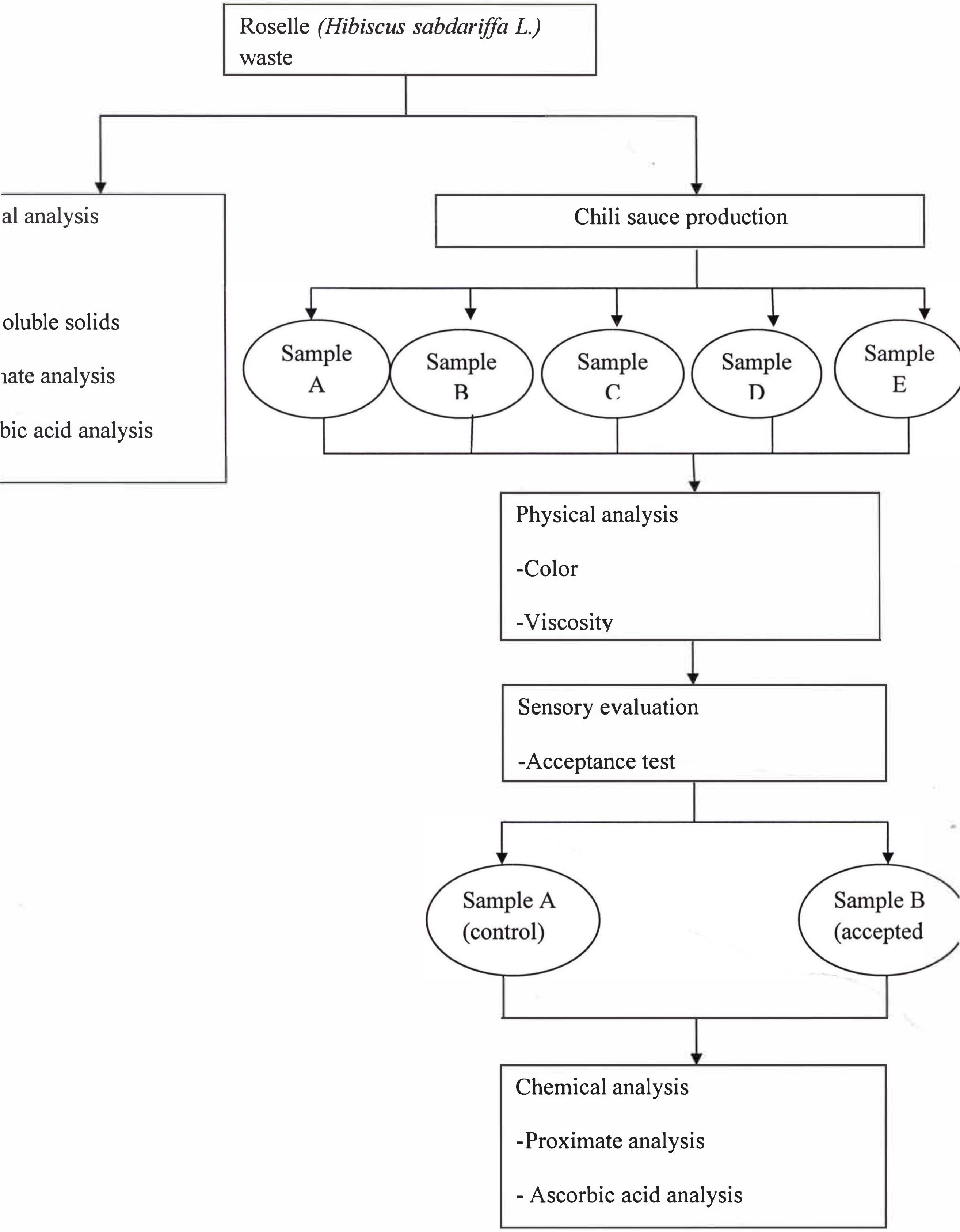

Figure 3.4: Experimental design of the whole process of chili sauces analysis

Independent variable

Table 3.2: Different percentage of Roselle waste and tomato puree in five samples of chili sauces prepared.

Ingredients	**Sample A**	**Sample B**	**Sample C**	**Sample D**	**Sample E**
Roselle waste	100%	75%	50%	25%	0%
Tomato puree	0%	25%	50%	75%	100%

Dependent variable

Table 3.3: Chemical analysis, physical analysis and sensory evaluation were determined.

Chemical analysis	**Physical analysis**	**Sensory evaluation**
pH	Color	Acceptance test
Total soluble solid	Viscosity	- Color
Proximate analysis		- Odor
-Fiber		-Viscosity
-Fat		- Taste
-Moisture		- Overall acceptance
-Carbohydrate		
-Ash		
-Protein		
Ascorbic acid		

3.3 PHYSICAL ANALYSIS

3.3.1 Determination of color

The color of the sauces sample was analyzed using colorimeter (Minolta CR-300). Sauces sample for 250ml was transferred to Petri dish and the color measurements were performed three times at different points (Oke et al., 2010). However, prior to color measurement, colorimeter was calibrated with a white standard tile. The result measured is in L, a* and b*. L is referred to change from black to white (numeric value in 0-100 scale), a* is refer to change in red (+value) to green (-value) and b* refer to change in yellow (+value) to blue (-value). The chromaticity parameters L, a* and b*, recorded were the average of three measurements for each replication.

3.3.2 Determination of viscosity

All chili sauce samples were analyzed using a Brookfield Digital viscometer with No. 4 spindles at 10 rpm. Positions as well as settings of the viscometer were adjusted to obtain precise measurements (Takada and Nelson, 1983). The results shown represent the average of three readings (Oke et al., 2010). The results of viscosity were recorded in cP.

3.4 CHEMICAL ANALYSIS

3.4.1 Determination of pH

All chili sauce samples were measured on the pH value. The pH value was taken and read directly from the pH meter (Cyber scan Series 600 Water portable Meter). Before use, the pH meter was calibrated with standard buffer solution of pH 7 and pH 14 that has been prepared. Prior to measure the pH value, 5 g of sauce sample was diluted and stirred completely with 20mL of distilled water to achieve equilibrium sample. The pH of the sauces was measured by immersed the glass electrode of the pH titrator in the sauce sample. The pH was recorded after the reading is constant and equilibrium to the room temperature (25°C) (Oke et al., 2010). The pH value was measured three times for each replication.

3.4.2 Determination of total soluble solid (°Brix)

Total soluble solid is the sugar content of the food. The total soluble solid in sauces was measured by using hand-handle refractometer. The refractometer was calibrated with distilled water prior to determine the total soluble solid of sauces sample. The distilled water was drop into refractometer prism and was clean up until dry. After that, the total soluble solid of chili sauce samples can be measured, one or two drop of the sauces sample was drop into the refractometer prism. The reading of total soluble solid was recorded and expressed as degree of °Brix (AOAC, 1995). The total soluble solid value was measured three times for each replication.

3.5 SENSORY EVALUATION

3.5.1 Acceptance test

The tests have been done to determined the acceptability and prefer ability of consumer to the chili sauces samples. 30 untrained panelists were chosen, they are from University Malaysia Terengganu students (male or female) in order to evaluate the five different formulations of chili sauces. The attributes that need to be evaluating for chili sauces were color, viscosity, odor, taste and overall acceptance. Chili sauces are a flavor enhancer, so it need carrier. The fish cracker has been prepared as a carrier for chili sauces acceptability. Samples are serving at University Malaysia Terengganu Food Science Restaurant.

Beside that, the hedonic scale has been chosen to measure the degree of liking for the chili sauces samples. Category scales neither ranging from like extremely, through neither like nor dislike, disliking extremely, with varying numbers of categories, were used. Panelists indicate their degree of liking for each sample by choosing the appropriate category (Watts et al., 1989). The 9 point of hedonic scales was used to evaluated the attributes of sauces samples with ranging score from the categories are converted to numerical scores ranging from 1 to 9, where 1 represents dislike extremely and 9 represents like extremely (Watts et al., 1989). Samples also coded with permutation number. The panel need to start evaluate samples from left to right.

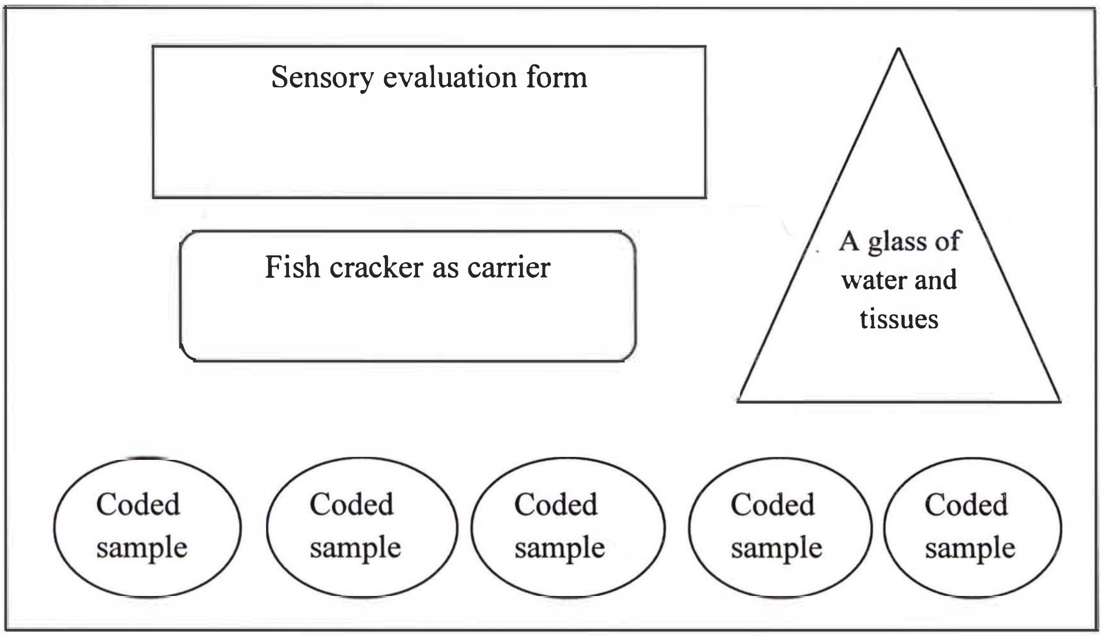

Figure 3.5: Illustrations of sensory evaluation for five different formulations of chili sauces samples

3.6 CHEMICAL ANALYSIS

3.6.1 Proximate analysis for Roselle waste and the chili sauces

Proximate analyses were conducted for determination of carbohydrate, moisture, protein, fiber, ash and fat. Roselle waste and two sample of chili sauces that obtain from sensory evaluation which were sample A (0% Roselle waste) as control and sample B (25% Roselle waste) as accepted were used in proximate analysis. The proximate analysis was determined in duplicate.

3.6.1.1 Determination of carbohydrate content

Carbohydrate content was determined by difference (AOAC, 1995). Carbohydrate of Roselle waste and two chili sauce sample was measured. The percentage of carbohydrate was calculated from equation below:

$$\% \text{ of carbohydrate} = 100\% - (\% \text{ of moisture} + \% \text{ of protein} + \% \text{ of fat} + \% \text{ of fiber} + \% \text{ ash})$$

(Equation 3.1)

3.6.1.2 Determination of moisture content

Moisture content of Roselle waste and both sauce samples were determined (AOAC, 1995) by drying a crucible in an oven for about 30 minutes at 100 °C. Then it was cooled in desiccators and weighed. Next, 5 g of sample were weight separately into the crucible. The samples in crucible were then placed in an oven for 24 hours at 105°C and then cooled in desiccators and reweighed. Weight of dried crucible without lid, sample and crucible plus sample was recorded and the difference in weight was assumed to be moisture loss. The percentage of moisture content was calculated as following equation:

$$\% \text{ of drying part} = \frac{\text{Weight of dry sample (g)}}{\text{Weight of sample (g)}} \times 100$$

$$\% \text{ of moisture part} = 100 - \% \text{ of drying part}$$

(Equation 3.2)

3.6.1.3 Determination of fat content

Fat content of sauces and Roselle waste was determined using 2055 Soctex manual extraction unit and control unit system (AOAC, 1995). Samples (2 g) were weighed as W_1. The pre dried extraction cup was weighed as W_2. The extraction was done using Soctex extraction for 1 hour with 70ml of petroleum ether, till it sink the extraction timber. Then, the ether was evaporated in distiller. The fat collected in extraction timber was dried into oven for 2 hours at 103°C. The sample was evaporated and cooled in desiccators for 15-20 minutes and was weighed as W_3.

Percentage of fat was calculated:

$$\% \text{ of fat} = \frac{W_3 - W_2}{W_1} \times 100$$

(Equation 3.3)

Where,

W1= weight of samples

W2= weight of extraction timber

W3= weight of extraction timber + fat

3.6.1.4 Determination of protein content

Protein content of the both chili sauces and Roselle waste sample was determined using the Kjeltec method (AOAC, 1995). One gram of the sauces sample, two tablet of the Kjeldahl catalyst and 12mL of concentrated sulfuric acid were added into a digestion tube and digested at 420 °C using a digestion unit for about 1 hour until a green solution was obtained. When the digestion was completed the sample was added with 75mL of distilled water and mixed with 40 % NaOH solution before being distilled using a distillation unit. The distillate was absorbed with 25 mL of 4%

boric acid solution plus 10 drops of green bromocresol indicator. The percentage of the total nitrogen was determined by back-titrating the boric acid solution with 0.1 N hydrochloric acid and calculated by the following equation:

$$\% \text{ of nitrogen} = \frac{\text{N of HCl} \times 1.4007 \times (A-B)}{\text{Mass of sample (mg)}}$$

(Equation 3.4)

Where N = concentration of hydrochloric acid, A = volume (mL) of hydrochloric acid used for sample titration, B = volume (mL) of hydrochloric acid used for blank titration. The mass of the sample was on the dry basis. The protein content of the sample was calculated as %Nitrogen × 6.25.

3.6.1.5 Determination of fiber content

Fiber content of Roselle waste and two chili sauce samples were determined. The analysis of crude fiber was conducted by using Fibretec 2021 Fibercap. In this analysis, 1.25% of sulfuric acid (H_2SO_4) and 1.25% Sodium Hydroxide (NaOH) was used. Pre dried fibercap capsule with lid was labeled and weighed (W_1). Two grams of samples (W_2) was weighed. Then, the samples and capsule was put to the carousel. As the reflux set were switched on, the water tap was opened and the H_2SO_4 was boiled. The capsules were put into the reagent for 20 minutes. After 20 minutes of boiling, the H_2SO_4 reagent was taken out and then rinsed by distilled water. Next, the boiling distilled water was used to rinse the capsules by swirling for 10 minutes. The process was repeated twice.

For alkaline extraction, the 1.25% Sodium Hydroxide (NaOH) was used as reagent. As the reflux set were switched on, the water tap was opened and the NaOH was boiled. The capsules were put into the reagent for 20 minutes. After 20 minutes of boiling, the NaOH reagent was taken out and then rinsed by distilled water. Next, the boiling distilled water was used to rinse the capsules by swirling for 10 minutes. The process was repeated twice.

The next steps of crude fiber determination were drying and ashing process. The pre dried crucibles were weighed as W_4. Here, the crucibles with the samples in the tray stand were dried for 2 hours at 103°C and cooled to the room temperature in desiccators for 30 minutes. Then, weighed it and labeled as W_3. The crucibles with residues were ash in the muffle furnace at least for 4 hours at 600°C. The ashing crucibles were cooled down to a temperature of 200°C before being removed from the furnace and were placed in desiccators. The samples were then left to be cooled in the room temperature at about 60 minutes and then it was weighed with a precision of W_5 (AOAC, 1984). The percentage of fiber was calculated by using the formula below:

$$\text{Percentage of fiber (\%)} = \frac{W_3 - (W_1 \text{ X } C) - (W_5 - W_4 - D)}{W_2} \text{ X } 100$$

Where $C = \frac{W_3}{W_2}$, $D = W_5 - W_4$

(Equation 3.5)

Where,

W_1 = weight of capsule + lid (g)

W_2 = weight of sample (g)

W_3 = weight of capsule + dried residue (g)

W_4 = Weight of pre dried crucible (g)

W_5 = weight of total ash + crucible (g)

C= Blank error for blank capsule

D= Weight of blank capsule after ashing (g)

3.6.1.6 Determination of ash content

Five gram of chili sauces and Roselle waste samples was accurately weighed in pre-dried crucibles. Ashing was done in muffle furnace at 550°C for 16 h. The sample was cooled in desiccators for 15-20 minutes (AOAC, 1995). The measurement of pre dried crucible weight, sample weight and weight after ashing was recorded. The ash content was calculated using the following formula:

$$\% \text{ of ash} = \frac{\text{Weight after ashing (g)} - \text{Weight of pre dried crucible (g)}}{\text{Weight of sample (g)}} \times 100$$

(Equation3.6)

3.7 Ascorbic acid (vitamin C) analysis for Roselle waste and chili sauce sample

The two chili sauce samples and Roselle waste was determined for its ascorbic acid (vitamin C) content. The analysis of ascorbic acid analysis was done by using iodometric method (Shamsul Azrin, 2006). One percent of starch indicator solution, iodine solution, ascorbic acid standard solution and sample solution was used in this analysis. Firstly, the preparation of 1% starch solution was done by added 0.50 g of soluble starch into 50 ml near boiling distilled water and the solution was well mixed, then allowed to cool before using. Next, potassium iodide (KI), potassium iodate (KIO3), sulfuric acid and distilled water was used in order to prepare iodine solution. 5 g of potassium iodide (KI) and 0.268 g of potassium iodate (KIO3) were dissolved in 200 ml of distilled water. Thirty milliliter of 3M sulfuric acid was inkled into the solution above and brought up to 500 ml with distilled water. Then, the solution was well mixed and properly labeled.

Standard solution for ascorbic acid also was prepared; 0.25 g of ascorbic acid was distilled in 100 ml distilled water and brought up to 250 ml with distilled water in volumetric flask and then the solution was well mixed. The sample solution was also prepared by homogenized 10 g of sample with 100 ml distilled water with a high speed blender. The sample was filtered up using Whatman paper 4. After that, 1ml of supernatant was diluted up to 25 ml with distilled water. The titration against ascorbic acid standard solution and sample solution was proceeding after all the solution was prepared.

The titration against ascorbic acid standard solution was done by adding 25 ml of ascorbic acid standard solution into 125 ml Erlenmeyer flask. Then, added 10 drops of 1% starch solution into Eylenmeyer flask as well. Burette was rinsed with small amount of iodine solution and then filled up with it. Initial volume was recorded. Next, ascorbic acid standard solution was titrated against the iodine solution. The endpoint of titration was indicated by dark blue color that persists after 20 seconds of solution. The final volume of iodine solution was recorded. Difference between final and initial volume is the volume of iodine solution required for titration. Titration was repeated twice and the result should agree within 0.1 ml. The same step of titration against ascorbic acid was used to titrate sample solution.

$$\frac{\text{Volume of } I_2 \text{ of 25 mL of sample}}{\text{Volume of } I_2 \text{ of 100 mL of ascorbic acid}} \times 100 \text{ mg}$$

(Equation 3.7)

3.8 Statistical analysis

The data obtained from physical analysis and sensory evaluation were analyzed of variance (one way ANOVA) by Fisher's test except for chemical analysis were analyzed using t test for on the individual rating for each characteristics or attributes to observe the degree of significance different ($p>0.05$) among samples. Significantly different means ($p>0.05$) are denoted by different superscripts. These were performed using Minitab 14 Software. All experiments were replicate two or more and the results shown are the mean ± standard deviation.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 PHYSICAL ANALYSIS

4.1. 1 Determination of color

The effects of substitution of Roselle waste in chili sauce on color has been measured using L (brightness), a*(redness) and b*(yellowness) value. It was found that the brightness of chili sauce produced were not significantly different for sample A sample B and sample C but it had significant difference for sample D and E. The L value was slightly highest for sample A compared to the sample B, C, D and sample E. L value for sample A was 23.56 ± 1.05 compared to L value for sample E which was only 17.33 ± 2.44. In addition, the L values in tomato sauce were slightly higher compared to the tomato juice preparations (Oke et al., 2010). The brightness of chili sauce was influenced by the color of Roselle waste used. According to Tsai et al. (2002), Roselle calyces have very attractive brilliant red color because of the anthocyanin pigments presence. In addition, the dark red colored type of Roselle has the highest content of anthocyanin followed by the light red colored type of Roselle while the green colored type of Roselle has no or just traces of anthocyanin. Although, in this experiment the dark red Roselle was used (Refaei et al., 2010). Du and Francis (1973) reported that, in dry Roselle calyces, there was about 1.5 g total anthocyanins per 100 g dry weight, expressed as Dp-3-glucoside. Recently, Pouget et al. (1990), using HPLC analysis, reported that Dp-3-sambubioside and Cy-3-sambubioside were the major and minor pigments respectively, which were responsible for the brilliant red color of Roselle calyces. Data for L value for five different formulations of chili sauces were shown in Figure 4.1.

The red color intensity of chili sauces were determined by a* value, a* is refer to change in red (+value) to green (-value). The redness of chili sauces were decreased from sample A to sample E and all chili sauce samples were not significantly different ($P<0.05$). The sample A which was 100% tomato puree showed higher a* value than another sample. Sample A obtained 12.65 ± 5.0 of a* value but sample D obtained the lowest red color intensity which was 7.24 ± 2.35. It might due to the lycopene, the main carotenoid content in the tomato itself. Furthermore, lycopene is responsible for deep red color in tomato products (Shi and Maguer, 2000). In the previous study by Oke et al. (2010), the tomato sauces preparation showed a higher a* value than tomato juices, tomato sauces possessed significantly higher red color intensity. The amount of tomato puree substitute will affect the level of redness in chili sauce. Data for a* value for five different formulations of chili sauces were shown in Figure 4.2.

The b* value was measured to determine the yellow component in chili sauce. Overall result for b* value for all chili sauce samples were decreased from sample A to sample E. Sample A contain highest b* value which is 6.99 ± 2.63 rather than sample E which obtained 4.70 ± 0.93, the lowest b* value. The decrease of yellowness from sample A to sample E might be due to the increasing amount of Roselle waste. The result obtained shown all chili sauce samples were not significantly different ($P>0.05$) for yellowness value in chili sauce samples. Data for yellowness of five different formulations of chili sauce were shown in figure 4.3.

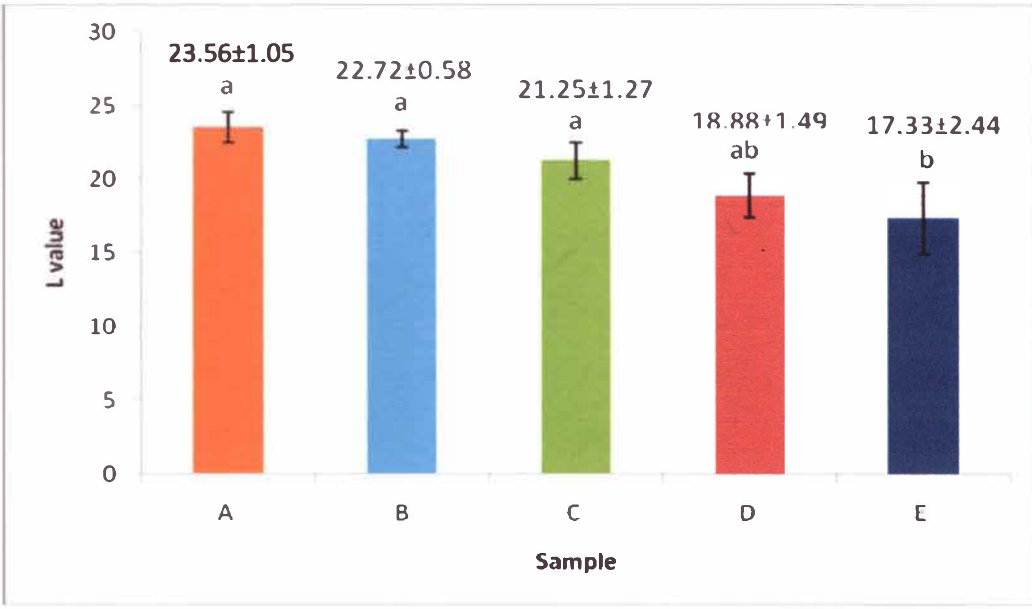

Figure 4.1: Histogram of L values for five different samples of chili sauces

*Mean values with different superscripts are significantly different ($p<0.05$)
*Mean values with same superscripts are not significantly different ($p>0.05$)
*A=0% Roselle waste, B=25% Roselle waste, C=50% Roselle waste, D=75% Roselle waste and E=100% Roselle waste

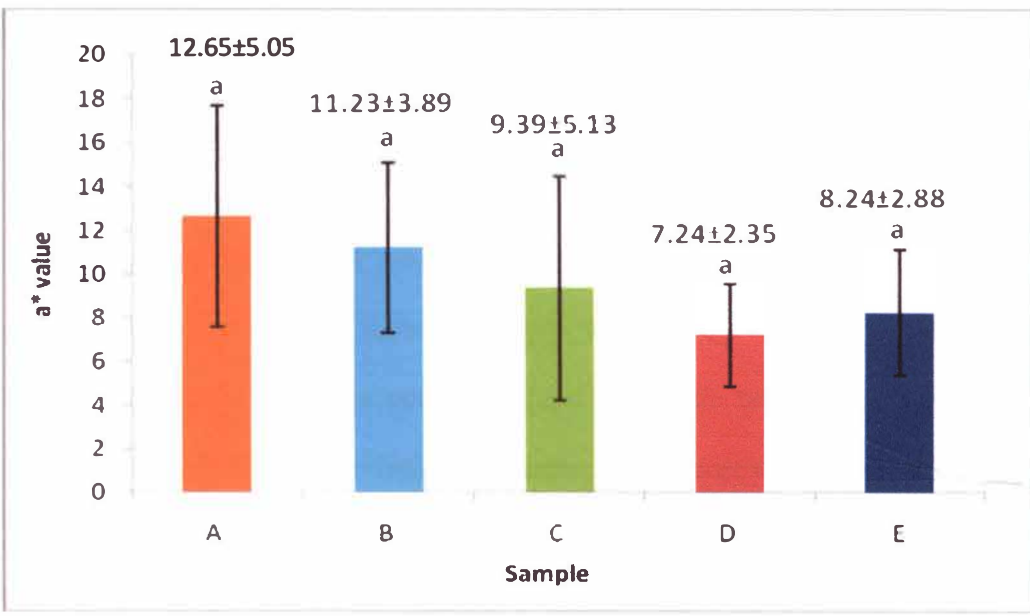

Figure 4.2: Histogram of a* values for five different samples of chili sauces

*Mean values with same superscripts are not significantly different ($p>0.05$)
*A=0% Roselle waste, B=25% Roselle waste, C=50% Roselle waste, D=75% Roselle waste and E=100% Roselle waste

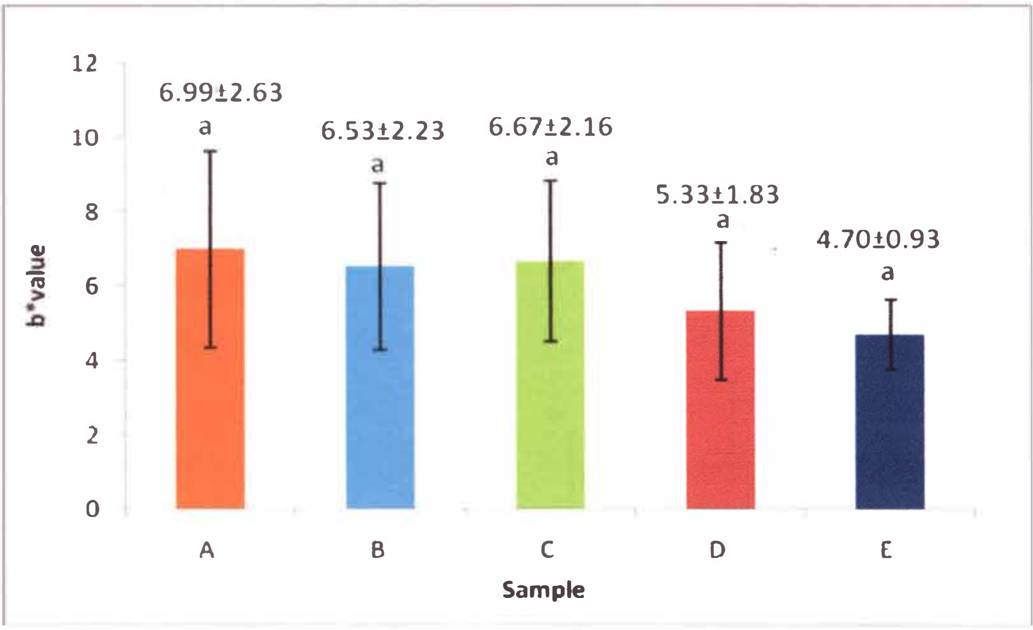

Figure 4.3: Histogram of b* values for five different samples of chili sauce

*Mean values with same superscripts are not significantly different (p>0.05)
*A=0% Roselle waste, B=25% Roselle waste, C=50% Roselle waste, D=75% Roselle waste and E=100% Roselle waste

4.1.2 Determination of viscosity

Viscosity is the one of various characteristics that which contributes to the acceptance of sauce (Rengsutthi et al., 2011). The result obtained for viscosity using spindle 4 (Brookfield digital viscometer) were between 9009-15284 cP. The range viscosity of another sauce such as yentafo sauces were between 4022-8866 cP. Yentafo sauces were used as main ingredient in yentafo noodles that very famous noodles in Thailand, which makes the yentafo noodles more different and outstanding than other kinds (Yingyongyuth et al., 2009). All sample of chili sauce was not significantly different (P>0.05). Sample E showed the highest viscosity which was 15284 cP but sample A shown the lowest value for viscosity which was 9009 cP. The highest viscosity for sample E might be due to the substitution of 100 % Roselle waste. Roselle waste has fiber content, so fiber is able to absorb water content from chili sauce and make the chili sauce more viscous and become thick. The data of five different formulations for viscosity was shown in figure 4.4.

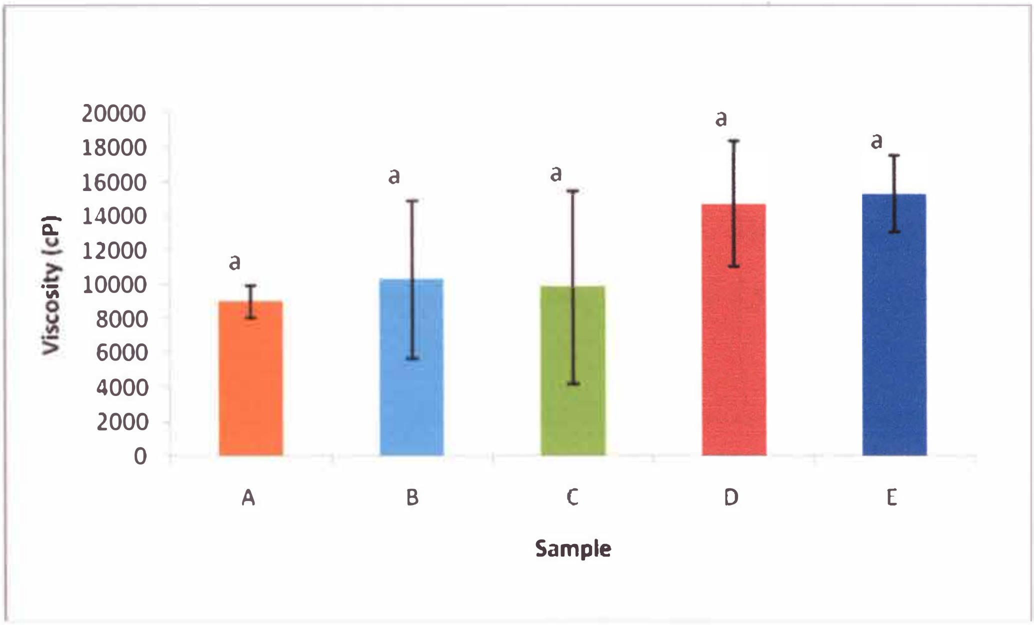

Figure 4.4: Histogram of viscosity for five different samples of chili sauces

*Mean values with same superscripts are not significantly different (p>0.05)
*A=0% Roselle waste, B=25% Roselle waste, C=50% Roselle waste, D=75% Roselle waste and E=100% Roselle waste

4.2 CHEMICAL ANALYSIS

4.2.1 Determination of pH value

The pH value of chili sauce samples as measured by pH meter (Cyber scan Series 600 Waterportable Meter) are shown in Figure 4.5. All chili sauces sample had pH value ranging between 3.94-2.65. Sample A was 3.94 ± 0.05, sample B was 3.75 ± 0.04, sample C had 3.50 ± 0.01, sample D had 3.13 ± 0.08 and sample E had 2.65 ± 0.08 of pH value. Furthermore, according to Rengsutthi et al. (2011), chili sauces had pH levels ranging between 3.58-3.61, chili sauce also classified as a high food item. The result shown that all chili sauce samples were had significantly different ($P < 0.05$). The decrease of pH value from sample A to sample E might be due to the amount of Roselle waste added into the chili sauce samples which was sample A (0%), sample B (25%), sample C (50%), sample D (75%) and sample E (100%). In addition, Roselle calyces had low level of pH value due to the high degree of its sourness. According to Mardiah (2009), Roselle calyces have high degree of sourness because it contain citric acid and malic acid component. Data of pH value for five different formulations of chili sauces were shown in figure 4.5 as following:

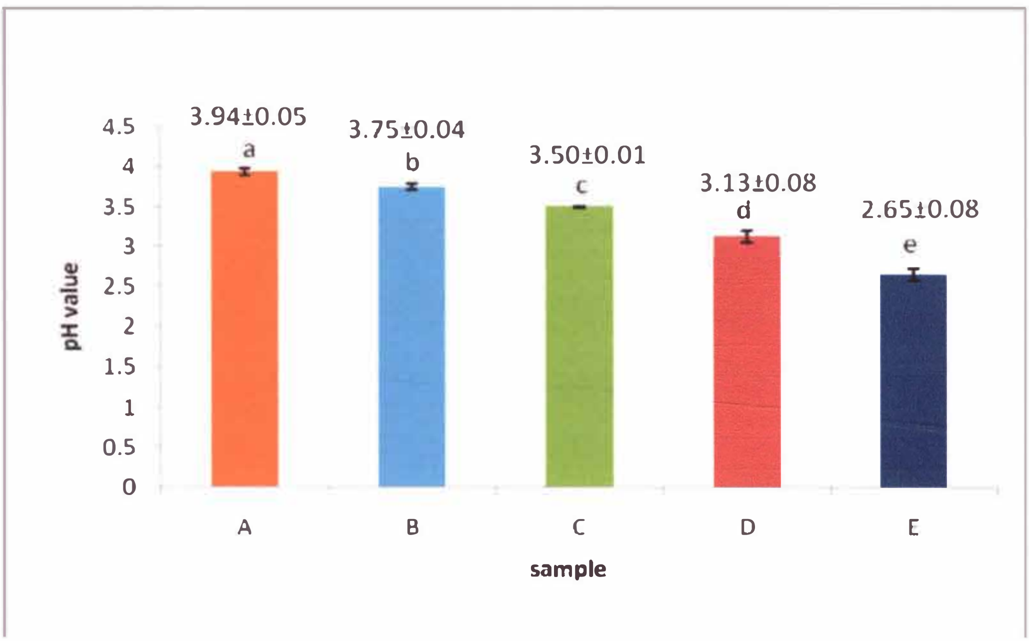

Figure 4.5: Histogram of pH value for five different samples of chili sauces

*Mean values with different superscripts are significantly different ($p<0.05$)
*A=0% Roselle waste, B=25% Roselle waste, C=50% Roselle waste, D=75% Roselle waste and E=100% Roselle waste

4.2.2 Determination of total soluble solid (°Brix)

°Brix is basically an indicator for total soluble solids in a fluid (used in the food industry for measuring the approximate amount of sugars in fruit juices, wine, soft drinks, and in the sugar manufacturing industry) and the soluble solids detected in chili sauce samples are mostly sugar (Kah et al., 2009). The soluble solid content in all chili sauce samples was ranging between 30.63-22.7 °Brix meanwhile based on Rengsutthi et al. (2011), the total soluble solid content in chili sauce were between 23.00-23.10 °Brix.

The result shown that, sample A had no significant difference ($P>0.05$) with sample B but it was significantly different ($P<0.05$) with sample C, D and E. Sample B shown the higher total soluble solids which is 30.97 ± 0.7 compared to sample A which is 30.63 ± 1.53 whereas sample C shown the lowest total soluble solid which is 22.7 ± 0.62. The data of five different formulations of chili sauces for total soluble solid content was shown in figure 4.6 as following:

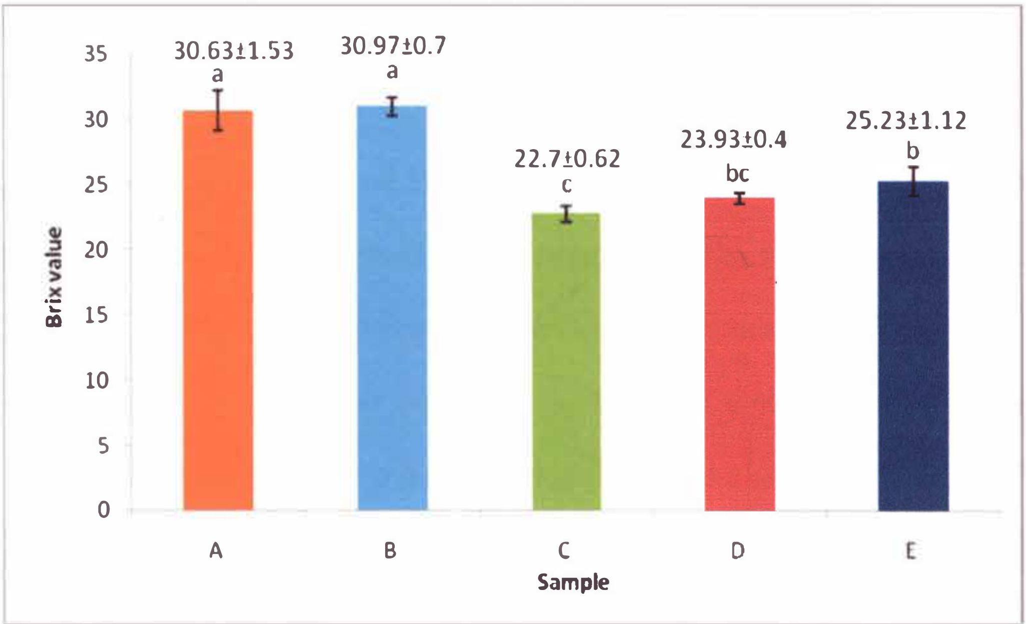

Figure 4.6: Histogram of °Brix value for five different samples of chili sauces

*Mean values with different superscripts are significantly different ($p<0.05$)
*Mean values with same superscripts are not significantly different ($p>0.05$)
*A=0% Roselle waste, B=25% Roselle waste, C=50% Roselle waste, D=75% Roselle waste and E=100% Roselle waste

4.3 SENSORY EVALUATION

Sensory evaluation of chili sauces was conducted based on the several attributes such as color, odor, taste, viscosity and overall acceptance. The sensory analysis was used hedonic scale. According to Watts (1989), hedonic test are designed to measure the degree of liking for a product. Panelists indicate their degree of liking for each sample by choosing appropriate category. The 9 point of hedonic scales was used ranging from 1 for dislike extremely and 9 for like extremely. The sensory analysis was performed by thirty untrained panelists consists of male and female students University Malaysia Terengganu. Samples are served at University Malaysia Terengganu Food Science Restaurant.

The result obtained for color showed a significant difference ($P<0.05$) for each sample of chili sauces. Sample B with 25% of Roselle waste had a highest scores compared to sample A, C, D and E. Sample B obtained 7.07 ± 1.23 score whereas sample A, C, D and E had decreased level of acceptance. The score of sample A, C, D and E were between 5.90-2.87 score. The decrease of acceptance might be because of the darker color of chili sauces due to the anthocyanin content in Roselle waste. Anthocyanin is a water soluble pigment responsible for the orangey-red color of the calyces (Tsai and Ou, 1996). Furthermore, Roselle also had brilliant red color (Tsai et al., 2002). The sensory score of color for five different formulations of chili sauce samples were shown in Figure 4.7.

Next, untrained panel need to evaluate viscosity of the chili sauces samples. The result for sensory evaluation of viscosity showed that sample C had the highest acceptance score between all chili sauce samples which was 7.53 ± 1.01 score. Sample A, B and C had significant difference ($P<0.05$) between each sample whereas Sample D had no significant difference ($P>0.05$) with sample E. Sample D and E had lowest accepted level among other three samples of chili sauces. Sample D had 3.30 ± 1.27 score and sample E obtained 2.60 ± 1.10 score. The lowest acceptance of sample D and E might be because based on physical analysis the viscosity of both samples was too thick and viscous. The thick and viscous of sample D and E due to the high amount of substitution of Roselle waste. Fiber content in Roselle waste can absorb water in chili sauces. The sensory score of viscosity for five different formulations of chili sauce samples were shown in Figure 4.8.

Beside, odor was also evaluated by untrained panelist in chili sauce evaluation. Odor of chili sauce that substitute with Roselle waste also depend percentage of

Roselle waste substitute in the chili sauce. The high level of sourness from Roselle waste were influence the odor of chili sauce. So, the result obtained for odor score was quite similar with taste score. There were significantly different ($P<0.05$) between each chili sauce samples. Sample B had the highest score which was 7.23 ± 1.28 score compared to the sample E had the lowest score for odor which was 2.90 ± 1.24 score. Figure 4.9 were shown the sensory score for odor of five different formulations of chili sauce samples.

Taste was another attribute for sensory evaluation of chili sauce samples. The result for taste as shown in figure 4.10. There was significantly different ($P<0.05$) between all chili sauce samples. Sample B had highest acceptance score followed by sample A, C, D and the lowest acceptance score was sample E. Sample B obtained 7.73 ± 0.98 score whereas sample E had only 2.53 ± 1.25 score. Chili sauce samples with high percentage of Roselle waste substitution had lowest scores because Roselle waste had high level of sourness (Mardiah, 2009). The panelist might not very accept and like the high level of sourness and give lowest score for that sample.

Next attribute, overall acceptance was evaluated. Based on figure 4.11, all chili sauce samples had significant difference ($P<0.05$) for overall acceptance attributes. Sample B with 25% of Roselle waste substitution obtained the highest acceptance scores in overall acceptance and sample E had lowest acceptance score. Sample B had 7.53 ± 1.01 scores rather than sample E obtained only 2.97 score. Furthermore, based on the scores of other attributes sample B obtained the highest score.

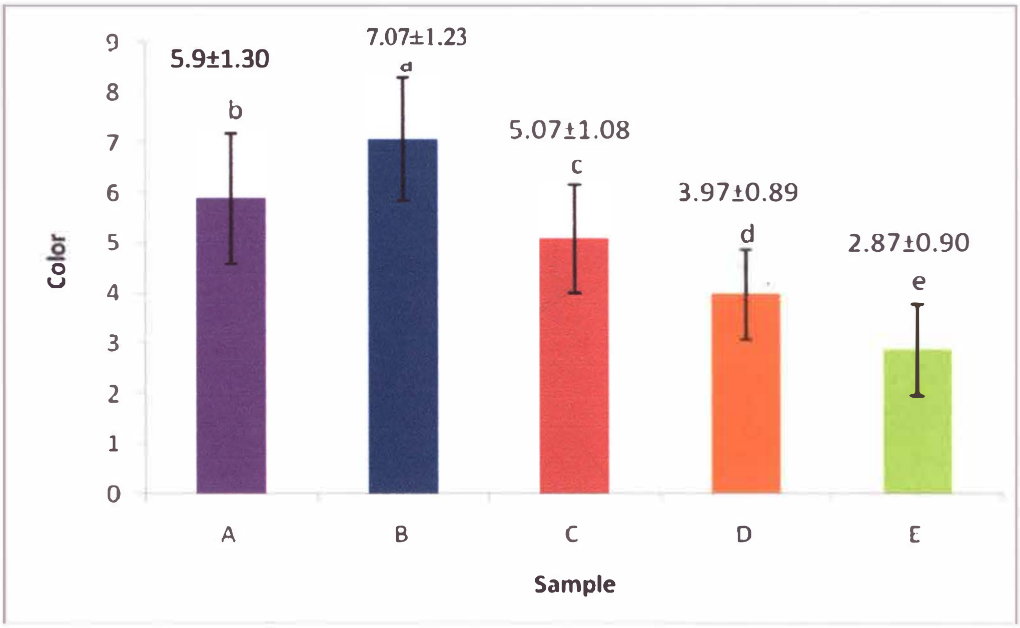

Figure 4.7: Histogram of color score for five different samples of chili sauces

*Mean values with different superscripts are significantly different ($p<0.05$)
*A=0% Roselle waste, B=25% Roselle waste, C=50% Roselle waste, D=75% Roselle waste and E=100% Roselle waste

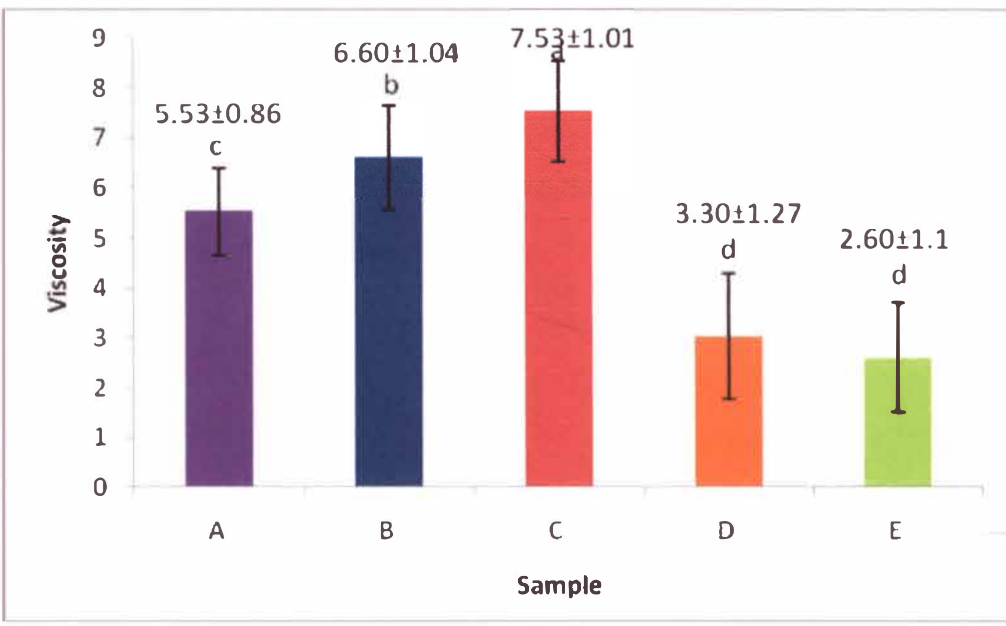

Figure 4.8: Histogram of viscosity score for five different samples of chili sauces

*Mean values with different superscripts are significantly different ($p<0.05$)
* Mean values with same superscripts are no significantly different ($p>0.05$)
*A=0% Roselle waste, B=25% Roselle waste, C=50% Roselle waste, D=75% Roselle waste and E=100% Roselle waste

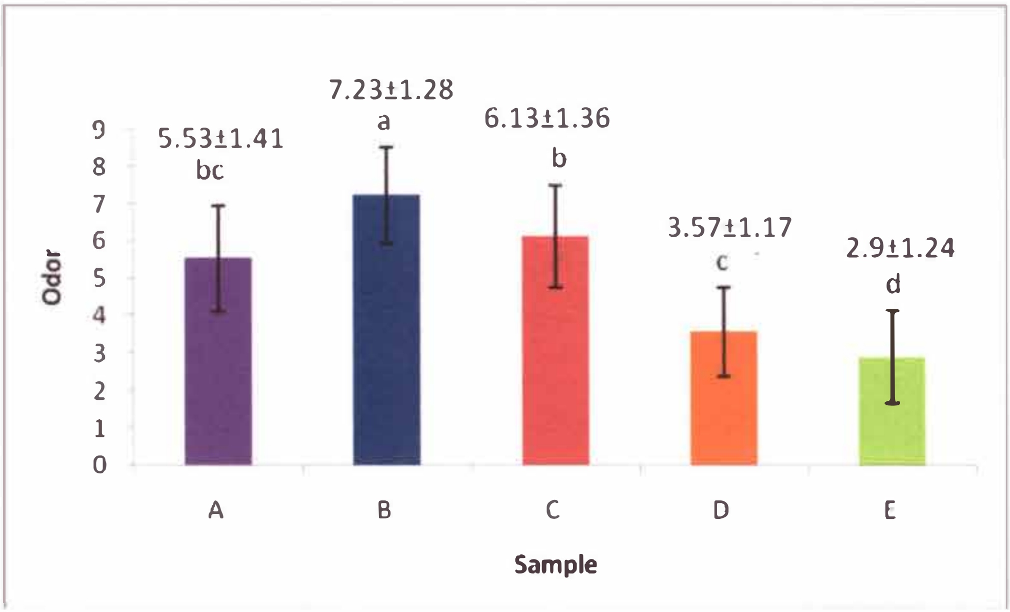

Figure 4.9: Histogram of odor score for five different samples of chili sauces

*Mean values with different superscripts are significantly different ($p<0.05$)
*A=0% Roselle waste, B=25% Roselle waste, C=50% Roselle waste, D=75% Roselle waste and E=100% Roselle waste

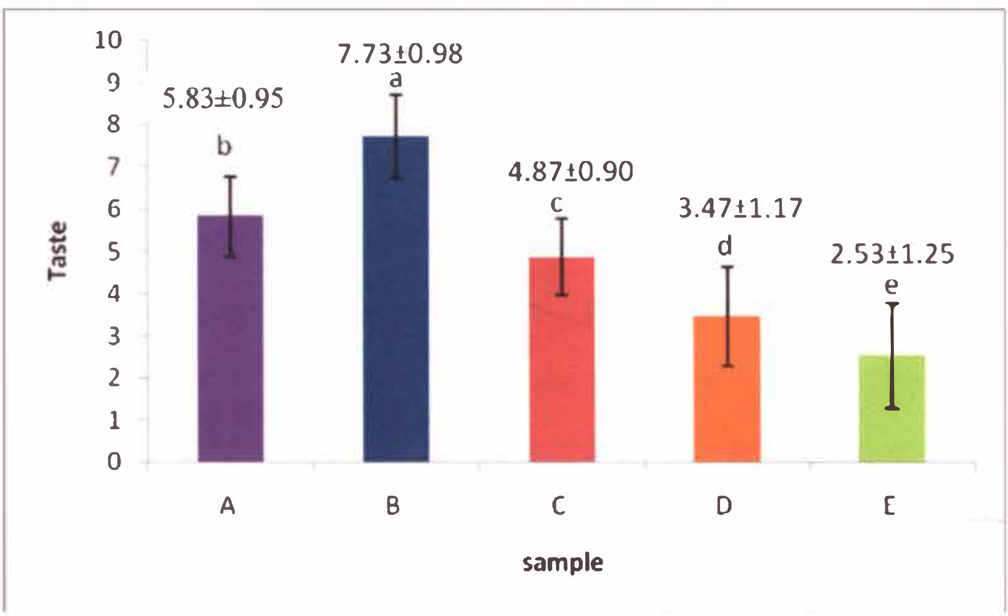

Figure 4.10: Histogram of taste score for five different samples of chili sauces

*Mean values with different superscripts are significantly different ($p<0.05$)
*A=0% Roselle waste, B=25% Roselle waste, C=50% Roselle waste, D=75% Roselle waste and E=100% Roselle waste

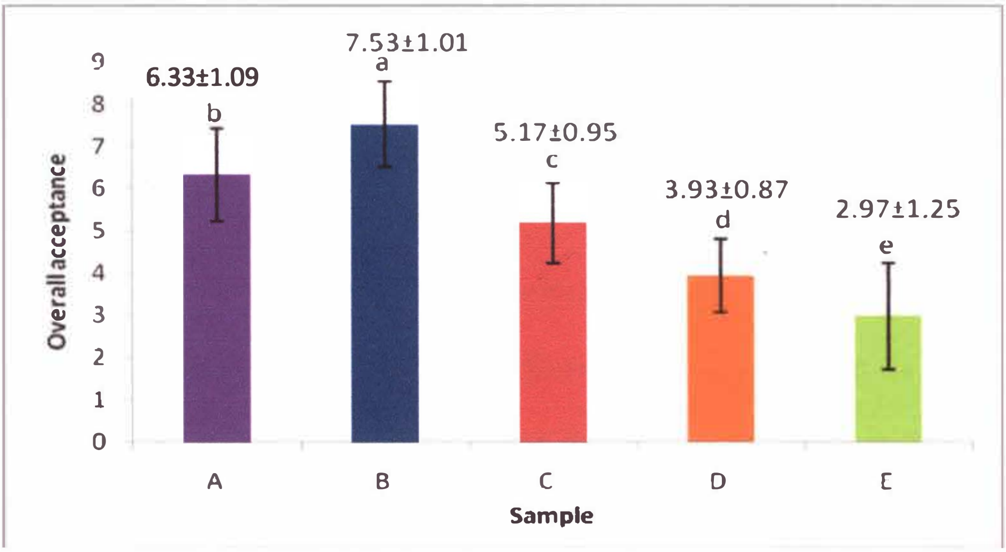

Figure 4.11: Histogram of overall acceptance score for five different samples of chili sauces

*Mean values with different superscripts are significantly different ($p<0.05$)
*A=0% Roselle waste, B=25% Roselle waste, C=50% Roselle waste, D=75% Roselle waste and E=100% Roselle waste

4.4 CHEMICAL ANALYSIS

4.4.1 Proximate analysis for Roselle waste

The result for proximate analysis of Roselle waste were shown that it had low carbohydrate content. It contains only 3.60 ± 0.88% of carbohydrate. Otherwise, it was high in moisture content for Roselle waste. The moisture content of Roselle waste was 92.31 ± 0.75% and Roselle waste had 0.38 ± 0.08% of protein content. According to Duke (1983) and Mat Isa et al. (1985), fresh Roselle calyces contain 84.5% of moisture content. Furthermore, the protein content of fresh Roselle calyces was slightly higher than Roselle waste which was 1.145% (Musa et al., 2006).

In addition, Roselle waste also contained 1.32 ± 0.18% of fat content and 2.3 ± 0.21% of fiber content. However, fat and fiber content were higher in fresh Roselle calyces. The fat content for fresh Roselle calyces was 2.61% and 12% of fiber content (Musa et al., 2006). The result given below indicates that Roselle waste had lower ash content which was 0.10 ± 0.02% only rather than 6.90% in fresh Roselle calyces (Musa et al., 2006). From the result obtained, the composition of Roselle waste was less than the composition of fresh Roselle calyces. The difference of the composition content between Roselle waste and fresh Roselle calyces, it might be due to the reduction or loss of some composition during the processing (Lawal, 1986), because Roselle waste had undergone heat processing prior to substitute with chili sauces. The result obtained for proximate analysis of Roselle waste was shown in table as below:

Table 4.1: Composition of carbohydrate, moisture, protein, fiber, fat and ash for Roselle waste

Composition	**Percentage (%)**
Carbohydrate	3.60±0.88
Moisture	92.31±0.75
Protein	0.38±0.08
Fiber	2.30±0.21
Fat	1.32±0.18
Ash	0.10±0.02

4.4.2 Proximate analysis of chili sauces

The proximate composition of chili sauces for carbohydrate, moisture, protein, fat, fiber and ash between control (sample A) and accepted (sample B) was shown in Table 4.2 . Based on the table 4.2, both samples A and B showed fair quantities of carbohydrate content. Carbohydrate content was between 25.16-25.49%. Sample A and sample B also had no significant difference ($P>0.05$) between each sample. Moisture content for both chili sauces had significant difference ($P<0.05$). Sample A had higher moisture content compared to the sample B. However, for fat analysis sample B had no significant difference ($P>0.05$) with sample A. This could be because of the influence of fat content in Roselle waste.

Protein content of both chili sauce sample was differed which the sample A containing more protein content (1.09 ± 0.18%) than sample B (0.87 ± 0.24%). There were no significantly different ($P>0.05$) between sample A and B. Meanwhile, the ash content also had no significant difference ($P>0.05$) between sample A (2.00 ± 0.27%) and B (2.02 ± 0.22%). Determination of fiber content shown that sample B had higher fiber content than in sample A. Sample B had 0.47% rather than sample A had 0.24% fiber content. The higher percentage of fiber content in sample B due to the 25% of Roselle waste substitution compared to sample A that had 0% of Roselle waste substitution.

Table 4.2: Composition of carbohydrate, moisture, protein, fiber, fat and ash for chili sauce samples

Composition (%)	Samples	
	A (control)	B (accepted)
Carbohydrate	25.16 ± 0.59^{a}	25.49 ± 0.39^{a}
Moisture	70.79 ± 0.04^{a}	69.65 ± 0.02^{b}
Protein	1.09 ± 0.18^{a}	0.87 ± 0.24^{a}
Fiber	0.24 ± 0.01^{a}	0.47 ± 0.03^{a}
Fat	0.89 ± 0.18^{a}	1.70 ± 0.19^{a}
Ash	2.00 ± 0.27^{a}	2.02 ± 0.22^{a}

*Mean values with different superscripts are significantly different ($p<0.05$)
*Mean values with same superscripts are no significantly different ($p>0.05$)
*A= 0% Roselle waste, B= 25% Roselle waste

4.4.3 Ascorbic acid analysis of Roselle waste

Ascorbic acid or vitamin C can be obtained from fruits or vegetables. Vitamin C also acts as an antioxidant, scavenging potential harmful molecules called free radicals (Shamsul Azrin, 2009). Ascorbic analysis of Roselle waste was determined using iodine titration. The result shown that ascorbic acid content for Roselle waste was only 1.91 ± 0.33 mg/100 g. According to Musa et al. (2006), ascorbic acid for fresh Roselle calyces was 6.7 mg/100 g. The decrease of ascorbic acid content in Roselle waste might be due to the pretreatment of Roselle waste. Fresh Roselle calyces were boiled to get the water, in order to produce cordial whereas Roselle calyces was removed and not used again. Roselle calyces that been removed was called Roselle waste. Therefore, Robertson and Samaniego (1986), degradation of ascorbic acid depends upon many factors such as oxygen, light, heat, storage time and temperature. According to Shamsul Azrin (2009), vitamin C is sensitive to temperature. The boiling process of fresh Roselle calyces reduces the amount of ascorbic acid in Roselle waste.

4.4.4 Ascorbic acid analysis of chili sauces

Ascorbic acid was analysed for two selected sample of chili sauce from sensory evalaution which was sample A and sample B. The result for ascorbic acid analysis was obtained in figure 4.12. The figure shown that there was significant difference ($P<0.05$) for sample A and sample B. Sample B had higher ascorbic acid compared to sample A. The Roselle waste substitution was influenced the vitamin C content in sample B. Sample B contained 2.2 ± 0.85 mg/100 g vitamin C whereas sample A had 1.91 ± 0.33 mg/100 g vitamin C.

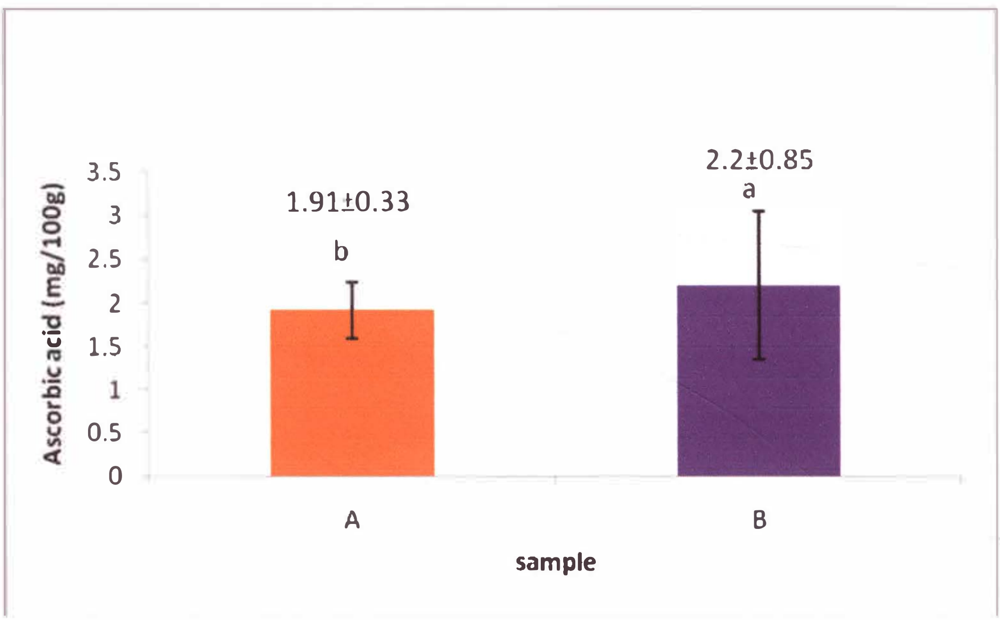

Figure 4.12 : Percentage of ascorbic acid for two selected sample of chili sauce

*Mean values with same superscripts are no significantly different ($p>0.05$)
*A= 0% Roselle waste, B= 25% Roselle waste

CHAPTER 5

5.1 CONCLUSION

This study shown that effects of tomato puree substitution with Roselle waste in chili sauce on the pH, °Brix value, viscosity and color. The pH value for all chili sauce samples were decreased due to the citric acid and malic acid content in Roselle waste. However, the viscosity of all chili sauce samples had increased from sample A, B, C, D and E. The substitution of tomato puree with Roselle waste in chili sauces did not improve the color of chili sauces due to the anthocyanin in Roselle that give brilliant red color to chili sauces. Meanwhile, sensory evaluation were evaluated for aroma, taste, viscosity, color and overall acceptance showed that sample B were the most accepted between all chili sauce samples. Furthermore, from proximate analysis moisture content of Roselle waste was higher (92.31 ± 0.75%) but low level of ash. Roselle waste also had 3.60 ± 0.88% of carbohydrate, 0.38 ± 0.08% of protein, 1.32 ± 0.18% of fat and 2.30 ± 0.21% of fiber. Beside, the proximate composition of sample A (control sample) and sample B (accepted sample) presented that sample B possessed high fat, fiber, carbohydrate, and ash content compared to the sample A. Results obtained for the ascorbic acid analysis, Roselle waste had low level of vitamin C compared with vitamin C in fresh Roselle calyces due to the degradation of vitamin C when exposure to heat whereas ascorbic analysis for sample A (control) and sample B (accepted), the vitamin C was high in sample B compared to the sample A. So, the Roselle waste was reused in chili sauces but with minimum effects on the pH, °Brix value, viscosity, color, ascorbic acid content, and proximate composition.

5.2 SUGGESTION FOR FURTHER STUDY

Chili sauces that substitute of tomato puree with Roselle waste was a new product and not familiar and popular among the consumer. It also not has been sold in local market. So, further study on chili sauces substitute of tomato puree with Roselle waste can be done, in order to improve its value and quality. In my opinion, the further study of shelf life on chili sauces can be carried on because Roselle waste had low level of pH and high degree of sourness, so it can act as antimicrobial agent. Certain microorganism cannot survive in the low pH condition. Although, Roselle waste act as antimicrobial agent, another preservatives did not had to be added in the chili sauces. Beside, Roselle waste can also act as value added in some product because it has natural brilliant red color and fiber content. It can give attractive color to '*apam*' rather than use the artificial coloring, adding Roselle waste into biscuits. The biscuits that added with Roselle waste had value added which is fiber content compared to the other biscuits. Fiber content in Roselle waste can act as thickening agents such as in 'kuah laksa' and jam.

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APPENDIX A

Statistical analysis for physical analysis

a) Determination of L value

1. Test for Equal Variances

Ho : σ 1 = σ 2 = σ 3 = σ 4= σ 5 (variance for all five population are same)

Ha : at least variance from 2 population are not same to each other.

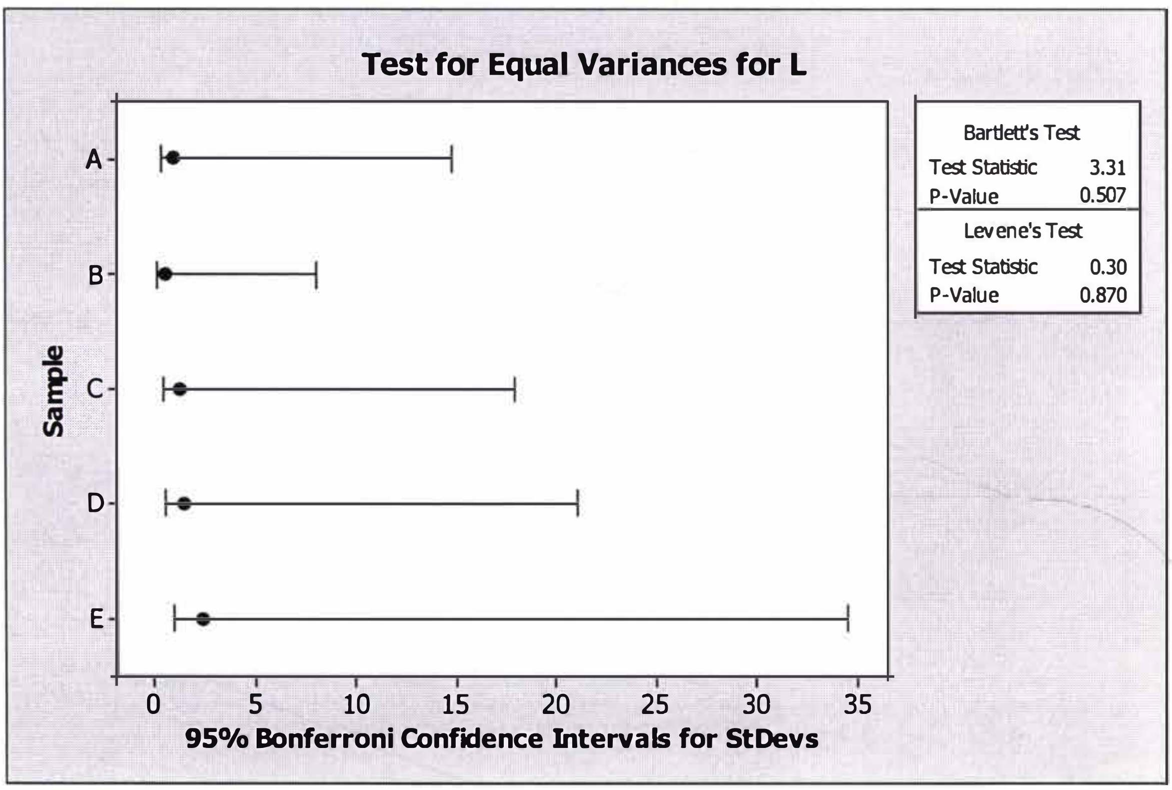
Test for Equal Variances: L versus Sample

95% Bonferroni confidence intervals for standard deviations

Sample	N	Lower	StDev	Upper
A	3	0.45813	1.05453	14.8946
B	3	0.24996	0.57535	8.1266
C	3	0.55348	1.27401	17.9947
D	3	0.64807	1.49172	21.0697
E	3	1.06076	2.44167	34.4871

Bartlett's Test (normal distribution)
Test statistic = 3.31, p-value = 0.507

Levene's Test (any continuous distribution)
Test statistic = 0.30, p-value = 0.870



Result:

The value obtained from both Bartlett's and Levene's test gives p > 0.05. So, Ho is accepted that all five populations have same variance.
Thus, the rules for ANOVA Test are fulfilled.
So, further test can be continuing with One-way ANOVA Test.

2. One-way ANOVA Test

One-way ANOVA: L versus Sample

```
Source  DF      SS     MS     F      P
Sample   4   81.53  20.38  9.06  0.002
Error   10   22.51   2.25
Total   14  104.04

S = 1.500   R-Sq = 78.37%   R-Sq(adj) = 69.71%


                             Individual 95% CIs For Mean Based on
                             Pooled StDev
Level  N    Mean  StDev  ---------+---------+---------+---------+
A      3  23.557  1.055                      (------*-----)
B      3  22.717  0.575                   (------*-----)
C      3  21.250  1.274              (------*-----)
D      3  18.877  1.492      (------*-----)
E      3  17.333  2.442  (------*-----)
                         ---------+---------+---------+---------+
                               18.0      21.0      24.0      27.0

Pooled StDev = 1.500


Fisher 95% Individual Confidence Intervals
All Pairwise Comparisons among Levels of Sample

Simultaneous confidence level = 75.51%


Sample = A subtracted from:

Sample   Lower  Center   Upper  --------+---------+---------+---------+-
B       -3.569  -0.840   1.889            (----*-----)
C       -5.036  -2.307   0.423         (----*-----)
D       -7.409  -4.680  -1.951    (-----*----)
E       -8.953  -6.223  -3.494  (-----*----)
                                --------+---------+---------+---------+-
                                     -5.0       0.0       5.0      10.0

Sample = B subtracted from:

Sample   Lower  Center   Upper  --------+---------+---------+---------+-
C       -4.196  -1.467   1.263           (----*-----)
D       -6.569  -3.840  -1.111      (----*-----)
E       -8.113  -5.383  -2.654  (----*-----)
                                --------+---------+---------+---------+-
                                     -5.0       0.0       5.0      10.0
```

```
Sample = C subtracted from:

Sample   Lower   Center   Upper   --------+---------+---------+---------+-
D       -5.103  -2.373   0.356           (----*-----)
E       -6.646  -3.917  -1.187       (----*-----)
                                  --------+---------+---------+---------+-
                                       -5.0       0.0       5.0      10.0
```

```
Sample = D subtracted from:

Sample   Lower   Center   Upper   --------+---------+---------+---------+-
E       -4.273  -1.543   1.186           (-----*----)
                                  --------+---------+---------+---------+-
                                       -5.0       0.0       5.0      10.0
```

Overall result:

From One-way ANOVA Test;
Ho rejected since p ‹ 0.05, there are significant different between all samples in terms of color.
From Fisher's LSD Test;

```
                              Individual 95% CIs For Mean Based on
                              Pooled StDev
Level  N    Mean   StDev  ---------+---------+---------+---------+
A      3  23.557   1.055                     (------*-----)a
B      3  22.717   0.575                  (------*-----)a
C      3  21.250   1.274             (------*-----)ab
D      3  18.877   1.492     (------*-----)b
E      3  17.333   2.442  (------*-----)b
                          ---------+---------+---------+---------+
                                18.0      21.0      24.0      27.0

Pooled StDev = 1.500
```

Summary result:

Sample	Mean of L value	Standard deviation
A	23.557 [a]	1.055
B	22.717[a]	0.575
C	21.250[a]	1.274
D	18.877[ab]	1.492
E	17.333[b]	2.442

b) Determination of color for a* value

1. Test for Equal Variances

Ho : σ 1 = σ 2 = σ 3 = σ 4= σ 5 (variance for all five population are same)
Ha : at least variance from 2 population are not same to each other.

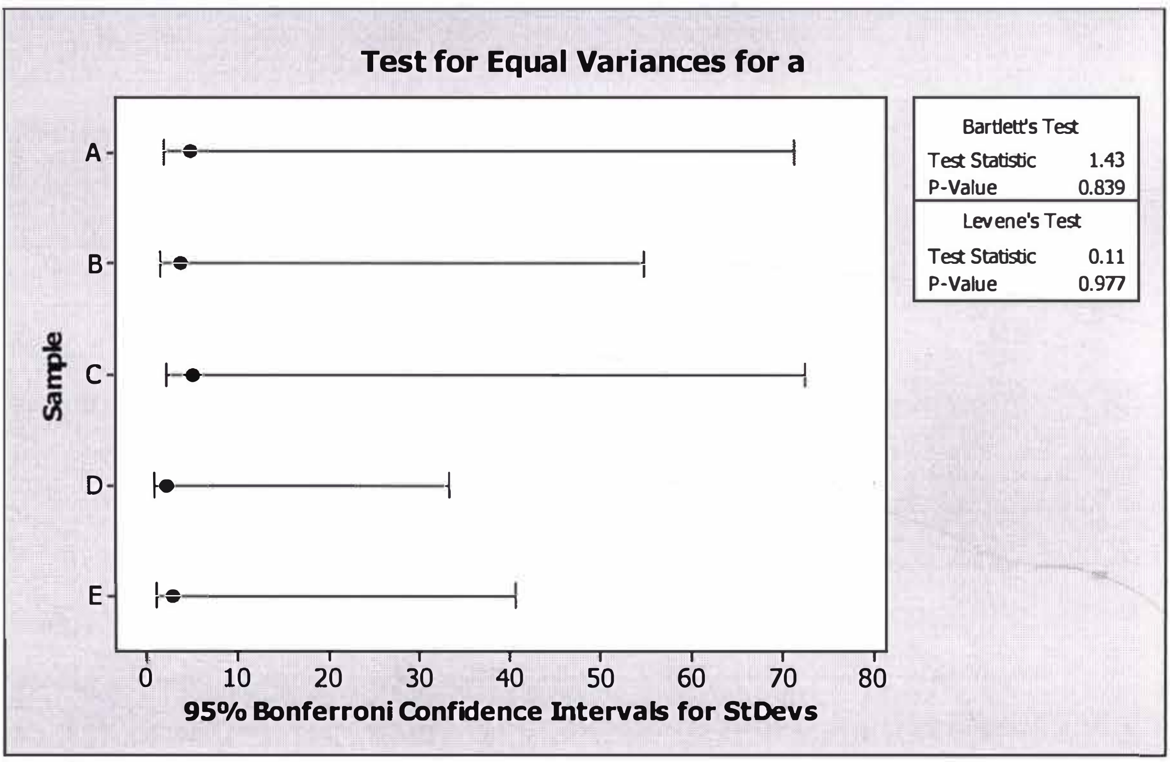
Test for Equal Variances: a versus Sample

```
95% Bonferroni confidence intervals for standard deviations

Sample  N    Lower    StDev    Upper
     A  3  2.19349  5.04899  71.3141
     B  3  1.69056  3.89135  54.9632
     C  3  2.22768  5.12769  72.4257
     D  3  1.02155  2.35140  33.2122
     E  3  1.25275  2.88358  40.7289


Bartlett's Test (normal distribution)
Test statistic = 1.43, p-value = 0.839


Levene's Test (any continuous distribution)
Test statistic = 0.11, p-value = 0.977
```



Result:

The value obtained from both Bartlett's and Levene's test gives $p > 0.05$. So, Ho is accepted that all five populations have same variance.
Thus, the rules for ANOVA Test are fulfilled.
So, further test can be continuing with One-way ANOVA Test.

2. One-way ANOVA Test

One-way ANOVA: a versus Sample

```
Source  DF     SS    MS     F      P
Sample   4   57.8  14.5  0.90  0.502
Error   10  161.5  16.2
Total   14  219.4

S = 4.019   R-Sq = 26.36%   R-Sq(adj) = 0.00%


                               Individual 95% CIs For Mean Based on
                               Pooled StDev
Level  N    Mean  StDev  -----+---------+---------+---------+----
A      3  12.650  5.049               (------------*------------)
B      3  11.223  3.891           (------------*------------)
C      3   9.393  5.128       (-----------*------------)
D      3   7.240  2.351  (------------*------------)
E      3   8.243  2.884     (------------*------------)
                         -----+---------+---------+---------+----
                            4.0       8.0      12.0      16.0

Pooled StDev = 4.019


Fisher 95% Individual Confidence Intervals
All Pairwise Comparisons among Levels of Sample

Simultaneous confidence level = 75.51%


Sample = A subtracted from:

Sample    Lower  Center  Upper  --------+---------+---------+---------+-
B        -8.739  -1.427  5.885        (---------*---------)
C       -10.569  -3.257  4.055     (---------*----------)
D       -12.722  -5.410  1.902  (---------*----------)
E       -11.719  -4.407  2.905   (----------*---------)
                                --------+---------+---------+---------+-
                                     -7.0       0.0       7.0      14.0

Sample = B subtracted from:

Sample    Lower  Center  Upper  --------+---------+---------+---------+-
C        -9.142  -1.830  5.482       (---------*----------)
D       -11.295  -3.983  3.329    (---------*----------)
E       -10.292  -2.980  4.332     (----------*---------)
                                --------+---------+---------+---------+-
                                     -7.0       0.0       7.0      14.0


Sample = C subtracted from:

Sample   Lower  Center  Upper  --------+---------+---------+---------+-
D       -9.465  -2.153  5.159      (----------*---------)
E       -8.462  -1.150  6.162        (---------*----------)
                               --------+---------+---------+---------+-
                                    -7.0       0.0       7.0      14.0


Sample = D subtracted from:

Sample   Lower  Center  Upper  --------+---------+---------+---------+-
E       -6.309   1.003  8.315          (---------*----------)
                               --------+---------+---------+---------+-
                                    -7.0       0.0       7.0      14.0
```

Overall result:

From One-way ANOVA Test;
Ho rejected since p ‹ 0.05, there are significant different between all samples in terms of color.

From Fisher's LSD Test;

```
                                   Individual 95% CIs For Mean Based on
                                   Pooled StDev
Level   N    Mean   StDev   -----+---------+---------+---------+----
A       3  12.650   5.049              (------------*------------)a
B       3  11.223   3.891          (------------*------------)a
C       3   9.393   5.128      (-----------*------------)a
D       3   7.240   2.351  (------------*------------)a
E       3   8.243   2.884     (------------*------------)a
                            -----+---------+---------+---------+----
                               4.0       8.0      12.0      16.0

Pooled StDev = 4.019
```

Summary result:

Sample	Mean of a* value	Standard deviation
A	12.650 [a]	5.049
B	11.233[a]	3.891
C	9.393[a]	5.128
D	7.240[a]	2.351
E	8.243[a]	2.884

c) Determination of color for b* value

1. Test for Equal Variances

Ho : σ 1 = σ 2 = σ 3 = σ 4= σ 5 (variance for all five population are same)
Ha : at least variance from 2 population are not same to each other.

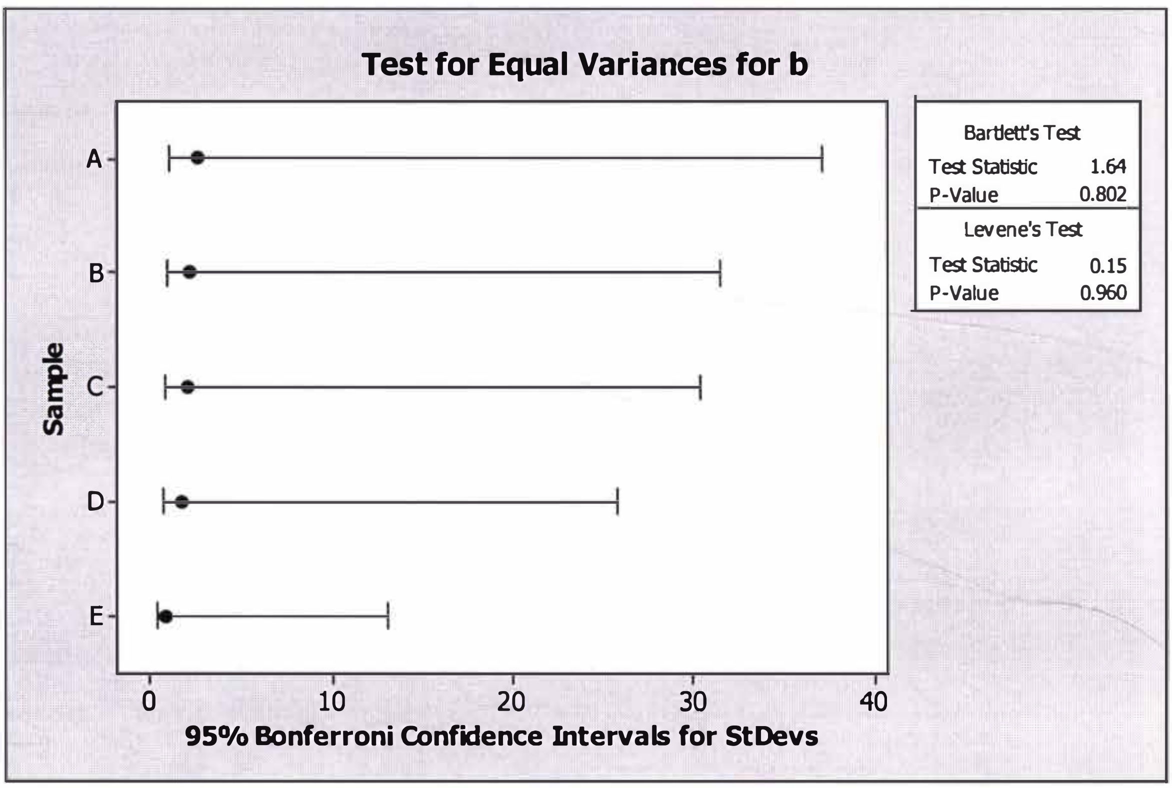
Test for Equal Variances: b versus Sample

```
95% Bonferroni confidence intervals for standard deviations

Sample  N    Lower     StDev     Upper
     A  3  1.14155   2.62763   37.1138
     B  3  0.96958   2.23179   31.5228
     C  3  0.93632   2.15523   30.4415
     D  3  0.79513   1.83023   25.8509
     E  3  0.40247   0.92641   13.0850


Bartlett's Test (normal distribution)
Test statistic = 1.64, p-value = 0.802


Levene's Test (any continuous distribution)
Test statistic = 0.15, p-value = 0.960
```



Result:

The value obtained from both Bartlett's and Levene's test gives p > 0.05. So, Ho is accepted that all five populations have same variance.
Thus, the rules for ANOVA Test are fulfilled.
So, further test can be continuing with One-way ANOVA Test.

2. One-way ANOVA Test

One-way ANOVA: b versus Sample

```
Source  DF     SS    MS     F      P
Sample   4  11.48  2.87  0.69  0.614
Error   10  41.48  4.15
Total   14  52.96

S = 2.037   R-Sq = 21.68%   R-Sq(adj) = 0.00%


                            Individual 95% CIs For Mean Based on
                            Pooled StDev
Level  N   Mean  StDev   +---------+---------+---------+---------
A      3  6.993  2.628               (------------*------------)
B      3  6.530  2.232             (------------*------------)
C      3  6.667  2.155             (------------*------------)
D      3  5.333  1.830       (------------*------------)
E      3  4.703  0.926   (------------*------------)
                         +---------+---------+---------+---------
                        2.0       4.0       6.0       8.0

Pooled StDev = 2.037


Fisher 95% Individual Confidence Intervals
All Pairwise Comparisons among Levels of Sample

Simultaneous confidence level = 75.51%


Sample = A subtracted from:

Sample   Lower  Center  Upper   +---------+---------+---------+---------
B       -4.168  -0.463  3.242         (-----------*------------)
C       -4.032  -0.327  3.378          (-----------*-----------)
D       -5.365  -1.660  2.045     (-----------*------------)
E       -5.995  -2.290  1.415   (-----------*------------)
                                +---------+---------+---------+---------
                             -6.0      -3.0       0.0       3.0


Sample = B subtracted from:

Sample   Lower  Center  Upper   +---------+---------+---------+---------
C       -3.568   0.137  3.842            (-----------*------------)
D       -4.902  -1.197  2.508        (-----------*-----------)
E       -5.532  -1.827  1.878      (-----------*-----------)
                                +---------+---------+---------+---------
                             -6.0      -3.0       0.0       3.0

Sample = C subtracted from:

Sample   Lower  Center  Upper   +---------+---------+---------+---------
D       -5.038  -1.333  2.372       (------------*-----------)
E       -5.668  -1.963  1.742     (-----------*------------)
                                +---------+---------+---------+---------
                             -6.0      -3.0       0.0       3.0

Sample = D subtracted from:

Sample   Lower  Center  Upper   +---------+---------+---------+---------
E       -4.335  -0.630  3.075          (-----------*-----------)
                                +---------+---------+---------+---------
                             -6.0      -3.0       0.0       3.0
```

Overall result:

From One-way ANOVA Test;
Ho rejected since $p < 0.05$, there are significant different between all samples in terms of color.

From Fisher's LSD Test;

```
                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level   N    Mean   StDev     +---------+---------+---------+---------
A       3   6.993   2.628                 (------------*------------)a
B       3   6.530   2.232               (------------*------------)a
C       3   6.667   2.155               (------------*------------)a
D       3   5.333   1.830         (------------*------------)a
E       3   4.703   0.926     (-------------*------------)a
                              +---------+---------+---------+---------
                            2.0       4.0       6.0       8.0

Pooled StDev = 2.037
```

Summary result:

Sample	Mean of b* value	Standard deviation
A	6.993 [a]	2.628
B	6.530[a]	2.232
C	6.667[a]	2.155
D	5.333[a]	1.830
E	4.703[a]	0.926

d) Determination of viscosity

1. Test for Equal Variances

Ho : σ 1 = σ 2 = σ 3 = σ 4= σ 5 (variance for all five population are same)
Ha : at least variance from 2 population are not same to each other

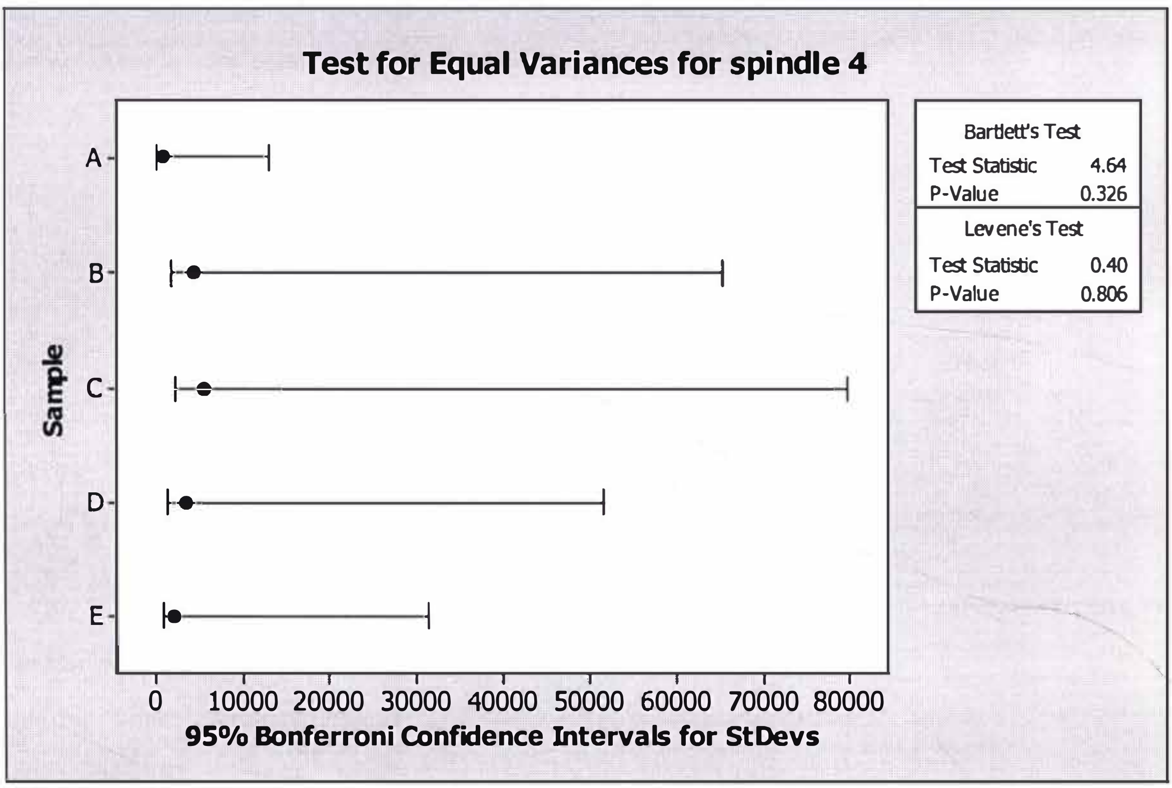
Test for Equal Variances: spindle 4 versus Sample

```
95% Bonferroni confidence intervals for standard deviations

Sample  N     Lower     StDev     Upper
     A  3    405.43    933.21   13181.1
     B  3   2011.30   4629.62   65390.7
     C  3   2449.79   5638.94   79646.8
     D  3   1593.52   3667.99   51808.2
     E  3    966.69   2225.14   31428.9


Bartlett's Test (normal distribution)
Test statistic = 4.64, p-value = 0.326


Levene's Test (any continuous distribution)
Test statistic = 0.40, p-value = 0.806
```



Result:

The value obtained from both Bartlett's and Levene's test gives $p > 0.05$. So, Ho is accepted that all five populations have same variance.
Thus, the rules for ANOVA Test are fulfilled.
So, further test can be continuing with One-way ANOVA Test

2. One-way ANOVA Test

One-way ANOVA: spindle 4 versus Sample

```
Source  DF         SS        MS     F      P
Sample   4  103517567  25879392  1.78  0.208
Error   10  145014434  14501443
Total   14  248532001

S = 3808   R-Sq = 41.65%   R-Sq(adj) = 18.31%


                           Individual 95% CIs For Mean Based on
                           Pooled StDev
Level  N   Mean  StDev  --+---------+---------+---------+-------
A      3   9009    933  (---------*---------)
B      3  10276   4630     (---------*--------)
C      3   9849   5639    (---------*--------)
D      3  14707   3668             (--------*---------)
E      3  15284   2225              (---------*--------)
                        --+---------+---------+---------+-------
                       5000     10000     15000     20000

Pooled StDev = 3808


Fisher 95% Individual Confidence Intervals
All Pairwise Comparisons among Levels of Sample

Simultaneous confidence level = 75.51%


Sample = A subtracted from:

Sample  Lower  Center  Upper  --------+---------+---------+---------+-
B       -5661    1267   8195           (---------*---------)
C       -6088     840   7768          (---------*---------)
D       -1230    5698  12626                 (---------*---------)
E        -653    6275  13203                  (---------*---------)
                              --------+---------+---------+---------+-
                                  -7000         0      7000     14000

Sample = B subtracted from:

Sample  Lower  Center  Upper  --------+---------+---------+---------+-
C       -7355    -427   6501        (---------*---------)
D       -2497    4431  11359               (---------*---------)
E       -1919    5009  11937                (---------*---------)
                              --------+---------+---------+---------+-
                                  -7000         0      7000     14000

Sample = C subtracted from:

Sample  Lower  Center  Upper  --------+---------+---------+---------+-
D       -2070    4858  11786                (---------*---------)
E       -1493    5435  12363                 (---------*---------)
                              --------+---------+---------+---------+-
                                  -7000         0      7000     14000

Sample = D subtracted from:

Sample  Lower  Center  Upper  --------+---------+---------+---------+-
E       -6350     578   7506          (---------*---------)
                              --------+---------+---------+---------+-
                                  -7000         0      7000     14000
```

Overall result:

From One-way ANOVA Test;
Ho rejected since p ‹ 0.05, there are significant different between all samples in terms of viscosity

From Fisher's LSD Test;

```
 Individual 95% CIs For Mean Based on
                              Pooled StDev
Level   N    Mean   StDev   --+---------+---------+---------+-------
A       3    9009     933    (---------*---------)
B       3   10276    4630       (---------*--------)
C       3    9849    5639      (---------*--------)
D       3   14707    3668               (--------*---------)
E       3   15284    2225                (---------*--------)
                            --+---------+---------+---------+-------
                           5000     10000     15000     20000

Pooled StDev = 3808
```

Summary result:

Sample	Mean of viscosity	Standard deviation
A	9009 [a]	933
B	10276[a]	4630
C	9849[a]	5639
D	14707[a]	3668
E	15284[a]	2225

APPENDIX B

Statistical analysis of chemical analysis

a) Determination of pH

1. Test for Equal Variances

Ho : σ 1 = σ 2 = σ 3 = σ 4= σ 5(variance for all five population are same)

Ha : at least variance from 2 population are not same to each other.

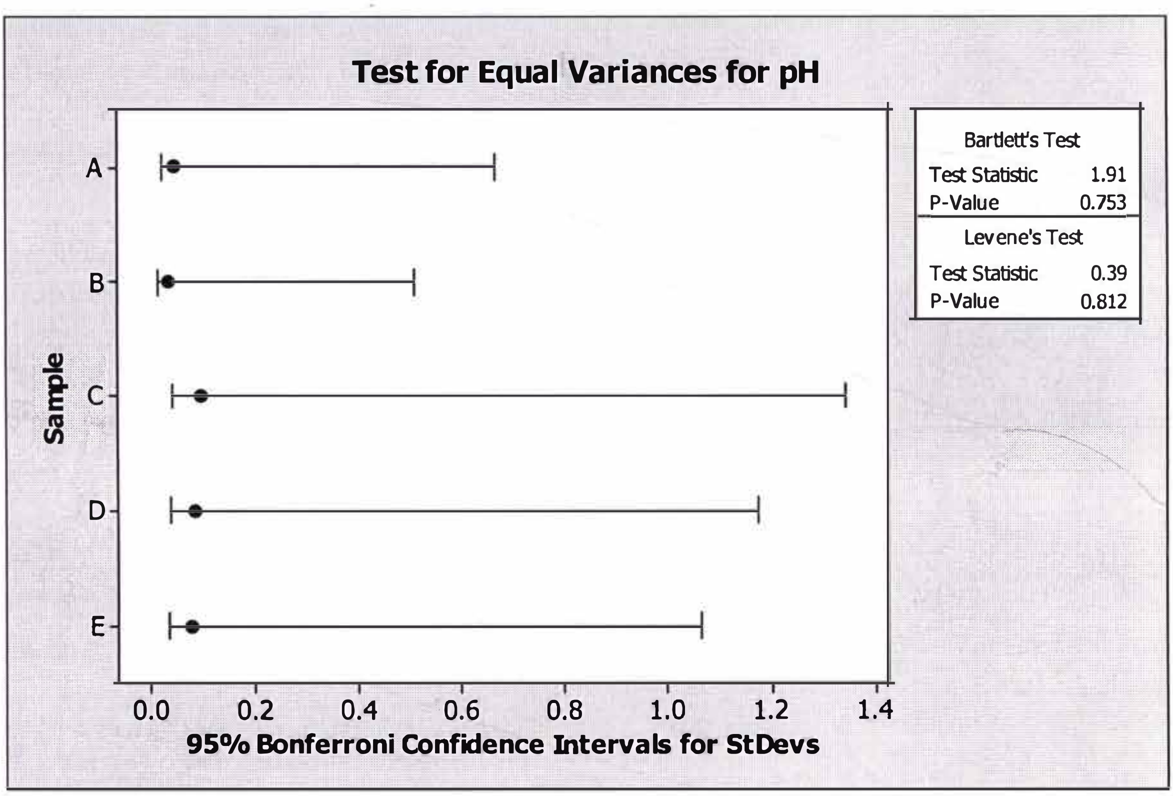
Test for Equal Variances: pH versus Sample

```
95% Bonferroni confidence intervals for standard deviations

Sample  N      Lower      StDev    Upper
     A  3  0.0205309  0.0472582  0.66749
     B  3  0.0156640  0.0360555  0.50926
     C  3  0.0412910  0.0950438  1.34244
     D  3  0.0361745  0.0832666  1.17609
     E  3  0.0327996  0.0754983  1.06637


Bartlett's Test (normal distribution)
Test statistic = 1.91, p-value = 0.753


Levene's Test (any continuous distribution)
Test statistic = 0.39, p-value = 0.812
```



Result:

The value obtained from both Bartlett's and Levene's test give $p > 0.05$. So, Ho is accepted that all five populations have same variance.
Thus, the rules for ANOVA Test are fulfilled.
So, further test can be continuing with One-way ANOVA Test.

1. One-way ANOVA Test

One-way ANOVA: pH versus Sample

```
Source  DF       SS       MS       F      P
Sample   4  3.18576  0.79644  158.02  0.000
Error   10  0.05040  0.00504
Total   14  3.23616

S = 0.07099   R-Sq = 98.44%   R-Sq(adj) = 97.82%


                           Individual 95% CIs For Mean Based on
                           Pooled StDev
Level  N    Mean   StDev  ------+---------+---------+---------+---
A      3  3.9433  0.0473                                (--*-)
B      3  3.7500  0.0361                           (--*-)
C      3  3.5033  0.0950                      (--*-)
D      3  3.1333  0.0833              (-*--)
E      3  2.6500  0.0755  (-*--)
                          ------+---------+---------+---------+---
                              2.80      3.20      3.60      4.00

Pooled StDev = 0.0710


Fisher 95% Individual Confidence Intervals
All Pairwise Comparisons among Levels of Sample

Simultaneous confidence level = 75.51%


Sample = A subtracted from:

Sample    Lower   Center    Upper     +---------+---------+---------+--------
-
B       -0.3225  -0.1933  -0.0642                   (-*-)
C       -0.5692  -0.4400  -0.3108                (-*-)
D       -0.9392  -0.8100  -0.6808            (*-)
E       -1.4225  -1.2933  -1.1642     (-*)
                                      +---------+---------+---------+--------
-
                                    -1.40     -0.70      0.00      0.70


Sample = B subtracted from:

Sample    Lower   Center    Upper     +---------+---------+---------+--------
-
C       -0.3758  -0.2467  -0.1175                   (*-)
D       -0.7458  -0.6167  -0.4875             (-*-)
E       -1.2292  -1.1000  -0.9708       (-*-)
                                      +---------+---------+---------+--------
-
                                    -1.40     -0.70      0.00      0.70
```

```
Sample = C subtracted from:

Sample    Lower    Center    Upper     +---------+---------+---------+--------
-
D       -0.4992  -0.3700  -0.2408                   (-*-)
E       -0.9825  -0.8533  -0.7242            (-*-)
                                       +---------+---------+---------+--------
-
                                     -1.40     -0.70      0.00      0.70
```

```
Sample = D subtracted from:

Sample    Lower    Center    Upper     +---------+---------+---------+--------
-
E       -0.6125  -0.4833  -0.3542                 (-*-)
                                       +---------+---------+---------+--------
-
                                     -1.40     -0.70      0.00      0.70
```

Overall result:

From One-way ANOVA Test;
Ho rejected since $p < 0.05$, there are significant different between all samples in terms of pH values.

From Fisher's LSD Test;

```
Individual 95% CIs For Mean Based on
                          Pooled StDev
Level  N    Mean   StDev  ------+---------+---------+---------+---
A      3  3.9433  0.0473                                (--*-)a
B      3  3.7500  0.0361                           (--*-)b
C      3  3.5033  0.0950                     (--*-)c
D      3  3.1333  0.0833            (-*--)d
E      3  2.6500  0.0755  (-*--)e
                          ------+---------+---------+---------+---
                              2.80      3.20      3.60      4.00
Pooled StDev = 0.0710
```

Summary result:

Sample	Mean pH	Standard deviation
A	3.9433^{a}	0.0473
B	3.7500^{b}	0.0361
C	3.5033^{c}	0.0950
D	3.1333^{d}	0.0833
E	2.6500^{e}	0.0755

b) Determination of °Brix value

1. Test for Equal Variances

Ho : $\sigma 1 = \sigma 2 = \sigma 3 = \sigma 4 = \sigma 5$(variance for all five population are same)

Ha : at least variance from 2 population are not same to each other.

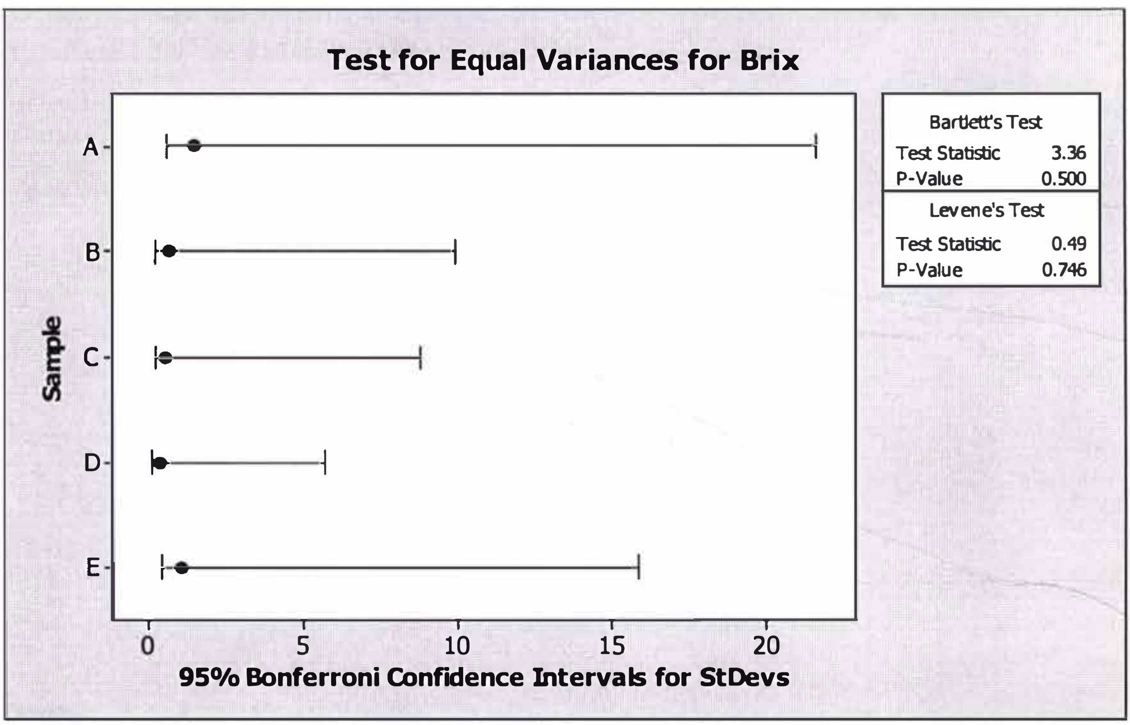
Test for Equal Variances: Brix versus Sample

```
95% Bonferroni confidence intervals for standard deviations

Sample  N     Lower     StDev    Upper
     A  3  0.665040  1.53080  21.6216
     B  3  0.305141  0.70238   9.9207
     C  3  0.271308  0.62450   8.8207
     D  3  0.175577  0.40415   5.7083
     E  3  0.488304  1.12398  15.8756


Bartlett's Test (normal distribution)
Test statistic = 3.36, p-value = 0.500


Levene's Test (any continuous distribution)
Test statistic = 0.49, p-value = 0.746
```



Result:

The value obtained from both Bartlett's and Levene's test gives $p > 0.05$. So, Ho is accepted that all five populations have same variance.
Thus, the rules for ANOVA Test are fulfilled.
So, further test can be continuing with One-way ANOVA Test.

2. One-way ANOVA Test

One-way ANOVA: Brix versus Sample

```
Source  DF       SS      MS      F      P
Sample   4  178.443  44.611  47.93  0.000
Error   10    9.307   0.931
Total   14  187.749

S = 0.9647   R-Sq = 95.04%   R-Sq(adj) = 93.06%


                               Individual 95% CIs For Mean Based on
                               Pooled StDev
Level  N    Mean  StDev  --------+---------+---------+---------+-
A      3  30.633  1.531                           (---*---)
B      3  30.967  0.702                            (---*---)
C      3  22.700  0.624  (---*---)
D      3  23.933  0.404      (---*---)
E      3  25.233  1.124          (---*---)
                         --------+---------+---------+---------+-
                              24.0      27.0      30.0      33.0

Pooled StDev = 0.965


Fisher 95% Individual Confidence Intervals
All Pairwise Comparisons among Levels of Sample

Simultaneous confidence level = 75.51%


Sample = A subtracted from:

Sample   Lower  Center   Upper  -------+---------+---------+---------+--
B       -1.422   0.333   2.088                (--*-)
C       -9.688  -7.933  -6.178   (--*--)
D       -8.455  -6.700  -4.945     (--*--)
E       -7.155  -5.400  -3.645       (--*--)
                                -------+---------+---------+---------+--
                                    -6.0       0.0       6.0      12.0


Sample = B subtracted from:

Sample    Lower  Center   Upper  -------+---------+---------+---------+--
C       -10.022  -8.267  -6.512  (--*--)
D        -8.788  -7.033  -5.278    (--*--)
E        -7.488  -5.733  -3.978       (-*--)
                                 -------+---------+---------+---------+--
                                     -6.0       0.0       6.0      12.0


Sample = C subtracted from:

Sample   Lower  Center  Upper  -------+---------+---------+---------+--
D       -0.522   1.233  2.988                (--*--)
E        0.778   2.533  4.288                  (--*--)
                               -------+---------+---------+---------+--
                                   -6.0       0.0       6.0      12.0
```

```
Sample = D subtracted from:

Sample    Lower   Center   Upper   -------+---------+---------+---------+--
E        -0.455    1.300   3.055                     (--*--)
                                   -------+---------+---------+---------+--
                                       -6.0       0.0       6.0      12.0
```

Overall result:

From One-way ANOVA Test;
Ho rejected since $p < 0.05$, there are significant different between all samples in terms of brix values.

From Fisher's LSD Test;

```
Individual 95% CIs For Mean Based on
                         Pooled StDev
Level  N    Mean   StDev  --------+---------+---------+---------+-
A      3  30.633   1.531                          (---*---)a
B      3  30.967   0.702                           (---*---)a
C      3  22.700   0.624  (---*---)bc
D      3  23.933   0.404      (---*---)c
E      3  25.233   1.124          (---*---)b
                          --------+---------+---------+---------+-
                               24.0      27.0      30.0      33.0

Pooled StDev = 0.965
```

Summary result:

Sample	Mean of °brix value	Standard deviation
A	30.633[a]	1.531
B	30.967[a]	0.702
C	22.700[c]	0.624
D	23.933[bc]	0.404
E	25.233[b]	1.124

APPENDIX C

1. Sensory form

Chili sauces

Date:
Panel:
Gender:
Sample code:

Instruction:

You are given **five (5) samples** of chili sauces substitute tomato with Roselle waste. Please taste and evaluate the sample from left to right. Tick the box to indicate your likeness intensity of each sample. Rinse your mouth with water before and after evaluating each sample. Thank you.

Color

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Dislike extremely — Neither like nor dislike — Like extremely

Odor

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Dislike extremely — Neither like nor dislike — Like extremely

Viscosity

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Dislike extremely — Neither like nor dislike — Like extremely

Taste

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Dislike extremely — Neither like nor dislike — Like extremely

Overall acceptance

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Dislike extremely — Neither like nor dislike — Like extremely

APPENDIX D

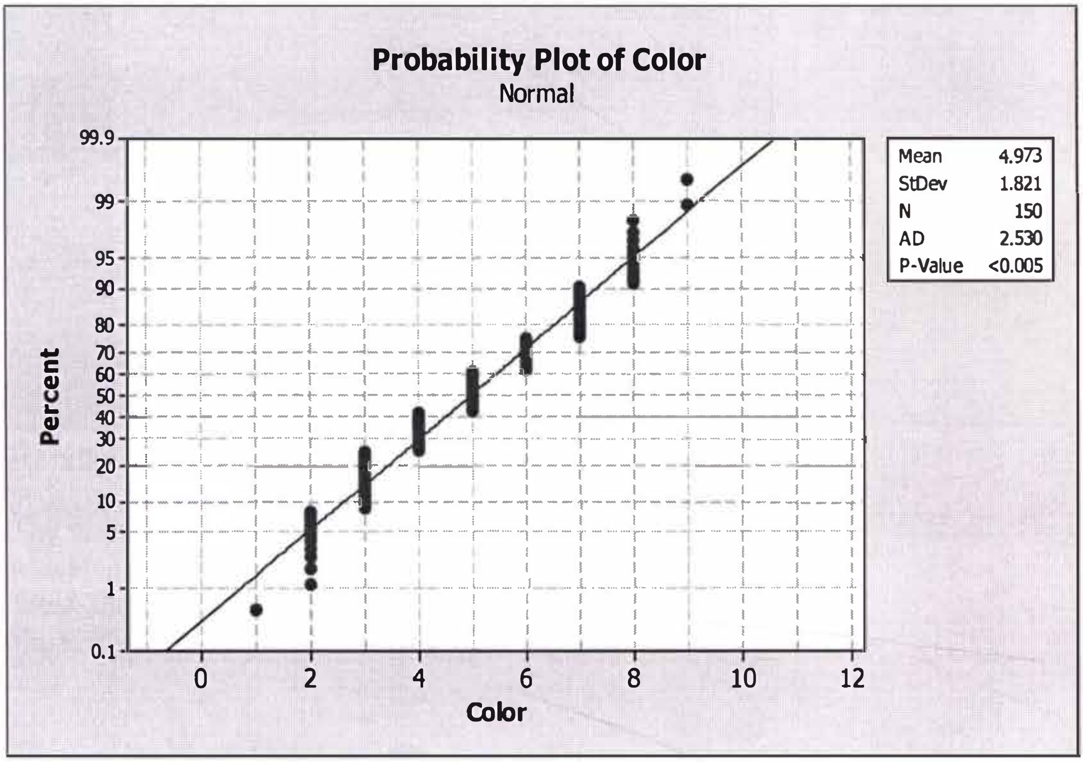
Sensory evaluation analysis using One way ANOVA

a) Color analysis

1. Normality Test

Objective: to confirmed the data distributed are normal.
Ho : data are distribute normally.
Ha : data are not distribute normally.

Probability plot of color.



AD : p-value = <0.005, P > 0.05
Result: since p > 0.05, so, Ho is rejected; the data are not distributed normally.

2. Test for Equal Variances

Ho : $\sigma 1 = \sigma 2 = \sigma 3 = \sigma 4 = \sigma 5$ (variance for all five population are same)
Ha : at least variance from 2 population are not same to each other.

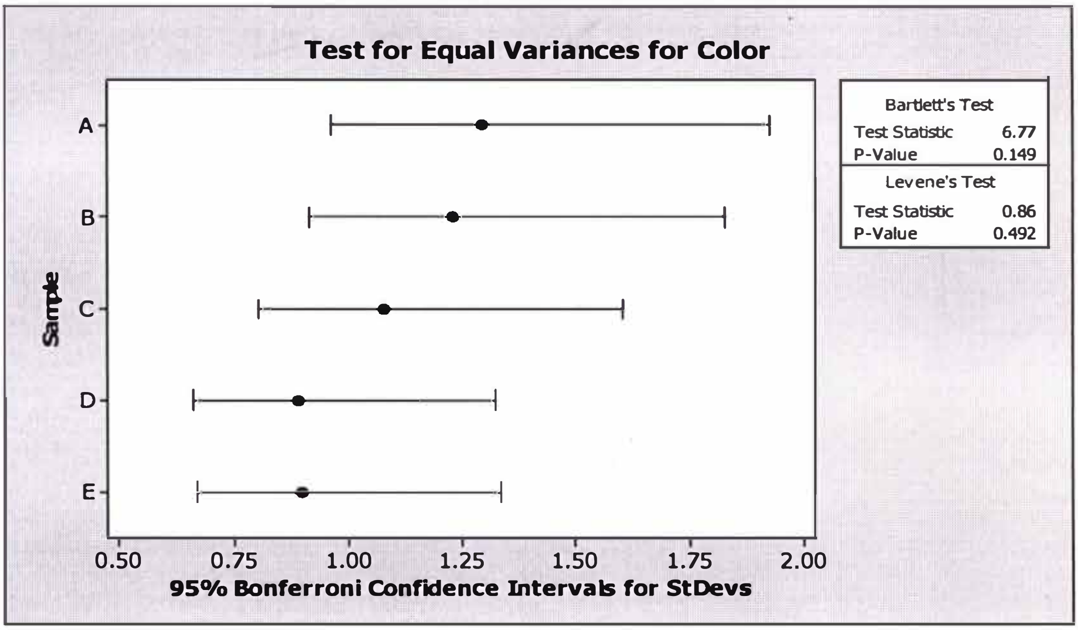
Test for Equal Variances: Color versus Sample

95% Bonferroni confidence intervals for standard deviations

Sample	N	Lower	StDev	Upper
A	30	0.964641	1.29588	1.92654
B	30	0.915522	1.22990	1.82844
C	30	0.804429	1.08066	1.60657
D	30	0.662446	0.88992	1.32301
E	30	0.669618	0.89955	1.33733

```
Bartlett's Test (normal distribution)
Test statistic = 6.77, p-value = 0.149


Levene's Test (any continuous distribution)
Test statistic = 0.86, p-value = 0.492
```



Result:

The value obtained from both Bartlett's and Levene's test gives $p > 0.05$. So, Ho is accepted that all five populations have same variance.
Thus, the rules for ANOVA Test are fulfilled.
So, further test can be continuing with One-way ANOVA Test.

3. One-way ANOVA Test

One-way ANOVA: Color versus Sample

```
Source   DF      SS     MS      F      P
Sample    4  321.03  80.26  67.32  0.000
Error   145  172.87   1.19
Total   149  493.89

S = 1.092   R-Sq = 65.00%   R-Sq(adj) = 64.03%


                           Individual 95% CIs For Mean Based on
                           Pooled StDev
Level   N   Mean  StDev  ----+---------+---------+---------+-----
A      30  5.900  1.296                      (-*--)b
B      30  7.067  1.230                             (--*--)a
C      30  5.067  1.081                (--*-)c
D      30  3.967  0.890         (-*--)d
E      30  2.867  0.900  (--*--)e
                         ----+---------+---------+---------+-----
                           3.0       4.5       6.0       7.5
```

```
Pooled StDev = 1.09

Fisher 95% Individual Confidence Intervals
All Pairwise Comparisons among Levels of Sample

Simultaneous confidence level = 71.73%


Sample = A subtracted from:

Sample   Lower  Center   Upper  ---------+---------+---------+---------+
B        0.609   1.167   1.724                       (--*-)
C       -1.391  -0.833  -0.276               (--*-)
D       -2.491  -1.933  -1.376           (-*-)
E       -3.591  -3.033  -2.476       (-*-)
                                ---------+---------+---------+---------+
                                      -2.5       0.0       2.5       5.0


Sample = B subtracted from:

Sample   Lower  Center   Upper  ---------+---------+---------+---------+
C       -2.557  -2.000  -1.443           (-*-)
D       -3.657  -3.100  -2.543      (--*-)
E       -4.757  -4.200  -3.643  (-*-)
                                ---------+---------+---------+---------+
                                      -2.5       0.0       2.5       5.0


Sample = C subtracted from:

Sample   Lower  Center   Upper  ---------+---------+---------+---------+
D       -1.657  -1.100  -0.543              (--*-)
E       -2.757  -2.200  -1.643          (-*-)
                                ---------+---------+---------+---------+
                                      -2.5       0.0       2.5       5.0


Sample = D subtracted from:

Sample   Lower  Center   Upper  ---------+---------+---------+---------+
E       -1.657  -1.100  -0.543              (--*-)
                                ---------+---------+---------+---------+
                                      -2.5       0.0       2.5       5.0
```

Overall result:

From One-way ANOVA Test;

Ho rejected since $p < 0.05$, there are significant different between all samples in terms of color.
From Fisher's LSD Test;

```
Individual 95% CIs For Mean Based on
                                Pooled StDev
Level     N    Mean   StDev   ----+---------+---------+---------+-----
A        30   5.900   1.296                        (-*--)b
B        30   7.067   1.230                               (--*--)a
C        30   5.067   1.081                  (--*-)c
D        30   3.967   0.890            (-*--)d
E        30   2.867   0.900   (--*--)e
                              ----+---------+---------+---------+-----
                                3.0       4.5       6.0       7.5

Pooled StDev = 1.092
```

Summary result:

Sample	Mean color	Standard deviation
A	5.900 ^{a}	1.296
B	7.067 ^{b}	1.230
C	5.067 ^{c}	1.081
D	3.967 ^{d}	0.890
E	2.867 ^{e}	0.900

b) Viscosity analysis

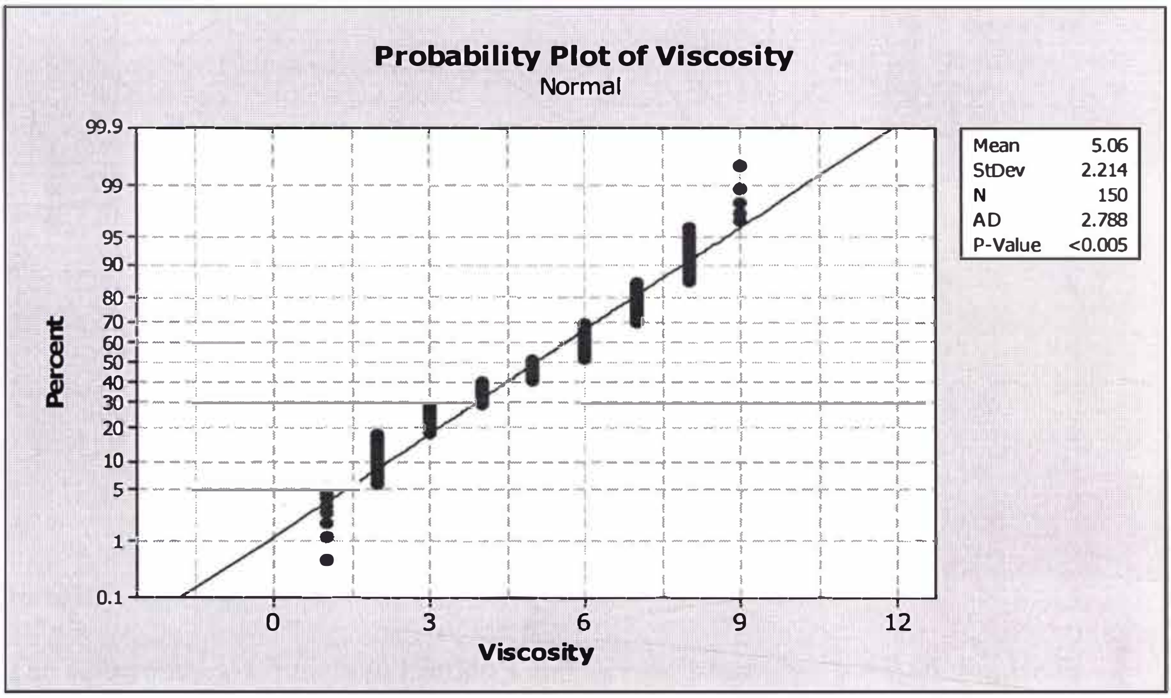
1. Normality Test

Objective: to confirmed the data distributed are normal.

Ho : data are distribute normally.

Ha : data are not distribute normally.

Probability plot of viscosity.



AD : p-value = <0.005, P > 0.05

Result: since p > 0.05, so, Ho is rejected; the data are not distributed normally.

2. Test for Equal Variances

Ho : σ 1 = σ 2 = σ 3 = σ 4= σ 5 (variance for all five population are same)

Ha : at least variance from 2 population are not same to each other.

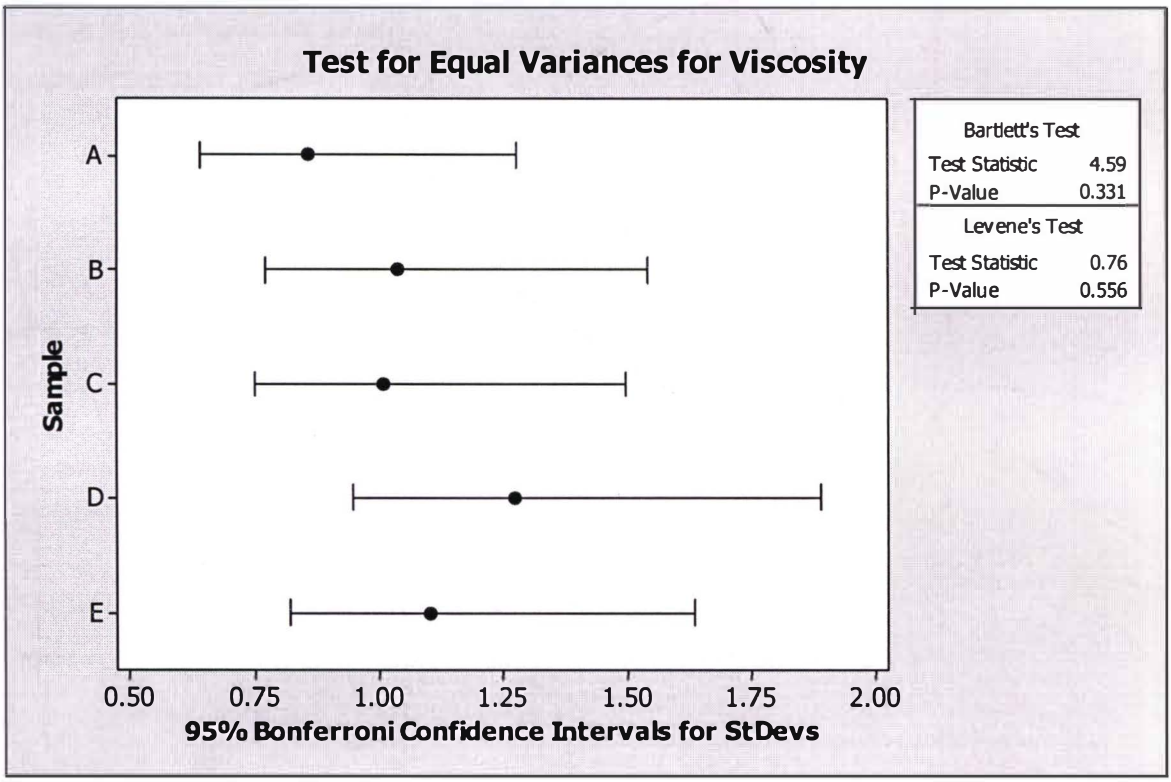
Test for Equal Variances: Viscosity versus Sample

```
95% Bonferroni confidence intervals for standard deviations

Sample   N     Lower     StDev     Upper
     A  30  0.640448  0.86037  1.27908
     B  30  0.772109  1.03724  1.54202
     C  30  0.750355  1.00801  1.49858
     D  30  0.947319  1.27261  1.89195
     E  30  0.820111  1.10172  1.63789
```

```
Bartlett's Test (normal distribution)
Test statistic = 4.59, p-value = 0.331


Levene's Test (any continuous distribution)
Test statistic = 0.76, p-value = 0.556
```



Result:

The value obtained from both Bartlett's and Levene's test give $p > 0.05$. So, Ho is accepted that all five populations have same variance.
Thus, the rules for ANOVA Test are fulfilled.
So, further test can be continuing with One-way ANOVA Test.

3. One-way ANOVA Test

One-way ANOVA: Viscosity versus Sample

```
Source   DF      SS      MS       F      P
Sample    4  566.16  141.54  124.91  0.000
Error   145  164.30    1.13
Total   149  730.46

S = 1.064   R-Sq = 77.51%   R-Sq(adj) = 76.89%
                          Individual 95% CIs For Mean Based on
                                       Pooled StDev
Level   N   Mean  StDev  -----+---------+---------+---------+----
A      30  5.533  0.860                     (--*-)c
B      30  6.600  1.037                            (--*--)b
C      30  7.533  1.008                                   (-*--)a
D      30  3.033  1.273     (-*--)d
E      30  2.600  1.102  (-*--)d
                         -----+---------+---------+---------+----
                            3.0       4.5       6.0       7.5
```

```
Pooled StDev = 1.064

Fisher 95% Individual Confidence Intervals
All Pairwise Comparisons among Levels of Sample

Simultaneous confidence level = 71.73%


Sample = A subtracted from:

Sample    Lower   Center    Upper  --------+---------+---------+---------+-
B         0.523    1.067    1.610                     (-*)
C         1.457    2.000    2.543                        (-*)
D        -3.043   -2.500   -1.957        (-*)
E        -3.477   -2.933   -2.390      (-*-)
                                   --------+---------+---------+---------+-
                                        -3.0       0.0       3.0       6.0


Sample = B subtracted from:

Sample    Lower   Center    Upper  --------+---------+---------+---------+-
C         0.390    0.933    1.477                    (-*-)
D        -4.110   -3.567   -3.023     (-*-)
E        -4.543   -4.000   -3.457    (-*)
                                   --------+---------+---------+---------+-
                                        -3.0       0.0       3.0       6.0


Sample = C subtracted from:

Sample    Lower   Center    Upper  --------+---------+---------+---------+-
D        -5.043   -4.500   -3.957   (-*-)
E        -5.477   -4.933   -4.390  (-*)
                                   --------+---------+---------+---------+-
                                        -3.0       0.0       3.0       6.0


Sample = D subtracted from:

Sample    Lower   Center   Upper  --------+---------+---------+---------+-
E        -0.977   -0.433   0.110                (-*)
                                  --------+---------+---------+---------+-
                                       -3.0       0.0       3.0       6.0
```

Overall result:

From One-way ANOVA Test;
Ho rejected since $p < 0.05$, there are significant different between all samples in terms of color.

From Fisher's LSD Test;

```
 Individual 95% CIs For Mean Based on
                                 Pooled StDev
Level    N   Mean   StDev   -----+---------+---------+---------+----
A       30  5.533   0.860                   (--*-) c
B       30  6.600   1.037                          (--*--) b
C       30  7.533   1.008                                 (-*--) a
D       30  3.033   1.273      (-*--) d
E       30  2.600   1.102   (-*--) d
                            -----+---------+---------+---------+----
                               3.0       4.5       6.0       7.5

Pooled StDev = 1.064
```

Summary result:

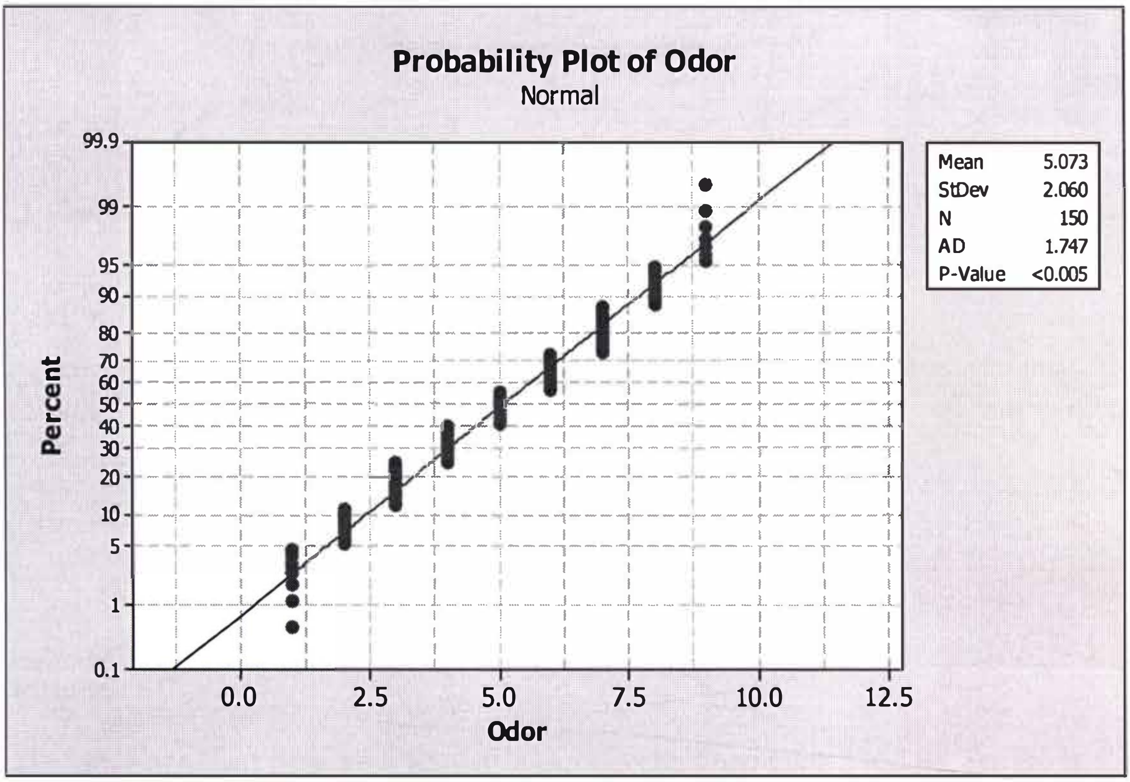
Sample	Mean viscosity	Standard deviation
A	5.533 [a]	0.860
B	6.600 [b]	1.037
C	7.533 [c]	1.008
D	3.033 [d]	1.273
E	2.600 [a]	1.102

c) **Odor analysis**

1. **Normality Test**

Objective: to confirmed the data distributed are normal.
Ho : data are distribute normally.
Ha : data are not distribute normally.

Probability plot of odor.



AD : p-value = <0.005, P > 0.05
Result: since p > 0.05, so, Ho is rejected; the data are not distributed normally.

2. **Test for Equal Variances**

Ho : σ 1 = σ 2 = σ 3 = σ 4= σ 5 (variance for all five population are same)
Ha : at least variance from 2 population are not same to each other.

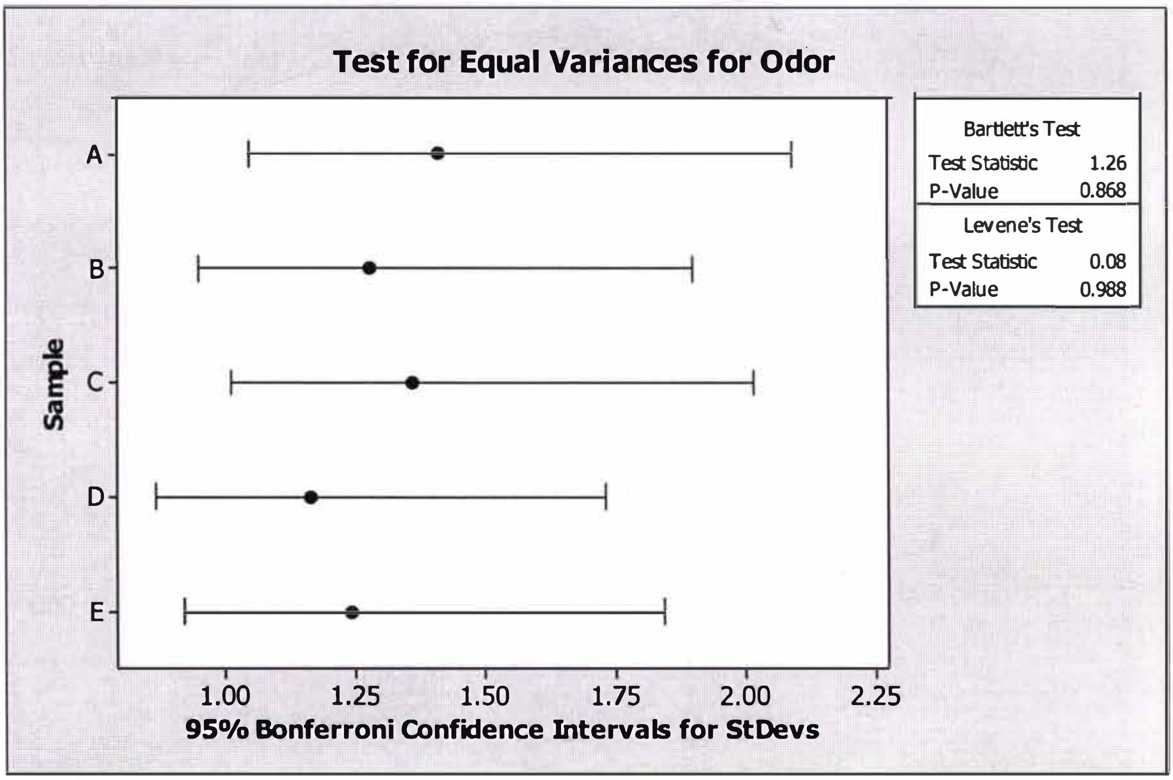
Test for Equal Variances: Odor versus Sample

95% Bonferroni confidence intervals for standard deviations

Sample	N	Lower	StDev	Upper
A	30	1.04787	1.40770	2.09277
B	30	0.95134	1.27802	1.89999
C	30	1.01075	1.35782	2.01862
D	30	0.86729	1.16511	1.73212
E	30	0.92418	1.24152	1.84573

```
Bartlett's Test (normal distribution)
Test statistic = 1.26, p-value = 0.868


Levene's Test (any continuous distribution)
Test statistic = 0.08, p-value = 0.988
```



Result:

The value obtained from both Bartlett's and Levene's test give $p > 0.05$. So, Ho is accepted that all five populations have same variance.
Thus, the rules for ANOVA Test are fulfilled.
So, further test can be continuing with One-way ANOVA Test.

3. One-way ANOVA Test

One-way ANOVA: Odor versus Sample

Source	DF	SS	MS	F	P
Sample	4	389.83	97.46	58.31	0.000
Error	145	242.37	1.67		
Total	149	632.19			

```
S = 1.293   R-Sq = 61.66%   R-Sq(adj) = 60.60%
```

```
                           Individual 95% CIs For Mean Based on
                                        Pooled StDev
Level    N    Mean   StDev   ----+---------+---------+---------+-----
A       30   5.533   1.408                      (--*--)b
B       30   7.233   1.278                                 (--*--)a
C       30   6.133   1.358                          (--*--)ab
D       30   3.567   1.165        (--*--)ab
E       30   2.900   1.242   (--*--)ab
                             ----+---------+---------+---------+-----
                               3.0       4.5       6.0       7.5
Pooled StDev = 1.293
```

```
Fisher 95% Individual Confidence Intervals
All Pairwise Comparisons among Levels of Sample

Simultaneous confidence level = 71.73%


Sample = A subtracted from:

Sample    Lower  Center   Upper      +---------+---------+---------+---------
B         1.040   1.700   2.360                               (--*-)
C        -0.060   0.600   1.260                           (-*--)
D        -2.626  -1.967  -1.307                (--*--)
E        -3.293  -2.633  -1.974              (-*--)
                                     +---------+---------+---------+---------
                                   -5.0      -2.5       0.0       2.5


Sample = B subtracted from:

Sample    Lower  Center   Upper      +---------+---------+---------+---------
C        -1.760  -1.100  -0.440                    (--*-)
D        -4.326  -3.667  -3.007         (-*--)
E        -4.993  -4.333  -3.674      (--*-)
                                     +---------+---------+---------+---------
                                   -5.0      -2.5       0.0       2.5


Sample = C subtracted from:

Sample    Lower  Center   Upper      +---------+---------+---------+---------
D        -3.226  -2.567  -1.907              (--*-)
E        -3.893  -3.233  -2.574         (--*--)
                                     +---------+---------+---------+---------
                                   -5.0      -2.5       0.0       2.5


Sample = D subtracted from:

Sample    Lower  Center   Upper      +---------+---------+---------+---------
E        -1.326  -0.667  -0.007                      (-*--)
                                     +---------+---------+---------+---------
                                   -5.0      -2.5       0.0       2.5
```

Overall result:

From One-way ANOVA Test;

Ho rejected since p ‹ 0.05, there are significant different between all samples in terms of color.

From Fisher's LSD Test;

```
                                   Individual 95% CIs For Mean Based on
                                   Pooled StDev
Level    N    Mean   StDev   ----+---------+---------+---------+-----
A       30   5.533   1.408                      (--*--)b
B       30   7.233   1.278                                 (--*--)a
C       30   6.133   1.358                          (--*--)b
D       30   3.567   1.165        (--*--)c
E       30   2.900   1.242   (--*--)d
                             ----+---------+---------+---------+-----
                               3.0       4.5       6.0       7.5

Pooled StDev = 1.293
```

Summary result:

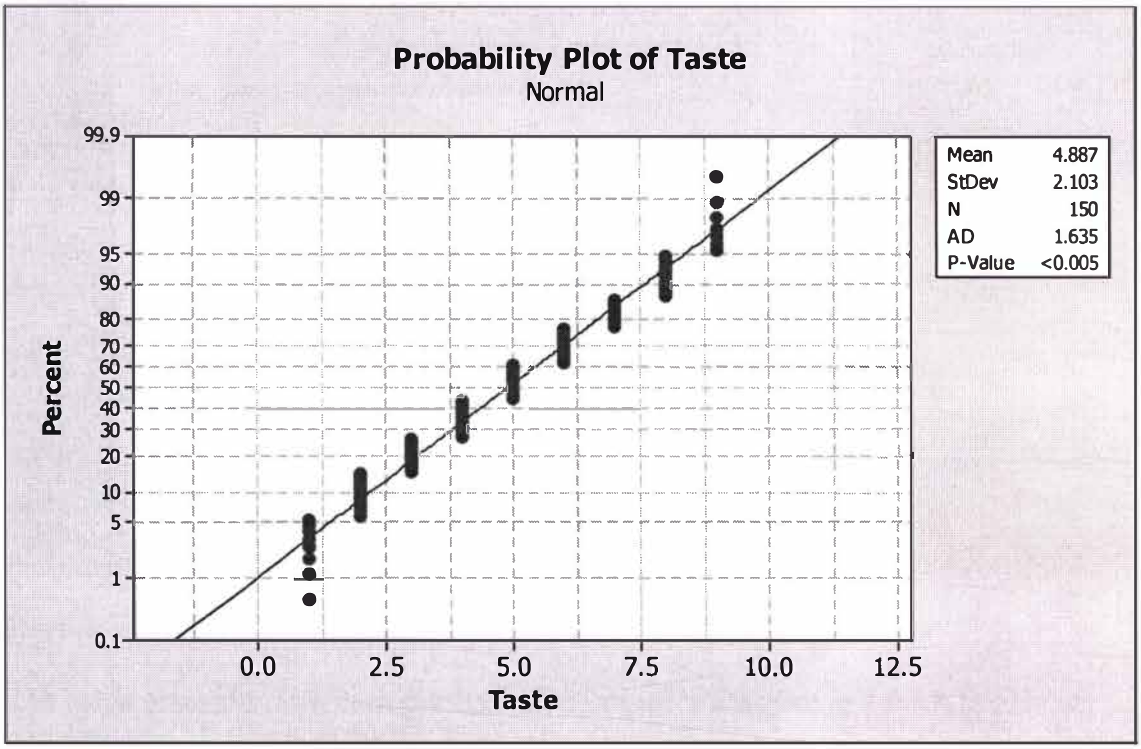
Sample	Mean odor	Standard deviation
A	5.533 [a]	1.408
B	7.233 [b]	1.278
C	6.133 [a]	1.358
D	3.567 [c]	1.165
E	2.900 [d]	1.242

d) Taste analysis

1. Normality Test

Objective: to confirmed the data distributed are normal.
Ho : data are distribute normally.
Ha : data are not distribute normally.

Probability plot of taste.



AD : p-value = <0.005, P > 0.05
Result: since p > 0.05, so, Ho is rejected; the data are not distributed normally.

2. Test for Equal Variances

Ho : σ 1 = σ 2 = σ 3 = σ 4= σ 5 (variance for all five population are same)
Ha : at least variance from 2 population are not same to each other.

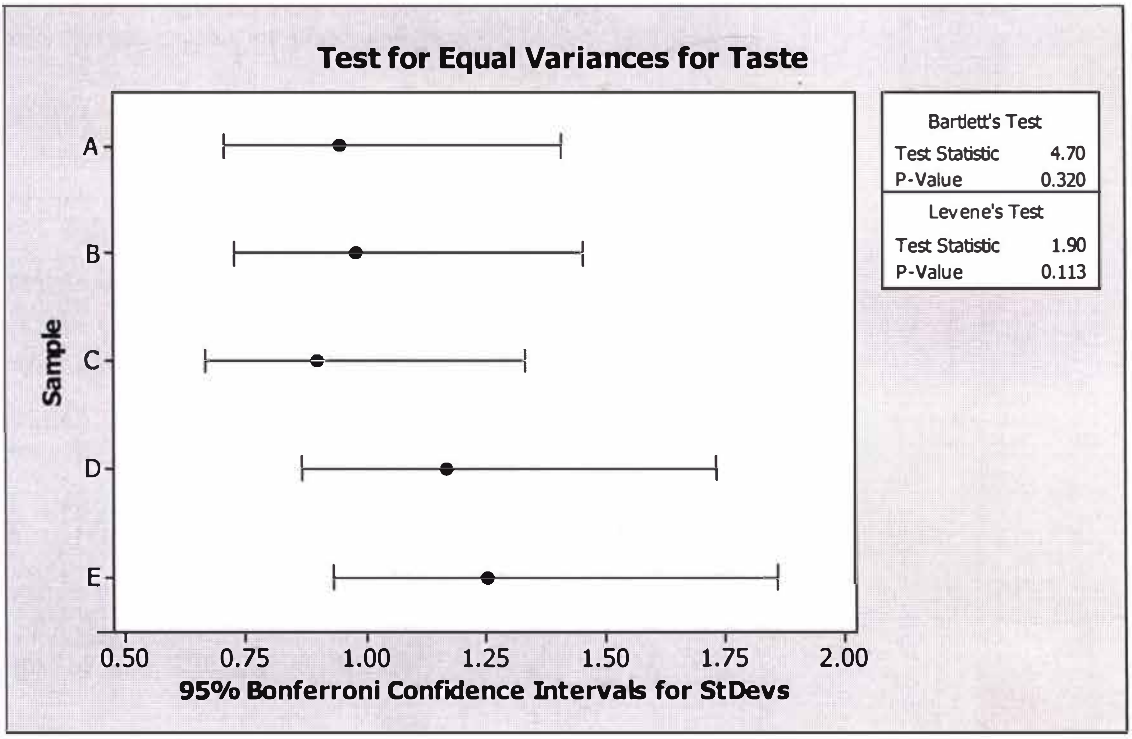
Test for Equal Variances: Taste versus Sample

95% Bonferroni confidence intervals for standard deviations

Sample	N	Lower	StDev	Upper
A	30	0.707091	0.94989	1.41217
B	30	0.729699	0.98027	1.45733
C	30	0.669618	0.89955	1.33733
D	30	0.868393	1.16658	1.73432
E	30	0.932069	1.25212	1.86149

```
Bartlett's Test (normal distribution)
Test statistic = 4.70, p-value = 0.320


Levene's Test (any continuous distribution)
Test statistic = 1.90, p-value = 0.113
```



Result:

The value obtained from both Bartlett's and Levene's test give $p > 0.05$. So, Ho is accepted that all five populations have same variance.
Thus, the rules for ANOVA Test are fulfilled.
So, further test can be continuing with One-way ANOVA Test.

3. One-way ANOVA Test

One-way ANOVA: Taste versus Sample

Source	DF	SS	MS	F	P
Sample	4	496.64	124.16	110.83	0.000
Error	145	162.43	1.12		
Total	149	659.07			

```
S = 1.058   R-Sq = 75.35%   R-Sq(adj) = 74.67%
```

```
                          Individual 95% CIs For Mean Based on
                                      Pooled StDev
Level    N    Mean   StDev  ------+---------+---------+---------+---
A       30   5.833   0.950                        (--*-)b
B       30   7.733   0.980                                     (--*-)a
C       30   4.867   0.900                  (-*--)ab
D       30   3.467   1.167          (-*--)ab
E       30   2.533   1.252  (--*-)ab
                            ------+---------+---------+---------+---
                                3.0       4.5       6.0       7.5
Pooled StDev = 1.058
```

```
Fisher 95% Individual Confidence Intervals
All Pairwise Comparisons among Levels of Sample

Simultaneous confidence level = 71.73%


Sample = A subtracted from:

Sample   Lower   Center   Upper  ---------+---------+---------+---------+
B        1.360    1.900   2.440                          (*-)
C       -1.507   -0.967  -0.427                (-*-)
D       -2.907   -2.367  -1.827           (-*-)
E       -3.840   -3.300  -2.760      (-*-)
                                 ---------+---------+---------+---------+
                                       -3.0       0.0       3.0       6.0


Sample = B subtracted from:

Sample   Lower   Center   Upper  ---------+---------+---------+---------+
C       -3.407   -2.867  -2.327          (*-)
D       -4.807   -4.267  -3.727     (-*-)
E       -5.740   -5.200  -4.660  (-*)
                                 ---------+---------+---------+---------+
                                       -3.0       0.0       3.0       6.0


Sample = C subtracted from:

Sample   Lower   Center   Upper  ---------+---------+---------+---------+
D       -1.940   -1.400  -0.860               (*-)
E       -2.873   -2.333  -1.793          (-*-)
                                 ---------+---------+---------+---------+
                                       -3.0       0.0       3.0       6.0


Sample = D subtracted from:

Sample   Lower   Center   Upper  ---------+---------+---------+---------+
E       -1.473   -0.933  -0.393                (-*-)
                                 ---------+---------+---------+---------+
                                       -3.0       0.0       3.0       6.0
```

Overall result:

From One-way ANOVA Test;

Ho rejected since $p < 0.05$, there are significant different between all samples in terms of color.
From Fisher's LSD Test;

```
                                 Individual 95% CIs For Mean Based on
                                 Pooled StDev
Level   N   Mean  StDev  ------+---------+---------+---------+---
A      30  5.833  0.950                        (--*-)b
B      30  7.733  0.980                                    (--*-)a
C      30  4.867  0.900                  (-*--)c
D      30  3.467  1.167         (-*--)d
E      30  2.533  1.252  (--*-)e
                         ------+---------+---------+---------+---
                             3.0       4.5       6.0       7.5

Pooled StDev = 1.058
```

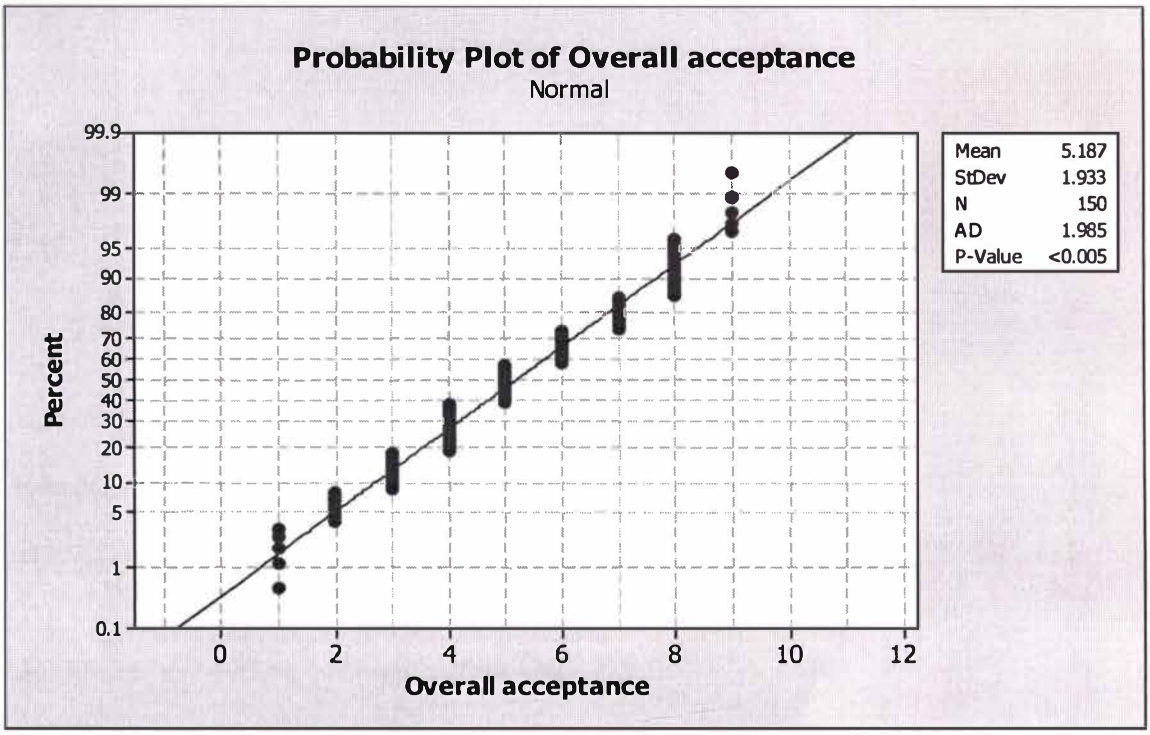
Summary result:

Sample	Mean odor	Standard deviation
A	5.833^{a}	0.950
B	7.733^{b}	0.980
C	4.867^{c}	0.900
D	3.467^{d}	1.167
E	2.533^{e}	1.252

e) **Overall acceptance analysis**

1. **Normality Test**
   Objective: to confirmed the data distributed are normal.
   Ho : data are distribute normally.
   Ha : data are not distribute normally.

Probability plot of overall acceptance



AD : p-value = <0.005, P > 0.05
Result: since p > 0.05, so, Ho is rejected; the data are not distributed normally.

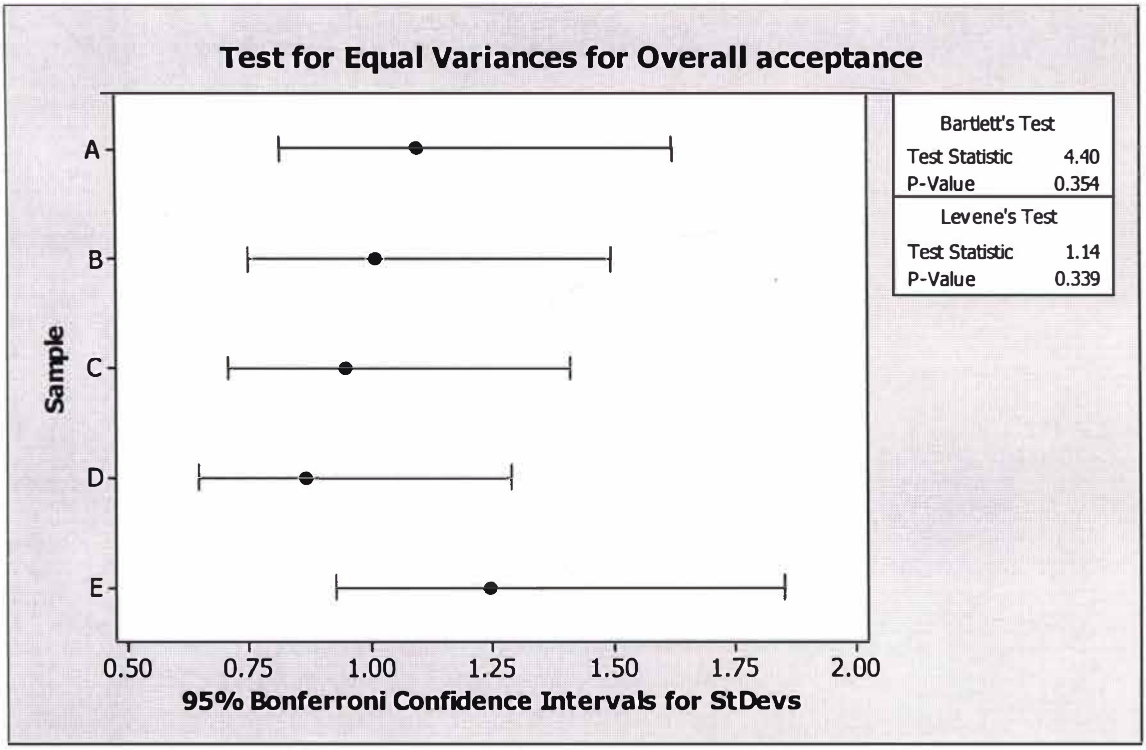
2. **Test for Equal Variances**
   Ho : σ 1 = σ 2 = σ 3 = σ 4= σ 5 (variance for all five population are same)
   Ha : at least variance from 2 population are not same to each other.

Test for Equal Variances: Overall acceptance versus Sample

```
95% Bonferroni confidence intervals for standard deviations

Sample   N      Lower     StDev     Upper
     A  30  0.813874  1.09334  1.62544
     B  30  0.750355  1.00801  1.49858
     C  30  0.707091  0.94989  1.41217
     D  30  0.646387  0.86834  1.29094
     E  30  0.926929  1.24522  1.85123
Bartlett's Test (normal distribution)
Test statistic = 4.40, p-value = 0.354


Levene's Test (any continuous distribution)
Test statistic = 1.14, p-value = 0.339
```



Result:

The value obtained from both Bartlett's and Levene's tests give $p > 0.05$. So, Ho is accepted that all five populations have same variance.
Thus, the rules for ANOVA Test are fulfilled.
So, further test can be continuing with One-way ANOVA Test.

3. One-way ANOVA Test

One-way ANOVA: Overall acceptance versus Sample

```
Source    DF      SS     MS      F      P
Sample     4  399.64  99.91  92.20  0.000
Error    145  157.13   1.08
Total    149  556.77

S = 1.041   R-Sq = 71.78%   R-Sq(adj) = 71.00%


                            Individual 95% CIs For Mean Based on
                                        Pooled StDev
Level    N   Mean  StDev   ---+---------+---------+---------+------
A       30  6.333  1.093                         (-*--)b
B       30  7.533  1.008                                 (-*--)a
C       30  5.167  0.950                 (-*--)ab
D       30  3.933  0.868         (-*--)ab
E       30  2.967  1.245   (--*-)ab
                           ---+---------+---------+---------+------
                             3.0       4.5       6.0       7.5

Pooled StDev = 1.041
```

```
Fisher 95% Individual Confidence Intervals
All Pairwise Comparisons among Levels of Sample

Simultaneous confidence level = 71.73%


Sample = A subtracted from:

Sample    Lower  Center   Upper  -------+---------+---------+---------+--
B         0.669   1.200   1.731                      (-*-)
C        -1.698  -1.167  -0.635             (-*-)
D        -2.931  -2.400  -1.869         (-*-)
E        -3.898  -3.367  -2.835      (-*-)
                                 -------+---------+---------+---------+--
                                     -3.0       0.0       3.0       6.0


Sample = B subtracted from:

Sample    Lower  Center   Upper  -------+---------+---------+---------+--
C        -2.898  -2.367  -1.835         (-*-)
D        -4.131  -3.600  -3.069     (-*-)
E        -5.098  -4.567  -4.035  (-*-)
                                 -------+---------+---------+---------+--
                                     -3.0       0.0       3.0       6.0


Sample = C subtracted from:

Sample    Lower  Center   Upper  -------+---------+---------+---------+--
D        -1.765  -1.233  -0.702             (-*-)
E        -2.731  -2.200  -1.669          (-*)
                                 -------+---------+---------+---------+--
                                     -3.0       0.0       3.0       6.0


Sample = D subtracted from:

Sample    Lower  Center   Upper  -------+---------+---------+---------+--
E        -1.498  -0.967  -0.435               (-*-)
                                 -------+---------+---------+---------+--
                                     -3.0       0.0       3.0       6.0
```

Overall result:

From One-way ANOVA Test;

Ho rejected since p ‹ 0.05, there are significant different between all samples in terms of color.
From Fisher's LSD Test;

```
                                    Individual 95% CIs For Mean Based on
                                    Pooled StDev
Level   N   Mean   StDev   ---+---------+---------+---------+------
A      30  6.333   1.093                         (-*--)b
B      30  7.533   1.008                                  (-*--)a
C      30  5.167   0.950                  (-*--)c
D      30  3.933   0.868        (-*--)d
E      30  2.967   1.245  (--*-)e
                           ---+---------+---------+---------+------
                            3.0       4.5       6.0       7.5

Pooled StDev = 1.041
```

Summary result:

Sample	Mean overall acceptance	Standard deviation
A	6.333 [b]	1.093
B	7.533 [a]	1.008
C	5.167 [c]	0.950
D	3.933 [d]	0.868
E	2.967 [e]	1.245

APPENDIX E

Statistical analysis for chemical analysis for chili sauces and Roselle waste

1. Proximate analysis

Hypothesis for the test is:
H0: $\mu A - \mu B = 0$
H1: $\mu A - \mu B \neq 0$

Where, $P > \alpha = 0.05$, the null hypothesis can be accepted and conclude that there was no significant difference between mean of the two sample.

a) Carbohydrate content

Two-Sample T-Test and CI: A, B

```
Two-sample T for A vs B

   N    Mean  StDev  SE Mean
A  2  25.155  0.587     0.42
B  2  25.485  0.389     0.28


Difference = mu (A) - mu (B)
Estimate for difference:  -0.330000
95% CI for difference:  (-6.655725, 5.995725)
T-Test of difference = 0 (vs not =): T-Value = -0.66 P-Value = 0.627 DF = 1
```

The t-value for the test is -0.66, which is associated with a P-value of 0.627. Thus, the null hypothesis at the $\alpha = 0.05$ level is accepted, there is no significant difference between the mean of sample A and B.

b) Mositure content

Two-Sample T-Test and CI: A, B

```
Two-sample T for A vs B

   N     Mean   StDev  SE Mean
A  2  70.7900  0.0424    0.030
B  2  69.6450  0.0212    0.015


Difference = mu (A) - mu (B)
Estimate for difference:  1.14500
95% CI for difference:  (0.71882, 1.57118)
T-Test of difference = 0 (vs not =): T-Value = 34.14 P-Value = 0.019 DF = 1
```

The t-value for the test is 34.14, which is associated with a P-value of 0.019. Thus, the null hypothesis at the $\alpha = 0.05$ level is rejected, there is significant difference between the mean of sample A and B.

c) Protein content

Two-Sample T-Test and CI: A, B

```
Two-sample T for A vs B

   N   Mean  StDev  SE Mean
A  2  1.090  0.179     0.13
B  2  0.869  0.245     0.17


Difference = mu (A) - mu (B)
Estimate for difference:  0.220500
95% CI for difference:  (-2.502640, 2.943640)
T-Test of difference = 0 (vs not =): T-Value = 1.03 P-Value = 0.491 DF = 1
```

The t-value for the test is 1.03, which is associated with a P-value of 0.491. Thus, the null hypothesis at the $\alpha = 0.05$ level is accepted, there is no significant difference between the mean of sample A and B.

d) Fiber content

Two-Sample T-Test and CI: A, B

```
Two-sample T for A vs B

   N     Mean    StDev  SE Mean
A  2  0.24305  0.00205   0.0014
B  2   0.4650   0.0339    0.024


Difference = mu (A) - mu (B)
Estimate for difference:  -0.221950
95% CI for difference:  (-0.527455, 0.083555)
T-Test of difference = 0 (vs not =): T-Value = -9.23 P-Value = 0.069 DF = 1
```

The t-value for the test is -9.23, which is associated with a P-value of 0.069. Thus, the null hypothesis at the $\alpha = 0.05$ level is accepted, there is no significant difference between the mean of sample A and B.

e) Fat content

Two-Sample T-Test and CI: A, B

```
Two-sample T for A vs B

    N    Mean    StDev  SE Mean
A   2   0.894    0.185     0.13
B   2  1.7020   0.0198    0.014

Difference = mu (A) - mu (B)
Estimate for difference:  -0.808500
95% CI for difference:  (-2.476174, 0.859174)
T-Test of difference = 0 (vs not =): T-Value = -6.16 P-Value = 0.102 DF = 1
```

The t-value for the test is -6.16, which is associated with a P-value of 0.102. Thus, the null hypothesis at the α = 0.05 level is accepted, there is no significant difference between the mean of sample A and B.

f) Ash analysis

Two-Sample T-Test and CI: A, B

```
Two-sample T for A vs B

    N   Mean  StDev  SE Mean
A   2  2.000  0.512     0.36
B   2  2.018  0.484     0.34


Difference = mu (A) - mu (B)
Estimate for difference:  -0.017500
95% CI for difference:  (-6.349606, 6.314606)
T-Test of difference = 0 (vs not =): T-Value = -0.04 P-Value = 0.978 DF = 1
```

The t-value for the test is -0.04, which is associated with a P-value of 0.978. Thus, the null hypothesis at the α = 0.05 level is accepted, there is no significant difference between the mean of sample A and B.

2. Ascorbic acid analysis of chili sauces

Two-Sample T-Test and CI: A, B

```
Two-sample T for A vs B

    N   Mean  StDev  SE Mean
A   2  1.910  0.325     0.23
B   2  2.200  0.849     0.60


Difference = mu (A) - mu (B)
Estimate for difference:  -0.290000
95% CI for difference:  (-8.454663, 7.874663)
T-Test of difference = 0 (vs not =): T-Value = -0.45 P-Value = 0.730 DF = 1
```

The t-value for the test is -0.45, which is associated with a P-value of 0.7.30. Thus, the null hypothesis at the α = 0.05 level is accepted, there is no significant difference between the mean of sample A and B.

CURRICULUM VITAE

Name	: Aloha Binti Ngah
Permanent Address	: T-86 Kg Teladas, Ayer Puteh, 24050 Kemaman, Terengganu.
Telephone Number	: 013-4265425
E-mail	: laha.aloha@gmail.com
Date of Birth	: 13 Oktober 1989
Place of Birth	: Cheneh Baharu
Nationality	: Malaysia
Race	: Malay
Gender	: Female
Religion	: Islam
Educational Background	:

2011-2008: Bachelor of Food Science (Food Technology)

University Malaysia Terengganu (UMT)

2008-2007: Kedah Matriculation College

2002-2006: Sekolah Menengah Kebangsaan Ayer Puteh

1997-2001: Sekolah Rendah Kebangsaan Ayer Puteh

EFFECTS OF TOMATO (LYCOPERCISON ENCULENTUM L.) PUREE SUBSTITUTION WITH ROSELLE (HIBISCUSSABDARIFFA L.) WASTE IN CHILI SAUSE ON THE PHYSOCEMICAL CHARACTERISTICS AND THEIR ACCEPTANCE LEVEL - ALOHA BINTI NGAH