Physicochemical Properties of Ice Cream Premix from Brown Rice (*Oryza sativa*) and Barley (*Hordeum vulgare*)

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DECLARATION

I hereby declare that the work embodied in this report is the result of the original research and has not been submitted for a higher degree to any universities or institutions

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I certify that the report of this final year project entitled "**Preparation of Premix Ice Cream from Brown Rice (*Oryza Sativa*) and Barley (*Hordeum Vulgare*)**" by **Thivashini a/p Kanasan**, matric number **F18B0293** have been done for the degree of Bachelor of Applied Science (Product Development Technology) with Honours, Faculty of Agro-Based Industry, Universiti Malaysia Malaysia.

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ABSTRACT

A few ingredients are required to produce ice creams such as creamer, sugar, salt, water, flavour, essence, and milk derived from an animal. Barley and brown rice provide the creaminess and categories as wheat, barley, and brown rice used as an alternative milk ingredient to produce healthy and vegan ice cream. Greater content of nutrients such as protein, lipids, minerals, and vitamins were contained in brown rice. Both soluble and insoluble fibre, protein, vitamins B and E, the minerals selenium, magnesium and iron, copper, flavonoids, and anthocyanin are contained in barley. Hence, this study was aimed to produce ice cream from brown rice (*Oryza sativa*) and barley (*Hordeum vulgare* L.). This product is majorly developed for the vegan, lactose intolerant, and health-conscious population. Physicochemical properties such as viscosity, pH value, protein, fibre and fat analysis were analyzed using the standard method. Furthermore, the sensory evaluation test determine consumer acceptance toward the brown rice and barley premix ice cream product. Based on the result, the range of the fat content of the brown rice and barley premix ice cream are 33.66 to 34.66 which are lower than the control. As for the protein content, the range of protein content of brown rice and barley ice cream premix are 0.88 to 0.93 which are higher than the control. While, the range of the 2.66 to 4.66 which are also higher than control. The range of the ash content of brown rice and barley premix ice cream are 0.92 to 0.96 which are higher than the control. This indicate that the brown rice and barley premix ice cream contain higher mineral content. According to the moisture content result, the range moisture content is 3.86 to 4.16. The range of the pH are 4.66 to 4.70. The range of the viscosity of the brown rice and barley premix ice cream are 3,14 to 3.44. As for the sensory evaluation brown rice and barley premix ice cream with raspberry flavour was chosen as the best formulation in terms of aroma, colour, taste, texture and overall acceptance. Hopefully, the development of this product can be one of the solutions to the vegan, lactose intolerant, and health-conscious population.

Keyword: Brown rice (*Oryza sativa*) and Barley (*Hordeum vulgare* L.), Physicochemical, Sensory Evaluation, Ice Cream, nutritional fact.

Sifat Fisikokimia Ais Krim Pracampur daripada Beras Perang (*Oryza sativa*) dan Barli (*Hordeum vulgare*)

ABSTRAK

Beberapa bahan diperlukan untuk menghasilkan aiskrim seperti krimer, gula, garam, air, perisa, pati, dan susu yang berasal daripada haiwan. Barli dan beras perang menyediakan krim dan kategori sebagai gandum, barli dan beras perang yang digunakan sebagai bahan susu alternatif untuk menghasilkan ais krim yang sihat dan vegan. Kandungan nutrien yang lebih besar seperti protein, lipid, mineral, dan vitamin terkandung dalam beras perang. Kedua-dua serat larut dan tidak larut, protein, vitamin B dan E, mineral selenium, magnesium dan besi, kuprum, flavonoid, dan antosianin terkandung dalam barli. Oleh itu, kajian ini bertujuan untuk menghasilkan ais krim daripada beras perang (*Oryza sativa*) dan barli (*Hordeum vulgare L.*). Sifat fizikokimia seperti kelikatan, nilai pH, protein, gentian dan analisis lemak dianalisis menggunakan kaedah piawai. Tambahan pula, ujian penilaian deria menentukan penerimaan pengguna terhadap produk ais krim pracampuran beras perang dan barli. Berdasarkan keputusan, julat kandungan lemak beras perang dan aiskrim pracampuran barli adalah 33.66 hingga 34.66 iaitu lebih rendah daripada kawalan. Bagi kandungan protein pula, julat kandungan protein beras perang dan pracampuran aiskrim barli adalah 0.88 hingga 0.93 iaitu lebih tinggi daripada kawalan. Manakala, julat 2.66 hingga 4.66 yang juga lebih tinggi daripada kawalan. Julat kandungan abu beras perang dan aiskrim pracampuran barli adalah 0.92 hingga 0.96 iaitu lebih tinggi daripada kawalan. Ini menunjukkan bahawa beras perang dan ais krim pracampuran barli mengandungi kandungan mineral yang lebih tinggi. Mengikut keputusan kandungan lembapan, julat kandungan lembapan ialah 3.86 hingga 4.16. Julat pH ialah 4.66 hingga 4.70. Julat kelikatan aiskrim pracampuran beras perang dan barli ialah 3,14 hingga 3.44. Bagi penilaian deria beras perang dan aiskrim pracampuran barli berperisa raspberi dipilih sebagai formulasi terbaik dari segi aroma, warna, rasa, tekstur dan penerimaan keseluruhan. Semoga pembangunan produk ini boleh menjadi salah satu penyelesaian kepada penduduk vegan, tidak bertoleransi laktosa dan mementingkan kesihatan.

Kata kunci: Beras perang (*Oryza sativa*) dan Barli (*Hordeum vulgare* L.), Fisikokimia, Penilaian Deria, Ais Krim, fakta pemakanan.

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CMC - Carboxymethyl cellulose

CHAPTER 1

INTRODUCTION

1.1 Research background

Among consumers of all ages, ice cream is a popular dairy product and a product that is easy to consume. A dairy aerated dessert that is frozen before consumption is known as ice cream (Shital Deosarkar, 2016). Furthermore, a few ingredients are required to produce ice cream such as creamer, sugar, salt, water, flavor, essence, but milk derived from an animal is the major ingredient of most ice cream. However, nowadays, researchers have developed to produce ice cream from different types of milk, such as almond milk, oat milk, and many more, with some alternative ingredients such as rice. There are no ice creams that are made without adding any types of milk in the market. Generally, the milk provides creaminess to the ice cream. Since barley and brown rice provide the creaminess and categorized as wheat, barley, and brown rice can be used as an alternative ingredient of milk to produce healthy ice cream. Higher dietary fibre consumption helps to a lower risk of colorectal and breast cancer. Brown rice has a lower glycaemic index due to its high content in fibre. Other than that, high amounts of proteins, unsaturated lipids, micronutrients, and several bioactive compounds are also contained in brown rice (Ahmed et al., 2018). In addition, nutritional, functional ingredients are extremely rich in barley grain. Fibre, phenolic acids, flavonoids, phytosterols, alkylresorcinols, benzoxazinoids, lignans, and folate, which contain antidiabetes, anticancer, antiobesity, preventive cardiovascular disease, antioxidant, antiproliferative, and cholesterol-lowering abilities, are the functional ingredients that are rich in barley

whole grains and its outer bran layer (Ahmed et al., 2018). According to the literature review, barley and brown rice study has been undertaken to enrich nutrient product, especially in ice cream. The objectives of the study are to develop healthy ice cream with alternative ingredients, to determine the physicochemical properties of barley and brown ice cream and to perform sensory evaluation toward barley and brown rice ice cream.

1.2 Problem statement

According to urbanization and moderation, ice cream is popular as a dessert. However, ice cream contains a high amount of fat due to the milk. It contains many calories that are very unhealthy for humans to consume. Generally, most of the ice cream is made from the skimmed milk and milk derived from animal, which contains a high amount of fat. But as a vegan-based product, some of the ice creams is made from plant-based milk such as almond milk, oat milk, and nut milk, which contain less fat and calories but expensive. Hence, this study aimed to develop a new ice cream from barley and brown rice and to perform its physicochemical properties as well as the sensory evaluation to know the consumer acceptance towards this new product. The barley and brown rice ice cream contain a high amount of nutrition. The barley and brown rice ice cream are healthier because it is rich in beneficial nutrients such as vitamins, minerals, dietary fibre, and magnesium. It also reduces hunger and may help to lose weight, improve digestion, protect against diabetes, reduce heart disease, and many more. Furthermore, the barley and brown rice ice cream are more suitable for those with lactose intolerant, vegan, and who are on a diet. In addition, barley and brown rice ice cream would be preferred by people who do not contain any types of milk.

1.3 Hypothesis

H_O: There is no significant difference between physicochemical properties and sensory evaluation of premix Ice cream from brown rice (*Oryza sativa*) and barley (*Hordeum vulgare*) in three different formulation

HA: There is significant difference between physicochemical properties and sensory evaluation of premix Ice cream from brown rice (*Oryza sativa*) and barley (*Hordeum vulgare*) in three different formulation

1.4 Scope of Study

This study focuses on the development premix ice-cream from brown rice and barley with other ingredients. The brown rice and barley premix ice cream will produce with three different formulation and flavour. The premix powder then analyses for its physicochemical properties (pH and viscosity) to compare the three formulations with control (commercialized product). Furthermore, the powdered premix ice cream analyse for the proximate analysis which are protein, fibre and fat contents. Finally, the sensory evaluation will be conducted among the untrained panellist to determine the best formulation.

1.5 Significance of study

The dietary fibre, protein, carbohydrate, fat, and mineral contents of brown rice and barley were extensively used in the production of ice cream in this research. This research identifies the customer's acceptance toward the healthy barley and brown rice premix ice cream by doing a sensory evaluation test. Barley and brown rice premix ice cream will be produced with three different formulations and flavours to determine the best formulation by conducting a sensory evaluation test. The three formulations will be

produced with different amounts of barley and brown rice in each formulation, and three different flavours such as coffee, vanilla, and chocolate. In addition, the physicochemical analysis such as fibre, protein, carbohydrate, fat, mineral, colour, concentration will also be performed. The outcome of the texture and taste of the Ice-Cream Premix from Brown Rice and Barley are similar as the other ice-cream which has been made of diary milk. However, the colour of the ice-cream is based on its flavour which is added. This product is fully vegan where barley and brown rice were replaced instead of diary milk. Thus, this product majorly for the vegan lactose introlent and health conscious consumer.

1.6 Objectives

1. To develop ice cream with alternative ingredients which is brown rice and barley
2. To determine the physicochemical properties of barley and brown ice cream
3. To perform sensory evaluation toward barley and brown rice ice cream

CHAPTER 2

LITERATURE REVIEW

2.1 Brown rice

One of the most important stable and high nutritive human food crops is brown rice (*Oryza sativa*) (Figure 2.1). Whole grain rice with an intact bran layer and the inedible outer hull removed are known as brown rice. The husk is removed from the whole rice grain or paddy during the milling process, resulting in whole brown rice grain (BR), which includes the outer bran layer, which is commonly brown in colour. The pericarp, the seed coat and nucellus, the germ or embryo, and the endosperm contained by the unmilled rice called as a brown rice (Ajimilah & Rosniyana, 1995). Due to the bran layer being dark brown in colour, which contains high amounts of vitamins like thiamine, niacin, pyridoxine, and minerals like manganese, phosphorus, and iron (Babu et al., 2009). Moreover, a greater content of bioactive compounds such as phenolic acids, flavonoids, γ-oryzanol, aminobutyric acid (GABA), α-tocopherol, and γ-tocotrienol contains in brown rice (Ahmed et al., 2019).

Figure 2.1 Brown rice (*Oryza sativa*) (Szalay, 2019)

2.2 Barley

An early cereal grain that has developed from a primarily food grain to a feed and malting grain as a result of domestication is barley (*Hordeum vulgare* L.) (Elke, 2013) (Figure 2.2). Furthermore, a member of the grass family Gramineae, the subfamily Festucoideae, the tribe Hordeae and the genus *Hordeum* is called barley. Barley has a huge amount of potential to be used as a partial or complete alternative for cereal grains as wheat *(Triticum aestivum),* oat *(Avena sativa),* rice *(Oryza sativa),* and maize in a variety of cereal-based food items *(Zea mays)* (Dinesh, 2020).

Figure 2.2 Barley

2.3 Creamer

Creamer can be categorized as non-diary and diary creamer. The colour and the stability of the emulsion impact the quality of the creamer. A natural emulsifier, such as protein concentrates derived from the Leguminosae family are used in the non-dairy creamer (Dedin, 2016).

2.4 Water

Water can be added as a liquid form to maintain the ice cream continuously. Water from the supply source must be filtered, while water from the milk source should have been washed during its flow and excretion from the memory gland. Water act as solvent and gives liquid medium texture (Qamar Abbas Syed, 2018).

2.5 Sugar

Sugar is added to ice cream, either in liquid or solid form, at a preferred amount. Ice cream contains 45 percent sugar to make it easier to prepare, store, and distribute. The characteristics of ice cream will not affect and enhance the total solid by the sugar. Sugar is added in ice cream to increase pleasing sweet flavour, to enhance solid content and viscosity (Qamar Abbas Syed, 2018).

2.6 Gelatine and carrageenan

A soluble albumin-like protein is called gelatine (Haug, 2009). Linear sulphated polysaccharides derived from Irish moss (*Chondrus crispus*) and other seaweed and algae are carrageenan. As for the thickening, stabilizing, and gelling, carrageenan is widely used in ice cream (MD, 2018). Gelatine and carrageenan are also categorized as a stabilizer in ice cream. Since stabilizers have a high water binding ability and are used in limited amounts, their impact on flavour and product value is minimal. The function of

the gelatine and carrageenan are to smoothen the texture, to give body to the product, to increase viscosity, not to affect the freezing point, prevent from texture coarsening and to give resistance during melting (Qamar Abbas Syed, 2018).

2.7 Flavour

Flavour is an essential ice cream property that adds all the ice cream ingredients' flavour. Furthermore, even at low concentrations, harsh flavour quickly becomes monotonous, while mild flavour incorporates easily and do not become monotonous at higher intensities. Flavour must be readily detectable and have a strong flavour (Qamar Abbas Syed, 2018). The flavour used for the brown rice and barley ice cream premix are raspberry, vanilla, and cocoa.

2.8 Corn flour

Corn starch is equivalent to other cereal starches in general, but it has the most in common with its genetically linked relatives, sorghum and millet, in terms of basic properties (Bemiller, 2016).

2.9 Carboxymethyl cellulose (CMC)

The sodium salt derivative of cellulose is carboxymethyl cellulose (CMC). It is water-soluble, unlike cellulose, and can be used as a dispersing agent, stabilizer, and thickening agent (Heinze et al., 2000).

2.10 Salt

Salt is added in the ice cream to reduce the freezing and melting point. The more concentration of salt in the ice cream the lower the freezing point (Fenster, 2017).

2.11 Nutritional value of brown rice

Generally, greater nutrients such as protein, lipids, minerals, and vitamins were found in brown rice. The major component of brown rice is a dietary carbohydrate that provides a good energy source for people. Due to the outer bran layer, the brown rice also contains a higher amount of dietary fibre, which helps to reduce the obesity and sugar level of diabetic people. Apart from that, the second major component of brown rice is protein. The protein concentration of brown rice is higher because protein is highly concentrated in the outer bran layer of rice grain. Due to the hypo allergenicity of its protein, rice flour is commonly incorporated into the gluten-free cereal food product. Unsaturated fatty acids such as oleic and linoleic acid are also contained in brown rice, a great source of healthy fatty acids. In addition, a greater content of minerals are also contained in brown rice. Generally, mineral plays a vital role in metabolism in the human body. Various vitamins such as vitamin B and vitamin E contained in brown rice. Therefore, malnutrition-related diseases resulting from the deficiency of minerals or vitamins can be prevented by the brown rice (Ahmed et al., 2019).

2.12 Nutritional value of barley

Both soluble and insoluble fibre, protein, vitamins B and E, selenium, magnesium and iron, copper, flavonoids, and anthocyanin are contained in barley. The soluble fibre in barley, beta-glucan, attaches to bile acids in the intestines, lowering plasma cholesterol levels. Soluble fibre that is absorbed and reduces cholesterol synthesis in the liver, thereby cleaning blood vessels. Bulkiness in the intestines is provided by the insoluble fibre, resulting in satiety and reduced appetite (Annapurna, 2011). The high amount of dietary fibre (14.8 g/100 g raw material) and good levels of other bioactive compounds and minerals, such as iron (6 mg/100 g raw material), zinc (3.3 mg/100 g raw material), and

calcium (50 mg/100 g raw material) are contained in barley. Moreover, higher protein contents are also contained in barley. Barley has been a good source of dietary fiber, especially β-glucan and antioxidant polyphenols, which helps to control cholesterol and blood glucose levels. Due to its vitamin E isomer, barley is also considered an essential dietary source of antioxidants (Michalia, 2020).

2.13 Uses

Barley is boiled to make a barley drink. Apart from that, barley also used as a natural sweetener. Furthermore, brown rice is used to produce brown rice porridge, pasta, and energy bar.

2.14 Physicochemical properties

Physicochemical properties determine the nutritional content such as protein fibre and fat and also the physical properties of ice cream such as overrun, viscosity and pH content. According to (Choo et al., 2010), the ash, viscosity, pH, moisture, protein, fibre, and fat content were analyzed to identify the physicochemical properties in ice cream formulated with virgin coconut oil (Choo et al., 2010).

2.15 Sensory evaluation

Generally, a scientific practice that involves sight, smell, taste, and touch to evoke, measure, evaluate, and analyse human reaction is a sensory evaluation about (Marjorie, 2015). The untrained panellist will participate in this sensory evaluation test, who will evaluate the final product according to appearance, taste, odour, and overall acceptability.

CHAPTER 3

METHODOLOGY

3.1 Material

There were some materials used during the experiment carried out. Brown rice, barley, creamer, corn flour, sugar, carrageenan, gelatine, salt, flavour and CMC are the ingredients that were used to produce the ice cream.

3.1.1 Chemical and reagent

The chemicals that used for product analysis are buffer solution in calibration pH meter, phosphate-buffered saline, sodium carbonate, sulphuric acid. Sodium hydroxide. 0.1 M hydrochloric acid, boric acid (4%), catalyst tablets, methyl red, petroleum ether.

3.1.2 Equipment

Equipment that is used in this experiment including bowl, pot, spatula, grinder, siever, stove, homo, homogenizer, freezer, weighing balance, pH meter, filter paper, volumetric flask, measuring cylinder (50 mL, 100 mL and 500 mL), conical flask (250 mL), retort stand, burette, round bottle flask, soxhlet machine, thimber, condenser, filter funnel, desiccator, hot plate and crucibles.

3.2 Method

3.2.1 Experimental design

The experiment were started with the grinding process of brown rice (*Oryza sativa*) and barley (*Hordeum vulgare* L.) into powder form. Formulation of ice cream with various flavour was created. The experiment was conducted after the development of the formulation. Proximate analysis was performed including fat, protein, fibre, ash and moisture analysis. Apart from that, physicochemical analysis was conducted to analyze pH and viscosity of the formulate sample. There are three different formulations.

3.2.2 Development of ice cream from brown rice and barli

Brown rice and barley was grinded into powder form and filtered. After that, the brown rice and barley was mixed with the other component following the formulation: creamer, sugar, cornflour, carrageenan, gelatine, salt, flavour, and CMC. Then, the premix was boiled with water until the liquid is homogenized with a homogenizer for 15 minutes. Then finally, the ice cream was store in the freezer.

Table 3.1 Formulation 1, 2 and 3 of Brown Rice (*Oryza Sativa*) and Barley (*Hordeum Vulgare*) ice cream Premix

INGREDIENT	Formulation 1 Quantity (g)	Formulation 2 Quantity (g)	Formulation 3 Quantity (g)
Brown Rice (Oryza sativa)	24.5	20.5	22.5
Barley (Hordeum vulgare)	20.5	24.5	22.5
Creamer	66.7	66.7	66.7
Sugar	100	100	100
Corn Flour	2.3	2.3	2.3
Carrageenan	2	2	2
Gelatin	6.7	6.7	6.7
Salt	1.7	1.7	1.7
Flavor (Vanilla)	2	2	2
CMC (1 %)	2	2	2
Total Weight	228.4	228.4	228.4

3.3 Selection of the best formula for the product

Brown rice and Barley ice cream premix was prepared using different formulations and flavours. To get the most acceptable formula for the final product, a sensory evaluation was conducted. The untrained panellist was participated in this sensory evaluation test, who evaluated the final product according to the appearance, taste, odor, and overall acceptability. Generally, a scientific practice that involves sight, smell, taste, and touch to evoke, measure, evaluate, and analyze human reaction is a sensory evaluation about (Marjorie, 2005). By using the SPSS, the result of the sensory evaluation was analyzed. The sensory evaluation was conducted in comparison of the three different formulations and flavour which to determine consumer acceptability toward the brown rice and barley ice cream premix.

3.3.1 Statistical analysis

The data collected from the sensory evaluation test was analyzed using the one-way analysis of variance (ANOVA). Generally, analyzing variation in a response variable (continuous random variable) measured under conditions defined by discrete factors (classification variables, often with nominal level) is a statistical technique of analysis of variance (ANOVA). As for the physicochemical analysis, the data were analyzed by comparing the data obtain from the analysis with 3 different formulations.

3.4 Physicochemical analysis

3.4.1 pH analysis

The pH was determine using the pH meter. One drop of the liquid sample was added on the pH meter and pressed the calibration button to get the pH value. Waited for few minutes to get the accurate reading. The data was recorded in triplicate (n=3). (Hulanicki, 2005). (Juliana Gobbi, 2016).

3.4.2 Viscosity analysis

The viscosity was determined by using the viscometer. The liquid was poured into the container. Sensor tip then move forward to the container and completely dipped into the liquid ice cream. Pressed the calibration button to get the data. The data then was recorded in triplicate (n=3). The non-frozen phase viscosity and the ice fraction produced during freezing determine the viscosity of ice cream. The most evolving property in the ice cream crystallization process is viscosity. This is because the liquid converting to a semi-solid due to the formation of ice crystals. The viscosity of an ice cream mixture rises because the temperature of the liquid mixture reduces, and the volume fraction of solid particles (ice crystals) rises (Alejandro De la Cruz Martinez, 2020).

3.5 Proximate analysis of brown rice and barley ice cream premix

3.5.1 Protein analysis

Protein content was determined using the common Kjeldahl method. First of all, one gram of the sample was weighed into the digestion tube. After that, in a digestion tube one gram of catalyst tablets was added with 12 mL of sulphuric acid. To set the catalyst and sulfuric acid ratio, a catalyst tablet was added to absolute performance. A catalyst tablet was added to accelerate the digestion process. The sample was inserted into the digester machine after it is prepared in a digestion tube and let for 2 - 3 hour. The sample was be heated until all organic compounds had fully broken down and the liquid became clear. The samples were then be removed from the digester and allowed to cool for at least 15 to 20 minutes. Then, 50 mL of 4% boric acid will be added on the other side, which is used as a receiver on the distillation unit as an indicator. Then, the digested sample was mixed with 80 mL distilled water and 50 mL of 40% sodium hydroxide to begin the distillation process. As a result, the distillation process continues until all of the ammonia in the sample has is released. Lastly, the receiver conical flask was carried to proceed with the titration process. Before undergoing the titration process, the 0.1 N hydrochloric acid were prepared, and the distillate will be titrated until a pink colour appeared. The data was recorded in triplicate (n=3) (Hanne et al., 2018). The percentage of total protein was calculated using the following formula:

$$\% \text{ Protein} = \% \text{ nitrogen} \times \text{factor}$$

$$\% \text{ Nitrogen} = \frac{(\text{mL standard acid} - \text{mL blank}) \times \text{N of acid} \times 14}{\text{Weight of sample}}$$

3.5.2 Fibre analysis

The fibre content of the ice cream was determined by using the automated system of fibre analyzer. Firstly, one gram of celite was added together with one gram of powdered sample into the fritted glass. The sample was then placed in the fibre analyzer device. Following that, the samples was washed by using acid NaOH by the machine. The sample was then put in a furnace for at least 5 hours at 503 ºC and allowed to cool. The residue was placed in a desiccator (George, 2003). Finally, the ash residue was then weighed in triplicate and was calculated using following formula:

$$\% \text{ Crude fibre} = \frac{W2 - W1}{\text{Sample}} \times 100$$

W2 - W1 = Crude fibre

W1 = Weight of sample

W2 = Weight of sample after furnace (ash)

3.5.3 Fat analysis

In an extraction thimble, two grams of the premix powdered ice cream was added together with petroleum ether. Before proceeding to the following step, the weight of the pre-dried round blotted sample was then recorded. After that, on the sample a layer of de-fatted cotton was placed. The sample was then placed into the extraction system part until it was connected to the magnet. Extraction started in the soxhlet extractor at a rate of 5 or 6 falls per second condensation for about 4 hours after heating the solvent that were inside the round bottled flask. Finally, the extracted fat, along with the flask, was put in the oven for 30 minutes at 105°C, and the weight was recorded. In a desiccator the sample was then replaced again and allowed it cooled and weighed. The weight then was ensured to

maintain in order to prevent further weight loss (Jennifer et al., (2006). The fat content was then calculated using the formula:

$$\% \text{ Crude fat} = \frac{(W2 - W1)}{\text{Sample (g)}} \times 100$$

W1 = Weight of empty flask

W2 = Weight of extracted fat and flask

S = Sample

3.5.4 Moisture analysis

One of the most important quality parameters for food products are moisture content. The test was carried out with a gravimetric approach using the Sartorius Moisture Analyzer. Technically, 2 g powdered ice cream mix was heated at 105 °C for 6 minutes. The result was recorded in triplicate (n=3) (Hassanein et al., 2015).

3.5.5 Ash analysis

The ash analysis was conducted by weighing 1 gram of sample and was placed it in a dried and pre-weighed ceramic crucible. Then the polymer was burned in a furnace at 550°C, and weighed the crucible after it had been cooled to room temperature in a desiccator. The ash content was then calculated using the formula:

$$\% \text{ Ash} = \frac{(\text{weight of crucible and ash} - \text{weight of crucible})}{(\text{weight of crucible and sample} - \text{weight of crucible})} \times 100$$

CHAPTER 4

4.1 Results and Discussion

4.1.1 Physicochemical Analysis

Table 4.1 Protein content of Brown Rice (*Oryza Sativa*) and Barley (*Hordeum Vulgare*) Premix ice cream

	Protein Content (%) mean ± standard deviation
Formulation 1	0.88 ± 0.32^{a}
Formulation 1	0.88 ± 0.32^{a}
Formulation 2	0.84 ± 0.14^{a}
Formulation 3	0.93 ± 0.16^{a}
Control (Commercialized product)	0.74 ± 0.08^{a}

Note : Values are expressed as mean ± standard deviation. Mean values with superscript of same alphabet are not significantly different ($p \geq 0.05$).

Generally, the major ingredient of ice cream is milk. Milk is rich in protein. Ice cream contains three essential structural functions that are provided by milk proteins. Whey protein is a globular protein with a high -helix structure and a well-balanced distribution of acidic-basic and hydrophobic-hydrophilic amino acids. During whipping, proteins in the serum phase of the mix lead to the formation of an air bubble interface capable of retaining small and stable air bubbles. Mix viscosity increases, especially in the unfrozen serum phase following cryo-concentration, resulting in improved body and texture and

lower ice recrystallization rates by the protein (Davoodi et al., 2016). Moreover, the stabilizer, such as gelatine, also attribute protein content to the ice cream. Gelatine is a nutrient-dense protein formed from collagen found in animals' skin and bones and also contains important amino acids.

The protein content was analyzed using the one-way Anova test. Based on the Table 4.1, the protein content of Brown Rice (*Oryza Sativa*) and Barley (*Hordeum Vulgare*) Premix ice cream for formulation 3 contain the highest amount of protein content which are 0.93 % compared to other formulation and control. This is because barley (*Hordeum Vulgare*) and brown rice (*Oryza Sativa*) were added more in formulation 3 than formulation 1 and formulation 2 which 22.5 gram of brown rice and 22.5 gram of barley were added. Therefore, both brown rice and barley enhance the protein content in formulation 3. Brown rice (*Oryza Sativa*) has a protein content ranging from 4.3 to 18.2 percent, with greater quantities of essential amino acid and lysine. Rice protein is mostly present between starch granules in protein bodies, while bran also has a high protein. 7 to 25 % of protein content are contained in barley. Albumin (water-soluble fraction), globulin (salt-soluble fraction), prolamin or hordein (alcohol-soluble fraction), and glutelin (glutelin) are the four solubility groups found in barley (alkali-soluble fraction). Meanwhile, the formulation 1 contains a higher amount of the protein than formulation 2 and control which are 0.88 %. This is because the amount of barley was added more than the brown rice whereas the protein content in barley is higher than the brown rice.

Based on the post hoc test, there are no significance difference between all the formulation and control. The significance level is difference between all the formulation

and control which the significance level is p ≥0.05. This is because milk, brown rice and barley contains a higher amount of protein content. Thus, the protein content in formulations 1, 2, 3, and control are almost similar and do not differ. However, the protein content in brown rice and barley is slightly higher than the milk. That is one of the factors which makes formulation 3 and formulation 1 contains a higher amount of protein content compared to the control, although there are not many differences between the three formulations and control.

Table 4.2 Fat content of Brown Rice (*Oryza Sativa*) and Barley (*Hordeum Vulgare*) Premix ice cream

	Fat Content (%) mean ± standard deviation
Formulation 1	33.66 ± 0.57^{a}
Formulation 2	34.33 ± 1.15^{a}
Formulation 3	34.66 ± 0.57^{a}
Control (Commercialized product)	42.00 ± 2.00^{b}

Note : Values are expressed as mean ± standard deviation. Mean values with different superscript are significantly different (p≤0.05).

Fat plays an important role in the microstructure of ice cream that develop during the ageing, freezing, and aeration processes reducing recrystallization rates during storage, helps in the producing appropriate melting characteristics, and improving the stability of air bubbles which help to prolong the shelf life. The major ingredient in ice cream that attributes a high amount of fat is milk. Generally, a wide variety of fatty acids, which

makes most complex fatty acid fractions found in nature, are composed of milk. The saturated fatty acids consist of around 60-70 % of the total fat content in the milk fat blend. Unsaturated fatty acids, particularly oleic acid, a monounsaturated fatty acid, are the remaining 30-40% of fats. Natural polyunsaturated acids with trans and cis binding, also known as conjugated linoleic acid, are also found in small amounts in milk and dairy products such as ice cream (Rolon et al., 2017).

9.3-mg of internal lipids and 3.7-mg of surface lipids were found in barley starch, for a total of 13-mg/g lipids. Malt starches have total lipid content ranging from 11 to 13-mg/g of starch. A good source of linoleic and other essential fatty acids contains in rice but it is also low in cholesterol. The aulerone layer of the rice kernel contains the majority of the fat. The majority of the fat in rice grains is unsaturated, that is rapidly oxidized by ambient oxygen. Moreover, stabilizer added in ice cream also may attribute a high amount of fat. Extraction of diethyl ether and petroleum ether was used to determine the fat content.

The fat content was analyzed by using one-way Anova test. Based on the Table 4.2, the fat content of Brown Rice (*Oryza Sativa*) and Barley (*Hordeum Vulgare*) Premix ice cream for control are higher than formulation 1, 2, and 3 which are 42.00 %. This is because the control is made of from the milk which attribute a higher amount of fat than the brown rice and barley. Whereas, the brown rice and barley contain a very small amount of fat content which are 3 % and 1 % respectively.

Based on the post hoc test, there is a significance difference between the formulation 1 and control ($p \leq 0.05$) 0.000. Moreover, there is significant difference between the

formulation 2 and the control which are ($p \leq 0.05$) 0.000. Also, there is significant difference between the formulation 3 and the control which are ($p \leq 0.05$) 0.000. But there is no significant difference between the formulation 1, 2, and 3. Although, different amount of brown rice and barley were added in the formulation 1, 2 and 3 the amount of fat content are slightly similar and does not have much differences because the brown rice and barley contain a small amount of fat content.

Table 4.3 Fibre content of Brown Rice (*Oryza Sativa*) and Barley (*Hordeum Vulgare*) Premix ice cream

	Fibre Content (%) mean ± standard deviation
Formulation 1	4.33 ± 0.57^{a}
Formulation 2	2.66 ± 1.15^{b}
Formulation 3	4.66 ± 0.57^{a}
Control (Commercialized product)	2.00 ± 0.00^{c}

Note : Values are expressed as mean ± standard deviation. Mean values with different superscript are significantly different ($p \leq 0.05$).

The fibre content is majorly contained in brown rice and barley. As for the brown rice has three times greater than the amount of fibre in white rice. The weight of stool enhances, carcinogens actions in intestinal mucosa prevents, easy emptying of faeces and supports normal colonic microfloral growth to produce beneficial components such as short-chain fatty acids by the insoluble dietary fibre. Meanwhile, the soluble and insoluble dietary fibre and other bioactive compound are generally high in barley (Dhingra et al, 2013). Dehulled barley has a total dietary fibre level of 10 to 28 %. The (predominantly)

insoluble dietary fibre portion (cellulose, AX, and lignin) is found primarily in the wheat bran whereas, the soluble dietary fibre fraction (mostly -glucan) is found in the endosperm cell wall.

The fibre content was analyzed by using the one-way Anova test. Based on the Table 4.3 fibre content of Brown Rice (*Oryza Sativa*) and Barley (*Hordeum Vulgare*) Premix ice cream for formulation 3 contain a higher amount of fibre content than formulation 1, 2 and control which are 4.66 %. This is because the amount of barley that were added in the formulation 3 is more than the formulation 1 and 2. The higher the amount of barley added in ice cream, the higher the fibre content are contained in the ice cream. Cereals, nuts, fruits and vegetables are the diets rich in fibre. Thus, this indicate that barley and the brown rice attribute the higher amount of fibre. Whereas the control made from the milk which contains lower fibre content compared to the formulation 1, 2 and 3 which are 2.00 %. This is might due to the milk does not contain fibre content. However, the lower amount of fibre that contained in the control might be contributed by the other ingredient that were added in ice cream.

Based on the post hoc test, there is no significant difference between the formulation 1, 2, 3 and the control which are $p \geq 0.05$. This is because the formulation 1 and 3 contain a slightly similar fibre content and do not have much differences. Meanwhile, the formulation 2 and control contain slightly similar amount of fibre content and does not have much differences. The significance level between the formulation 1 and control are lowest. This is because the average amount of the fibre in formulation 1 is higher among

the formulation and the control. Meanwhile, the average amount of fibre in control is lower than the formulation 1, 2, and 3.

Table 4.4 Ash content of Brown Rice (*Oryza Sativa*) and Barley (*Hordeum Vulgare*) Premix ice cream

	Ash Content (%) mean ± standard deviation
Formulation 1	0.94 ± 0.01^{a}
Formulation 2	0.92 ± 0.01^{b}
Formulation 3	0.96 ± 0.01^{a}
Control (Commercialized product)	0.44 ± 0.01^{c}

Note : Values are expressed as mean ± standard deviation. Mean values with different superscript are significantly different ($p \leq 0.05$).

The amount of ash in a food sample is essential because it indicates the mineral nutrients in the food which helps to determine the amounts of important minerals in the sample. Well-known essential nutrients that play an important role in the effective functioning body activity are mineral. In comparison to other micronutrients, Fe and Zn are two of the most important for the human body (Rolon, 2017).

Brown rice has various amounts of iron (Fe), phosphorous (P), magnesium (Mg), potassium (K), zinc (Zn), and copper in its mineral content (Cu). Fe is found at the highest concentration in brown rice. Brown rice contains B-vitamins, which may help to avoid disorders caused by vitamin deficiency. As for the barley both soluble and insoluble fiber, protein, vitamins B and E, selenium, magnesium and iron, copper, flavonoids, and anthocyanin are contained in barley. As for the milk, calcium is rich in milk and dairy products, contributing for over 55% of total calcium supply. Milk and its products made up 10–14 % of the average daily intake of potassium, magnesium, and zinc. Milk was the most important source of potassium and magnesium, accounting for 6.8% of potassium and 5.6 percent of magnesium, accordingly. Riboflavin and vitamin B12 are the most common vitamins in milk and its products.

The ash content was analyzed by using the one-way Anova test. Based on the Table 4.4 ash content of Brown Rice (*Oryza Sativa*) and Barley (*Hordeum Vulgare*) Premix ice cream for formulation 3 contain higher amount of ash content compared to formulation 1, 2 and the control which are 0.96 %. This is because the amount of brown rice that were added is higher than the formulation 1 and 2. However, the control that are made from the milk, the amount of ash content is lower than the formulation 1, 2 and 3 which are 0.44 %. This indicate that the amount of mineral in brown rice are higher.

Based on the post hoc test, there is significant different between formulation 1 and the control which are $p \leq 0.05$. This is because the minerals in formulation 1 are higher due to the higher amount of brown rice. Meanwhile, there are significance difference between the formulation 2 and control which are $p \leq 0.05$. This is because brown rice is more rich

in minerals than the milk. In addition, there is a significant difference between the formulation 3 and the formulation 2 which are $p \leq 0.05$. This is because the minerals in formulation 3 are higher due to the higher amount of brown rice than the formulation 2. Moreover, there is significant difference between the formulation 3 and the control which are $p \leq 0.05$ (0.000). This is also indicated that brown rice is rich in minerals than milk.

Table 4.5 Moisture content of Brown Rice (*Oryza Sativa*) and Barley (*Hordeum Vulgare*) Premix ice cream

	Moisture Content (%) mean ± standard deviation
Formulation 1	4.02 ± 0.14^{a}
Formulation 2	4.16 ± 0.12^{a}
Formulation 3	3.86 ± 0.16^{a}
Control (Commercialized product)	4.12 ± 0.07^{a}

Note : Values are expressed as mean ± standard deviation. Mean values with superscript of same alphabet are not significantly different ($p \geq 0.05$).

The amount of water in grain such as barley is measured by its moisture content. The barley kernel develops a moisture variation. Depending on its moisture content as well as the temperature and relative humidity of the surrounding air, a grain kernel will either decrease or increase moisture. Rice grain quality and palatability are related to moisture content, which is vital in determining shelf life. Generally, the moisture content in milk is also higher (Upadhyay, 2018).

The moisture content was analyzed using the AOAC standard moisture analyzer. The moisture content was analyzed by using the one-way Anova test. Based on the Table 4.5,

moisture content of Brown Rice (*Oryza Sativa*) and Barley (*Hordeum Vulgare*) Premix ice cream for formulation 2 contains a higher amount of moisture content compared to the formulation 1, 3 and the control which are 4.16 %. This is because the amount of barley in formulation 2 are higher which attribute higher amount of moisture content.

Based on the post hoc test, there is no significant difference between the formulation 1, 2, 3 and the control which are all significance level of $p \geq 0.05$. This is because the average of the formulation 1, 2, 3 and the control are slightly similar and do not differ. This indicate that water content in formulation 1, 2, 3 and the control are also slightly similar.

Table 4.6 pH of Brown Rice (*Oryza Sativa*) and Barley (*Hordeum Vulgare*) Premix ice cream

	pH Content (%) mean ± standard deviation
Formulation 1	4.70 ± 0.00^{a}
Formulation 2	4.66 ± 0.57^{a}
Formulation 3	4.66 ± 0.57^{a}
Control (Commercialized product)	4.63 ± 0.57^{a}

Note : Values are expressed as mean ± standard deviation. Mean values with superscript of same alphabet are not significantly different ($p \geq 0.05$).

The pH was determined using the pH meter. pH analysis measures how acidic or basic the substance is when dissolved in water (Hulanicki, 2005). The overall scale of the pH is 0 to 14. While pH is 7 it is considered neutral. Acidity indicates when the solution of pH is lower than 7. At the same time, the base indicates when the solution of pH is greater

than 7. The determination of pH is essential to analyze in ice cream because it affects the composition of ice creams, especially milk proteins, mineral salts, and dissolved gases (Juliana Gobbi, 2016). The pH of ice cream mix is generally around 6.3. The composition of the mix affects acidity and pH which raises acidity and decreases pH. Milk proteins, mineral salts (mostly citrates and phosphates), and dissolved carbon dioxide generate the apparent or natural acidity of the ice cream mix. The bacterial fermentation of lactose in dairy products produces lactic acid, which causes developed acidity. Developed acidity is probably present in the dairy products used in the ice cream when the acidity of the ice cream is above normal. Greater mix viscosity, decreased whipping rate, lower flavour, and a less stable ice cream are all caused by high acidity. Because heat and acidity enhance protein denaturation, the latter may contribute to 'cook on' during processing and pasteurization. Generally, the pH of barley is 4.5. The pH of the brown rice ranges from 6.2 to 6.7 (Hulanicki, 2004).

The pH value was analyzed by using the one-way Anova test. Based on the table 4.5 pH value of Brown Rice (*Oryza Sativa*) and Barley (*Hordeum Vulgare*) Premix ice cream for formulation 1 have highest pH value compared to the formulation 2, 3 and control which are 4.70 %. This is because the amount of brown rice is higher in formulation 1. Brown rice contain higher pH value than the barley. Meanwhile, the control has lower pH value compared to the formulation 1, 2, and 3 which are 4.63 %. Although the control are made from the milk which generally contain high pH value, this is might be because of the cooking processing.

Based on the post hoc test, there is no significant difference between the formulation 1, 2, 3 and the control which are all significance level of $p \leq 0.05$. This is because the average of pH value is slightly similar and does not have much difference. This indicate that the formulation 1, 2, 3 and the control are acidic because the pH value is below than 7.

Table 4.7 Viscosity of Brown Rice (*Oryza Sativa*) and Barley (*Hordeum Vulgare*) Premix ice cream

	Viscosity Content (%) mean ± standard deviation
Formulation 1	3.14 ± 0.51^{b}
Formulation 2	3.44 ± 0.05^{a}
Formulation 3	3.38 ± 0.57^{a}
Control (Commercialized product)	2.12 ± 0.00^{c}

Note : Values are expressed as mean ± standard deviation. Mean values with different superscript are significantly different ($p \leq 0.05$).

The liquid's viscosity is essential. Viscosity, or a liquid's resistance to flow, is the internal friction that prevents one part of the fluid from flowing over another. For optimal whipping and air retention, a particular level of viscosity is required. The mix's viscosity is influenced by temperature, the concentration, type, and degree of hydration of the stabiliser, carbohydrates, colloidal salts, and proteins in the mix, the type of heat treatment, whether the mix is homogenised prior to holding, and the rate of shear in the holding of ice cream. Viscosity rises as the stabiliser, protein, corn syrup solids, fat, and total solids concentrations rise, with each contributing less in that order in terms of

composition. Viscosity can be affect due to their impact on casein and whey proteins by heat and salts (such as calcium, sodium, citrates, phosphates). Pasteurisation temperatures, homogenization pressures can be increase, and up to 4 hours of ageing will all increase the viscosity of the ice cream when the handling and processing the ice cream (Upadhyay, 2018).

The viscosity value was analyzed by using the one-way Anova test. Based on the table 4.5 pH value of Brown Rice (*Oryza Sativa*) and Barley (*Hordeum Vulgare*) Premix ice cream for formulation 3 have higher viscosity compared to the formulation 1, 2 and control which are 3.38 %. This is because the concentration of the barley is thicker. Higher amount of barley was added in formulation 3. Whereas, the viscosity value of the control is lower which are 2.12 %. This might affect by the temperature during the cooking process when the ice cream was pasteurized and affect by the pressure when the ice cream were homogenized.

Based on the post hoc test, there is significant difference between the formulation 1 and 2 which are $p \geq 0.05$. There is significant difference in terms of viscosity between the formulation 1 and 3 as well. Also, there are significance difference in terms of viscosity between the formulation 1 and control.

Table 4.8 Sensory Evaluation of Brown Rice (*Oryza Sativa*) and Barley (*Hordeum Vulgare*) Premix ice cream

Samples	Sensory Attributes				
	Aroma	Colour	Texture	Taste	Overall Acceptability
F1	5.66±1.06	5.70±0.74	6.20±0.55	6.03±0.92	6.23±0.62
F2	5.70±0.91	5.70±0.98	5.96±0.71	5.73±0.90	5.86±0.73
F3	6.56±0.56	6.23±0.85	6.50±0.50	6.60±0.62	6.60±0.49
C	4.00±0.00	4.13±0.34	4.00±0.00	4.53±0.50	4.50±0.50

Table 4.8 reflect that the sensory attributes of Brown Rice *(Oryza Sativa*) and Barley (*Hordeum Vulgare*) Premix ice cream and the control which is commercialized ice cream. Three formulations of ice creams were produced. There is significant difference in all attributes of premix ice creams. This indicate that brown rice and barley premix ice cream affect the sensory evaluation. The impression of food is strongly influenced by aromas. Aroma is an important characteristic in ice cream. This can indicate consumer preferences as to accept or reject the ice cream before tasting it. The overall mean of the aroma is 5.48 ± 1.19. The mean of aroma for formulation 3 are greater than the formulation 1, 2 and control which are 6.56 ± 0.56 while the mean of aroma for control are lower which are 4.00 ± 0.00. This is because raspberry flavour was added in the formulation 3 which attribute a stronger aroma. Raspberries have a variety of aroma compound that contribute to its flavour. Therefore, most of the penelist preferred the formulation 1. In ice cream, colour is the most important sensory attribute. Consumers have an almost instant impression of ice cream flavour and quality by looking at its colour. The overall mean of the colour is 5.14 ± 1.09. There is significant difference between formulation 1, 2, 3 and

control. The mean of colour for formulation 3 are greater than the formulation 1, 2 and control which are 6.22 ± 0.85 while the mean of colour for control are lower which are 4.13 ± 0.34.This is because the colour of the raspberry is pink purplish in colour which resemble the raspberry. Therefore, majority of the panellist preferred the formulation 3. While, the control is vanilla flavour which are white in colour.

The taste of ice cream is sweet and influenced by the flavour as well. The overall mean of the taste is 5.72 ± 1.06. There is significant difference between formulation 1, 2, 3 and control. The mean of colour for formulation 3 are greater than the formulation 1, 2 and control which are 6.60 ± 0.62 while the mean of colour for control is lower which are 4.53 ± 0.57. This is because the taste of the raspberry gives a fruity flavour. Therefore, majority of the preferred the formulation 3.

The texture of ice cream is the thick and one of the most important characteristics. The overall mean of the taste is 5.67 ± 1.11. There is significant difference between formulation 1, 2, 3 and control. The mean of texture for formulation 3 are greater than the formulation 1, 2 and control which are 6.50 ± 0.50 while the mean of texture for control are lower which are 4.00 ± 0.00. This is because the texture of the raspberry is creamy. Therefore, majority of the panellist preferred the formulation 3.

Based on the overall acceptance, the overall mean of the taste is 5.80 ± 0.92. There is significant difference between formulation 1, 2, 3 and control. The mean of overall acceptance for formulation 3 are greater than the formulation 1, 2 and control which are 6.60 ± 0.49 while the mean of overall acceptance for control are lower which are 4.50 ± 0.50. This is because the overall acceptance of the raspberry contains stronger aroma,

good taste and colour and creamy. Therefore, majority of the panellist preferred the formulation 3. In conclusion, the formulation 3 are the best formulation among the formulation.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In conclusion, objective of this study which were to develop ice cream with alternative ingredients, determine the physicochemical properties of barley and brown ice cream and perform sensory evaluation toward barley and brown rice ice cream are accomplished. For the overall, the ice cream was produced with a difference amount quantity of brown rice and barley. The formulation 3 that containing equal amount of brown rice and barley have high nutritious and are rich in protein, fibre, minerals and vitamins than the formulation 1, 2 and control (commercialized ice cream.

For the physicochemical properties, the formulation 3 was determined as the high nutritious formulation, and for the sensory evaluation the formulation 3 was chosen as the best formulation in terms of aroma, taste, colour, creaminess, and overall acceptance.

5.2 Recommendation

Brown rice (*Oryza Sativa*) and barley (*Hordeum Vulgare*) ice cream Premix has proved as healthy ice cream. Moreover, it also showed the best nutritional value. Furthermore, the sensory evaluation among the panellist also proved that brown rice (*Oryza Sativa*) and barley (*Hordeum Vulgare*) ice cream Premix with raspberry flavour as highest

preferences compared to the market mushroom flavour. For further study, it is recommended that brown rice (*Oryza Sativa*) and barley (*Hordeum Vulgare*) Premix ice cream combine with some other ingredients such as almond and pistachio to enhance the taste better and could improvise the nutritional content as well.

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APPENDIX

ANOVA

Protein_content

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.057	3	.019	.486	.701
Within Groups	.314	8	.039		
Total	.371	11			

Multiple Comparisons

Dependent Variable: Protein_content

Tukey HSD

		Mean Difference			95% Confidence Interval	
(I) Sample	(J) Sample	(I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
F1	F2	.04667	.16166	.991	-.4710	.5644
	F3	-.04667	.16166	.991	-.5644	.4710
	C	.14000	.16166	.822	-.3777	.6577
F2	F1	-.04667	.16166	.991	-.5644	.4710
	F3	-.09333	.16166	.936	-.6110	.4244
	C	.09333	.16166	.936	-.4244	.6110
F3	F1	.04667	.16166	.991	-.4710	.5644
	F2	.09333	.16166	.936	-.4244	.6110
	C	.18667	.16166	.669	-.3310	.7044
C	F1	-.14000	.16166	.822	-.6577	.3777
	F2	-.09333	.16166	.936	-.6110	.4244
	F3	-.18667	.16166	.669	-.7044	.3310

Report

Protein_content

Sample	Mean	N	Std. Deviation
F1	.8867	3	.32332
F2	.8400	3	.14000
F3	.9333	3	.16166
C	.7467	3	.08083
Total	.8517	12	.18359

ANOVA

Fibre_content

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	14.917	3	4.972	9.944	.004
Within Groups	4.000	8	.500		
Total	18.917	11			

Multiple Comparisons

Dependent Variable: Fibre_content

Tukey HSD

		Mean Difference			95% Confidence Interval	
(I) Sample	(J) Sample	(I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
F1	F2	1.66667	.57735	.078	-.1822	3.5155
	F3	-.33333	.57735	.936	-2.1822	1.5155
	C	2.33333*	.57735	.016	.4845	4.1822
F2	F1	-1.66667	.57735	.078	-3.5155	.1822
	F3	-2.00000*	.57735	.035	-3.8489	-.1511
	C	.66667	.57735	.669	-1.1822	2.5155
F3	F1	.33333	.57735	.936	-1.5155	2.1822
	F2	2.00000*	.57735	.035	.1511	3.8489
	C	2.66667*	.57735	.007	.8178	4.5155
C	F1	-2.33333*	.57735	.016	-4.1822	-.4845
	F2	-.66667	.57735	.669	-2.5155	1.1822
	F3	-2.66667*	.57735	.007	-4.5155	-.8178

*. The mean difference is significant at the 0.05 level.

Report

Fibre_content

Sample	Mean	N	Std. Deviation
F1	4.3333	3	.57735
F2	2.6667	3	1.15470
F3	4.6667	3	.57735
C	2.0000	3	.00000
Total	3.4167	12	1.31137

ANOVA

Moisture_content

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.158	3	.053	3.123	.088
Within Groups	.135	8	.017		
Total	.293	11			

Multiple Comparisons

Dependent Variable: Moisture_content

Tukey HSD

		Mean Difference			95% Confidence Interval	
(I) Sample	(J) Sample	(I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
F1	F2	-.14333	.10607	.559	-.4830	.1963
	F3	.15667	.10607	.492	-.1830	.4963
	C	-.09667	.10607	.800	-.4363	.2430
F2	F1	.14333	.10607	.559	-.1963	.4830
	F3	.30000	.10607	.085	-.0397	.6397
	C	.04667	.10607	.970	-.2930	.3863
F3	F1	-.15667	.10607	.492	-.4963	.1830
	F2	-.30000	.10607	.085	-.6397	.0397
	C	-.25333	.10607	.157	-.5930	.0863
C	F1	.09667	.10607	.800	-.2430	.4363
	F2	-.04667	.10607	.970	-.3863	.2930
	F3	.25333	.10607	.157	-.0863	.5930

Report

Moisture_content

Sample	Mean	N	Std. Deviation
F1	4.0233	3	.14012
F2	4.1667	3	.12741
F3	3.8667	3	.16258
C	4.1200	3	.07211
Total	4.0442	12	.16323

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
pH	Between Groups	.007	3	.002	.889	.487
	Within Groups	.020	8	.003		
	Total	.027	11			
Viscocity	Between Groups	3.415	3	1.138	750.614	.000
	Within Groups	.012	8	.002		
	Total	3.427	11			

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Sample	(J) Sample	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
pH	F1	F2	.03333	.04082	.845	-.0974	.1641
		F3	.03333	.04082	.845	-.0974	.1641
		C	.06667	.04082	.414	-.0641	.1974
	F2	F1	-.03333	.04082	.845	-.1641	.0974
		F3	.00000	.04082	1.000	-.1307	.1307
		C	.03333	.04082	.845	-.0974	.1641
	F3	F1	-.03333	.04082	.845	-.1641	.0974
		F2	.00000	.04082	1.000	-.1307	.1307
		C	.03333	.04082	.845	-.0974	.1641
	C	F1	-.06667	.04082	.414	-.1974	.0641
		F2	-.03333	.04082	.845	-.1641	.0974
		F3	-.03333	.04082	.845	-.1641	.0974
Viscocity	F1	F2	-.30667*	.03180	.000	-.4085	-.2048
		F3	-.24333*	.03180	.000	-.3452	-.1415
		C	1.02000*	.03180	.000	.9182	1.1218
	F2	F1	.30667*	.03180	.000	.2048	.4085
		F3	.06333	.03180	.267	-.0385	.1652
		C	1.32667*	.03180	.000	1.2248	1.4285
	F3	F1	.24333*	.03180	.000	.1415	.3452
		F2	-.06333	.03180	.267	-.1652	.0385
		C	1.26333*	.03180	.000	1.1615	1.3652
	C	F1	-1.02000*	.03180	.000	-1.1218	-.9182
		F2	-1.32667*	.03180	.000	-1.4285	-1.2248
		F3	-1.26333*	.03180	.000	-1.3652	-1.1615

*. The mean difference is significant at the 0.05 level.

Report

pH

Sample	Mean	N	Std. Deviation
F1	4.7000	3	.00000
F2	4.6667	3	.05774
F3	4.6667	3	.05774
C	4.6333	3	.05774
Total	4.6667	12	.04924

Report

Viscocity

Sample	Mean	N	Std. Deviation
F1	3.1400	3	.05196
F2	3.4467	3	.00577
F3	3.3833	3	.05774
C	2.1200	3	.00000
Total	3.0225	12	.55820

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Aroma	Between Groups	103.633	3	34.544	60.409	.000
	Within Groups	66.333	116	.572		
	Total	169.967	119			
Color	Between Groups	74.158	3	24.719	41.298	.000
	Within Groups	69.433	116	.599		
	Total	143.592	119			
Taste	Between Groups	68.425	3	22.808	39.197	.000
	Within Groups	67.500	116	.582		
	Total	135.925	119			
Creaminess	Between Groups	115.400	3	38.467	142.712	.000
	Within Groups	31.267	116	.270		
	Total	146.667	119			
Ovreall_acceptance	Between Groups	75.667	3	25.222	70.444	.000
	Within Groups	41.533	116	.358		
	Total	117.200	119			

Report

Sample		Aroma	Color	Taste	Creaminess	Ovreall_acceptance
F1	Mean	5.6667	5.7000	6.0333	6.2000	6.2333
	N	30	30	30	30	30
	Std. Deviation	1.06134	.74971	.92786	.55086	.62606
F2	Mean	5.7000	5.7000	5.7333	5.9667	5.8667
	N	30	30	30	30	30
	Std. Deviation	.91539	.98786	.90719	.71840	.73030
F3	Mean	6.5667	6.2333	6.6000	6.5000	6.6000
	N	30	30	30	30	30
	Std. Deviation	.56832	.85836	.62146	.50855	.49827
C	Mean	4.0000	4.1333	4.5333	4.0000	4.5000
	N	30	30	30	30	30
	Std. Deviation	.00000	.34575	.50742	.00000	.50855
Total	Mean	5.4833	5.4417	5.7250	5.6667	5.8000
	N	120	120	120	120	120
	Std. Deviation	1.19511	1.09848	1.06875	1.11018	.99241

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