CHAPTER III

DEVELOPMENT, CHARACTERIZATION AND PHYSICO-CHEMICAL ANALYSIS OF HALAL CEREAL BAR MADE FROM PUFFED GLUTINOUS RICE AND *SUNNAH* FOODS

3.1 INTRODUCTION

In recent years, consumers demand in the aspect of food product development has changed significantly. Betoret et al. (2011) and Brouns and Vermeer (2000) indicated that foods today are not intended only to provide satiety and to provide necessary nutrients; they are also consumed to prevent nutrition-related diseases and enhance physical and mental well-being of consumers. These types of foods are termed as functional foods. The functional foods offer an outstanding opportunity to improve the quality of products. Functional food products used to be fortified with vitamins and/or minerals. The focus, nowadays, has shifted to foods enriched with dietary fibre (DF) and micronutrients such as omega-3 fatty acids, phytosterol (Betoret et al., 2011).

Fibre possesses many physicochemical functions which contribute to physiological attenuation such as cholesterol and fat binding, decrease in blood glucose levels, prevention of constipation and facilitation of good colonic health. The most widely fibre source for products containing cereals are: wheat, oat, barley, rice, rye (Foschia et al., 2013). For this reason, the main cereal used in this study is glutinous rice, dietary fibre of 2.80/100 mg. Glutinous rice was puffed which was used in the production of cereal bars. Selected *Sunnah* fruits like raisins, dates and figs were combined with the cereal used and agglutination syrups (glucose syrup and honey) in different combinations to give desired fibre content asides the satisfaction of hunger and provision of necessary nutrients.

Consumers tend to have a great liking for consumption of snacks nowadays. Due to the consumers` growing demand for natural, healthy and convenient foods, efforts are being made to enhance fast foods nutritive value by adjusting their nutritional constituents. Cereal bars are popular and convenient foods which make them best food system to supply fibre and phenolic antioxidants in fruits (Sun-Waterhouse et al., 2010). Cereal bars otherwise known as granolas are made from a compacted combination of dried fruit and cereals. Granolas stand out among snacks because of their balanced nutritive value and accessibility (Silva et al., 2013). Cereal bar is a dry granulated cereal snack that exhibits a lower water activity (Macedo et al., 2013). Glucose syrup is the common binding element of granola ingredients supplying quick absorption of energy (Silva et al., 2013).

Dutcosky et al. (2006) suggested that increased cereal bars' consumption is related to the lifestyles adjustment and the demand for snacks and convenient meals. Consumers have effortlessly accepted cereal bars because they are nutritious and wholesome. Cereal bars have an acceptable stability between energy, minerals, fat, vitamins, protein, fibre; cereals promote consumers' health (Ryland et al., 2010). Lima (2004) reported that the greatest challenge in obtaining a good cereal bar is a combination of many ingredients with main functionality like minerals, vitamins, fibres, proteins, binding agents and turns them into a product with decent appearance, aroma, flavor, and texture while trying to attain specific target nutrients.

It has been observed that processing of *Sunnah* foods has not received much attention. In the Holy Qur'an, Muslims are enjoined to consume *Sunnah* foods. Eating healthy foods and not excessively are encouraged in the *Halal* diet. As a result, Muslims who keep *Halal* diet will never overeat and become obese. Allah has repeatedly emphasised the consumption of *Halal* food in the Qur'an: *"O mankind! Eat of that which is lawful and wholesome in the earth, and follow not the footsteps of the Devils. He is an open enemy for you".* (Al- Quran. Al-Baqarah 2:168).

The *Sunnah* fruits used in this study include figs (*Ficus carica*), raisins (*Vitis vinifera L.*) and dates (*Phoenix Dactylifera*). The fruits are mentioned in the Holy Quran and *Hadith* as beneficial fruits. Prophet Muhammad (SAW) also said *"If I had to mention a fruit that descended from Paradise I would say it is the fig, because the fruits of Paradise do not have pits... eat from these fruits for they prevent hemorrhoids & piles and help gout"(Tib Nab Awi, Hadith 467,page 486).* Imam Ali (PBUH) refers to the grape (raisins is a dried grape) and says: The grape is both a fruit and a food; it is sweet and delicious. Imam Ali (PBUH) not only refers to grape as a useful fruit, he also introduces it as a wholesome food. Grape is effective in removing sorrow, stress and depression. Prophet Muhammad (SAW) said *"Dates are able to strengthen stomach, liver, memory, to grow body development, cure illness and as food and drink that sated."* (Ibnu Qayyim in Tib An Nabawi).

This research main aim was to formulate cereal bar from selected *Sunnah* fruits and puffed glutinous rice with honey and glucose syrup as a binding agent. The physicochemical properties of the developed formulations were investigated; which included moisture, fat, fibre, protein, ash, carbohydrate and water activity.

3.2 MATERIALS AND METHODS

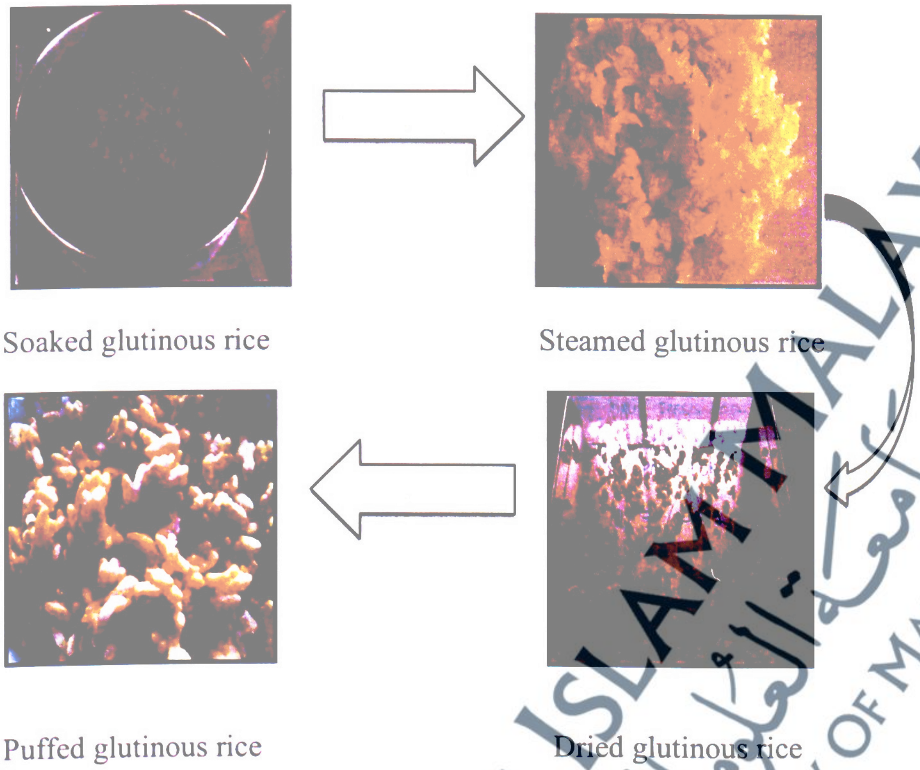
3.2.1 Sample Preparation

The glutinous rice and other ingredients: glucose syrup, honey, the dried fruits (dates, figs and raisins), black cumin and saffron were purchased at TESCO supermarket, Nilai, Malaysia. All the chemicals used for the study were of analytical reagent grade.

3.2.2 Preparation of puffed glutinous rice

200g glutinous rice was thoroughly cleaned and soaked in water, with 0.5g of saffron added, for 24 hours. The soaked glutinous rice was steamed and dried overnight at temperature 155°C using an Excalibur Food Dehydrator Parallex (USA) to a moisture content of 6.75%. The dried glutinous rice flakes was stored in a dry plastic container with a cover/lid in a cool dry place. The preparation of the puffed glutinous rice is shown in Figure 1.

Figure 1: Preparation of puffed glutinous rice



3.2.3 Preparation of puffed glutinous rice cereal bar

The dried fruits (dates, figs and raisins) were diced. 3g of Black cumin was added to the dried fruits in a stainless steel bowl. The glucose syrup and honey were heated in a pot on gas burner to homogenize the binding agents. The heated binding agents were poured into the bowl that contained the dry ingredients and thoroughly mixed with wooden spoon. The mixture was heated in an oven at 100°C for 15 minutes and the mixture (cereal bar) was removed from the oven and allowed to cool before cutting into rectangular shapes; 11cm long, 3cm wide and 1.5cm thick, according to the method used by Freitas & Morreti (2006). Each of the cereal bar weighed 27g. The formulations of the cereal bars are shown in Table 12. Flowchart for the production of the cereal bars is shown in Figure 2, while samples of the six formulations of the bars are displayed in Figure 3.

Table 12: Formulations of binding agents: honey and glucose syrup and dried ingredients (PGR, dates, figs, raisins and black cumin) for each of the formulation.

Ingredients	Formulations					
(g)	**A**	**B**	**C**	**D**	**E**	**F**
PGR	200	200	200	200	200	200
Dates	150	150	100	100	50	50
Figs	150	150	100	100	50	50
Raisins	150	150	100	100	50	50
BC	3	3	3	3	3	3
GS	70	140	70	140	70	140
Honey	100	50	100	50	100	50

Abbreviation: PGR (Puffed glutinous rice); BC (Black cumin); GS (Glucose syrup).

*Brands: Dates (Mariami); Honey (Tesco).

Figure 2: General Flow Chart for the production of *Sunnah* cereal bars

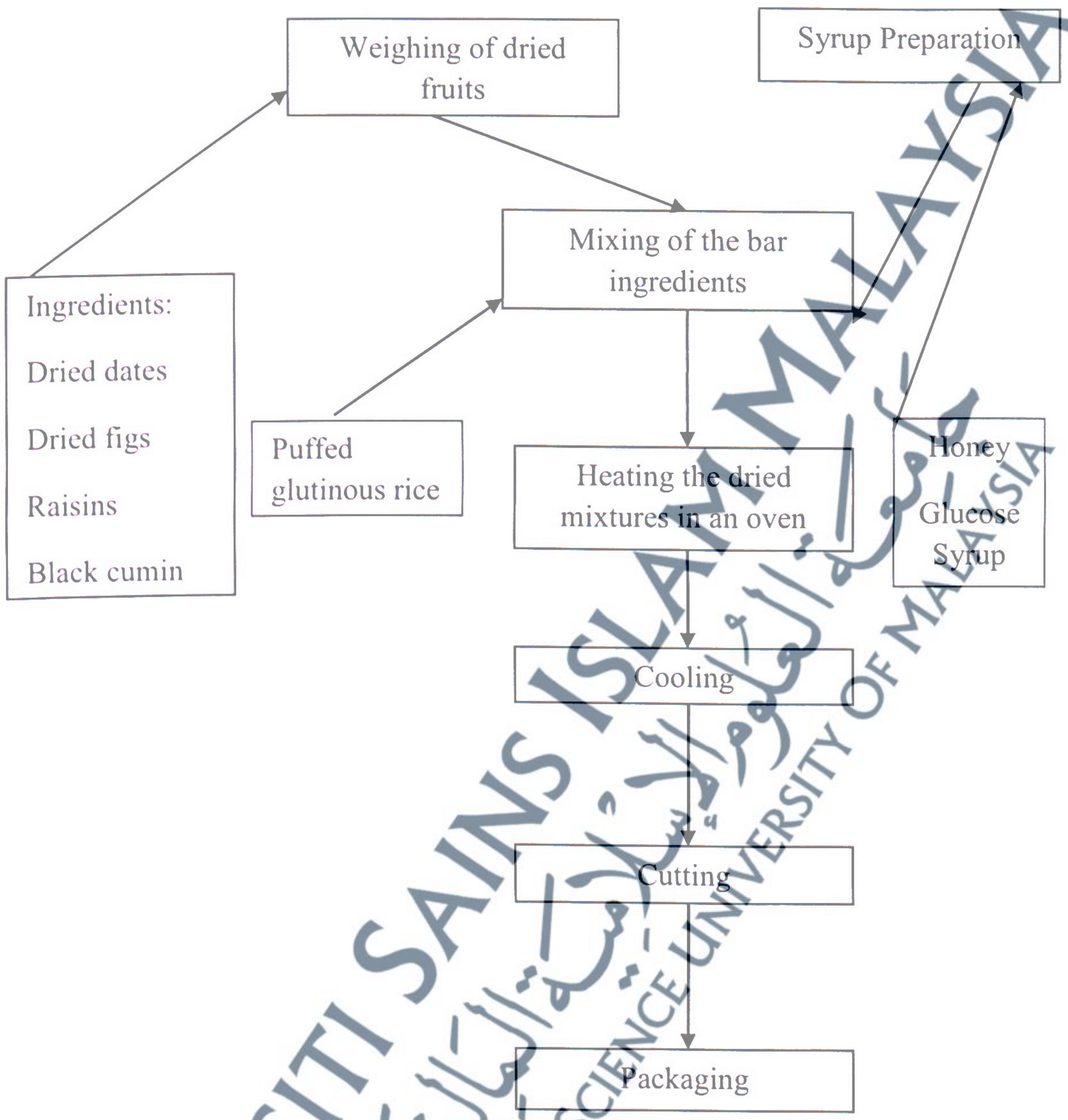


Figure 3: Formulations/Samples of the *Sunnah* cereal bars.

3.2.4 Proximate Analysis of *Sunnah* cereal bar

3.2.4.1 Moisture content Analysis

Moisture content in puffed glutinous rice cereal bar was measured using the moisture analyzer (AND MX-50 Moisture analyzer, Japan) at 160°C. 5.0g of the *Sunnah* cereal bar samples were weighed into the dish and spread evenly using glass rod to increase the surface area of *Sunnah* cereal bar and increase contact area between the sample and heat. The weight of the sample was measured in each minute until constant weight was obtained (Nielsen, 2003).

Moisture content percentage was calculated based on the formula:

$$\textbf{Moisture content (\%)} = \frac{W1 - W_2}{W_1} \times 100 \qquad (1)$$

W_1 = weight in g, of sample before drying

W_2 = weight in g, of sample after drying

3.2.4.2 Crude Fibre Analysis

Crude fibre was determined using the Gerhardt Method (fibre bag), which involved two phases of washing. 1.0g of *Sunnah* cereal bar was weighed and inserted into the fibre bag. The glass spacers were inserted into the fibre bags and the fibre bags were inserted into the carousel. Then, the samples were defatted using 100 mL of petroleum ether. After a short drying process in the fume cupboard about (2 minutes), the carousels were immersed in washing solution. After the washing phase was finished, the fibre bags were put into the crucibles. The crucibles were dried in oven at pre-ashed at 600°C and weighed when cooled. The fibre bags were later incinerated at temperature of 600°C overnight (Nielsen, 2003).

After the incineration, the crucibles were weighed and the percentages of crude fibre in the *Sunnah* cereal bar samples were calculated based on the formula:

$$\textbf{Crude Fibre (\%)} = \frac{100 \times [(C-A) - (D-E)]}{B} \qquad (2)$$

Blank Value E = D − F

A= Weight of Fibre Bag in g

B = Sample weight in g (had to be adjusted according to dry content)

C = Weight of Crucible and dried Fibre Bag after digestion, in g

D = Weight of crucible and ash in g

E = Blank value of the empty Fibre Bag in g

F= Weight of Crucible in g.

3.2.4.3 Crude Fat Analysis

Fat contents in *Sunnah* cereal bar samples were analysed using solvent extraction method (Nielsen, 2003). The samples were weighed and folded in filter papers (Whatman™, 1). Then, they were inserted into extraction thimbles, which contained three pieces of boiling stones and covered by glass wool. Petroleum ether (140 mL) was later poured into the extraction flasks in which thimbles that contained the samples had been placed. Then, the samples in the thimbles underwent extraction in the Gerhardt fat extractor at 150°C for 6 hours. The boiling stones were used to stabilize the boiling process. The samples were dried in the Binder drying oven (Binder Inc. USA) at 105°C overnight and the final mass were measured (Nielsen, 2003). The percentages of fat in the *Sunnah* cereal bar samples were calculated based on formula:

$$\textbf{Fat (\%)} = \frac{(m_2 - m_1)}{m_0} \times 100 \qquad (3)$$

m_1 = weight of the empty extraction beaker with boiling stones in g

m_2 = weight of the extraction beaker with fat after drying in g

m_0 = weight at the start of the analysis in g.

3.2.4.4 Crude Protein Analysis

Crude protein contents in the *Sunnah* cereal bar samples were determined by using the Kjeldahl in Kjeldatherm-system. The samples (1.0g), 20 mL of sulphuric acid and two pieces of kjeltabs were added into the digestion tubes. Then, the samples underwent the next procedure (determination of the protein content by titration) in Kjeldatherm machine (Nielsen, 2003). Percentages of nitrogen and crude protein contents in the *Sunnah* cereal bar samples were determined automatically by the Kjeldatherm machine based on the formula:

$$\textbf{Nitrogen (\%)} = \frac{1.4007 \times c \times (V - V_b)}{\text{Sample weight (g)}} \qquad (4)$$

c = concentration of the standard-acid solution: sulphuric acid 0.1N or c = 0.05 mol/L.

V = consumption of the standard acid used in ml (Sample)

Vb = consumption of the standard acid in ml (Blank Sample)

% raw protein = %N ×6.25.

*6.25 is the Nitrogen to Protein Conversion Factors for glutinous rice flakes cereal bar samples.

3.2.4.5 Ash Analysis

The ash content is an estimated measure of the mineral salts and other organic matter in a sample. The ash contents in the *Sunnah* cereal bar samples are the organic residues after combustion at a temperature of 575±25°C. Dry ashing method was used for determination of ash content (Feng, 2003). *Sunnah* cereal bar samples (3.0g) were put into crucibles. The samples were charred before ashed in muffle furnace oven.

Thereafter, the samples were combusted in muffle furnace at temperature of 600°C, and then the crucibles and the ash were cooled to at least 250°C. Then, the crucibles with the ash were transferred to a desiccator to cool prior to weighing (Nielsen, 2003). Percentages of ash contents in the puffed glutinous rice cereal bar samples were determined based on the formula:

$$\textbf{Ash (\%)}\ \text{(Dry basis)} = \frac{M_{ash}}{M_{dry}} \times 100 \qquad (5)$$

M_{ash} = Weight of the sample after ashing.

M_{dry} = Weight of the dry sample before ashing.

3.2.4.6 Total Carbohydrates Determination

Carbohydrates were calculated by the difference method (FAO, 1998; AOAC, 2000), using the formula below:

Carbohydrate (%) = 100 - % moisture - % protein - % lipid - % ash – % fibre. (6)

3.2.4.7 Energy contents (Kcal) Determination

The following formula was used (Kristin, 2010):

Energy Kcal = (% Carbohydrate × 4) + (% Protein × 4) + (% Fat × 9) (7)

3.2.4.8 Water Activity Determination

Water activity of the *Sunnah* cereal bar samples was measured at 25°C (± 0.2 °C) using an electronic dew-point water activity meter, Aqualab Series 3model TE (Decagon Devices), equipped with a temperature-controlled system which allowed a temperature stable sampling environment. The equipment was calibrated with saturated salt solutions (Favetto et al., 1983). The sample was placed in a tight measuring chamber at a controlled steady temperature, during the equilibration the sample releases humidity and equal relative humidity at the level of the electrical sensor was observed (Mathlouthi, 2001). The water activity values of the bars were displayed on the machine and the readings were taken.

3.2.4.9 Data Analysis

Data obtained from all the analysis were analysed using the Minitab (16.2.1 version software). All determinations were performed in triplicate. The statistical analyses were conducted using one-way ANOVA procedures. Test of significance were tested at $P<0.05$. Tukey's test was used to differentiate between the mean values.

3.3 RESULTS AND DISCUSSION

3.3.1 Moisture Contents

Moisture analysis of cereal bar made from puffed glutinous rice and *Sunnah* foods are shown in Table 13. The moisture contents of the six formulations ranged between 11.35% and 18.73% (w/w). The moisture contents of the bars varied, based on the percentages of fruits added, (Freitas & Moretti, 2006). The moisture contents of the experimental bars were lower than the moisture contents of bars produced by Santos et al (2011). Santos et al. (2011) formulated their bars with jackfruits. The moisture contents obtained for their three formulations were between 20.26 and 21.40%. The moisture contents obtained in this work, when compared with the work of Santos et al. (2011), were lower than those obtained by Santos and his colleagues. This showed that the moisture contents in this work were better than theirs because lower moisture content would extend/prolong the shelf stability of the product.

Table 13 Proximate analysis, energy contents and water activity values of *Sunnah* cereal bars

Parameters	Formulations					
	A	B	C	D	E	F
Moisture (%)	16.41^{a}	18.73^{a}	17.02^{a}	17.12^{a}	11.35^{b}	12.90^{ab}
Protein (%)	3.38^{a}	3.56^{a}	3.58^{a}	4.04^{a}	3.91^{a}	3.52^{a}
Fat (%)	10.30^{a}	10.72^{a}	9.78^{ab}	8.93^{b}	7.31^{c}	7.32^{c}
Crude Fibre (%)	9.39^{b}	6.32^{c}	13.42^{a}	4.24^{d}	1.81^{e}	1.94^{e}
Ash (%)	1.71^{ab}	1.88^{a}	1.28^{ab}	1.41^{ab}	1.03^{ab}	0.97^{b}
Carbohydrate (%)	58.31^{c}	58.80^{c}	54.92^{d}	64.25^{b}	74.59^{a}	73.35^{a}
Energy (Kcal)	339.47^{c}	345.90^{c}	322.06^{d}	353.54^{b}	379.80^{a}	373.37^{a}
Water activity (a_w)	0.597^{a}	0.586^{a}	0.577^{ab}	0.590^{a}	0.587^{a}	0.557^{b}

*Means in columns and rows with different superscripts differ ($p < 0.05$).

A (*Sunnah* foods – 450g, honey – 100g, glucose syrup – 70g), **B** (*Sunnah* foods – 450g, honey – 50g, glucose syrup – 140g), **C** (*Sunnah* foods – 300g, honey – 100g, glucose syrup – 70g), **D** (*Sunnah* foods – 300g, honey – 50g, glucose syrup – 140g), **E** (*Sunnah* foods – 150g, honey – 100g, glucose syrup – 70g), **F** (*Sunnah* foods – 150g, honey – 50g, glucose syrup – 140g).

The trend of moisture contents obtained in this work follow the same pattern as the work of Rehman et al. (2012). It was that revealed progressive increase in moisture contents occurred with increasing amount of fruit used in their research. It was also revealed in this study that there was steady decrease in the moisture contents of the samples formulated in this work as the fruit contents was decreasing. The results also correlated with of Ahmed et al. (2005), who detected an upsurge in moisture contents which ranged between 19.66 and 21.10% in papaya fruit bars.

The results of moisture contents obtained by Souza et al. (2014), 7.19% - 8.24%, who made cereal bars with whole flour of pseudo-cereals new cultivars; the bars probably had a lower moisture contents compared to the bars in this work as a result of different in cereals and fruits used in the formulation. Amount of fruits added to the ingredients could also be responsible for higher moisture content. The *Sunnah* fruits had moisture contents higher than 15%; raisins (15.43%), figs (30.05%) except dates that had 7.20%. The higher the fruit contents, the higher the moisture contents. There was significant difference ($P<0.05$) in the moisture contents. The values of the moisture contents of formulations **A-D** were not different significantly due to the amount of fruit contents in the samples while samples **E** and **F** were significantly from them because of lower amount of fruits added.

This observation was in line with findings of Freitas & Moretti (2006) and Gomes et al. (2009). Freitas & Moretti (2006) formulated cereal bar with banana; the bar had a moisture content of 10.71%. Another corroborating finding is the study carried out by Pagamunici et al. (2014b). The moisture contents of their gluten-free cookies ranged from 14.90-16.78%. The moisture contents in this study followed the same trend. Torres et al. (2011) obtained an average of 21.01% for cereal bars containing jackfruit seed and jenipapo. The values obtained were higher than those found in this work. The fruits used in this bar contributed to the moisture contents because moisture contents of raisins and figs were a bit high. Al-Farsi et al. (2007) reported that moisture and carbohydrate are the predominant components in dates and their by-products. Low value of moisture contents indicated that these cereal bars can be stored for a long period of time without spoilage and it will not be vulnerable to microbial growth (Oloyede, 2005).

3.3.2 Protein Contents

The protein contents of the bars were low, (Table 13). Fruits generally have low protein content. The protent contents in this study were in line with the work of Santos et al. (2011). The protein contents of their bar samples ranged between 4.60% and 4.80%. It can be concluded that puffed glutinous rice and dried *Sunnah* fruits could also be used to formulate cereal bar of appreciable protein contents. The percentages of the crude protein in the fruits are raisins (3.07%); figs (3.30%) and dates (2.60%). The cereal bars could be agreed upon to be a nutritious snack. Torres et al. (2011) obtained an average protein content of 0.05%. The values in this work were higher than the values in their study. Pagamunici et al. (2014) values of 6.83%-7.66% were than the values obtained in this work probably because of the new cultivar of Amaranth used in the formulation of their samples.

The cereal bar in this study presented protein composition close to those of Santos et al. (2011) whose samples' crude proteins percentages ranged between 1.00 and 4.80%. The protein content increased progressively and uniformly with the increase in grain concentrations in the cereal bar formulations, this is in agreement with studies accomplished by Enriquez et al. (2003). Cereal bars usually have low protein content (Mahanna & Lee, 2010). The data on the crude protein showed non-significant difference ($P>0.05$) in the formulations. The addition of the fruits resulted in the minimum increase in the protein contents because the fruits are low in crude proteins. This is in concurrence with analysis carried out by Rehman et al. (2012).

Glutinous rice is gluten-free, this also contributed to the low protein content recorded in this study. Generally, gluten-free products possess low protein content (Segura & Rosell, 2011). Furthermore, the result obtained for the protein contents in this work is comparable to the results of Ryland et al. (2010), in the development of cereal bar with micronized flaked lentils and oat, an average protein content of 4.22% was obtained. Ananthan et al. (2013) obtained a protein content of 10.49% when cashew nuts and flaxseed were used in the formulations. Previous study by Torres et al. (2011) showed that the protein content of cereal bar by using exotic fruits also had low protein content, approximately 0.05%. The quantity of protein obtained in this study might be different because of the ingredients/fruits are different. The incorporation of *Sunnah* fruits, binding agents such as honey and glucose syrup, with glutinous rice flakes produced low protein contents but higher than previous research of Torres et al. (2011), their formulations had crude protein percentages that ranged from 0.03 to 0.05%.

3.3.3 Crude Fat Contents

The crude fat contents of cereal bar of different formulations ranged between 7.31% and 10.72%. This was close to the result of Souza et al. (2014). They concluded in their work that gluten-free granolas had average of 1.714% ash, 7.64% moisture, 11.82% total fat 9.23% protein, and 69.60% carbohydrate. The fat results obtained in this study were in the range of the fat result obtained in the work of Ananthan et al. (2013), 19.44%. The little different in the fat contents can be attributed to the difference in the ingredients used for the formulations of the cereal bars. The formulation also possesses higher fat contents when compared to the work of Ryland et al. (2010), an average of 7.61% except samples **E** and **F**, which could be as a result of higher puffed glutinous rice contents which had crude fat of 0.19%.

The fat contents of the bars in this work was in close proximity of the fat results of bars formulated with whole flour from a new cultivar of *Amaranth* by Pagamunici et al. (2014a). The fat contents of their samples ranged between 7.46% and 8.21%. The fat composition of the granola bars prepared with *Agave tequilana* by Zamora-Gasga et al. (2014), ranged between 14.17% and 15.60%. The difference could be traced to the 14 g/100 g vegetable oil and 49 g/100 g soy lecithin used in their formulations. Mendes et al. (2013) obtained moisture, 11.85%; ash, 2.09%; protein, 9.91%; fats, 14.55%; and carbohydrates, 61.61%; from a granola formulated using baru and fruit peels. The fat in this study is comparable to the fat composition obtained by them. The high fat contents recorded in formulations **A** and **B** were probably due to the combined fats in the fruits. The crude fat results were in agreement with Souza et al. (2014) and Rehman et al. (2012). Higher fat compositions (7.31 -10.72%) were obtained in this study than those cereal bars formulated by addition of dried murici (Guimaraes & Silva, 2009) whose bars had crude fats of 4.70 g/100 g, but comparable to the bars made from pulp of baru and almond in three different formulation, whose compositions was between 10.48 and 11.06% (Lima et al., 2010). Contrary to other researches that presented higher contents than cereal bars elaborated in this work, the higher values could be because of incorporation of fruits that are lower in fats, according to findings by Lima et al. (2010). Freitas & Moretti (2006) analysed granolas formulated with several types of cereals and banana; they discovered that the bars had reduced lipid contents. In their work, the sample with wheat germ exhibited 10.57% fats. The results in this research were comparatively closer to those obtained by Freitas & Moretti (2006).

There was a steady increase in fat content with gradual increase in composition of fruits. Same trend was also observed by Rehman et al. (2012) in the physicochemical characterization of apricot-date bars. The fat compositions in the present study were higher than the fat the fat content obtained by Moura et al. (2013), a fat content of 4.70%. Rehman et al. (2012) also obtained a range of 7.30 – 7.32% of fat in their bars which correspond to the values obtained in samples **E** and **F** in this study. Thus, from the results, cereal bar made with puffed glutinous rice and the *Sunnah* fruits could also produce a bar with a fat content which made the cereal bar to be accepted as a wholesome snack. The considerably superior fat contents the bars possess might be necessary to replace the energy burnt in the course of bodily workout as a result of the exhausted energy during exercise (Grden et al., 2008).

3.3.4 Crude Fibre Content

The fibre results of the bars in this study ranged from 1.81% to 13.42%, (Table 13). This was closer to the result of obtained by Mendes et al. (2013). They elaborated cereal bars with pulp and baru almond. The compositions of their bars had average fibre contents of 18.13%. The crude fibres of the bars obtained in this research were similar to the levels found by Lima et al. (2010), the contents ranged between 14.86 and 16.73%. The higher fibre result obtained in their research were due to different in fibre contents of the fruits used in the bar formulations. From Table 13 and Figure 4, formulations **E** and **F** had lower fibre contents because of lower fruit contents. It is evident from the results that the fibre contents were directly proportional to the amount of fruits used in formulating the cereal bars. It could be compared to the results obtained by Rehman et al. (2012), their study on 15-30% apricot-date bars yielded fibre contents that ranged from 5.66-6.14%. Moura et al. (2013) obtained a fibre content of 13.40% which is very closer to the highest fibre contents of the cereal bars formulated in this present work (formulation **C**).

3.3.5 Ash Contents

The ash contents of the bars ranged from 0.97 – 1.88%. Increasing the amount of fruits increased the ash contents (Table 13). The ash contents of the bars in this research were comparable to the ash results of the bars formulated by Zamora-Gagsa et al. (2014). The ash contents obtained in their study "chemical composition and in vitro starch hydrolysis of cereal bars formulated with *Agave tequilana* ingredients" yielded ash results that varied between 0.95 and 1.05% (Zamora-Gagsa et al., 2014). The results in this study were comparable to the ash results of the cereal bars developed with *Sunnah* fruits and puffed glutinous rice. Lima (2004) used cashew to produce cereal bars, the author obtained 1.63% ash which was in the range of the ash of the cereal bars in this work (Figure 4).

There was significant difference ($P < 0.05$) among the samples' ash contents. The formulations presented ash contents similar to those of Souza et al. (2014) and Pagamunici et al. (2014a), they obtained 1.59-1.81% and 1.34-1.37 of ash in their bars produced from a new cultivar of *Amaranth* and whole flour of pseudo-cereal new cultivars respectively. Mendes et al. (2013) reported that granolas formulated with baru and fruit peels had ash value of 2.09%. Ananthan et al. (2013) found out that cereal bar made of flaxoat and nuts had total ash content of 2.33%. The ash contents of the bars in this research were also in agreement with results obtained by Carvalho (2008) in the development of cereal bars with *Lecythis pisonis* Camb. *Dipteryx lacunifera Ducke* and *Sterculia striata St. Hill et. Naud* with the inclusion of pineapple peels in three different formulations. The ash results varied between 1.08 and 2.30%.

Ash value is directly proportional to the mineral contents of the ingredients used in the formulation. The ash results in this study can be traced to the *Sunnah fruits* which can be regarded as origin of minerals, notably calcium, iron zinc and magnesium as stated by Fernandes et al. (2010) and Lima et al.(2010), they used almond of baru in their formulation of cereal bars and obtained ash content of 3.03%. Cecchi (2003) revealed that whole grains and cereals possess total ash contents of 0.30 to 3.30%; cereal bars made with puffed glutinous rice and *Sunnah* fruits in this research showed substantial ash content.

Similarly, there was little difference among the ash contents of the formulations, except **B** and **F**. The two formulations were significantly different ($P<0.05$) from each other. Formulation **B** had the highest ash content probably because of higher fruit contents (450 g) compared to formulation **F** (150 g) with lower fruit compositions. It could be deduced that the fruits contributed to the ash contents of the formulations, similar to that reported by Fernandes et al., (2010) and Lima et al. (2010). The ash contents of the cereal bars in this study were lower than the results obtained by Rehman et al. (2012), 4.06 – 4.20% and Moura et al. (2013) who recorded a value of 2.90%.

3.3.6 Carbohydrate content

There were significant differences ($P< 0.05$), Table 13. The total carbohydrate contents of the samples ranged from 58.31 to 74.59%. This was comparable to the results obtained by Souza et al. (2014), the carbohydrate contents obtained in their study ranged between 68.33 and 71.57%. They further reported that gluten-free products, in which glutinous rice belongs (81.68% carbohydrate), present high carbohydrate content. The carbohydrate composition in these Sunnah fruit-based bars was higher than the previous study of Reyland et al. (2010) in which the average carbohydrate contents recorded in their cereal bars was 13.38%. Mendes et al. (2013)

reported 61.61% as the carbohydrate content of their cereal bar developed with rice flakes, oat, baru and fruit peels. The carbohydrate results in this present work were therefore comparable to with some samples having higher carbohydrate contents than their cereal bar.

The higher carbohydrate contents obatined in this *Sunnah* cereal bars were in concurrence with the results obtained by Freitas & Moretti (2006); their cereal bars were formulated using high vitamin and protein contents and they obtained a value of 60.97%. The carbohydrate results obtained in this research were also comparable to those obtained in the study done by Carvalho (2008) in granolas formulated with *Lecythis pisonis Camb.,* (63.90%); also within the range of results of for cereal bars formulated by the same author with *Sterculia striata* St. *Hill*. Et *Naud* and *Dipteryx lacunifera* Ducke, 70.70 and 69.30 % respectively, (Figure 4).

The high carbohydrate compositions are due to the addition of puffed glutinous rice and honey used for the preparation of cereal bars as reported by Mendes et al. (2013); they used rice flakes and glucose syrup in the preparation of their bars. As reported by White & Doner (1980), honey is primarily a high-energy carbohydrate food and glucose syrup also has higher carbohydrate content according to USDA, (2012). The honey and glucose syrup contribute to high carbohydrate contents in cereal bars. The incorporation of dried *Sunnah* fruits and the binding agents (honey and glucose syrup) produced cereal bars with high carbohydrate content, (Figure 4). The *Sunnah* fruits also contributed to high carbohydrate contents found in the bars; dates possess carbohydrate content of (52.6 – 88.6 g/100g), raisins has 79.18 g/100g while figs contains 63.87 g/100g as its carbohydrate composition.

3.3.7 Energy content

The energy values of the cereal bars formulated with puffed glutinous rice and *Sunnah* fruits in this research varied between 322.06 Kcal and 379.80 Kcal, Table 13. The energy contents among all samples of the cereal bars were significantly different ($P<0.05$). Lima et al. (2010) reported that the energy contents for granolas made with pulp and baru almond (337.37 Kcal); cereal bars developed using macauba nuts had energy value of 348.66 Kcal, but the energy contents were lower to the values obtained in the work of Carvalho (2008) on cereal bars formulated with *Lecythis pisonis* Camb., *Sterculia striata* St. Hill et Naud and *Dipteryx lacunifera* Ducke nuts combined with the inclusion of peel of pineapple; the energy contents varied between 407.50 and 434.00 Kcal.

Formulations **E** and **F** showed higher energy contents, 379.80.and 373.37 Kcal respectively. This was attributed to lower fruit contents, i.e. higher cereal to fruit ratio (Mendes et al., 2013). Souza et al. (2013) reported an average of 180.39 Kcal of energy content in their study. This was quite lower to the levels obtained with cereal bars formulated with *Sunnah* fruits as their fruit base. The overall formulations produced comparable energy contents. Besides, the carbohydrate contents of the cereal bars are close to other studies reported by Shaheen et al. (2013) & Mendes et al. (2013) with values of 325.46 – 386.96 Kcal and 416.99 Kcal, respectively. The values were also in agreement with the levels obtained by Mourao et al. (2009) who obtained values from 377 to 404 Kcal. However, the value of 284.00 Kcal recorded by Moura et al. (2013) is lower than the values obtained in this study. Thus, the puffed glutinous rice and the *Sunnah* fruits could be considered as high caloric value cereal bars, Figure 5.

Figure 4: Proximate composition of *Sunnah* cereal bars

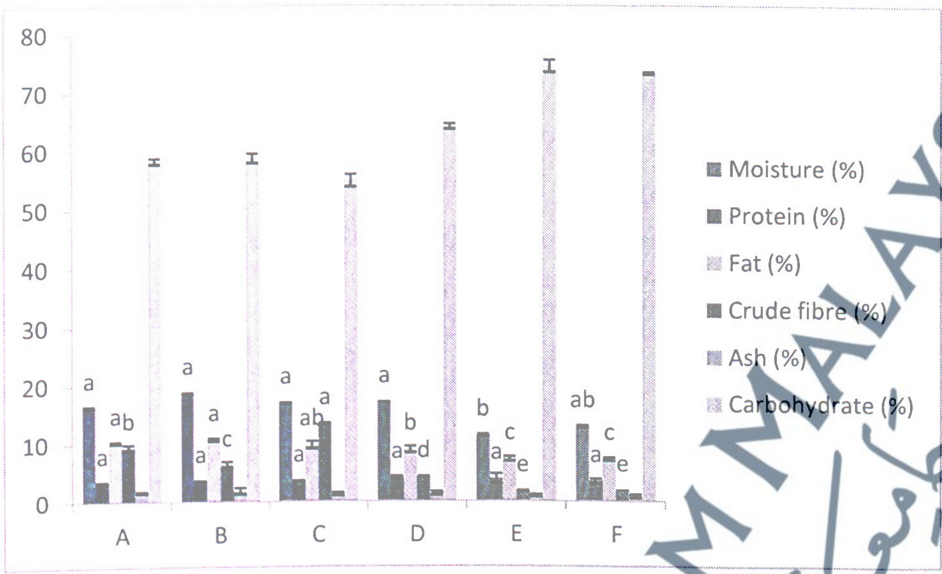
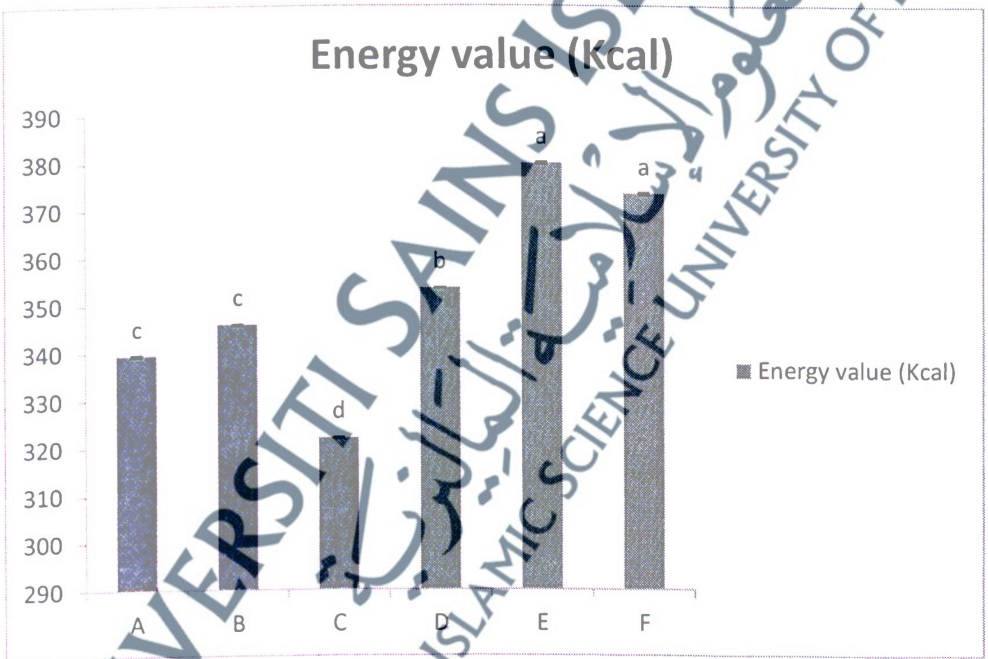


Figure 5: Energy values of *Sunnah* cereal bars



3.3.8 Water Activity

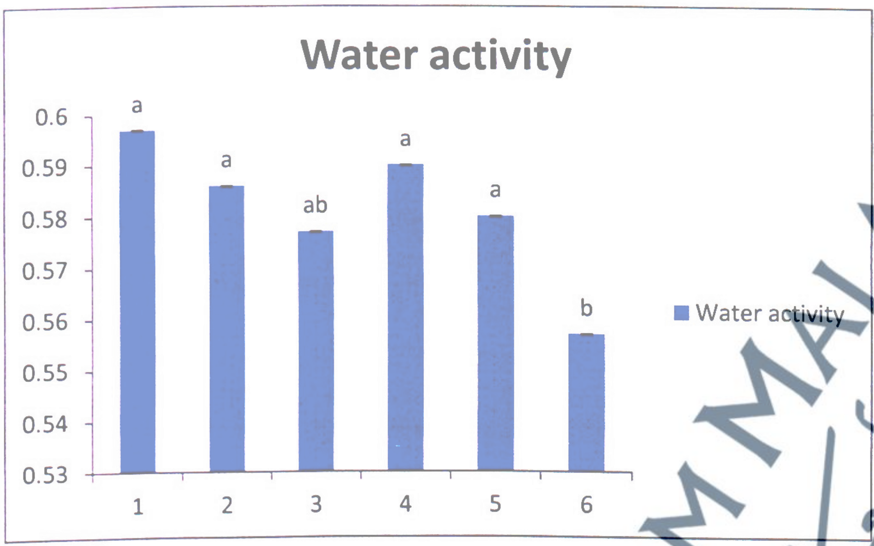
This test was conducted to determine the effect of water activity on the texture, shelf-life and to establish any relationship between water activity and moisture content. The values obtained in Table 13 and Figure 6 show the water activity of the formulations of the cereal bars. The water activity of the formulations was statistically different (P<0.05). The values ranged from 0.557 to 0.597. Water activity is a significant meansused in forecasting existing water in foods. Its level defines growth of undesirable microbes, CCP (critical control point), food hazards, packaging requirements and standards for various preserved foods (Fontana, 2000).

Table 13 and Figure 6 show that the treatments (varying fruit and binders' compositions) had significant effect on water activity, a_w. Moisture contents increased because of *Sunnah* fruits in different formulation. The highest water activity, a_w, (0.597) was observed in formulation **A** which together with formulation **B** contained the highest quantity of *Sunnah* fruits (a total combination of 450g each) against the lowest a_w contained in formulation **F** (0.557) which has the lowest *Sunnah* fruits, a total combination of 150g. The gradual increase was detected in the formulations. This trend tallied with the observations of (Estevez et al., 1995), they discovered that water activity reduced from 0.710 to 0.520 upon storage of nut and cereal bars for 0 and 60 days.

The results of water activity found in the cereal bars in this study were similar to the results of Silva et al. (2013), who obtained water activity of 0.560 in cassava flour-based bars. The water activity, a_w, of *Sunnah* cereal bars were lower than the results reported by Aigster et al. (2011), 0.690 in granolas. Loveday et al. (2009) reported a value of 0.650 in their research for the protein bars formulated. Sharon (2009) in their study reported that preferable water activity for cereal bars should be between 0.450 and 0.570. The results of water activity in this research were closer to the values stated by Sharon (2009). According to Rehman et al. (2012), the results found in their work, using apricot and date to formulate bars, the water activity values ranged from 0.534 to 0.546; data obtained for *Sunnah* cereal bars are comparable to their values (Figure 6).

Contrary to the results obtained by Souza et al. (2014) for the water activity of bars formulated with whole flour of pseudo-cereals new cultivar. They found water activity that varied between 0.430 and 0.470. The difference noted in the values when compared to those obtained for *Sunnah* cereal bars is attributable to the difference in ingredients and fruits and the puffed glutinous rice employed. According to Ananthan et al. (2013), cereal bars formulated in their research with flaxoat and nut presented water activity in the range of 0.330 to 0.730. It was further stated that when the cereal bars were stored for 45 days, no visible microbial growth that could cause spoilage was observed at 0.730 water activity. The results in this study were however, lower than the levels obtained by Moura et al. (2013) and comparable to the levels obtained by Shaheen et al. (2013) with water activity levels of 0.684-0.704 and 0.580-0.597 respectively.

Figure 6: Water activity values of *Sunnah* cereal bars



The cereal bars formulated in this study presented low water activity which could contribute to the prevention of microbial growth (Souza et al., 2014). It could be concluded that the formulation of a nutritious cereal bar from glutinous rice flakes and *Sunnah* fruits followed the process to final formulation which assisted the cereal bars to present appreciable water activity values (Ryland et al., 2010).

3.4 CONCLUSION

The proximate composition and water activity analysis displayed the characteristics of *Sunnah* cereal bars. The composition (proximate) and water activity values of cereal bars from *Sunnah* fruits and puffed glutinous rice were comparable to the values obtained by other researchers. Puffed glutinous rice and dried *Sunnah* fruits can be used to prepare nutritious cereal bars of good nutritive value that could supply substantial amount of proteins, carbohydrates, dietary fibre, fats and energy values. The water activity of the cereal bars was not tolerable to microbial growth. The lipid, ash moisture, fibre, carbohydrate and energy values were all in the range of the values recorded by previous researchers. To make the cereal bars a wholesome one in term of nutrient value, the protein content must be improved. A legume, pulse or a nut may be added. It will achieve many purposes. Protein and fats would increase and this would eventually contribute to the higher energy contents. Consequently, this will produce cereal bars of higher nutritive values.