CHAPTER II

2.0 LITERATURE REVIEW

2.1 Cereal Bar

Cereal bar or granola is a nutritious food as a result of their rich content of protein, lipids, and carbohydrate (Estevez et al., 2000). It is produced from a compacted aggregation of dried fruits, cereals and binders. Glucose syrup represents the major binding constituent of the cereal bar ingredient (Silva et al., 2013). Degaspari et al. (2008) reported that the widely used materials in producing granola are cereals- rice, oat, soy and wheat. These cereals are regarded as an excellent group as a snack because of their elevated nourishing content. Cereal bars are wholesome (healthy); excellent source of energy food which aids the revitalisation of vigour after work out and drills when utilised as snacks (Brito, 2005).

There has been an increase in the consumption of cereal bars; this was as a result of attitudinal change towards need and consumption of healthy snacks by the consumers (Dutcosky et al., 2006). Ryland et al. (2010) found that consumers readily chose granola because they are wholesome. They contain high fiber, adequate calories, fat, protein, vitamins, minerals which are good to the consumers' health (Zamora-Gasga et al., 2014). It is stated that it is well acknowledged that fibre plays a significant role in disease prevention and enhanced health of consumers. Zamora-Gasga et al. (2014) stated further that one way to increase fibre intake is through its incorporation in food commodities, though this procedure brings the challenge of maintaining satisfactory sensory acceptance.

On the other hand, granola can also be regarded as a snack that fit in to the light food market because of the nutritional contents, especially for athletes (Pehanich, 2003). Several types of cereal bars were formulated by Freitas & Moretti (2006). They made a cereal bar with banana which had carbohydrates (60.97%), moisture (10.71%), protein (15.31%), crude fat (5.65%), fibre (5.17%) and 2.20% ash. A homemade cereal bar evaluated by Brito et al. (2004) had 80.85% carbohydrate, 7.63% moisture, 0.68% fats, 1.13% ash, 6.27% protein, and 3.44% fibre. They also concluded that cereal bars may demonstrate different nutritional components based on the ingredients used in making the bars. Cereal bars are among the RTE expedient food products dominating bigger area in the consumer market; they do satisfy hunger and also as an excellent foundation of nourishments and an appropriate channel for a meal replacement (Catherine & Johnston, 2012).

It is a common practice in the food industry to mix different ingredients with both functional and nutritional features together (Gomes et al., 2009). The granola eaters are keen about the energy output and the ingredients' combination used to process foods (Mahanna et al., 2009). Nut can also be included as an ingredient in making cereal bars to enhance the flavour and to add the nutritional quality (Silva et al., 2013). According to Ferreira (2004), cereal bar are made from processed cereal grains that are incorporated with other ingredients such as dehydrated fruits, chestnuts, nuts almonds, sugars, chocolates etc. Freitas & Moretti (2005) observed that the production process of granola may cause changes displayed in different cereal bars formulated because there would be inconstistency in samples and batches. Cereal bar is in the same group of natural Ready-to-Eat cereals, and appealing to consumers as they possess both health and flavor related requirements which include no additives, added

sugars and also no preservatives (LaGrange et al., 1991). To preserve sweetness, cereal producers utilise unadulterated and unprocessed honey, which pass on a golden colour and sweet flavour that many consumers have preference for (LaGrange and Sanders, 1988). Cereal bar demand has risen progressively as consumers look for snacks that have reduced fat and richer in wholesome and more nutritive ingredients; hence can contribute to a balanced diet (Celis et al., 1996; Liesse, 1993). Esteller et al. (2004) stated that ingredients in cereal bars should be appropriately formulated to ensure a mutual supplementation with respect to physical attributes and texture, particularly, the water activity's point of balance.

Demand of healthy cereal bars have gained more significance and popularity in the world market in recent times, today the market is offering a variety of cereal bars under different brands. The diverse types of "granola" available today with good sensory features and consumer request have names like chewy cereal bars, organic bar, choco bar, muffin bar and fruit filled bars. These bars are usually packed in metallised polyester films and have a short shelf life of three to four months (Ananthan et al., 2012). Loveday et al. (2009) reported that there are varieties of cereal bars that are called protein bars; the authors stated further that protein bars are a suitable and wholesome food presentation that was initially formulated for athletes but is now elaborated to attract a wide range of health-cognizant consumers. The authors further reported that these types of bars contain 15-35% protein; consisting almost completely of dairy or protein of soybean due to their health values and cost efficiency. More so, vitamins, minerals and fibre are habitually added to enhance the nutritional value.

2.2 Breakfast Cereal/Ready to eat Cereals

Fast (1987) defined breakfast cereals as 'processed grains for human consumption'. The major grains employed in the production of breakfast cereal are barley, corn, wheat, rice and oats. Breakfast cereal products can be divided into: (1) ready-to-eat breakfast cereals; (2) hot breakfast cereals; and (3) alternative breakfast products based primarily on cereal grains, such as waffles, toasted pastries, cereal bars, and other muffins, frozen products, and bagels (Caldwell et al., 2004). Ready-to-eat cereals are frequently made from mixtures of one or several grain components with other ingredients; they require extensive processing, are usually fortified with vitamins and minerals, and are particularly packaged to protect their texture, flavour, and nutrition during storage as well as to exhibit their contents in such a way as to aesthetically appeal to and attract the consumer.

Ready-to-eat breakfast (RTE-BC) cereals and their products play a vital function in the human nutrition and physiological advantages to humans (Paul et al., 2010). RTE are regarded as an inexpensively competitive source of nutrients (Gretchmen, 1995). The overall breakfast cereals market grew by 3.7% annually over the period 2006–2010 to reach a value of USD 28 billion in 2010 and ready-to-eat cereals dominate the market with 87% of the market share (Datamonitor, 2011). The breakfast cereal industry has emerged as an important segment of the food industry.

Ready-to-eat cereals are manufactured from mixtures of grain components with other ingredients; they require extensive processing and are usually fortified with vitamins and minerals. They are specifically packaged to protect their flavour, texture, and nutrition during storage as well as to show their contents in such a way as to visually appeal to and entice the consumer.

The new inclination for eating of healthy, novel and convenience food, which has occurred lately, has led the market of cereal-bars to a steady growth. Cereal bars are considered healthy type of food, because they are rich in fiber but are low in fat (Bower & Whitten, 2000). Commercially available cereal bars have now been produced, and they mostly have the same nutrient composition as traditional breakfast cereals. They are nutritious; contain lots of minerals, vitamins, and low fat. Recent findings state that cereal bars provide additional fibre, protein and antioxidants that aid in recovery (Sharifah & Norazizah, 2001). Esteller et al. (2004) stated that granolas are produced from processed cereal grains that can be aggregated with various ingredients that include dehydrated/crystallized fruits, chocolates, chestnuts, nuts, whole cereals, sugar, candies, and almonds. The ingredients must be appropriately mixed to guarantee a joint enhancement in term of flavor, texture and physical characteristics, more importantly, the point of balance of water activity and the physicochemical properties.

Bower & Whitten (2000) stated that the sensory aspects of cereal bars are more important to consumer experience and degree of liking. Chocolate, chewy and nutty bars are the mostly prefered due to the levels of filling texture, crunchy, sweetness chewy and flavor. Mostly, children have preference for chocolate cereal bars but they are not as wholesome as plain cereal bars (Freitas & Moretti, 2006).

2.3 Nutritional Value of Cereal Bars

Cereal bars contain high contents of both soluble and insoluble fibre and resistant starch. It is a source of carbohydrates, proteins, vitamins (mainly B complex), iron and omega 3 and linoleic acid (polyunsaturated fats) and low saturated fats. However, nutritional values of cereal bars depend on the ingredient combinations (Silvino,

2011). Cereals' consumption plays an important function; inhibit protracted illnesses such as diabetes, colorectal cancer, coronary heart disease (CHD). Cereals are considered as prime functional ingredients in the food industries that deal in cereal food (Charles & Louise, 2005; Mcketvith, 2004). Paul et al. (2010) reported that Ready-to-eat (RTE) breakfast cereals and their products, a group which cereal bar belongs, perform a significant function in human nutrition with an exact role and functional values to the consumers. They are regarded as the economically viable basis of nourishments (Gretchmen, 1995). Catherine & Johnston (2012) described granolas as one of the RTE convenient products dominating larger space in the consumer market which not only satisfy the hunger, but also demonstrate a quality source of nourishment and a suitable meal supplement.

2.4 Physicochemical Properties of Cereal Bars

Torres et al. (2011) developed a few formulations of granolas with exotic fruits such as jenipapo and jack fruit seeds. The cereal bars was formulated using dry raw materials (bran of oat and rice) and agglutinative ingredients (glucose syrup and honey). They evaluated the cereal bars for texture, proximate, mineral composition and sensory characteristics and the results showed that exotic fruits, accurately prepared can be utilized to elaborate new cereal bars that displayed characteristics functional aspect, regional, and calorie reduction when compared to commercial cereal bar brands. Their results showed that cereal bars formulated with five percent jenipapo and fifteen percent of jack fruit seeds; have low protein content (0.05%) for all the bars. The carbohydrate content was also reported to be low.

Lima (2004) observed that cereal bars has a moisture of 7.40%, 9.73% of protein, ash (1.63%), fats (9.70%) and 5.84% of fibre. Freitas & Moretti (2006) found out that

cereal bars formulated with textured soy protein and toasted wheat germ has 15.31% protein, lipid (5.64%), ash (2.20%), 5.17% of fibre, 10.71% moisture and carbohydrate (6.97%). Gutkoski et al. (2007) reported that cereal bars made from oat had protein content of 9.79%, lipids of 5.17%, fibre (10.69%), and carbohydrate (58.88%).

Carlvaho et al. (2011) worked on the formulation and sensory acceptance of cereal bars made with of almonds of chichá, sapucaia and gurguéia nuts, and pineapple peel and reported these fruits can be effectively used in the production of cereal bars which is accepted by consumers. They reported a higher score for sensory acceptance; colour (5.30 to 6.60), flavour (5.1 to 6.4), overall impression (4.70 to 6.10) and texture (4.10 to 5.30) in functional cereal bar with high vitamin and protein content. This result deviated from the one reported by Freitas & Moretti (2006) for sensory acceptance for sapucaia bar.

Freitas & Moretti (2006) also evaluated three formulations of banana flavoured-functional cereal bars in which they obtained lower scores for sensory properties like appearance, colour, texture and overall impression, however, higher scores were obtained for taste and flavour. Homemade cereal bars made by Brito et al. (2004) reported that scores for the appearance and colour were not highly rated. The consumers' overall impression results were not different from results of Carlvaho et al. (2011). Macedo et al. (2009) also reported that moisture content and firmness could be used as the indicator of shelf-life. They affirmed that there was a relative high negative correlation between moisture content and firmness.

Santos et al. (2011) in their research evaluated the proximate contents and the acceptance of homemade bars by using both light and traditional bars as reference.

Their results showed that formulated bar had protein content (2.73- 4.80 g/100g) whose values were close to products already found in the market. The fibre contents however, were higher, 24.40%. Their formulations of 30% and 40% of seed meals had the highest acceptance because of their good taste and higher acceptance scores.

Sun-Waterhouse et al. (2010) attempted to develop snack bars with high dietary fibre (DF) and polyphenol contents. The snack bar base was formulated from nutritional assessment of snack bar based on the total DF, phenolic, protein, fat, uronic acid (UA) and moisture contents, water activity, Hunter L*a*b* colour, hardness, and phenolic composition. Their results showed that snack bars with added apple DFs gave the highest amount of total DF and concluded that snack bars enhanced with apple DF and Apple Polyphenol Extract (APE) may be a convenient functional food, offering a good source of DF and a good source of DF and apple polyphenols.

Sensory properties determine the consumer preference for cereal bars. Besides, sensory analysis, physical properties of a product can be of great value. Water activity, moisture content and texture determination can assist to establish the amount of new ingredients added which will not change the product significantly from the suitable target value parameters combinations (Silvino, 2011).

Water activity (a_w) is one of the most essential properties and majorly used in food systems. It explains the extent to which the water is available in the food for the participation in biochemical reactions and growth of microbes, including chemical deteriorative reactions (Labuza, 1970). Water activity is generally measured to know if the product has reached the critical zone where spoilage reactions may or may not happen (Mathlouthi, 2001).

Water activity can influence the stability, safety and the texture of the cereal bars. Doherty and Ward (1997) related that cereal bars are usually developed to have less water activity that should be less than 0.65; some have very low water activity, as low as 0.30. They stated further that the water activity can be reduced by removing water from the formulation and/or addition of low molecular weight solutes. According to the authors, protein bars have typical moisture content in the range of 10-15%.

Torreggianni (1995) reported that diced fruits are usually used as essential ingredients or as extra materials in many composite formulated foods. The author stated further that water activity of the ingredients must be managed in such systems in order to avoid moisture migration. Maltini et al. (2003) stated that water activity is said to likely have more importance to the quality and stability of food than the total water content in such food product because a_w is a determinant for the proliferation spoilage microbes; a well-connected link exist between degradation by chemical, enzymatic and physical reactions in foods. More so, moisture migration in multidomain foods such as cereal bars, obey a_w, not moisture content. The moisture content indicates the amount of water contained in a certain food and can be expressed as the percentage of dry weight. It can also be used to measure freshness and stability of the cereal bar (Silvino, 2011).

2.5 Textural Properties of Cereal bar

Texture is essential for consumer acceptance in the ready-to-eat cereal products (e.g. cereal bars). Textural instruments are effective tools in product development phases. Textural tests evaluate either comprehensive or tensile forces. Textural Profile Analysis is commonly used in which samples are compressed by a round plate, until a certain percentage of their original thickness will be obtained (Kim et al., 2009).

Texture is being explored, it is not only known as the absence of flaws, but also as a positive quality feature signifying freshness of produce, brilliance of food preparation and contributing to the pleasure of eating (Szczesniak, 2002). She further described texture as "the sensory and functional manifestation of the structural, mechanical and surface properties of food detected through the sense of vision, hearing, touch and kinesthetics". Lawless and Heyman (1998) defined food texture as "all the rheological and structural (geometric and surface) attributes of the product perceptible by means of mechanical, tactile and where appropriate, visual and auditory receptors".

Texture in RTE cereals is essential for the acceptance of product by consumers. Textural characteristics of foods are identified by consumers as vital indicators of quality that influence product acceptability (Szczesniak & Kleyn, 1963; Szczesniak & Kahn, 1972). Crispness is among the major indicator; it is considered as the major property of texture of breakfast cereal (Martinez-Navarrete et al., 1998; Sauvageot & Blond, 1991). Compression tests were used to assess crispness in ready-to-eat breakfast cereals (Nixon & Peleg, 1995). Hardness of cereal is another factor (Ferriola & Stone, 1998) while Bourne (2002) reported that an exceptionally important sensory acceptability factor of appearance is the the texture.

Szczesniak (1990) asserted that the most significant quality affecting consumer acceptability is the crispness. Burrington (2001) opined that crunchiness measurement is more than just eating the cereal. Vincent et al. (2002) stated that crisp product that does not produce the anticipated sound upon biting is considered to be stale and of poor quality or processed wrongly. The authors stated further that it is important for technologists and scientists to understand the sensory perception of textural attributes like crispness in order to ensure that products are of best textural properties and

display qualities of satisfaction to consumers. It should be possible to predict the perceived texture of a food from the interaction between its mechanical properties and the processing conditions within the mouth based on knowledge of product mechanical properties (Vincent et al., 2002).

2.6 Packaging of Cereal Bars

Packaging materials offers ways to preserve, protect, merchandise, market and distribute foods. They play an essential function in how food products reach the consumers in a safe and wholesome way without compromising quality. The interactions between food and contact with the packaging materials contribute to changes that take place over time in food products (Raheem, 2012).

Packaging acts as an important phase of the process, protecting and extension of shelf-life of food in order to minimize food wastage, with addition of convenience and as an information provider to consumers. During distribution chain, cereal bar may be exposed to numerous environmental conditions provided there is a gradient between water activity inside and outside the packaging material, it can lead to migration of water molecules via the package that can lead to an upsurge of internal water activity, hence resulting to upsurge of moisture content and subsequently loss in the quality of the cereal bar (Macedo et al., 2013).

Physical and chemical changes reduce the shelf-life of cereal bars. Composition of cereal bars and environmental conditions affect its rate of deteriorative reactions (Macedo et al., 2009). It has been established that numerical determination of quality deterioration of cereal bars is essential for the estimation of its shelf-life and packaging (Galic et al., 2011; Macedo et al., 2011). Transfer of moisture in the

packaged food depends on the water activity of the food, temperature of the environment, humidity conditions of storage and the permeability of the package to water vapour. Hence, determination of shelf-life is related to the permeability properties of the packaging materials; this highlights the importance of packaging design (Macedo et al., 2013).

Cereal products (e.g. cereal bars) are mostly packaged in paper or polyethylene packaging (Galic et al., 2009). Macedo et al., (2013) reported a change in water activity (a_w) internal and external of the package as a result of movement of water molecules via the package which led to a rise in the internal water activity that ultimately increased the moisture content which resulted into loss in the quality of the granola bar.

Macedo et al., (2013) applied the Quality by Design (QbD) approach for packaging and shelf-life determination of Granola by determining the water vapour transmission rate (WVTR) of packaging films; they also validated and predicted the shelf-life of packed Granola using BOPP and biodegradable films like NM,NK and N913. It was reported that the Granola's shelf-life under accelerated conditions varied between 2 and 13 days; this depends on the packaging films; in a normal conditions of storage (20°C and 75% RH), shelf-life of Granola was 33, 90, 269, and 271 days for NM, NK, N913 and BOPP packages, in that order.

2.7 Shelf Life of Cereal bars

IFST (1993) defined shelf-life as the time during which a food product remain safe, abide by label declaration of nutritional data and retain desired sensory, chemical, physical and microbiological characteristics when stored under the recommended

conditions. Hence, to evaluate shelf-life objective indexes associated with nutrition, physicochemical or microbiological properties of food have to be explicitly assessed (Wansink & Wright, 2006; Cardello, 1995). Shelf-life is a function of environmental factors, time, and susceptibility of the food product to quality change (Labuza & Szybist, 2001). Chemical, biological and physical changes that occur throughout the food chain always result in product loss of quality and these changes might affect nutritional, microbiological or sensory quality eventually.

Lawless & Heymann (2010) stated that in numeorous products, alterations in sensory factors arise maily before any hazard to consumers' health is reached. Hough (2010) claimed that the shelf-life of several food products is reduced by differenee in their sensory qualities. Chaiyasit et al. (2007) reported cereal bars are susceptible to oxidative deterioration because of the substantial amount of fats and significant amount of polyunsaturated fatty acids. This in turn reduces the stability of the bars upon storage. The rancidity of fats by oxidation may lead to the formation of poisonous products, colour and changes in texture, destruction of vitamins and essential fatty acids that lead to loss of nutritional value.

Moisture content has been detected as the essential quality parameter and the relative humidity is a very powerful environmental factor (Macedo et al., 2009). Cereal bar's shelf-life is reduced by physicochemical changes. The rate of deteriorative reactions is determined by the bar's composition and environmental factors. Galic et al., (2011) and Macedo et al., (2011) indicated that computable evaluation of deterioration in quality of cereal bar is crucial for assessing the shelf-life and packaging. There are several methods to prevent deterioration during the study of shelf-life; control of temperature and water activity, effective packaging is also inclusive (Kong & Singh,

2011). Food packaging performs a crucial role in defining the shelf life of foods because they function as a barrier for oxygen and loss/gain of moisture in food products (Khan et al., 2008; Sharma et al., 1990).

2.8 Fruits Cited in the Holy Quran and Hadith: Nutritional Benefits

It is stated in the Holy Qur'an that fruits like figs, fenugreek, quince, water melon, date, olive, coriander and pomegranates are gifts of Allah. Fresh dried fruits are the natural food of man. These fruits possess abundant amounts of necessary nutrients. The fruits contain fibre, proteins, vitamins, minerals, enzymes and carbohydrates. The fruits digest easily and exert a laxative effect on the digestive tract because of their fibre contents. Those that are consuming and living on fruits will always enjoy good health. Furthermore, the illness caused by the consumption of unnatural foods can be effectively treated by fruits. Fresh and dry fruits are a good food and a good medicine for certain ailments (Anon, 2013a).

Fruits, eaten raw or consumed as fresh juice, help in retaining and balancing of the body's moisture level. The little amount of sodium in fruits serves as an excellent way for those who prefer to consume a diet devoid of salt. Dry fruits (Appendix I) like dates, raisins and apricots are abundance sources of iron and calcium, which make excellent compact to the fortification of bones and good blood maintenance. Human beings have used plants as medicine from time immemorial. Fruits were classified as a source of important medicine; they serve as medicinal plants which started in the previous phases of human civilization (Malik, 2001).

The Holy Quran describes the significance of plants used for different ailments in different chapters of the Holy Quran. Almighty Allah in the Holy Quran says: And the

earth He has put down (laid) for the creatures. Therein are fruits, date palms producing sheathed fruit-stalks (enclosing dates). And also corn, with (its) leaves and stalks for fodder and sweet-scented plants. Then which of the blessings of your lord will you both (jinn and men) deny? (Al - Quran. Al- Rahman 55:10-13).

2.9 Nutrients in *Sunnah* Fruits

2.9.1 Dates (*Phoenix dactylifera* L.)

Phoenix dactylifera L. also known as the date palm (Figure a-c, APPENDIX I), is an important plant in the dry regions of North Africa and Southwest Asia (Dowson, 1982; Zaid, 1999; Al Farsi & Lee, 2008). It is among the human's ancient cultivated plant that has been used as food for 60 centuries (Amer, 1994). Date fruits are an important source of nutrition, particularly in the wastelands where few plants can thrive because of the severe conditions. Date fruits are a reliable source of cheap food and are an essential part of Arabian diet. Dates are of religious importance to all Muslims all over the world and are mentioned in many chapters and verses in the the Holy Quran. Dates are habitually eaten when Muslims want to break the day long fast during the Ramadan period (Dowson, 1982; Al-Shahib & Marshall, 2003; Al Farsi & Lee, 2008). The date (*Phoenix dactylifera* L.) is a high-energy fruit and a very popular food commodity in the Arab region, that they were called the "Fruit of Life" (Anon, 2013b).

Sulieman et al. (2012) suggested that date fruits could still be used as foods for incoming generations because of its incredible economic, nutritional and health values. Date also possesses aesthetic and environmental benefits. The authors stated further that date proffers useful prospects against hunger and diseases. Al-Shahib &

Marshall (2003) stated that dates contain carbohydrates (total sugars 44% - 88%), proteins (2.3% - 5.6%), fats (0.2% - 0.4%), fibres (6.4% - 11.5%), minerals and vitamins, (Table 1). According to Al-Showiman (1998), it is very interesting to note that date fruits contain high compositions of protein (2.3% - 5.6%), when compared to other fruits; apples (0.30%), oranges (0.70%), bananas (1.00%) and grapes (1.00%). Al Farsi et al. (2005) reported that 23 different amino acids were found in date proteins; many of these amino acids were not found in other popular fruits, (Table 1). Date fruit contain a high concentration of proline, aspartic acid, alanine, theonine valine, iso-leucine, and leucine. The fruit also contain appreciable amount of essential amino acids which translates to high nutritional value (Sulieman et al., 2012).

Table 1: Composition of the various essential nutrients in dates

Composition	Lowest reported	Highest reported
Moisture (g/100g)	7.2	50.4
Fat (g/100g)	0.1	1.4
Ash (g/100g)	1.0	1.9
Protein (g/100g)	1.1	2.6
Amino acids (mg/100g)		
Alanine	30	133
Arginine	34	148
Aspartic acid	59	309
Cysteine	13	67
Glutamic acid	100	382
Glycine	42	268
Histidine	0.1	46
Isoleucine	4	55
Leucine	41	242
Lysine	42	154
Methionine	4	62
Phenylalanine	25	67
Proline	36	148
Serine	29	128
Threonine	23	95
Tryptophan	7	92
Tyrosine	15	156
Carbohydrates (g/100g)	52.6	88.6
Fructose	13.6	36.8
Glucose	17.6	41.4
Sucrose	0.5	33.9
Fibre (g/100g)		
Soluble	0.4	1.3
Insoluble	3.03	7.4
Total	3.57	10.9

Source: Al Farsi & Lee (2008).

Al Farsi & Lee (2008) reported that the world production of dates has increased from about 4.60 million tons in 1994 to 6.9 million tons in 2004 and expectations are that their cultivation will continue to increase. Dates contain more than 80% of monosugars (Myhara et al., 1999), a variety of B-complex vitamins B_1, B_2, B_3 (Nicotinic acid) and vitamin A (Retinol), dietary fibre, minerals and excellent source

of iron (Table 2); they contain 0.90mg/100g of fruits (Fleming et al., 1998; Al- Hooti et al., 1997; Jwanny et al., 1996). Dates contain 70% carbohydrates, most of which is in the form of sugars which make the fruits are a high source of energy and it is estimated that 100 g of the flesh can provide 314 kcal of energy (Al Farsi & Lee, 2008). Al-Showiman (1998) reported that carbohydrates in dates are mostly in the form glucose and fructose, which are absorbed easily by the human body. Drying of date decreases the water activity and this increases the sugar concentration. This makes the shelf life of dry dates are high and are available for extended periods of time (Al-Shahib & Marshall, 2003). Date fruits are also used as a sweetener (Al-Shahib & Marshall, 2003). The pits of date possess excellent protein (5.1 g/100 g), phenolics (3942 mg/100 g), and antioxidants (Table 3), dietary fiber (73.1 g/100 g), (80,400 µmol/100 g), fat (9.0 g/100 g) (Al Farsi & Lee, 2008); can also be utilized in improving the nourishments of incorporated foods (Habib & Ibrahim, 2009). Al-Shahib & Marshall (2003) further reported that date fat contains excellent myristic acid, palmitic acid, olic acid, oleic acid and stearic acid, just to mention a few. Dates contain phenolics which possess strong antioxidative properties, (Table 3). The antioxidative properties prevent oxidative damage to DNA, lipids, proteins, and cell membranes, which play an important role in preventing chronic diseases such as cancer and cardiovascular disease (Hollman, 2001). Fung and Hu (2003) reported that dates have contributed to greater longevity and a lower risk of coronary artery disease among the people around the world.

Table 2: Composition of the various essential minerals and vitamins in dates

Minerals (mg/100g)	**Lowest reported**	**Highest reported**
Mg	31.0	150
Na	1.00	261
Ca	5.00	206
P	35.0	74
K	345.0	1287
Mn	0.01	0.4
Fe	0.10	1.5
Zn	0.02	0.6
Cu	0.01	0.8
Se	0.24	0.4
Vitamins (µg/100g)		
A (Retinol)	3.0	44.7
B_1 (Thiamin)	50	120
B_2 (Riboflavin)	60	160
B_3 (Niacin)	1274	1610
B_6(Pyridoxal)	165	249
B_9 (Folate)	39	65
C (Ascorbic acid)	400	16,000

Source: Al Farsi & Lee (2008).

Date flesh contains abundant amount of carbohydrates (73.5%) together with ash (1.5%), protein (2.3%), lipids (0.2%), vitamins, and fifteen mineral elements (Al-Shahib & Marshall, 2003). The polysaccharides from date fruit have been used as a functional constituent and provide bioactive compounds in the formulation of drugs (Puri et al., 2000). Dried fruits and dates possess superior polyphenol composition with exceptional nutritive values that enhance plasma lipoprotein and provide oxidation protection (Vinson et al., 2005). These have also been recognised as having

antioxidant and antimutagenic properties and assist in restraining cardiovascular diseases (Vayalil, 2002).

Dates provide natural sugars; possess dietary fibre in a tremendous quantity, particularly, when mixed with legumes/pulses and cereals; they are also superior to other confectioneries, (Table 1), (Puri et al., 2000; Anonymous, 2002; Al-Farsi et al., 2005). Absorption of high moisture content of fresh dates by cereal or legume flours, thus providing suitable matrix to cereal bar and thereby, enhance its storability (Ahmed & Robinson, 1999; Barreveld, 1993). In addition, nutritive values in cereals, nuts, dates, and legumes might balance each other. Imporatant nutrients such as minerals and vitamins possess good bioavailability in natural forms as compared to established processed foods.

Several biochemical researches have consistently confirmed that high fruit consumption is linked to a reduced risk of numerous protracted diseases: cancers, Parkinson, Alzheimer, CHD, CVD, aging, atherosclerosis, and inflammation (Dillard & German, 2000; Fuhrman et al., 1995; Joseph et al., 1999; Prior & Cao, 2000; Wargovich, 2000).

Table 3: Composition of the various essential phytochemicals in dates

Phytochemicals	Lowest reported	Highest reported
α-carotenoids (µg/100g)	3.0	3.0
β-carotenoids (µg/100g)	2.5	146
Zeaxanthin (µg/100g)	33.0	33.0
β-Zeaxanthin	9.0	9.0
Lutein (µg/100g)	28.0	541
Neoxanthin (µg/100g)	184	381
Phenolics (mg/100g)	3.91	661
Anthocyanins (mg/100g)	0.2	1.5

Source: Al Farsi & Lee (2008).

Date has potential to provide an optimal mixture of phytochemicals including dietary fibre, phenolics and natural antioxidants. Dates are used as functional foods and ingredients in pharmaceuticals, nutraceuticals and medicines (Al- Farsi et al., 2007); they can be considered as an excellent source of food ingredients. They possess remarkable technological functionality that serves as a vital source of dietary fibre. High relative proportion of oleic acid in date fruits can protect against UV light that cause cellular damage in human body (Besbes et al., 2004). American Cancer Society advocates intake of at least 20-35g of dietary fibre per day supplied through dates. It is reported that eating one date daily will assist to maintain healthy eyes for a lifetime. Modern medicine survey also showed that dates are useful in reducing pain and heart rate of baby (Haouari et al., 1995).

Aisha (R.A.) used to prescribe dates for those suffering with giddiness. It is now well known that low blood sugar and low blood pressure are among the causes of giddiness. Dates are able to do this because it contains abundant simple sugars (fructose and dextrose). Date is mentioned and honoured in the Holy Qur'an, and recommended by Prophet Muhammad (SAW). 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).

"And shake toward you the trunk of the palm tree; it will drop upon you ripe, fresh dates." (Al- Quran. Surah Maryam 19: 25).

Almighty Allah mentioned dates and date palms in the Qur'an in several verses, thus showing their importance. The Prophet (SAW) likened a good Muslim to the date palm saying, "Among trees, there is a tree like a Muslim. Its leaves do not fall"(Hadith).

Dates (tamar) are a traditional and popular food for breaking the daily Ramadan fast. Eating dates after fasting helps to maintain blood sugar levels, and is an excellent source of dietary fiber, potassium, magnesium, and complex sugars. The Prophet (SAW) says:

"One who starts the morning every day with the date of Ajwa, poison and magic will not affect him that day till the night. Another narrator mentioned seven dates of Ajwa." Bukhari (5768)

Allah's Messenger said: *A family which has dates will not be hungry* (Muslim, Narrated Aisha, R.A).

The ajwah dates come from Paradise, and they are a remedy for poison (Narrated: Abu Huraira, Transmitted: Tirmidhi, a Hassan tradition).

2.9.2 Figs (*Ficus carica*)

Fig is described as "nature's most nearly perfect fruit" (CFAB, 2012).The citation of fig in the first verse of Surat at-Tin (Al-Quran. Surah Tin 95:1) shows the importance of the fruit. Figs (Figure d, APPENDIX I), have higher fibre content than all other fruits. Figs contain both omega-3 and omega-6 and phytosterol. Fig fruits contain higher mineral contents than any other fruits (Qazi, 2009). Dried figs are excellent source of minerals like calcium, copper, potassium, manganese, iron, selenium and zinc, appreciable amount of B-complex group of vitamins such as niacin, pyridoxine, folates, and pantothenic acid (Umapathi, 2012).

According to Shaikh (2005), fig is a member of the mulberry family. It is one of the sweetest fruits when fully ripe. Marcia (2000) reported that figs contain high amounts of amino acids: leucine, lysine, valine and arginine. It also contains minerals such as magnesium, sodium and phosphorus. A study performed at University of Scranton, USA, revealed that dried figs have a higher content of phenol, which rich in antioxidants, than other fruits. The level of phenol in figs is much higher than the levels in other fruits and vegetables (Vinson, 1999). According to CFAB (2012), the antioxidants in fruits and vegetables protect certain diseases. Antioxidants neutralize harmful substances (free radicals) that come up as a result of chemical reactions in the human body. Antioxidants prevent destruction of cells in the body (Vinson, 1999).

Figs are a rich source of minerals, vitamins and dietary fibre; they are free of fat and cholesterol; contain a high number of amino acids (Veberic et al., 2008; Solomon et

al., 2006), (Table 4). The laxative effect of *Ficus carica* was also reported by Lee et al. (2012). The benefits of figs indicate the compassion of Allah towards human beings. The special blessings of figs can be seen in the way fig is mentioned in the Quran (Al-Quran. Al- Tin 95:1), (I swear) by the fig and the olive. Prophet Muhammad (PBUH) 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 and piles and help gout*"(Tib Nab Awi, Hadith 467,page 486).

Table 4: Nutrients Found in Dried Figs

Proximate	**Unit**	**Value per 100g**
Water	g	30.05
Energy	kcal	249
Protein	g	3.30
Total lipid, fat	g	0.93
Carbohydrate	g	63.87
Fibre, total dietary	g	9.80
Total sugar	g	47.92
Minerals		
Calcium	mg	162
Iron	mg	2.03
Magnesium	mg	68
Phosphorus	mg	67
Potassium	mg	680
Sodium	mg	10
Zinc	mg	0.55

Source: California Fig Advisory Board. Report, 1998.

2.9.3 Raisins (*Vitis vinifera*)

The word, "raisin" means dry grape. Grapes are normally preserved in form of raisins. Raisins (Figure e, APPENDIX I) are dense sources of energy, vitamins such as thiamin, pyridoxine, riboflavin, and pantothenic acid, minerals like calcium, iron, manganese, magnesium copper, fluoride, and zinc, and anti-oxidants (Umapathi, 2010). Raisins contain a lot of phenolic compounds that have a wide range of biochemical and pharmacological influences. These phenolics include anticarcinogenic, antiantherogenic, anti-inflammatory, antimicrobial and antioxidant activities (Karakaya et al., 2004).

Raisins also contain phytochemical compound called resveratrol. Resveratrol, a polyphenol anti-oxidant, has anti-inflammatory, anti-cancer, blood cholesterol lowering activities. Raisins, despite tasting sweet, have a low-to-moderate glycemic index (GI) of 50-64. Raisins can be used to replace other high-GI snack foods and can also serve as pre-exercise snacks. Therefore, those craving for adoption of a low-GI diet should consider raisins as a wholesome fruit serving to be used as a snack or with a meal (Stacey, 2011). Stacey (2011) further stated that raisins offer both a sweet, snack-like flavour and possess a low GI. Raisins specifically offer themselves to snacking, because they are sweet, movable and do not escalate the risk of dental caries (LaMonte et al., 2004). Adopting a low-GI diet offers all essential nutrients and reduces the risks of chronic diseases like type II diabetes and cardiovascular disease (CVD) (Stacey, 2011). Table 5 shows the selected essential nutrients seedless raisins.

Table 5: Selected Essential Nutrients in Seedless Raisins

Nutrient	Units	Values per serving 100 g
Proximates		
Water	g	15.43
Energy	Kcal	299
Carbohydrate	g	79.18
Sugars (total)	g	59.19
Protein	g	3.07
Total lipid (fat)	g	0.46
Fibre, total dietary	g	3.7
Minerals		
Calcium	mg	50
Iron	mg	1.88
Magnesium	mg	32
Potassium	mg	749
Phosphorus	mg	101
Sodium	mg	11
Zinc	mg	0.22

Source: USDA (2015a) Nutrient Database for Standard Reference, Release 27.

Allah (SWT) refers to the grape as a fruit for the pious – if used properly. It is said in verses 31 and 32 of Surah Naba: "Indeed a triumph awaits the God wary (in Paradise), gardens and grape yards." Imam Ali (PBUH) refers to the 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.

Islamic hadiths have pointed to the eye-catching effects of a specific kind of raisin called currant. This currant is produced from drying out of black and red grapes. Prophet Mohammad (PBUH) says: Do not neglect the eating of currants, since it preserves the health and soundness of the body. The currant produces a good temper in humans and boosts the nervous system and makes a skinny and weak body, very strong (Tib Nab Awi, Hadith 809, Bab Zebib).

2.9.4 Saffron (*Crocus sativus*)

Saffron is regarded as the world's most expensive spice. There are varieties of chemical components present in the stigma of the saffron plant. These chemical components include carbohydrates, minerals, mucilage, vitamins such as riboflavin and thiamine, color pigments such as crocin, anthocyanin, carotene, lycopene, Zeaxanthin and aromatic terpenic essence called "safranal" and flavoring substances such as picrocrocin (Mohammad, 2010). Some medicinal properties of saffron are: it aids digestion, strengthens the stomach and is anti-tympanites, treats insomnia, strengthens memory power, increases concentration, reacts against spasm, fights depression, the Alzheimer's and Parkinson's diseases, controls blood pressure disorders, reduces high cholesterol levels, alleviates iron deficiency (anaemia) in girls, reduces chances of such heart diseases; arteriosclerosis (Habibi & Bagheri, 1989).

Saffron assists in improving heart conditions due to the presence of thiamine, riboflavin and mineral components. It aids in curing of respiratory disorders such as

asthma, cough and influenza. It helps in blood circulation in the retina, cures the inflammation of the liver and urogenital infections (Baker & Negbi, 1983).

Rasulallah (SAW) used to recommend olives and saffron in cases of pleurisy (Tib Nab Awi, Hadith 463).

Ali Abi Talib (RA) once said "*Those who take Za'faran and together with 2 spoons of honey everyday will be admired for their memory until they are being accused as witch*." (Tibbul Imama Ali: 381).

2.9.5 Black cumin (*Nigella Sativa.* L)

Black cumin is among the most respected therapeutic seeds historically. It is mentioned in the hadith but was not carefully investigated until about forty years ago. The acceptance and recognition of black cumin was extremely improved by the conceptual belief in the herb as a cure for several diseases. It occupies extraordinary place for its wide range of medicinal value. The seed of black cumin possesses complex chemical composition. The seed has more than a hundred various chemical constituents; these include rich sources of all the essential fatty acids (Ramadan & Moersel, 2002a). Black cumin seeds are a bit piquant, they are mostly used whole in cooking curries, pastries and Mediterranean cheeses. The seeds have very little aroma, however, are carminative, that is, black cumin seeds aid digestion and relieve flatulence, promote peristalsis and elimination. Black cumin tastes bitter and peppery with a crunchy texture (Al-Gaby, 1998). Its seeds are utilized for edible and therapeutic purposes.

Black cumin also known as Habbatus sauda is also used as a condiment in bakery, as food flavor in bakery products and cheese (Aboutabl et al., 1986; Merfort et al., 1997).

Nigella sativa has a vital function in human nutrition and health. It has been stated that it has antitumor activity (Worthen et al., 1998), antioxidant property (Houghton et al., 1995), antibacterial activity and a stimulatory influence on the immune system (Morsi, 2000; Salem & Hossain, 2000). Furthermore, black cumin seeds are an excellent source of many essential nutrients that are found to have a very positive result on human health. The seeds contain a good substitute source of essential fatty acids (Cheikh-Rouhou et al., 2007). In addition, the seeds contain large amount of important minerals. Potassium, the most abundant, phosphorus and calcium followed (Takruri & Dameh, 1998).

Nigella sativa essential oil inhibits microbes and aids in getting rid of intestinal worms (Ramadan & Moersel, 2002a; Evans, 1996; Kapoor, 1990). Evans (1996) suggested that the water-retentive protein in the seeds of black cumin has the capability of aiding the skin to repel free radical aggression. Its seeds have been used to advance health and fight disease for years, particularly in the Middle East and Southeast Asia. The seed is known Al-Habat-El- Sauda or Haba-Al-Barka in Arabic countries (Ramadan & Moersel, 2002a; Nadkarni, 1976). *Nigella sativa* seeds are aromatic in nature and are utilized as a condiment and as a spice in cooking. The seeds are employed as a carminative, diuretic and native medicine (Hedrick, 1972; Baytop, 1984). According to Babayan et al. (1978), black cumin seeds possess 35.5% fat, 21% protein, 34.3% carbohydrate, 5.5% moisture and 3.7% ash. Table 6 shows the chemical characteristics of *Nigella* seeds.

Table 6: Chemical characteristics (dry basis) of the Tunisian Nigella seeds (TNS) and the Iranian variety (INS)

Component	TNS	INS
Dry matter (%)	91.35±0.26	95.92±0.70
Oil [a]	28.48±0.05	40.35±0.16
Crude protein [a]	26.70±0.35	22.60±0.24
Ash [a]	4.86±0.06	4.41±0.01
Potassium [b]	783±6.61	708±7.98
Magnesium [b]	235±4.87	260±48.70
Calcium [b]	572±21.50	564±33.40
Phosphorus [b]	48.90±0.04	51.90±0.01
Sodium [b]	20.80±2.21	18.50±3.17
Iron [b]	8.65±0.65	9.42±0.88
Copper [b]	1.65±0.03	1.48±0.21
Zinc [b]	8.04±0.21	7.03±0.49
Manganese [b]	4.43±0.11	3.37±0.21
Total carbohydrate [a]	40.00±0.46	32.70±0.41

[a] In % dry matter basis.

[b] In mg/kg of dry matter.

Source: Cheikh-Rouhou et al. (2007).

Black cumin possesses numerous pharmaceutical and nutritional applications. Its seed can be added to tea coffee, casseroles or breads etc. The seed, when grounded might be mixed with honey. The seeds are widely utilized as natural antidote; they are broadly utilised as condiment, carminative, spice, and aromatic (Al-Gaby, 1998; Atta-ur- Rahman et al., 1992). Conventionally, black cumin seeds are being used as diaphoretic, diuretic, liver tonic and the like. In confectionery, black cumin seeds when mixed with other ingredients, are used in treating indigestion, diarrhea, sour belching, dyspepsia and can act as breath deodouriser (Ramadan, 2007). The seed of

Nigella sativa, when added with other ingredients have been used to cure dyspnoea and obesity. The seed possesses anti-bilious property and are administered to treat intermittent fevers. They also serve as remedy to hepatic and digestive disorders (Usmanghani et al., 1997; Nadkarni, 1976). The seeds are used to treat leucoderma, eczema, freckles and pimples, used as anthelmintic and antibacterial agent (Ramadan & Moersel, 2002a; Evans, 1996; Kapoor, 1990).

Nigella sativa contains protein and amino acids, reducing sugars, mucilage, alkaloids and organic acids (Al-Gaby, 1998; Duke, 1992). The seeds contain crude fibre, mineral elements (iron, sodium, copper, zinc, phosphorus and calcium), vitamins (Takruri & Dameh, 1998), β-carotene and fat-soluble vitamins are abundant in *Nigella sativa* (Ramadan & Moersel, 2002b). Akhtar & Shah (1993) and Al-Awadi et al. (1991) suggested that black cumin may prove to be a useful therapeutic agent in the cure of non-insulin dependent diabetes mellitus; it was also found to be useful in lowering of the blood glucose level drastically after oral administration. Black cumin seed and its oil are efficient as a tonic to promote health and prevent diseases (Hailat et al., 1995). They also have antimicrobial effects against bacterial, fungal and parasitic organisms (Chowdhury et al., 1998), anthelmintic activity against hookworms and nodular worms (Agarwal et al., 1979). Black cumin can also prevent dental caries (Ferdous et al., 1992). Several hadiths talked about the usefulness of Black cumin to human health.

The Prophet told us that the Black Seed is a cure for every disease. The Arabic word '*Shifaa'* (cure) came without the definite article which means that it is an indefinite word that covers most cures. This means that the Black Seed contributes to the cure of

every disease. It has been scientifically proved that the immunity system is the only system that has the ability to combat diseases and produce cells that kill viruses.

The Prophet Muhammad once advised his followers: "*Use the black seed, because it contains a cure for every type of ailment except death."* (Hadith. Al-Bukhari. Kitab al-Tib. Bab al-habbat al-Saida'a. #5688).

"Habbatus Sauda herbal medicine is Great medicine for every human being because it has powerful remedy for each & every disease except death." (Hadith. Muslim. Kitab al-salam. Bab al-Tadawi. #2215).

Abu Hurayrah narrated that the Prophet said: *"Use this Black Seed regularly, because it is a cure for every disease, except death."* (Hadith. Muslim. kitab al-Salam. Bab al-Tadaawi bi al-habbat al-Sauda. #2215).

Black seed is said to help with digestion, and also contains antihistamine, anti-inflammatory, anti-oxidant, and analgesic properties. Muslims often consume black seed to help with respiratory ailments, digestive issues, and to boost the immune system.

Based on these facts, it was concluded that the Black Seed is a cure for every disease because it strengthens the immunity system which is responsible for curing diseases and combating viruses.

These scientific facts are obvious. No one can claim the credit of knowing these facts fourteen centuries ago, except a Prophet. Allah Almighty says: *"Nor does he (the Prophet) speak of (his own) inclination. It is not but a revelation revealed."*(Quran al-Najm53: 3-4).

The Prophet (PBUH) also says: "Keep your Black Al-Sauda, because it truly is healing for all diseases except As-Sam (Death)"(Hadith. Al-Hākim Al-Nisābūri. # 7442).

2.10 Glutinous Rice

Glutinous rice is also known as sticky rice, *Oryza sativa var. glutinosa*, also called sweet rice or waxy rice (Supat et al., 2008). It is a form of short-grain rice. It has higher starch content than its medium. This sticky rice is a staple food in many Asian countries. Glutinous rice has opaque grains, contains low content of amylose and is notably sticky when cooked. It is referred to as glutinous rice, because it is being glue-like or sticky. There are many cultivars of glutinous rice; these include japonica, indica and tropical japonica strains. Its husk, bran and germ are normally removed by manufacturers in producing it. In addition, the glutinous rice is comparatively healthy because it has low fat content but it does not offer the nutritive value of brown or wild rice (Gray, 2011). Glutinous rice is an important raw material in the production of baked snacks because it expands easily and produces more porous texture (Athapol et al., 1997; Jomduang & Mihamed, 1994). It is an attractive ingredient in the baking/confectionery industry because of its attractive white colour, bland taste, and ease of digestion (Kadan et al., 2003). Glutinous rice has a protein quality with a chemical score of 55-59 and a protein content of about 6-7% (Supat et al., 2008).

Furthermore, the glutinous is major type of cultivated rice with long-standing importance in Asia. Glutinous rice demonstrates the capacity for plants to evolve phenotypic modifications in response to local cultural preferences. An important culinary and cultural element all around East Asia, glutinous rice is commonly reserved for use in festival foods and desserts, although it also serves as the staple

food in upland regions of Southeast Asia (Golomb, 1976). The glutinous white rice contains 169 Kcal; 153 Kcal comes from carbohydrate, 2.8Kcal comes from fats and 13.4 Kcal comes from protein. Glutinous contains no cholesterol (USDA, 2012). It is a known fact that glutinous white rice provides less considerably less fibre than other types of rice. Glutinous rice contains no gluten (Gray, 2011). Table 7 shows the proximate and mineral contents of glutinous rice.

Table 7: Proximate and mineral contents of glutinous rice

Nutrient	Unit	Value per 100 g
Proximates		
Water	g	10.46
Energy	kcal	370
Protein	g	6.81
Total lipd (fat)	g	0.55
Carbohydrate	g	81.68
Fibre, total dietary	g	2.80
Minerals		
Calcium	mg	11.00
Iron	mg	1.60
Magnesium	mg	23.00
Phosphorus	mg	71.00
Potassium	mg	77.00
Sodium	mg	7.00
Zinc	mg	1.20

Source:USDA, 2015c.National Nutrient Database for Standard Reference, Release 27.

Glutinous rice is a good source of selenium, a valuable mineral. It provides antioxidant protection for body tissues, shields cells from being damaged, which is mostly caused by free radicals. Selenium benefits the thyroid gland by its regulation of

the activity of thyroid hormones, also keeps the blood vessel walls to function appropriately. Glutinous rice also provides health benefits as a result of its manganese contents. Manganese is needed for a healthy body metabolism. It aids in processing of carbohydrates, proteins and cholesterol. It also assists in production of proteoglycans, a type of protein required for healthy cartilage and bone tissue (Anon, 2014).

In addition, glutinous rice lacks the starch amylase which is approximately up to 30% of the total starch in non- glutinous rice endosperm (Morishima et al., 1992). Glutinous rice is differentiated from other types of rice by having no (or insignificant amounts of) amylose, and high amounts of amylopectin (the two main components of starch). Amylopectin is accountable for the sticky quality of glutinous rice. The difference has been traced to a single mutation that was selected for by farmers. (Anon, 2002; Kenneth & Michael, 2002). Glutinous rice does not contain dietary gluten thereby it should be safe for gluten-free diets.

2.11 Binding Agents

2.11.1 Honey

According to Sato and Miyata (2000), honey is a natural assembled energetic food improved and secreted by honey bee *Apis mellifera*. The primordial Egyptians using honey as a wholesome food had revealed its use as a healing substance; this is referred to in Surat El-Nahl in the Holy Quran (Molan, 1992a). Honey can be used as an ingredient in food or as part of nutraceuticals (El-Sherbiny & Rizk, 1979). Lately, consumers worldwide are increasingly demanding for natural food and products alleged to improve their health. A good example is honey that possesses that contains

lactose, sucrose and maltose with other valuable nutrients which can be used to formulate food products (Chick et al., 2001).

Honey is an excellent source of minerals namely potassium, phosphorus, calcium and magnesium (Table 1 and 2). Honey is not proposed as a proteinous food but it contains chains of free amino acids that are essential for health promoting effects (Buchanan & Gibbons, 1986). Honey is turning out to be an increasingly popular condiment in food products (Curda & Plockova, 1995). Honey contains fructooligosaccharides (FOS) that functions as prebiotics in the gut, hence, honey could be of great value in the model of functional foods (Slavin, 1997). Honey contains high glucose and fructose content which are source of energy that is promptly usable. The fructose content (Henry & Crapo, 1991), traces of nutritional substances and the originality of the raw, unprocessed product is responsible for its established use as a sweetener besides its suitability for diabetics, athletes and elderly people (Esti et al., 1997). Nutrient compositions of honey and energy content of honey are shown in Table 8.

Table 8: Chemical Composition and energy value of honey

Constituent	Mean	Range
Water (g)	18.6	17.50-20.60
Protein (g)	0.38	0.30-0.50
Fat (g)	0	0
Fructose (g)	38.8	35.90-42.10
Glucose (g)	33.9	26.30-39.80
Sucrose (g)	2.4	1.70-3.00
Iron (mg)	1.3	0.90-2.00
Copper (µg)	90	-
Calcium (mg)	4.5	3.60-5.00
Phosphorus (mg)	18	16.00-20.00
Potassium (mg)	47	43.00-50.00
VitaminB1 (µg)	3	2.00-4.00
VitaminB2 (µg)	50	20.00-100.00
Nicotinamide (µg)	130	100.00-200.00
Energy value	302kcal/1263kJ	-

Source: Souci et al. (1990).

It is quite obvious from the chemical composition of honey (Table 8), that it derives its nutritional values from high glucose and fructose contents; they make honey to be a legitimate source of energy (Report of Sugars Task Force, 1986; DH RHSS 41, 1991). Honey recommended at breakfast time when the main calorie intake must be glucide in order to satisfy the appetite after the physiologic overnight fasting. Simple glucides are crucial at breakfast because they are absorbed rapidly and can contribute about 20% energy intakes (Magnati et al., 1994). Honey, in its either raw or refined form is advised as a substitute for sucrose because it is a stronger sweetener and yield lower haematic levels of glucose and insulin in view of the fact that it contains a larger amount of fructose (Henry and Crapo, 1991).

Table 9: Mineral contents in ppm and ash in % w/w of Galician honeys

Variable	Samples' Number	Mean	SD	CoV
Sodium	91	138	47.3	0.34
Potassium	91	1572	670	0.43
Calcium	91	102	34.2	0.34
Magnesium	91	106	73.2	0.69
Copper	91	1.11	0.393	0.35
Iron	91	5.12	3.62	0.71
Manganese	91	4.02	2.514	0.63
Phosphorus	91	110	50.7	0.46
Chlorine	91	245	134.9	0.55
Silicon	91	9.16	5.765	0.63
Sulphur	91	68	23.1	0.34
Ash	91	0.408	0.147	0.36

Source: Rodriguez-Otero et al., (1994).

Honey has been utilized as a food and medical product from time immemorial. Honey is the only available natural sweetener; it is an important food for humans from ancient time (Crane, 1983; Crane, 1975). The principle that honey is a medicine, an ointment and a nutrient was established since ancient time. It is being used, not only as a nutrient but also as a medicine (Jones, 2001). In the earliest time honey was being used for both nutritional and medical functions (Crane, 1975; Jones, 2001; Crane, 1999; Allsop and Miller, 1996). Table 9 shows the mineral components contained in honey.

2.11.1.1 Composition of honey

The constituent of honey is somewhat unpredictable. It is solely determined by the floral source; but, certain external factors also perform some roles, factors like seasonal, environmental and processing. Honey comprises of at least 181 substances

(Chow, 2002). Honey is a supersaturated solution of sugars; majorly compose of fructose (38%) and glucose (31%). It also contains minerals, protein, free amino acids, enzymes and vitamins (Perez, 2002; Terrab et al., 2003). A series of minor constituent is also present in honey; most of them are known to have antioxidant properties. The antioxidants include phenolic acids and flavonoids (Martos et al., 2000; Tomas-Barberán et al., 2001; Dimitrova et al., 2007), few enzymes (glucose oxidase, catalase) (Molan & Betts, 2004) and amino acids (Patzold & Bruckner, 2006; González-Paramás et al., 2006; Pérez et al., 2007).

Honey is primarily made up of carbohydrates, (Table 10). The carbohydrate constitutes roughly 95% of honey dry weight. It is a highly complex mixture of sugars, most of which are in the instantly digestible form in the small intestine (Jeffrey & Echazarreta, 1996). In the course of digestion after honey ingestion the major carbohydrates, fructose and glucose, are speedily transported into the blood to be utilized for energy requirements by the human body (Bogdanov et al., 2008).

Honey possesses about 0.5% proteins, mostly enzymes and free amino acids. Protein content has been presented in honey from dissimilar floral sources (Azeredo et al., 2003). The three major honey enzymes are diastase; it decomposes starch/glycogen into smaller sugar units, invertase – decomposing sucrose into fructose and glucose, and glucose oxidase that produces hydrogen peroxide and gluconic acid from glucose (Bogdanov et al., 2008).

Table 10: Average composition of nutrients in honey (data in g/100 g)

Component	Average (%)
Water	17.2
Fructose	38.19
Glucose	31.28
Sucrose	1.31
Disaccharides, calculated as maltose	7.31
Higher sugars	1.5
Free acid as gluconic	0.43
Lactone as gluconolactone	0.14
Total acid as gluconic	0.57
Ash	0.169
Nitrogen	0.041
Minerals	0.2
Amino acids, proteins	0.3
pH value	3.9

Source: Bogdanov et al., (2008); Terrab et al., (2003); Pérez, (2002); Chow (2002)

The amount of total free amino acids in honey represent between 10 and 200 mg/100g with proline as their main contributor, representing about 50% of the total free amino acids (Iglesias et al., 2004). Besides proline, there are other 26 amino acids in honeys, their comparative amount depending on its origin (nectar or honeydew). Pollen is the core source of honey amino acids. The main amino acids identified in honey from different botanical and geographical origin are: glutamic acid, aspartic acid, asparagine+serine, glutamine, histidine, glycine, threonine, b-alanine, arginine, a-alanine, g-aminobutyric acid, proline, tyrosine, valine, ammonium ion (NH_4+), methionine, cysteine, isoleucine, leucine,tryptophan, phenylalanine, ornithine and lysine (Pérez et al., 2007; González-Paramás et al., 2006; Iglesias et al., 2004; Hermosín et al., 2003).

It is acknowledged that different trace and mineral element concentration exist in honey; though this depends on its botanical and geological origin (Bengsch, 1992). Trace elements perform a crucial role in the biological activities linked with honey; these elements have a variety of known and unknown biological functions. Different trace and mineral elements were examined in botanically and geological defined honey (Stocker et al., 2005; Conti, 2000). Vitamins such as phyllochinon (K), thiamin (B_1), riboflavin (B_2), pyridoxine (B_6) and niacin are described in honey; though the amount of vitamins and minerals is low (Bogdanov et al., 2008). The aroma profile is among the most distinctive attributes of a food product, both for its organoleptic quality and genuineness (Careri, 1994). Honey flavour is an essential quality for its application in the food industries and is also a selection standard for the consumers' choices (Cuevas-Glory et al., 2007).

Polyphenols are another prominent group of compounds concerning the appearance and the functional features of honey (Tomas-Barberán et al., 2001; Martos et al., 2000; Ferreres et al., 1991; Amiot et al., 1989). It was suggested by Wahdan (1998) that flavonoids and phenolic acids might be a part of antibacterial activities of honey. It was further reported that honey also has been shown to hinder the Rubella virus in vitro (Fahey & Stephenson, 2002). The antioxidants that occur naturally in honey aid its antioxidant capacity. The antioxidants and some of its enzymes include glucose oxidase, catalase, ascorbic acid, organic acids, Maillard reaction products, proteins and amino-acids (Blasa et al., 2006; Vela et al., 2007; Perez et al., 2007; Estevinho et al., 2008; Nagai et al., 2006; Beretta et al., 2005; D'Arcy, 2005; Gheldof et al., 2002; Aljadi & Kamaruddin, 2004; Frankel et al., 1998; Inoue et al., 2005; Fahey & Stephenson, 2002).

Phytochemicals contained in honey are thought to be responsible for the increase in defence against oxidative stress. Honey contains phenolic compounds which are collected by the bees from the plants where they gather nectar (Marcucci et al., 2001; Fiorani et al., 2006). They are also able to protect humans, thereby creating a potentially protective antioxidant barrier. Honey has also been reported to reduce skin inflammation, oedema and exudation; it promotes wound healing, diminishes scar size and stimulates tissue regeneration (Molan, 2001b). Honey in its natural and pure form possesses antibacteria compound that inhibits many enteropathogenic organisms; *Salmonella* and *Shigella* species, and enteropathogenic *Escherichia coli* (Jeddar et al., 1985). Honey has strong inhibition against agent that causes gastritis and peptic ulcers, *Helicobacter pylori* (Ali et al., 1999; Osato et al., 1999). It was found out that honey could shorten the duration of diarrhea in patients that have bacterial gastroenteritis which is normally caused by organisms like *Salmonella, Shigella* and *Escherichia coli*.

Constituents of honey have prebiotics effects that are same as that of fructooligosaccharides (Sanz et al., 2005). Yaghoobi et al., (2008) reported that honey improves cardiovascular risk factors in healthy humans and in patients with higher risk factors. They concluded that natural honey consumption ameliorates factors of cardiovascular risk, especially people with higher factors of risk; honey improves body weight of patients that are obese (Yaghoobi et al., 2008). Honey was responsible for significant lowering of rise of plasma glucose in diabetic patients (Al-Waili, 2004).

2.11.1.2 Functional Properties of Honey

Honey is an attractive ingredient for healthy foods (Perez-Alvarez et al., 2008). The key concepts of nutrition are undergoing significant change. The conventional concept

of "adequate nutrition", that is, a diet that provides nutrients (carbohydrates, proteins, fats, vitamins, and minerals) in sufficient quantities to satisfy human needs, is tending to be replaced by the concept of "optimal nutrition," which includes, besides the above, the potential of food to promote health, improve general well-being, and reduce the risk of developing certain illnesses. This is where functional foods, also known as nutraceuticals, designed foods, therapeutic foods, superfoods, or medicinal foods, play their part (Nagai & Inoue, 2004). Amongst foods that have the characteristic of functionality are honey, propolis and royal jelly; they all originate from the beehive (Perez-Alvarez et al., 2008).

Honey forms part of customary medicine in many cultures (Gómez-Caravaca et al., 2006), though it is mostly used as sweetener. The intrinsic characteristics of honey affect the growth and continued existence of microbes; especially the low pH and high sugar in honey prevent the growth of many species of microbes (Iurlina & Fritz, 2005). Phenolic compounds are antioxidants; they are responsible for the functional properties linked with honey (Kerem et al., 2006; Almaraz et al., 2007).

Functional foods have attracted increasing interest because of consumers' growing concerns about their health; this has prompted greater research effort into such foods. One of the most crucial properties in functional foods is their antioxidant capacity that contributes to the prevention of some illnesses, which include cardiovascular diseases, cancer and diabetes (Ames et al., 1993; Gutteridge & Halliwell, 1994). Honey could be used as functional foods because of their naturally high antioxidant potential. Aside from sugars, honey has many small constituents with antioxidant activity (Gheldof et al., 2002), amino acids and proteins, carotenes, phenolics and flavonoids, ascorbic acid, organic acids and Maillard reaction products (Aljadi & Kamaruddin, 2004;

Schramm et al., 2003; Al-Mamary et al., 2002). Osztmiansk and Lee (1990); Chen et al (2000) reported that honey has been in use as sweetener since ancient times; modern studies have also suggested honey may be a food protector. As stated earlier, honey possesses many substances that could act in this manner. These substances include ascorbic acid, flavonoids, α – tocopherol, small peptides. Also, enzymes like glucose oxidase, catalase and peroxidase (Jeon & Zhao, 2005; Ferreres et al., 1993). Quercetin and ruetin, flavonoids which are found in honey display antiviral activity against HSV, syncytial virus, poliovirus and Sindbis virus (Orsolic & Basic, 2005; Yao et al., 2004; Middleton & Chithan, 1993; Selway, 1986). Anti-ulcerous power is another functional property of honey (Bruschi et al., 2003; Gurbuz et al., 2000). This ability has been ascribed to the presence of phenolics, especially flavonoids (Hiruma-Lima et al., 2006; Batista et al., 2004; Gracioso et al., 2002).

Vilegas et al. (1999) reported that flavonoids have inhibitory effect on acid secretions, thus preventing the formation of peptic ulcers. Sugars, the main components of honey have antibacterial activity owing to their osmotic effect (Molan, 1992). Honey contains lysozyme which is a strong antimicrobial agent (Bogdanov, 1997). Cushnie and Lamb (2005) stated that other flavonoid like galangin found in the propolis, also offers antibacterial action.

2.11.1.3 Contribution of Honey to Health and Nutrition

The major nutritive and healthiness related compositions in honey are carbohydrates, and about 25 diverse higher carbohydrates. Honey is composed of small amount of minerals, proteins, polyphenols, amino acids, trace elements, vitamins and enzymes. It has an array of positive nutritional and health effects, if consumed at higher doses of 50-80g/intake (Bogdanov et al., 2008).

Due to honey's high carbohydrate content and functional properties; it is an outstanding source of energy for athletes. It is the only natural available sweetener; it is an important food for humans (Bogdanov et al., 2008). The major sugars in honey are the monosaccharides and about 25 different oligosaccharides (Doner, 1977 & Siddiqui, 1970). During digestion process, honey after ingested, the fructose and glucose present in honey are quickly transported into the blood for utilization to provide energy required in the human body (Bogdanov et al., 2008).

Manganese, chromium and selenium contained in honey are essential, particularly for teenagers. Other minerals present in honey are iodide, sulphur, silicon, boron, molybdenum, cobalt and fluoride. They are all vital in human nourishment. Honey possesses 0.3-25ppm choline and 0.06-5ppm of acetic acid and choline (Heitkamp, 1984). Choline is important for cellular membrane repair and composition; cardiovascular and brain function. Acetylcholine, on the other hand, acts as a neurotransmitter (Bogdanov et al., 2008).

Polyphenols in honey mainly flavonoids; they have antioxidant properties. Examples of polyphenols in honey are phenolic acid derivatives, luteolin, chrysin, kaempferol, phenolic acids, apigenin, galangin and quercetin (Tomas-Barberan et al., 2001). Honey hinders the growth of microbes. The antibacterial effect of honey, chiefly against gram-positive bacteria, is well known (Molan, 1997; 1992a; 1992b; Bogdanov, 1997). The lower a_w of honey prevents bacterial growth. The low pH of honey can also be accountable for the antibacterial action (Yatsunami & Echigo, 1984). Doner (1977) and Siddiqui (1970) reported that nigerose; a type of sugar contained in honey possesses an immunoprotective property (Murosaki et al., 2002).

Orsolic et al. (2003) stated that honey stimulates the immune system and its ingestion may be of advantage with regard to cancer and metastasis inhibition. Swellam et al. (2003) reported that honey is an effective agent that can inhibit the growth of different bladder cancer cell lines. White & Subers (1963) in their report stated that hydrogen peroxidase that is being produced by the glucose oxidase in honey could be the inhibitory substance against bacteria. Honey ingestion inhibits the growth of bacteria that cause caries; this is due to honey's antibacterial activity (Molan, 2001a; Steinberg et al., 1996). Honey has a positive effect against dental plaque development and gingivitis and it can also be used in place of refined sugar in the production of candy (English et al., 2004; Molan, 2001b).

According to the "Hadith", Prophet Mohammed (SAW) recommended honey against diarrhoea. The slight purgative properties of honey are utilized in the cure of constipation in Eastern part of Europe (Potschinkova, 1992). Addition of honey to infant nutrition improved their body and made them to have a better blood formation, an increase in a better skin colour, haemoglobin content and it aids digestion (Mommsen, 1957; Takuma, 1995; Frauenfelder, 1921). Bianchi (1977) reported that babies that are fed with honey had an enhanced uptake of calcium, and lighter and thinner faeces. Honey increased appreciably the frequency of the heart and the level of the glucose in the blood during performace of athletes (Kreider et al., 2002). Honey has an irrefutable effect on hepatitis A by decreasing alanine aminotransferase activity and bilirubin production (Baltuskevicius et al., 2001). Honey ameliorates the condition of patients who underwent cancer radiation therapy by decreasing the occurrence of mucositis as a result of radiation (Biswal et al., 2003).

Honey possesses some amino acids; proline, phenylalanine, including aspartic acid. These are the amino acids in honey that have more than 200ppm concentration. Pure honey has antiseptic activity towards many microbes especially the intestinal tract *Escherichia coli*, *Shigella* and *Salmonella* species (Jeddar et al., 1985). Gastric ulcers have been effectively treated by the use of honey as dietary supplement (Kandil et al., 1987). Studies by Katsilambros et al. (1988) postulated that honey might be an appropriate sweetener for the type 2 diabetic patients.

Previous studies by Bansal et al. (2005) stated that honey is a popular sweetener and a common household product worldwide. It is neither irritating nor toxic. Honey has a variety of positive nutritional and health effects.

The prophet (SAW) has advised his followers to "*Make use of the two cures: honey and the Quran.*" It is narrated in the Sahihan that Abu Said al-khudri said: "*A man came to the Prophet (SAW) and said, "My brother is complaining about stomach ache, "or complaining about diarrheoa." The prophet advised him to give him some honey. The man went and came back later, saying, "I gave him some honey, but it did not help", or he said, "It made his diarrhea worse." He repeated this like three times; all the while the Prophet (SAW) continued telling him, "Give him some honey." In the third or fourth time, the Prophet (SAW) said "Allah has said the truth while your brother's stomach has lied.*" The Messenger of Allah (SAW) said '*Allah spoke the truth and your brother's belly has lied. Go and give him honey to drink.' He went and gave him honey and was cured.*" (Hadith. Bukhari. Vol. 5. P2152. #5360).

Both the holy Qur'an and Hadith refer to honey as a healer of disease.

'And thy Lord taught the bee to build its cells in hills, on trees and in (men's) habitations..... There issues from within their bodies a drink of varying colours, wherein is healing for mankind. Verily in this is a Sign for those who give thought'. (Quran. Al-Nahl 16:68-69).

The Prophet (SAW) said:'*Honey is a remedy for every illness and the Qur'an is a remedy for all illness of the mind, therefore I recommend to you two remedies, the Qur'an and honey*. (Hadith. Al-Bayhaqi. Vol. 9. P344. #19349 . Al-Albani. Al-Silsilah al-Sahihah.Vol. 4. P174. #1633).

Honey has also been mentioned in the authentic Sunnah. It is reported that the Prophet (SAW) said: "Cure is in three (things): a drink of honey, a slash of the knife used in Hijaamah and branding (cauterising) by fire. And I prohibit my nation from cauterising." (Hadith. Bukhari.Kitab al-Tibb. Bab al-Shifa. #5356). In another hadith, it states: "Upon you is the two cures; the honey and the Qur'aan" (Hadith. Ibn Maajah. Vol. 2. p. 1142 #3452).

It is also mentioned as one of the foods of Jannah: "The description of Paradise which the pious have been promised is that in it are rivers of water the taste and smell of which are not changed; rivers of milk of which the taste never changes; rivers of wine delicious to those who drink; and rivers of clarified honey, clear and pure..."(Quran. Muhammad 47:15). Honey was mentioned repeatedly by the Prophet as a "healing," a "blessing," and "the best medicine."

2.11.2 Glucose Syrup

Glucose Syrup, also known as corn syrup is food syrup made from starchy crops like wheat, barley and rice. It is food syrup made from the hydrolysis of starch. The

functions of glucose syrup in food samples are to soften texture, add volume, prevention of crystallization of sugar and enhancement of flavor. Glucose syrup is the most feasible substitute for sugar. It is an aqueous solution of several compounds mainly glucose, dextrose and maltose. There are important physical features of glucose syrup, these include high fermentation ability, viscosity, hygroscopic, sweetness, colligate properties and its ability to facilitate browning reactions. More so, it also adds mouth feel and suitable characteristics in the preparation of variety of products (Hull, 2010). Glucose syrup that is used in the manufacture of confectionery contains varying amount of glucose, higher oligosaccharides and maltose, it can also contain 10% to 43% glucose (Jackson, 1995).

Glucose syrup possesses higher sugars, they are viscous and sticky and its combination properties are reason for their being cohesive. This makes these types of glucose syrups ideal for use as a binder in cereal bars where the syrup holds the various ingredients together to obtain a solid bar. The glucose syrup will most times enhance or change the perception of a flavor. Usually, syrups with low viscosity have a greater flavor. Food binders such as those that are effective to bind particulates so as to form a cereal bar, or those useful to bind and form a ready- to-eat (RTE) cereal cluster, are often based on sugar syrup, making water activity control comparatively easy (Sharon et al., 2009).

The water activity, a_w, of the food binder syrups that are used to produce cereal bars preferably have a water activity of less than 0.55. Sucrose, corn syrup, dextrose and other sugars are often combined with water to provide binder syrup having a considerable taste and mouth feel. The sucrose, dextrose, corn syrup and others are known to bind free water so that the water present in the syrup does not migrate to the

particulates. In the case of rice bubbles and other crisp particulates and in the combined product, moisture migration from the syrup to the dried ingredients and become soggy, stale and easily compacted (Sharon et al., 2009).

2.12 Water Activity

Water activity (a_w) is a critical factor for determining food product shelf life, since it influences the potential for microbial growth (Davis, 1995; Galić et al., 2009). A low a_w can diminish, or even prevent microbial activity and mold formation (Davis, 1995). Sugar molecules limit water availability in a food product, by forming hydrogen bonds with water molecules (Chinachoti, 1995). This interaction between the sugar and water molecules corresponds to a decrease in a_w (Chinachoti, 1995).

Packaging requirements for fresh bakery goods are often minimal as many of the products are for immediate consumption. However, packaging can be an important factor in extending the shelf life of other cereal-based goods (toast, frozen products, biscuits, cakes, pastas). Some amount of the texture changes and flavor loss manifest over the shelf life of a soft-baked good can usually be minimized or delayed by effective use of packaging materials. The gains in the extension of shelf life will be application specific. It is recognized that defining the shelf life of a food is a difficult task and is an area of intense research for food product development scientists (food technologists, microbiologists, packaging experts). Proper application of chemical kinetic principles to food quality loss allows for efficiently designing appropriate shelf-life tests and maximizing the useful information that can be obtained from the resulting data. In the development of any new food product including reformulating, change of packaging, or storage/distribution condition (to penetrate into a new market), one important aspect is the knowledge of shelf life (Galic et al., 2009).

According to Rahman and Labuza (1999), physical, chemical and microbial stability of food is highly influenced by the water content and its interaction with ingredients in such food. Water activity concept is a dependable evaluation of microbial growth, lipid oxidation, non-enzymatic activities, and the texture of foods after the manufacturing processes. Safety and spoilage of foods are the main concerns of food producer, retailers and also consumers. Preservation through dehydration needs data on thermodynamic features relating to water activity (a_w) (Sablani et al., 2007).

Water activity has been used to a large extent to evaluate the storage stability of a food product. A food product is more stable at water activity of about 0.10 to 0.30 (Rockland & Nishi, 1980). Sablani et al. (2007) reported that a better understanding of water sorption isotherm which has a link with water activity is an important tool in controlling stability and packaging requirement of food. Softening is noticed in food when the water activity goes beyond critical water activity, a_{wc} (Katz & Labuza, 1981). The critical water activity at which food/products relinquish their freshness is usually 0.50±0.20 (Hough et al., 2001; Katz & Labuza, 1981; Peleg, 1994).

2.13 Mineral Nutrients and Human Nutrition

Minerals are defined as organic substances present in all body tissues and fluids and their presence is vital for the maintenance of some physical and chemical processes which are important to life. Mineral nutrients are synonymous to water, carbohydrates, fats, proteins, vitamins and the enzymes needed to digest them, they are also important to life (Soetan et al., 2010). Mineral nutrients are basically metals and other inorganic compounds. Major minerals namely phosphorus and potassium are needed in amounts of up to 10g/day. The requirement on a daily basis of secondary and micro minerals

ranges from 400 to 1500mg/day and 45µg/day – 11mg/day respectively (Gupta & Gupta, 2014).

Humans need various mineral nutrients known to perform important role in maintaining human health (Gupta & Gupta, 2014). Minerals are the key to the engines called vitamins. No vitamins can be absorbed or perform its intended role without the specific minerals in very specific amounts. They are essentially metals and other inorganic compounds that supply much of our skeletal structure such as bones and teeth. More so, they are important to numerous body processes (Gupta & Gupta, 2014). Mineral nutrients can be divided into major, secondary and micro/trace minerals. The division is based on the requirement by humans instead of their comparative importance. Examples of major mineral nutrients are phosphorus and potassium, secondary: calcium, magnesium and sulphur; while macro or trace are boron, chlorine, chromium, fluoride, iodine, iron, manganese, molybdenum, nickel, selenium, sodium, vanadium and zinc (Gupta and Gupta, 2014). In this study, the mineral elements determined are sodium (Na), calcium (Ca), magnesium (Mg), iron (Fe), zinc (Zn), copper (Cu) and manganese (Mn).

2.13.1 Relationship of Mineral Nutrients to Human Nutrition

Mineral nutrients are completely important for good health. It has been established by scientists that no less than 28 mineral elements are required for normal nutrition (Health Lifestyles Inc., 1993). In addition, they are more crucial than vitamins. With the absence of vitamins, the body can make some use of minerals, whereas with absence of minerals, vitamins are unusable (Health Lifestyles Inc., 1993). In contrast to the body's complex organic compounds (lipids, carbohydrates, proteins and vitamins) that are utilized metabolically in the production of energy, minerals are

frequently found in the form of salts in the body, they are inorganic and not metabolized (Carpenter et al., 2013). They stated further that minerals do not only impart hardness to bones and teeth but also perform generally in metabolism, for examples, as electrolytes in managing the movement of water in and out of cells, as constituents of enzymes, and also components of many organic molecules.

2.13.2 Recommended daily doses of all minerals studied

All foods contain numerous mineral nutrients; on the other hand, some are higher in certain mineral nutrients than other minerals (Gupta & Gupta, 2014). A dietary requirement, as defined by Sutherland et al. (1998), is the lowest continuing intake of a nutrient that, for a specified indicator of adequacy, will maintain a defined level of nutrition in an individual. An important dietary constituent is the one that body cannot produce in adequate quantities to maintain health. Recommended dietary allowances are based on approximation of the dietary requisites, and are intended to avert deficiency diseases and upgrade health through a sufficient diet (Lenntech, 1998). Table 11 shows the daily dosages of the mineral elements.

Table 11: Recommended daily dosages of mineral nutrients

Mineral nutrient	Lenntech (1998)	Balch and Balch (2000)
Calcium (mg)	1000	1500-2000 (as citrate or ascorbate)
Copper (mg)	2	2-3
Iron (mg)	15	18-30
Magnesium (mg)	350	750-1000
Manganese (mg)	5	03-10
Sodium (mg)	2400	-
Zinc (mg)	15	30-50

A range of values from recommended daily intake to maximum recommended daily allowance of daily reference intakes.

2.13.2.1 Calcium

Calcium is reported to be the fifth most abundant element by mass in the earth's crust. It is ubiquitous, and it provides a number of health benefits to the human body (Stipanuk & Caudill, 2012). Commonly well-known health benefit of calcium is the vital role it plays in the development of strong bones. Virtually all the body's calcium can be found in the bones and teeth. There are also numerous studies which state that adequate calcium intake helps young people to develop strong bones while keeping the bones of older people strong and healthy. Calcium also assists in prevention and treatment of various bone-related illnesses, such as osteoporosis (Stipanuk & Caudill, 2012).

Besides fulfilling the needs for calcium ions required in many intracellular functions as well as for the regulation of blood clotting i.e. homeostasis, nearly all of the body's remaining calcium exist in skeletal salts that reinforce the body. It enables ambulation, and also protects internal organs. A predetermined amount of calcium forms the teeth which, after formation remains fixed in the oral cavity and unlike the bones, do not partake in calcium metabolism (Anderson & Garner, 2011). It has been advised that young adults should be encouraged to increase their total calcium intakes to no less than the suggested daily allowance of 1000mg/day for explanations extending beyond bone health (Skinner et al., 2011). The tolerable upper limit for calcium intake level ranges from 1000 – 3000 mg/day; this is based on calcium excretion or kidney stone formation (Ross et al., 2011).

2.13.2.2 Copper

Copper is an important mineral for human health and at the same time can be lethal; this depends upon amount ingested (Araya et al., 2007). Copper is related to bone health, immune function and frequency of infections, cardiovascular risk and variations in cholesterol metabolism (Araya et al., 2007). Copper deficiency, at the same time, leads to decreased iron levels in some tissues and iron deficiency anaemia (IDA) (Kuo et al., 2004). It has been acknowledged that copper is important for health for more than three quarters of century (Klevay, 2011). In the past decade, there has been growing interest in the concept that marginal deficits of copper can lead to the development and progression of many ailments such as cardiovascular disease and diabetes (Uriu-Adams & Keen, 2005). Insufficiency of copper during pregnancy can lead to gross structural deformity in the conceptus (embryo), and continuing neurological and immunological abnormalities in the offspring (Uriu-Adams & Keen, 2005). Good sources of copper are whole grains, sunflower seeds, beans, cashews, dried fruits (US National Library of Medicine, 2013). Natural food such as cereals in which glutinous rice belongs contains sufficient copper to provide up to 50% of the required copper intake in a balanced diet (Copper Development Association, 2013).

2.13.2.3 Iron

Iron deficiency (ID) and iron deficiency anaemia (IDA) are the most widespread nutritional disorders throughout the world (Akhter et al., 2005; Paesano et al., 2010). IDA may result from a low dietary intake, insufficient intestinal absorption, excessive blood loss e.t.c. (Akhter et al., 2005). The ID and IDA malady (sickness), especially those caused by increased iron requisite during pregnancy, signify a high risk for premature delivery, foetal growth hindrance, low birth weight, and poorer neonatal

growth (Paesano et al., 2010). Women of the reproductive age are the most affected. IDA influences physical and cognitive development at an initial age in children, always resulting in irreparable outcomes (Beinner & Lamounier, 2003).

Ferrum is needed for the production of myoglobin in muscles and haemoglobin in blood. Human body needs iron for the building of many proteins in the blood. It is also found in numerous proteins in the body where it accomplishes many functions (Stipanuk & Caudill, 2012). The health benefits of iron mostly involve conveying life-giving oxygen to human body cells. About sixty-six percent of iron is found in haemoglobin. IDA may often trigger severe fatigue, body weakness and associated health diseases (Organic Information Service Private Limited, 2013).

The most terrible result of iron exhaustion is iron deficiency anaemia, and it is even now considered the most widespread nutrition deficiency worldwide (Clark, 2008). ID has a negative effect on intelligence and behavioural developments in babies (Milman, 2011). Nutritional sources of iron are discovered in two types: heme iron and non-heme iron. Heme iron is mainly from animal sources, i.e. meats (Ohio State University, 2013). Non – heme iron is supplied from plant sources and essential components of animal tissues. Non – heme sources that are high in iron include fortified breads, cereals, corn and flours (Ohio State University, 2013; Stipanuk & Caudill, 2012).

2.13.2.4 Magnesium

This is the fourth most abundant mineral element in the body. It is important to good health. About half of total body magnesium is found in the bones. The remaining 50% is found mainly in body's cells tissues and organs (National Institute of Health, 2013).

Magnesium plays a vital role in nervous system, muscle function, strong bones, regulation, relaxation and contraction of muscles, the production of proteins, production and transportation of energy throughout the body (Stipanuk & Caudill, 2012). Magnesium, in addition, has a vital function to play in reducing the threat of developing cardiovascular disease (Stipanuk & Caudill, 2012). Bae & Choi (2011) reported that magnesium plays an important role in the attack of chronic disease like arteriosclerosis, diabetes, obesity, metabolic syndrome and hypertension.

Diets high in fruits and vegetables supply nutrients like magnesium that is related to bone health and can also produce an alkaline environment, reduce calcium excretion and therefore improve bone density (Kitchin & Morgan, 2007). Magnesium requirement is described with the use of biochemical and electrophysiological standard. The recommended dietary allowance of magnesium is thought to be 320mg/day (Gupta & Gupta, 2014). Magnesium plays a part in many chronic, metabolic disease-related conditions (Champagne, 2008). The likelihood that magnesium (Mg) deficiency is the cause of several major depressions and associated mental health problems including IQ loss and addiction is greatly important to public health. The estimated average requirement for children is 55-80mg/day while reference daily allowance is 70-100mg/day (Griffin et al., 2008).

Rosanoff et al. (2012) reported that in contrast to calcium, Mg is an "orphan nutrient" that has been examined considerably less heavily. Low Mg intakes and blood levels are associated with type 2 diabetes, hypertension, atherosclerotic vascular disease, unexpected cardiac death, osteoporosis, migraine headache, asthma and colon cancer. Some legumes, soy nuts and seeds, whole unrefined grains, sunflower seeds, peanuts,

and corn are good sources of Mg (National Institute of Health, 2013; Stipanuk & Caudill, 2012).

2.13.2.5 Manganese

Manganese is an important trace element found in all tissues; it is needed for normal carbohydrate digestion, lipid, protein, and amino acid digestion (Erikson et al., 2007). Manganese performs an essential function in bone and cartilage development and healing of wound. Manganese is a trace mineral element that is vital to all forms of life on earth. It is merely required in very small amounts in human body. It is so little to the extent that manganese deficiency has hardly ever been documented in humans (Stipanuk & Caudill, 2012). Manganese is both an essential trace elements; at higher doses, a toxic metal to human beings (Bornhorst et al., 2010). Manganese deficiency and toxicity may arise under special diets and health conditions. Neurotoxicity is the most adverse effect of unduly ingested manganese, but hepatoxicity, pulmonary toxicity, reproductive and developmental manganese toxicity may also be significant in human beings (Schafer & Anke, 2005). Good food sources of manganese are fruits, vegetables, legumes, olives, avocado and nuts (Bornhorst et al., 2010).

2.13.2.6 Sodium

Sodium is a mineral element found in salt, which is high in sodium. A little amount of sodium is found naturally in foods (Health Stand Nutrition Consulting Inc., 2011). Low nutritive caloric and sodium intakes may be helpful in relation to the development of diabetic retinopathy in African American patients that have type 1 diabetes mellitus (Roy & Janal, 2010). Health Stand Nutrition Consulting Inc. (2011) suggested that people should intend to have a daily sodium intake of less than 1500

mg. Most sodium consumed is concealed in foods (Health Stand Nutrition Consulting Inc., 2011).

2.13.2.7 Zinc

Zinc is regarded as an important trace mineral element; it is crucial in healing of wound. It is also needed for metabolic activity of 300 of the enzymes in the body; it is considered important for cell division and in the production of DNA and protein (Life Extension Foundation for Longer Life, 2013). Zinc deficiency is widespread in the less developed countries. As many as two billion people may be growth retarded as a result of zinc deficiency (Prasad, 2008). Zinc deficiency is known to be related to insulin resistance in obese people (Kim & Lee, 2012). Zinc, when take in excess, may lead to abnormal cramping, diarrhoea, and vomiting (Life Extension Foundation for Longer Life, 2013).

The upper limit of zinc intake is suggested to be 40 mg/day for adults (Life Extension Foundation for Longer Life, 2013). Excellent sources of zinc are poultry, seafood, nuts, seeds, whole grains, legumes and cereals (Life Extension Foundation for Longer Life, 2013; Rangan & Samman, 2007). The impact of cereals to zinc intake has increased significantly since 1995, as a result of more market availability of zinc-fortified breakfast cereal; cereal products provide 68% of total zinc intake (Rangan & Samman, 2007).