

Research Article

Development of a High Fiber Breakfast Porridge from Millet, Macadamia Nuts and Bananas

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Abstract Many people, including Diabetics consume processed porridge as part of breakfast in their households, which is low in fiber. Maybe this is due to lack of knowledge about how fiber is of importance in their bodies or lack of commercially available local varieties of high fiber porridges. Therefore, the nutritional content of breakfast meals can be improved by including high fiber porridge. The aim of this study was to develop a high fiber porridge using millet, macadamia nuts and banana, to analyze the proximate composition of the porridge, microbiology quality and the sensory attributes. The high fiber porridge was analyzed for its microbiology quality, carbohydrate, moisture, energy, protein, fat, ash, metals and fiber, which showed that the porridge falls in the range of known porridges and cereals on the market. The sensory attributes were good, giving an overall acceptance of the flavor, colour, texture and taste. The research showed that millet, macadamia nuts and banana used in combination have a high possibility of increasing the fiber one requires per day to sustain a healthy life. In this research the raw materials were sterilized and the finished product was aseptically sealed to ensure food safety.

Keywords *Diabetics; High fiber*

1. Introduction

Hoseney (1994) explains that, after fasting overnight we must break the fast in the morning with breakfast. Although certainly anything can be and is eaten at breakfast, morning is traditionally a time when many cereal products are consumed, in addition to sweet rolls and breads. Due to westernization, most people have since abandoned consumption of whole grain products even though they are nutritious being high in fiber. This has led to weight gain, susceptibility to chronic diseases such as Diabetes Mellitus, heart diseases. Since whole grain products which do not undergo refining have been associated with poor people, it has become difficult to convince people to eat such products with regards to their health benefits. In this research the high fiber porridge was developed to address this issue, in that millet has been fermented to make it more edible, with macadamia nuts and banana added to eat to produce a distinct flavor. Eventually, the porridge is much acceptable because it is not merely millet only. Whole grain products are known to assist in maintenance of normal blood glucose levels in Diabetic people thus this research was conducted with Diabetic people very much in mind.

According to Akoth et al. (2012) in order to encourage consumption and utilization of millets, domestic and commercial product development can be employed as has been the case in many other countries which use these cereals as their staples.

Diabetes mellitus is a complex disorder characterized by chronic hyperglycemia which results from malfunction in insulin secretion and/or insulin action, both causing impaired metabolism of glucose, lipids and proteins (Mayfield, 1998; Kim, Ju, Choi., 2006). It is prevalent worldwide and known to be one of the major causes of death. The prevalence of diabetes in urban African communities is increasing with ageing of the population and changes in lifestyle associated with urbanization and westernization. However, the prevalence is still low in traditional rural communities, about 1-2%, except in some specific high-risk groups, where about 1-3% or more adults have diabetes. The combination of rising prevalence of diabetes and the high rate of long-term complications in Africans is believed to lead to a drastic increase of the burden of diabetes on health systems of African countries in the very near future. The chronic hyperglycemia of diabetes is associated with long-term complications viz- dysfunction and failure of various organs especially the eyes, kidneys, nerves, heart and blood vessels.

According to experts, the number of people with Diabetes in Zimbabwe is growing as revealed by Biriwasha (2011). The Herald Newspaper, according to Biriwasha (2011) in the last survey conducted in 2005 only 10% of the total population had diabetes, yet in 2003 Zimbabwe recorded more than 90,000 cases of diabetes, an increase of 3000 from the 1997 figure. Now the cases of Diabetes have increased dramatically, hence it has become a concern of millions. The Diabetic Association of Zimbabwe (ZDA) estimated in 2011 that around 400 000 people in the country have the condition but many are unaware of their condition. And many people are suffering from Diabetes and do not have any or enough dietary knowledge about it, a ZDA official was quoted in The Herald Newspaper. It is sad that a lot of people have died because of this condition without knowing it and its dietary therapy and only relatives will know about it after a post-mortem has been conducted, added the ZDA official. Preparation of supplementary food is vital in the management of diabetes. In this study the researcher developed a high fiber breakfast porridge using locally available ingredients which are millet, macadamia nuts and bananas.

The researcher developed the porridge from the whole millet grain, thus most nutrients are available which include protein, zinc, iron, magnesium, anti-oxidants, vitamin-B, E and phytochemicals. These nutrients boost one's immune system and fight infections. Eating porridge on a regular basis may help stabilize blood-sugar levels. The porridge however contains high fiber which may improve digestion, reduce high blood cholesterol and help prevent heart diseases. The fiber content in porridge helps slow the absorption of sugar, which may improve blood-glucose levels for people who suffer from diabetes. Also controlling blood glucose levels, reduces risk of kidney problems, stroke and heart diseases.

Not only do high fiber foods, such as this porridge help in digestion, they also may help in weight loss. The high fiber foods are generally low in calories but high in volume. This helps one stay full longer and may help one reduce the amount of food one consumes throughout the day.

2. Nutritive Value of Foods

2.1. Whole Grain

2.1.1. Nutrition Value of Millet

Table 1: Nutritive value of millet

Nutrient	Quantity
Water	11.6 g
Energy	354.6 kcal
Protein	12.4 g
Fat	4.9 g
Carbohydrate	71.4 g
Calcium	31.1 mg
Phosphorous	289.7 mg
Iron	9.6 mg
Potassium	30 mg
Sodium	11 mg
Vitamin A	30 mg
Ascorbic acid	0.75 mg
Thiamin	0.35 mg
Riboflavin	0.16 mg
Niacin	2.03 mg

Nutritive Value of Foods of Zimbabwe (2000).

2.1.2. Health Benefits of Millet as a Whole Grain

Millet contains 50-60% starch, which is converted to glucose by the digestive enzymes. The glucose is then absorbed into the blood through the small intestines and provides energy to the entire body which is required for processes such as basal metabolism, physical activity. Also, there is a great sense of satiety because of the fiber content, in this case the fiber swells in the stomach reducing additional food intake, thus preventing hyperglycemia and obesity. Whole grain millet does not contain cholesterol and it also contribute to its reduction in the blood due to the laxative action of the bran lowering cholesterol. It is wisest to eat the whole grain just as it is provided by nature, since it contains the ideal proportions of nutrients. The bran is rich in fiber, vitamins, minerals. The endosperm is formed by granules of starch and proteins. Also, the germ is very rich in B Vitamins and Vitamin E as described by George and Pamplona-Roger (2008).

2.2. Banana

Banana is mostly grown in Central America, India and South East Asia. *Musaceae* is the botanical family. The family comprises some 200 species of trees and bushes, primarily tropical known for their bunches of fleshy fruit. The genus *Musa* which includes the common banana and all of its variants, is the most abundant of the family consisting of some 60 species. *Banana Musa Paradisiaca* is rich in potassium making it excellent for cardiac disorders. The fruit provides water constitutes about 80-93%. This is living pure, uncontaminated water that contains numerous biologically active substances. Sugars present most abundant are glucose and sucrose, which is absorbed directly into the blood stream without need for digestion, thus proving quick energy. Most fruits contain little or no starch, since it is converted to simple sugars (glucose and fructose) during the maturation process. The banana is the fresh fruit richest in starch (1-2%). Banana contains soluble fiber (pectin and hemicellulose). Above all, Vitamin C and provitamin A (beta-carotene), which are powerful antioxidants. Minerals present are particularly potassium, magnesium, calcium and iron as cited by George and Pamplona-Roger (2008).

2.2.1. Nutritive Value of Banana

Table 2: *Nutritive value of banana*

Nutrient	Quantity
Water	73.9 g
Energy	94.7 g
Protein	1.3 g
Fat	0.3 g
Carbohydrate	24.3 g
Calcium	7.0 mg
Phosphorous	21.7 mg
Iron	0.5 mg
Potassium	332.0 mg
Sodium	2.7 mg
Vitamin A	54.38 mg
Ascorbic acid	10.90 mg
Thiamin	0.04 mg
Riboflavin	0.05 mg
Niacin	0.70 mg
Vitamin B6	0.47 mg
Folic acid	19.9 mg

Nutritive Value of Foods of Zimbabwe (2000).

2.2.2. Health Benefits of Banana

George and Pamplona-Roger (2008) indicates that banana does not contain cholesterol, purine (which form uric acid), anti-nutritive factors which interfere with absorption of other nutrients and toxic substances. The fruit contains flavonoids, anthocyanins and other phytochemicals, acting as true medicine avoiding arteriosclerosis maintaining the fluidity of the blood and preventing cancer. Banana contains Vitamin C and A which as antioxidants which help in prevention of cancer, premature aging and some other diseases. Despite all this, the fruit can be eaten naturally without cooking and other processes. Banana has a diuretic effect which facilitates the elimination of wastes and blood impurities such as uric acid (detoxifies). Due to the fiber present the fruit produces greater sense of satiety and facilitates in bowel movement.

2.3. Macadamia Nuts

Grossbauer (2007) states that these are edible dried fruits of a tree enclosed in hard shells. Macadamia nuts belong to the family of *Proteaceae*, *genus* macadamia with the scientific name *Macadamia Integrifolia*. They are an important source of protein following legumes ranging from 10-25% by weight, particularly in diets that do not contain meat. Macadamia Nuts have a very high fat content and therefore energy dense from 70-90% of the total energy comes from fat. These nuts have a high dietary fiber content of about 5-15%. Nuts remain fresh for a limited time due to their high content of unsaturated fats which is why these macadamia nuts were defatted in this research to increase product shelf life. Nuts are a good source of B-vitamins and Vitamin E, but about 75% of the B-vitamins are destroyed but the roasting process.

According to George and Pamplona-Roger (2008), until recently, many nutritionists felt that oleaginous (oily) nuts were harmful to the heart and arteries due to their high fat content. It has been realized that this is not the case; diverse studies have confirmed that they act to protect the arteries and reduce cholesterol levels, supporting the beliefs of many of the pioneers of natural diet as far back as the 19th Century. There are those who deprive themselves of the health benefits of nuts,

simply because they are afraid, they will cause them to gain weight. Calories for calorie nuts are less fattening than meat, sausages, milk fats or refined sweets.

George and Pamplona-Roger (2008) stipulates that, the so-called RENO study regarding heart-healthy diets which was carried out in the United States demonstrated that in general, those who regularly eat nuts are more health conscious and weigh less than those who do not eat them. We can be assured that nuts are not fattening if they are eaten in moderation and in place of other calorie rich foods and not in addition to them, thus in this research a small amount of macadamia nuts was in cooperated to the product.

2.3.1. Nutritive Value of Macadamia Nuts

Table 3: *Nutritive value of macadamia nut*

Nutrient	Quantity
Moisture	2.9 g
Energy	702 kcal /2936 kilojoules
Protein	8.3 g
Total Fat	73.7 g
Saturated fat	11.04 g
Monounsaturated fat	58.17 g
Polyunsaturated fat	1.27 g
Cholesterol	0.0 g
Carbohydrate	8.4 g
Fiber	5.3 g
Calcium	70 mg
Iron	2.4 mg
Magnesium	116 mg
Phosphorous	136 mg
Potassium	368 mg
Sodium	5.0 mg
Zinc	1.71 mg
Copper	0.30 mg
Thiamin	0.35 mg
Riboflavin	0.11 mg
Niacin	2.1 mg

MRC Food Composition Tables (1996).

2.3.2. Health Benefits of Macadamia Nuts

George and Pamplona-Roger (2008) examines that, they provide energy and are very nutritious, eaten raw or processed. Macadamia nuts are a healthful alternative to meat given their richness in protein, minerals and vitamins. Their oil is comprised of mono or polyunsaturated fatty acids which are easily metabolized and not tend to be deposited in the body like cholesterol which they do not contain. They do not cause obesity to the contrary; they aid weight gain when they replace other high calorie foods in the diet. Macadamia nuts are a good source of choline, a vitamin factor that forms part of lecithin and improves liver function. These nuts reduce low density lipoproteins (harmful) and increase high density lipoproteins to protect against arteriosclerosis. Phytochemicals available such as ellagic acid, flavonoids and phenolic compounds are potent antioxidants. Phytosterols are substance present in nuts which are similar to cholesterol but of vegetable origin, that block the absorption of cholesterol in the intestines. Isoflavones protect against arteriosclerosis, osteoporosis and cancer. Due to their very low carbohydrate level they are well tolerated by Diabetics in moderation.

2.3.3. Effects of Macadamia Nuts

Whole nuts are difficult to chew especially in the elderly, hence in this research the macadamia nuts were powdered to incorporate them into the porridge. They may cause allergic reactions in small children and should not be given to infants under the age of 12 months, which is why in this research the porridge should not be given to infants and young children. Nuts may produce indigestion in persons with system disorders. Hence in this research the nuts were processed to improve tolerance by being lightly roasted, use in a limited quantity, had skins removed by blanching or scalding as stipulated by George and Pamplona-Roger (2008).

2.4. Combination of Whole Grains, Fruits and Nuts

According to George and Pamplona-Roger (2008), today it is known that a breakfast rich in grains and fruit improves physical and mental performance all morning. These complement each other, for instance fruits contain antioxidants which nuts lack, hence when one consumes the product antioxidants would be available, unlike if the nuts were to be eaten on their own. This research was done in consideration of the Mediterian diet which includes combination of fruits and nuts as foods, which is also good for vegetarians. Proteins in nuts are quite complete deficient in lysine and methionine which are complemented by grains rich in methionine, as well as milk use in the cooking of porridge in this research.

3. Methods

3.1. Research Design

Qualitative and quantitative design

3.2. Population of Study

The researcher used three different populations which included the raw materials used to develop the high fiber porridge, porridges and people at Zimbabwe Diabetic Association in Harare.

Population A - fermented millet, roasted and defatted macadamia nuts and dried banana

Population B - 10 high fiber porridges

Population C - 85 people who attended the monthly Diabetic meeting at the Zimbabwe Diabetic Association in Harare

3.3. Sample and Sampling Techniques

The sampling technique used in this research was a multi-stage sampling, which is a combination of two or more sampling techniques this was done to increase efficiency and to reduce bias. Systematic sampling was conducted in which subjects were selected at regular intervals, thus every third person was selected, after which the population was divided into strata or subgroups by age, gender and sex and separate random samples were selected, which involved each sample unit amongst a population of 85 people having the same probability of being selected using random numbers in the strata. The researcher used the following samples:

Samples 1 -10: 10% of samples 1-10 high fiber porridges, which is 100 g.

Diabetic sample: 35% of population C

Data Collection Procedures and Techniques

Observation

Interviews

Questionnaire

3.4. Production of High Fiber Porridge

3.4.1. Processing of Millet, Its Effects and Nutrient Stability

I. Washing and soaking

2 kg of millet was washed and soaked to allow extended steeping in excess cold or warm water overnight for 12 hours, after which water was drained off. Soaking induced leaching out of water soluble anti-nutritional factors and Vitamin C and B-Vitamins. Glucosides, phytates, oligosaccharides and tannins were all significantly reduced, according to Kadam and Salunkhe (1985). Although water soluble micronutrients were also lost by leaching, extended soaking had the net effect of enhancing protein solubility index and the availability of limiting amino acids of edible grains as cited by Borhade, Kadam and Salunkhe (1984).

II. Germination / Malting

Marovatsanga and Taylor (1994) postulates that, in seeds germination triggers off the enzyme systems of sprouting seeds leading to the breakdown of complex macronutrients of proteins, carbohydrates, lipids into simpler forms that are more easily assimilated. Some vitamins such as C, E, B-complex are known to increase. Anti-nutrients such as oligosaccharide starches are reduced as much as 90%, lectins, tannins as much as 50% and phytates as much as 90%. Amylolytic enzymes residual in seed malts can be resourcefully applied for the purpose of viscosity-thinning to facilitate the design of high nutrient density porridges. Thus, the millet was then exposed to air covered by a cloth and was germinated for 3 days with continuous turning to avoid millet from decaying.

III. Fermentation

Lori (1993) postulates that, by increasing titrable acidity and reducing pH of porridge, it precludes contamination by acid intolerant microbes. Due to the aversion of the invasion of these potential contaminant's fermentation imparts attributes of robust stability and safety in the product and thereby pre-empts diseases infection such as diarrhea and salmonellosis, mycotoxic infections, such as aflatoxins. The effect of fermentation as an isolated treatment, on the viscosity of porridge is still uncertain and even controversial. While microbial exo-enzymes from fermentations can have a thinning effect on viscosity due to the hydrolysis of starches and proteins, lowered pH of medium towards and the iso-electric point of porridge proteins may reduce effects on viscosity. In this research natural fermentation was carried out for 3 days, in which useful microorganisms were already in the millet (starter material) whereby conditions only need to be set up to get the process going, as highlighted by Labuza and Erdman (1984).

IV. Dry roasting or toasting

Marovatsanga and Taylor (1994) indicate that, it is a hydrothermal treatment at high temperatures which can be carried out in simple low-cost mechanical equipment that is easy made in developing countries. The millet was dried and roasted for 6 hours at 105°C, with constant stirring to avoided the

wet millet from burning and sticking to the oven tray. Problems associated with high propensity of wet starches are to stick and burn on equipment surfaces during toasting can be contained by careful manipulation of moisture content and particle size. These same parameters are also applied together with stirring and the regulating process of temperature to control the heat transfer. Both cooking and drying occur simultaneously in the process. Since toasting is a high temperature hydrothermal treatment, it reduces the level of heat-labile vitamins, protease inhibitors and lectins, volatile glucose present, titrable acidity, though this adverse effect is not likely significant. Due to significant degrees of dextrinization of starches during high temperatures-dry toasting, has a diminishing effect on porridge viscosity. However, this is counteracted to some extent by the increased swelling capacity of cooked, gelatinized starch.

V. Dry milling

The dried and roasted millet was milled into powder, for it to be mixed into final porridge product. The millet was milled whole. Figure 1 illustrates the processing of millet.

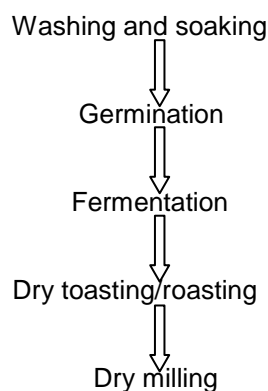


Figure 1: The processing of millet

3.5. Processing of Macadamia Nuts, Its Effects and Nutrient Stability

Pamplona-Roger (2008) highlights that, it is best to naturally dry macadamia nuts after they have been shelled to facilitate storage. Macadamia nuts remain fresh for only a limited time due to their high unsaturated fatty acids, which easily become rancid by oxidation. But in this research the Macadamia nuts were defatted to increase the porridge's keeping quality. For this reason, particularly in Mediterranean regions various methods have been developed to prepare them in ways that keep them useful for longer and take full advantage of their flavor. Once they have been dried, they can be processed in a variety of ways to make them easier to eat. Fat soluble vitamins are also lost during the defatting process.

3.5.1. How Defatting of the Macadamia Nuts was done using the Solvent Extraction Method

The macadamia nuts were dried to allow penetration of organic solvent for efficient extraction. The dried nuts were finely ground to increase the surface area of lipid exposed to the solvent. Grinding was carried out at a low temperature to reduce the tendency of lipid oxidation from occurring. No acid hydrolysis was conducted in the research since the nuts were being processed for human consumption resulting in lipids that are complexed with proteins and carbohydrates being left behind. Figure 2 illustrated how macadamia nuts were processed.

3.5.2. Batch Solvent Extraction Method was used as follows:

- i. 500 g of Macadamia nuts were mixed with 750 ml of ether and hexane in a flask in the fume hood at each washing.
- ii. The flask was stoppered to allow vigorous shaking releasing pressure at intervals, the organic solvent (ether and hexane) and aqueous phase were allowed to separate by gravity.
- iii. The aqueous phase was then decanted off.
- iv. The solvent was evaporated off the macadamia nuts.
- v. Processes were repeated to improve extraction efficiency.
- vi. The defatted nuts were dried, roasted and finely powdered.

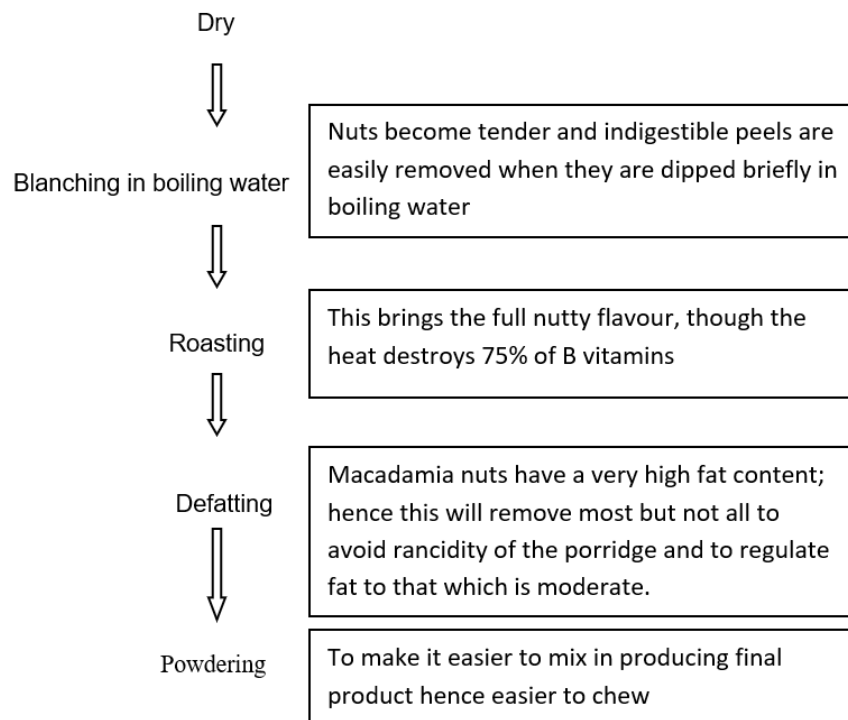


Figure 2: *How macadamia nuts were processed*

3.6. Processing of Banana Fruit, Its Effects and Nutrient Stability

Pamplona-Roger (2008) indicates that Bananas can be processed in a variety of ways to make it easier to eat or to preserve and incorporate into a product. All of these methods result in the loss of some portion of vitamins and flavonoids, which are the most unstable nutrients. Carbohydrates and minerals are not affected. Figure 3 illustrated how bananas were processed.

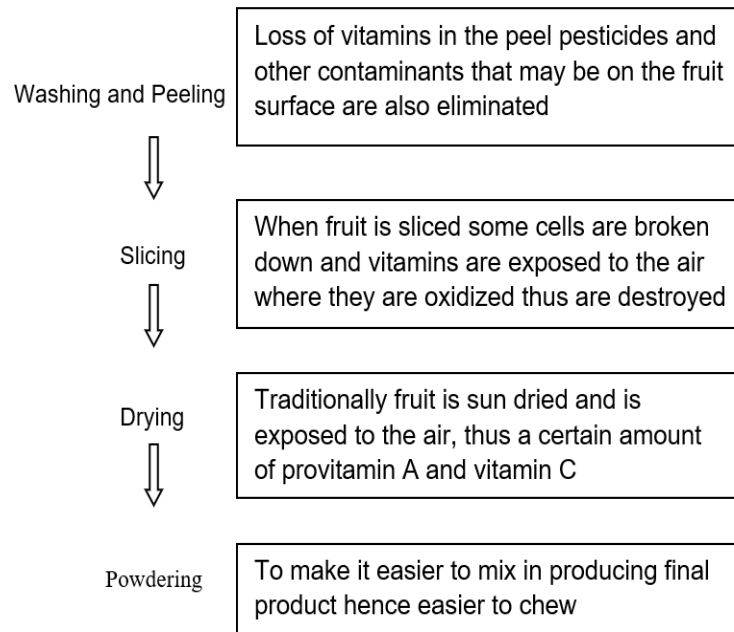


Figure 3: How bananas nuts were processed

The summary of processing ingredients into final product is illustrated in Figure 4 below.

3.7. Chemical Analysis of High Fiber Porridge, according to Egan, Kirk and Sawyer (1981)

3.7.1. Microbiology Determination

The conditions in the microbiology laboratory were kept as aseptic as possible to avoid contaminating the samples from the contaminated air, and this procedure was the first to be done to avoid contamination if the high fiber porridge packages were opened for other reasons in the Foods Laboratory. Different media were prepared to identify different microorganisms namely total *coliforms*, total bacterial count, *E. coli*, *Bacillus cereus*, *Staphylococcus aureus*, *Salmonella*, *Shigella*, yeasts and molds.

3.7.2. Moisture Analysis

Accurately weighed 5g samples into crucible were heated in a thermostatically controlled oven at 100 - 105 °C, whilst being stirred. Heating was conducted for 4 hours until all the moisture was lost. Samples were cooled in a desiccator for 30 minutes and were weighed to determine the moisture lost.

3.7.3. Ash Determination

5g of samples were weighed into silica or platinum dishes (about 7cm in diameter) which were previously ignited and cooled before weighing. The samples were charred on a hot plate in a fume cupboard, and then eventually ignited in a muffle furnace at 500-550°C. The samples were allowed to cool on an asbestos block and they were placed in a desiccator and allowed to cool before weighing to obtain the ash content.



Figure 4: The summary of processing ingredients into final product

3.7.4. Determination of Metals

Dry ashing was carried out where 5g samples were weighed and put in crucibles which were then put in a muffle furnace at 500 - 600°C after charring to destroy organic matter in silica or platinum dishes .Precaution was taken, against low results which may be due to volatilization of element ,combination of absorption of the element with ash constituents or the vessel used or incomplete extraction of ash such difficulties were avoided by using an accurately controlled muffle furnace ,and by aiding an ash aid (magnesium oxide nitrate, sodium carbonate and sulphuric acid) to the food before ashing and by using a suitable acid for the extraction. Once ash was obtained from the muffle furnace it was prepared into solution for Atomic Absorption Spectroscopy where (it was be read to give results) in the following manner:

I. For Iron, Copper, Zinc and Lead

The ash was dissolved in 5% Hydrochloric acid, and was filtered and diluted to 100ml using distilled water in a volumetric flask to make solution (I).

II. For Sodium

10ml of solution (I) was added to 2 ml of 50 000 ppm of potassium nitrate and was topped up to 50ml in a 50cm³ volumetric flask using distilled water.

III. For Potassium

10ml of solution (I) was added to 2 ml of 50 000 ppm of cesium nitrate and was topped up to 50ml in a 50cm³ volumetric flask using distilled water.

3.7.5. Fat Determination

The amount of fat extracted in food depends on the method used. Fat content may be considered as consisting of the free lipid constituents which can be extracted using less polar solvents such as light petroleum fractions, such as hexane, diethyl ether and bound lipid constituents which require more polar solvents like alcohol for their extraction. The Werner Schmid method achieves dissolution of the food by acid hydrolysis where the material is heated in a boiling water bath with HCL to breakdown the protein and the fat separates as a layer on the top of the acid liquid.

A weight of 2g of homogenous samples was added to each 25x200 mm B19 glass stoppered tube. Powdered dry materials were wetted with little alcohol. A requisite amount of HCL was added to each tube and were digested in a water bath for 15 minutes, while being shaken or macerated at frequent intervals. The tubes were then cooled and a requisite amount of 95% alcohol was added, mixed and cooled again. 25ml of ether were added to each B19 tube which were stoppered and shaken for not less than 1 minute. Also, 25ml hexane was then added and shaken as well for one minute, and the two phases were allowed to separate the upper phase being clear.

The stoppers were washed carefully with a few of hexane collecting washings in the tubes. Special crooked siphon tubes (with a draw off level of 1-2mm above the aqueous level) were used to transfer the upper phase from each tube to 100ml beaker flasks containing two anti-bumping stones/chips each. The washings were blown off into the beaker flasks, by raising the siphon tubes above and rinsing them with about 5ml hexane, without disturbing the lower phases. The beaker-flasks were covered with watch glasses and mixed solvents were evaporated on a hot water bath. The beaker-flasks were cleaned with a clean cloth and placed into the oven at 95°C for drying. From the oven the beaker-flask were placed on dry glass/metal plates to cool before weighing.

3.7.6. Crude Fiber Determination

Crude fiber is that which is insoluble and combustible residue which remains after the sample has been treated under prescribed conditions, for example consecutive treatments with light petroleum, boiling dilute sulphuric acid, boiling dilute sodium hydroxide, dilute hydrochloric acid, alcohol and ether. The product largely consists of hemicelluloses and lignin.

5g samples were transferred to a thimble and extract with ether in Soxhlet for several hours to remove fat. The defatted samples were transferred for weighing in beakers. And most of the ether was allowed to evaporate on top of an oven. Finally, samples were dried for 1 hour at 105°C, cooling was done in a desiccator. It is the defatted sample which was used for crude fiber determination hot plate

was switched on for about 5 minutes before commencing and at the same time H_2SO_4 was heated. 2g of defatted dry samples were transferred to 750 ml Erlenmeyer flask (ground stoppered). 200ml of boiling 1.25% H_2SO_4 then added and swirling was done and the flask was placed on a hot plate immediately for the acid in the flask to boil for 30 minutes. A reflux condenser with air tube was then connected. At this time the alkali solution was brought to incipient boil.

The flasks were moved from the source of heat and filtered immediately through Whatman papers (11cm) in Hartley funnels using only gentle suction, washings were done several times with boiling water. The funnels were then dismantled and filter papers were placed in large 90°C funnels. Using 200ml boiling NaOH solution contained in a wash bottle, residues on the filter papers were washed into original Erlenmeyer flasks. Immediate filtrations were done through Whatman 541 12.5cm papers in 60° funnels, washes with hot water, 1% hot acidulated water and finally twice with 95% ethanol were done. Draining was allowed for 10 minutes and the residue on the filter papers quantitatively transferred to a previously ignited crucible. The crucibles and contents were placed in hot air oven at 105°C. Cooling was done in a desiccator, weighed and ignited at 550°C reweighed.

3.7.7. Protein Determined

Appropriate quantities of prepared samples were placed into 700ml kjeldahl flasks. At the same time a blank was prepared. 30-40 ml concentrated H_2SO_4 , 10.6 kg of kjeldahl catalyst, boiling chips and 1 selenium tablet was added to each kjeldahl flask including the one with the blank. The flasks were placed over an electric hot plate. Heating was cautiously done at first in case of frothing and finally boiled at red heat (with occasional rotation to disperse charred particles) until solution is clear and free from yellow colorants. The incipient boiling was maintained for a further 60 minutes. The flasks were cooled, and 300ml of distilled water was added and re-cooling was allowed. Then, 3 drops of silicone antifoam, 1ml phenolphthalein indicator, 100mls sodium hydroxide and a few pieces of granulated Zinc were added to the kjeldahl flasks.

The receiving 500ml Erlenmeyer flasks were then prepared adding 40ml boric acid and about 10 drops of mixed indicator without undue delay connection was done to splash heads on a distillation bank with the end of the vertical condensers just dipping into the liquid in the prepared receiving flasks. After the connection the flasks were swirled to distribute the alkali, such that at this stage the solution would be alkaline and show a red violet coloration. Finally, the hot plate was turned to maximum heat and rapid distillation was done to 250-300 ml, lowering the receiving flasks and the heat was turned off. Titration was then done with 0.2 NH_2SO_4 to a pink end point. And finally, calculations were done for determine protein concentration.

3.7.7. pH Determination

Each 5g sample was added to 10 ml of water and brought to heat to form a thick paste (10 % of the package high fiber porridge) and cooling was done. The electrode of a pH meter was removed from a buffer solution with a Ph of 4.0, and was wiped and rinsed with distilled water and was then dipped into the sample and readings were noted as the procedure was repeated for all samples.

NB: Carbohydrate, energy determination was calculated by using results obtained from protein, fat, moisture, crude fiber and factor values.

3.8. Sensory Evaluation

According to Srilakshmi (2003), sensory evaluation is when the quality of a food product is assessed by means of human sensory organs. When the quality of food is assessed by means of human sensory organs the evaluation is said to be sensory or subjective or organoleptic. Watts, Ylimaki, Jeffrey and Elias (1989) reveals that the senses used are sight, taste, touch and smell to evoke,

measure, analyses and interpret reactions to the characteristics of food which they perceive. Subjective methods of evaluation of food quality have been developed scientifically through an understanding of the manner in which sensory organs function to detect colour, taste, flavor and others all affecting the quality and acceptance of food. Food is subjected to sensory evaluation because it is the acceptability of the consumer that is the final determinant of change in the processing of a product.

Sharma (2010), postulates that, every time food is eaten a judgement is made. Quality is a very important parameter for judging the edible nature of any food. Sensory quality is a combination of different perception that comes into play in choosing and eating foods. Appearance can be judged by the eye for example colour, uniformity and absence of defects. The effective characteristic is not the property of the food, but the subject's reaction to the sensory qualities of the food. The reaction is highly conditioned by a variety of psychological and social factors and in final analysis, plays a vital role in the acceptance and preferences of food products. Mouth feel is the texture determined by how food feels on the tongue. Taste is dependent on taste buds and Odour on the volatilization of food compounds to be picked by the nose and all three contribute to the flavor of the porridge.

In this research sensory evaluation was done by 30 people at the Zimbabwe Diabetic Association using a Hedonic rating test which was aimed at measuring how acceptable the high fiber porridge. The porridge was rated according to how much it is liked or disliked by the panelists. The limits of the scale were 0-5 that was extremely dislike and extremely like. After the rating on pre-mentioned scales, the results were analyzed for preference with data from large untrained panel according to Sharma (2010).

4. Results and Discussion

Table 4: Formulation of samples 1 to 10

Sample number	Ingredients Ratio to Make 100 grams
1	80 g undefatted millet 10 g undefatted macadamia nuts 10g banana
2	80 g undefatted millet 10 g defatted macadamia nuts 10g banana
3	80 g fermented millet 10 g defatted macadamia nuts 10g banana
4	80 g defatted millet 10 g defatted macadamia nuts 10g banana
5	80 g fermented millet 10 g undefatted macadamia nuts 10g banana
6	80 g defatted millet 10 g undefatted macadamia nuts 10g banana
7	65 g fermented millet 25 g defatted macadamia nuts 10g banana
8	70 g fermented millet 15 g defatted macadamia nuts 15g banana
9	75 g fermented millet 15 g defatted macadamia nuts

	10g banana
	90 g fermented millet
10	5 g defatted macadamia nuts
	5g banana

Table 5: Experimental analysis (per 100 grams) of all 10 samples

Parameter	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Microbiology										
Coliforms (cfu/g)	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG
<i>E.coli</i> (cfu/g)	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG
<i>Salmonella</i> (cfu/g)	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG
<i>Shigella</i> (cfu/g)	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG
<i>S.aureus</i> (cfu/g)	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG
<i>B.cereus</i> (cfu/g)	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG
Yeasts (cfu/g)	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG
Moulds (cfu/g)	39	06	NG	NG	NG	NG	NG	NG	NG	NG
Chemical moisture %	7.2	6.2	4.5	6.5	4.8	6.7	5.0	4.3	5.3	3.0
Fat %	8.5	6.8	4.5	4.0	8.5	7.3	5.5	5.3	5.3	3.3
Crude fibre %	25.3	19.2	10.5	10.2	11.3	21.0	9.0	10.0	11.0	14.5
Protein %	17.0	12.4	15.2	15.2	15.0	16.0	14.3	15.0	14.6	12.9
Carbohydrate%	42.0	55.5	65.3	64.1	60.5	49.0	66.3	65.5	64.0	66.3
Energy (kcal/g)	301.9	318.4	346.7	337.2	363.0	331.2	355.1	352.9	345.3	329.6
Ph	6.1	6.3	5.9	6.4	6.1	6.4	6.1	6.0	6.0	6.0
Ash %	2.5	2.0	2.0	2.0	1.8	2.7	3.0	2.0	2.3	1.8
Pb (ppm)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cu (ppm)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zn (ppm)	35.9	41.8	42.0	39.9	40.5	45.9	39.7	38.3	43.7	44.9
Fe (ppm)	50.5	49.6	39.0	51.5	43.7	56.1	43.3	38.9	66.8	47.0
Cd (ppm)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Na (ppm)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
K (ppm)	664.6	768.9	872.3	741.9	676.8	674.0	764.2	840.0	887.4	658.2

ND - Not Detected, NG - No Growth, cfu/g - colony forming units per gram (kcal/g) - kilocalories per gram, Pb - Lead Cd – Cadmium, Na - Sodium Cu – Copper, K - Potassium Zn – Zinc, ppm - parts per million (milligrams per kilogram).

Table 6: Key of comparison market samples

All Bran	A
Bran flakes	B
Corn flakes	C
Weetabix	D
Rice Krispes	E
Jungle Oats	F
Morvite	G
Cerevita	H
Ace Instant Porridge	I
Corn Soya Blend	J

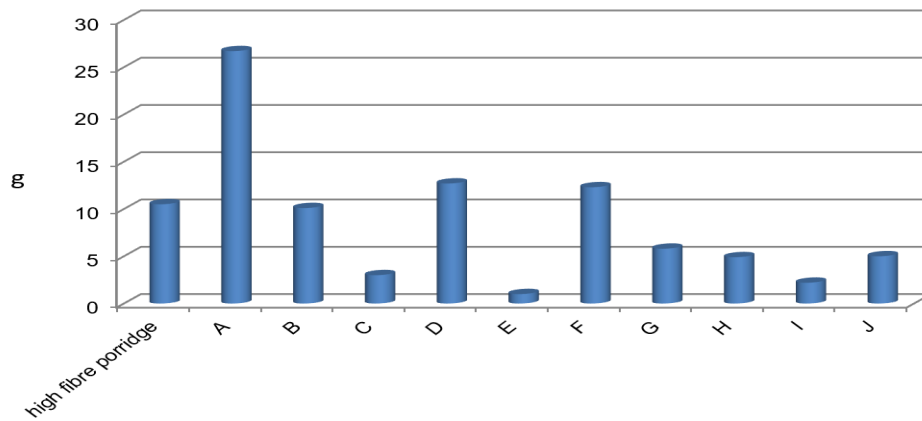


Figure 5: Fiber content per 100 g

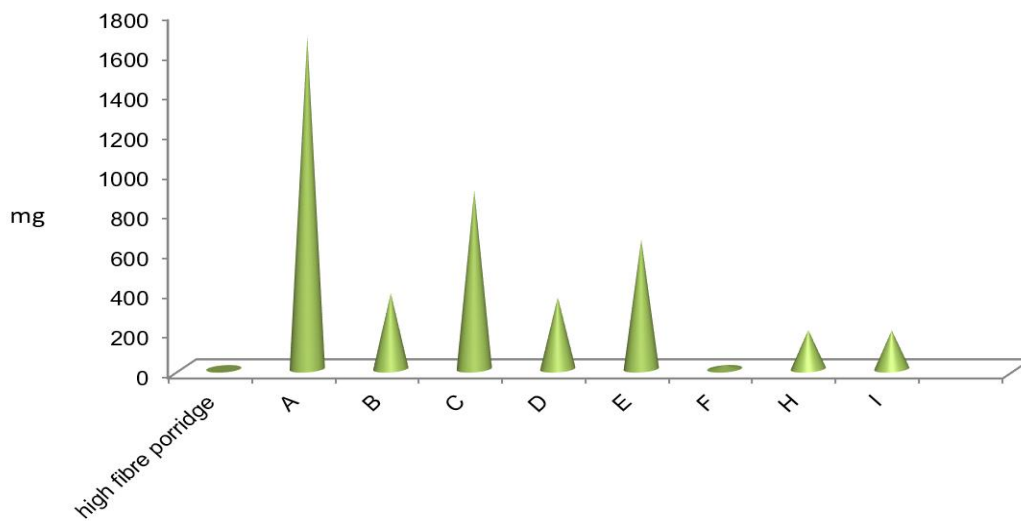


Figure 6: Sodium content per 100 g

This study serves to show that the porridge developed is high in fiber because according to Food and Food Standards (Food Labelling) Regulations, 2002 Fourth Schedule (Section 6) Part A, for a food to be claimed to be high in fiber it should have it from 6 g per 100 g and above, thus the developed porridge has 10.5 g per 100 g which is high. As illustrated above the developed product fall in the range of other cereals or porridges which are regarded to have high fiber such as A, B, D and F which already exist on the market (Figure 1).

As illustrated above in Fig 6, the sodium content of the developed porridge was 0 because it was not detected during chemical analysis by the Absorption Spectrum since no salt or any sodium containing additive was added during its development. Thus, the developed high fiber is said to be sodium free according to Food and Food Standards (Food Labelling) Regulations, 2002 Fourth Schedule (Section 6) Part A. Porridges or cereals with sodium below 40 mg are said to be very low in sodium and those with sodium below 120 mg are said to be low in sodium and those having levels above 120 mg are said to be high in sodium (Figure 2).

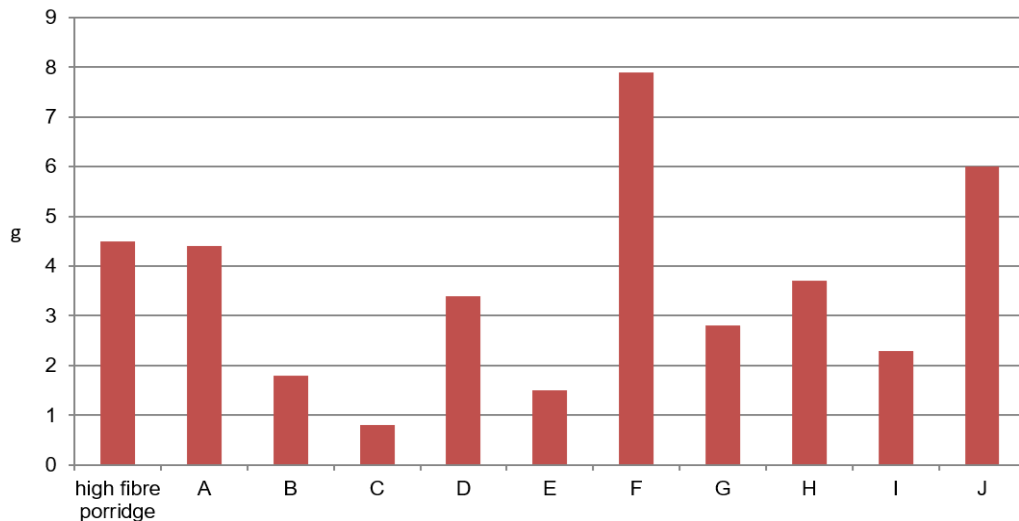


Figure 7: Fat content per 100 g

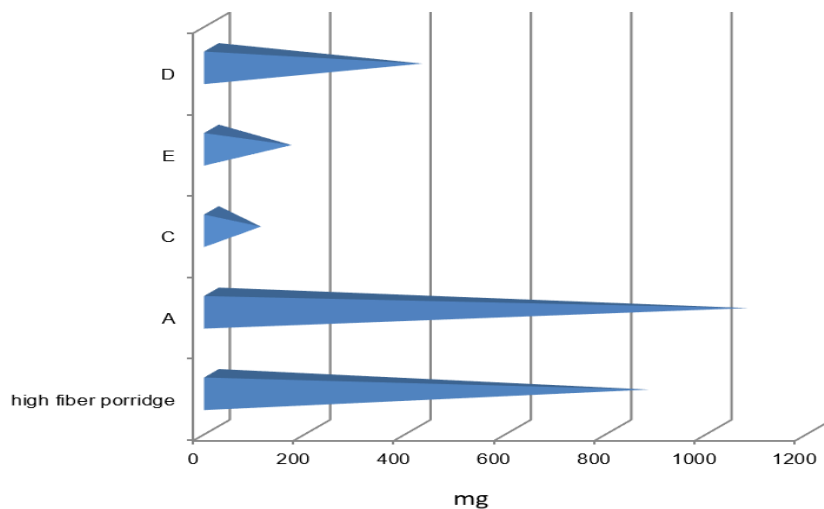


Figure 8: Potassium content per 100 g

Food and Food Standards (Food Labelling) Regulations, 2002 Fourth Schedule (Section 6) Part A, the developed porridge contains moderate or medium fat at 4.5 g per 100g because foods with fat content between 3 - 20 g per 100g is said to be moderate and as illustrated above in Figs 7 and 8 most porridges or cereals fall within that range. Some cereals and porridges which have 3g or less are regarded to be low in fat such as C, E, B and G (Figure 3).

As demonstrated above the developed porridge has a much higher potassium content almost as high as that in A as compared to other cereals or porridges on the market such as C, D and E, this is due to the banana which is part of the ingredients used to make the porridge (Figure 4).

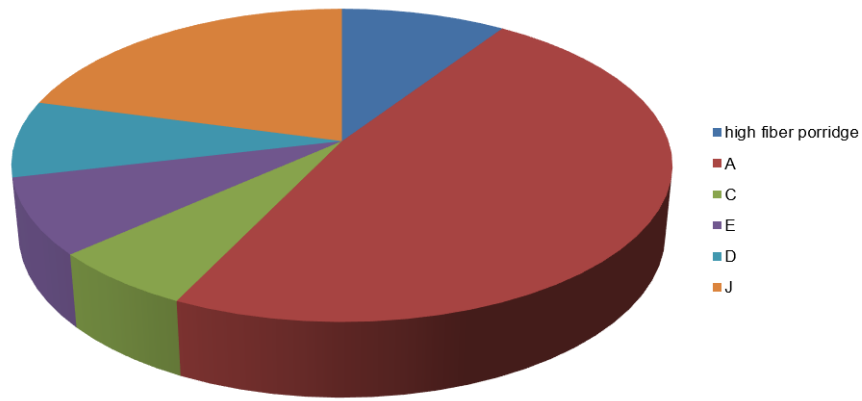


Figure 9: Moisture content per 100 g

Since the porridge developed was developed basing on the corn soya blend which is also a dry product which was analyzed and used a guide or standard at Government Analyst Laboratory its moisture content of 4.5% is acceptable for such a dry product in comparison with the corn soy blend which has a moisture content of 10% (Fig 9). Also, as shown below (Fig 10) most of the porridge or cereals available on the market has a moisture content between 2-10% to improve the keeping quality (Figure 5).

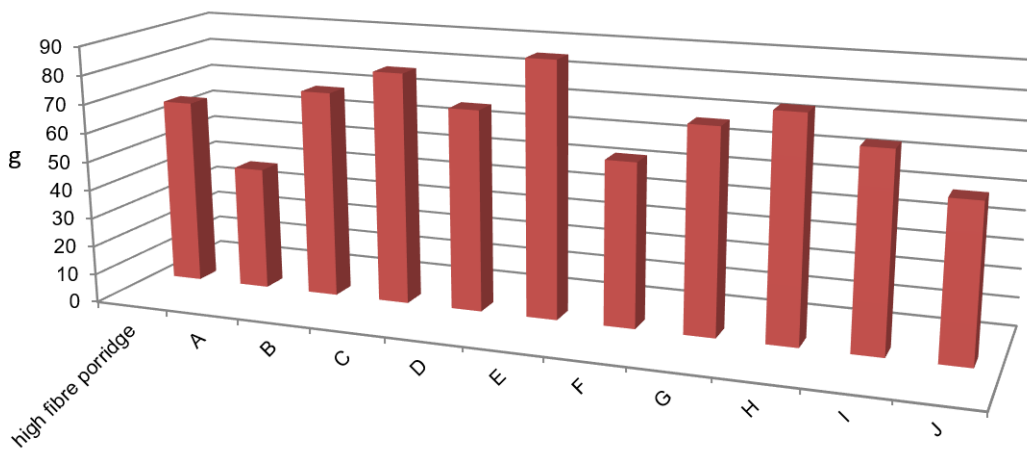


Figure 10: Carbohydrate content per 100 g

This study shows that the developed porridge contains an acceptable carbohydrate content since in comparison with the guide, J contains 54 g, the developed porridge has 65 g which falls in the range for other porridges and cereals already available on the market which ranges from 43 g - 90 g. The developed porridge is sugar free since no sugar was added as part of its ingredients (Figure 6).

The protein content of the developed porridge falls within the range of other porridges and cereals at 15.2 g which is almost the same level as all B, F and J. But as presented above most porridges and cereals have protein content between 5 - 16 g, so the developed product falls within the acceptable range (Figure 7).

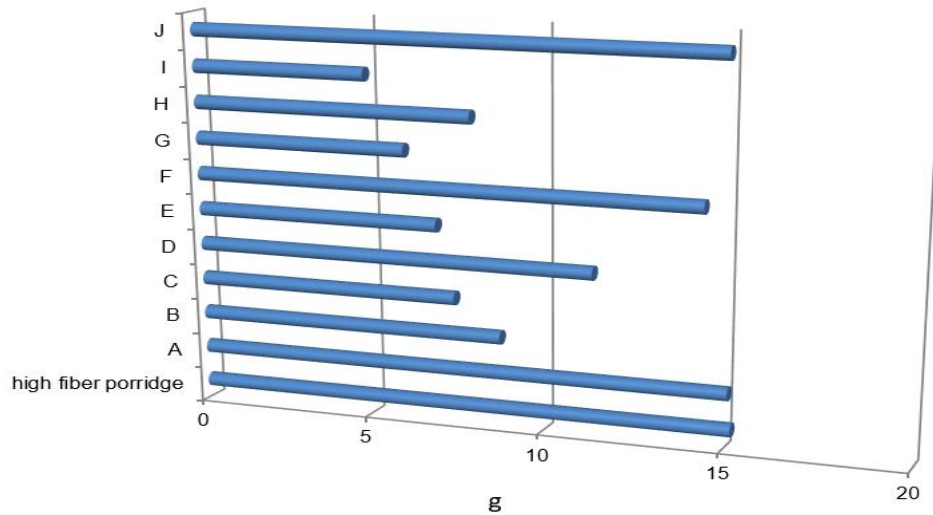


Figure 11: Protein content per 100 g

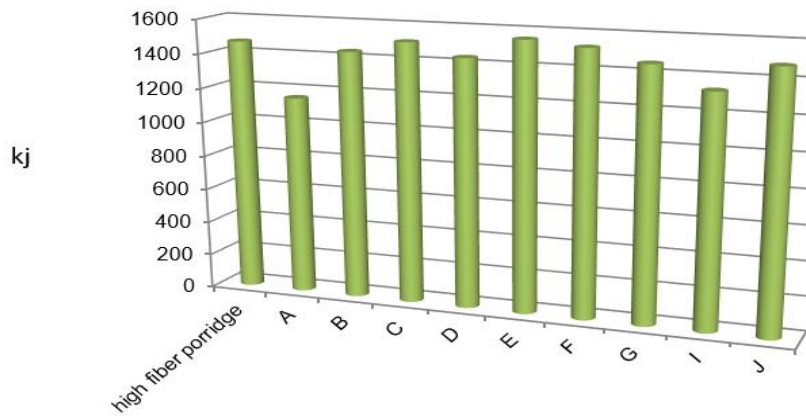


Figure 12: Energy content per 100 g

The value of the developed porridge falls within the range of other porridges and cereals at between 1156 -1556 kJ per 100 g. So, the developed product falls within the acceptable range at 1469 kJ (Figure 8).

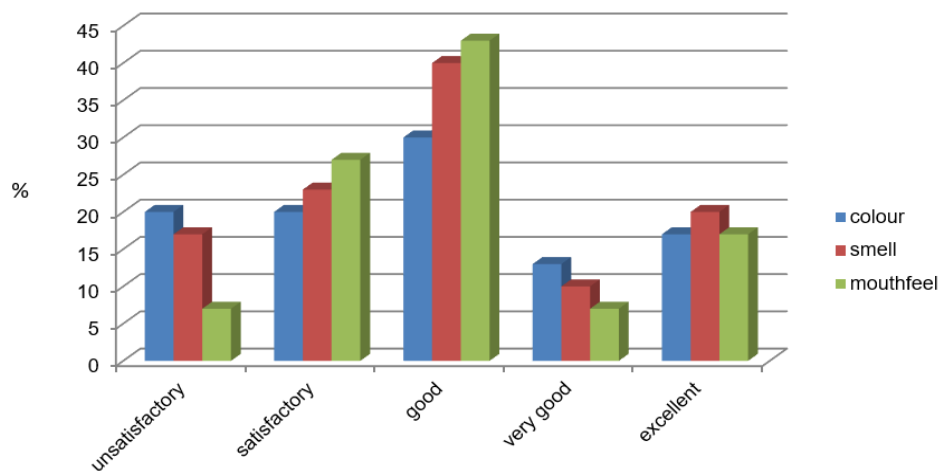


Figure 13: Colour, smell and mouth feel evaluation results

According to Srilakshmi (2010), colour is an index of quality to induce product acceptance through sight which plays a role in the assessment of the lightness of foods. The high fiber porridge is expected to have a particular colour since it is millet based. Flavor has three components which are odor, taste and mouth feel. Mouth feel is attributed to by the texture which is how the food feels on the tongue. A substance which produces odor or smell must be volatile and the molecules of the substance must come in contact with receptors in the epithelium of the olfactory organ. Aroma is able to penetrate even beyond the visual range then comparatively volatile compounds are abundant. The volatility of aroma is related to the temperature of the food. High temperatures tend to volatilize aromatic compounds, making the quite apparent for judging, cool and cold temperatures inhibit volatilization. As shown in Figure 13 above colour had an acceptance level of 80%, smell had an acceptance level of 83% and mouth feel had an acceptance level of 93% because the porridge cooked well and produced a fairly thick consistency (Figure 13).

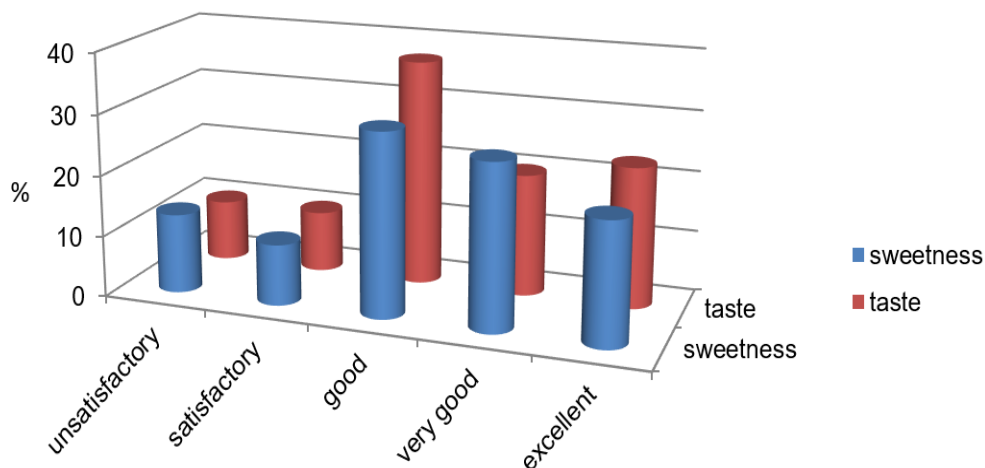


Figure 14: Sweetness and taste evaluation results

Srilakshmi (2010), explained taste as a sensation which is registered by taste buds such as bitter or sweet. Food is valued for its taste; hence the millet-based porridge is expected to have a certain taste, due to its constituency. Figure 14 shows that sweetness had an acceptance level of 83% and taste had an acceptance level of 90%. Food is accepted when there is a pleasant association between colour, mouth feel, smell, taste and sweetness. The overall acceptance level of the porridge was 85.5%. According to Troccaz (2011), other studies reveal that temperature pose an effect on sensory quality. People who first tasted the porridge will it was hot or warmer gave a different judgement from those who last tasted the porridge while it was now less warm or almost cold rather. Watts et al (1989), stipulates that mouth feel can be determined by the chewiness of food until it is ready for swallowing, to evaluate the force required to penetrate food product on the market (Figure 10).

Discussion

According to Paul and Southgate (1998), many breakfast porridges are packed at moisture content of around 2-10%, but rapidly absorb moisture once the packet is opened. This makes the high fiber porridge acceptable because at a moisture content level of 4.5% it falls within that range. Other breakfast porridges may be fortified, but the high fiber porridge was not fortified. Vitamin loss is significant during cooking of porridges, since most vitamins are heat liable. The high fiber porridge is acceptable since cooks well, with maximum gelatinization giving a fairly thick consistency depending on the quantity of the cooking milk or water.

According to the Food and Food Standards (Food Labelling) Regulations Fourth Schedule (Section 6) Part A (2002), the high fiber porridge qualifies to be claimed a high fiber product at 10.5 g fiber per 100 g, because for any product to be claimed for high fiber it should have 6 g of fiber per 100 g or more. The high fiber porridge is also sugar free because no sugar was added to the product during its manufacture, which is suitable for diabetic people. Any product with 0.5 g of sugar or less is considered sugar free. The product is also sodium free because no sodium was detected, despite the fact that no salt was added during the porridge manufacture. Any product with 5 mg of sodium or less per 100 g is regarded as sodium free. Therefore, the high fiber porridge is suitable for Diabetic people because it helps them stick to their recommended daily allowances.

The high fiber porridge does not taste so sweet because it contains no sucrose (table sugar), but contains a little amount of fructose attributed to by the banana. Diabetic people have the same nutrient requirements as everyone else, but the percentage of nutrients may differ from a normal diet. Food and Food Standards (Food Additives and Prohibited Substances) Regulations First Schedule (Section 3) (2001), the high fiber porridge is acceptable because it contains no detectable poisonous substances such as Lead, Mercury, Zinc and which makes these substances fall within the acceptable limits making the product suitable for human consumption.

According to Howthorn (1981), if reliable results are to be obtained during sensory evaluation, the taste panel work must be carried out in an appropriate surrounding, in a quiet room set aside for the purpose and the environment must be free from other smells such as those from the cooking of other foods not linked to the procedure. Lighting must be constant when colour assessment is to be made. However, the taste panel used was untrained and this might have affected the outcome of the sensory evaluation results. Also, the taste panel were in the same room and not in booths, so they were able to see each other which might have resulted in them influencing each other through facial expressions, for instance in the sourness of the fermented porridge.

5. Conclusions

This chapter gave a detailed and clear overview of the results. A presentation was given on the results of the research findings to show the relationship between the results, objectives of the study and the hypothesis.

The research was too a greater extend successful because the researcher conducted many formulations and processes to finally come up with the best porridge, which was then compared to other porridges and cereals already known on the market to reveal if the high fiber porridge fit in the range of other known porridges and cereals and if it had a better chance on the market as well. The high fiber porridge fit to have a high fiber claim and its nutritional constituency is suitable for a porridge product according to the Food and Foods Standards at Government Analyst Laboratory. The results in the previous chapter show a clear picture of how the product is was successfully developed because it met the recommended standards and it fit well among other products on the market.

All the objectives were met clearly and the hypothesis H₀2 to H₀5 were accepted as compared to already known products. The first two objectives were met through various processing techniques and formulations. The third and fifth objectives were met by all the analysis done at Government analyst laboratory. The fourth objective was fulfilled by consumer evaluation process at the Diabetic monthly meeting at Zimbabwe Diabetic Association. The development of the high porridge was proved to be successful and of significance to many including non-diabetic people.

The high fiber porridge was liked very much, consumers were astonished with such a brilliant idea and they were actually asking when they would expect to see the product on the market so they can purchase it, because the product could help solve their problems. The laboratory physicochemical

analysis done determined that the porridge is suitable for human consumption because it is free from toxic substances such as heavy metals and microorganisms. Consumers accepted the porridge because it cooks well, is not sweet since it contains no sugar and has a unique flavor as evidenced from their comments.

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