FLOUR FROM THE MORAMA BEAN: COMPOSITION AND SENSORY PROPERTIES IN A BOTSWANA PERSPECTIVE

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DECLARATION

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and that I have not previously, in its entirety or in part, submitted it at any university for a degree.

Signature: …….

Date: ……

ABSTRACT

This study was undertaken in view of the high incidence of malnutrition problems such as protein-energy malnutrition and diabetes type 2 in countries like Botswana, and due to worldwide interest in underutilised and underdeveloped crops.

Morama bean, the seed of *Tylosema esculentum* (family Fabacae), occurs naturally in the drier areas of Southern Africa, including Botswana, where it is, to a small extent, harvested as wild plant for human consumption. Due to the potential of this crop there is increasing interest in its cultivation. Despite its traditional use as food source in Botswana, little is known about its nutritional value, benefits and disadvantages, and its use as food was therefore the reason for this research. A specific aim was to improve the school feeding programme with this readily available indigenous product.

To establish the effect of cultivation on the quality of the product, Morama Beans were sourced from wild and half-wild plants which grow as natural intruders in fields where other crops are cultivated. No significant differences were noted, which indicates that cultivation practices do not affect the product adversely.

Because the raw product is not palatable, the beans are traditionally roasted. In this study four heat applications were made and the products were milled. Firstly, sensory evaluation was conducted to identify the product with the best sensory profile and secondly, the effect of heat treatments on nutritional composition was established. With regard to the sensory profile, a trained panel established that a heat treatment at 150°C for 20 minutes gave the most favourable sensory profile. Different heat treatments did not have a significant effect ($p>0.05$) on the nutritional composition, but the treatment at 120°C for 40 minutes contained significantly more moisture.

Consequently the flour with the best sensory profile (150°C for 20 min) was added at different concentration levels to two traditional Botswana dishes, namely sorghum porridge and samp & beans (*dikgobe)*. Firstly, it was established which level of supplementation was the most acceptable for a focus group of seven Batswana. They preferred the 5% level of supplementation. Secondly, the nutritional contribution (macronutrients, gluten content and calculated glycaemic index value) of both dishes at the 5% supplementation level was established within a meal-plan. The addition increased the protein content by 27 g and the fat content by 29 g per meal-plan and made a significant contribution to magnesium, zinc and iron content.

Due to the increase in celiac disease, the gluten content of Morama Bean flour was investigated, as Morama Beans, unlike other legumes, have high prolamine content. The results indicate that Morama Bean flour can be included in a gluten-free diet – a property that will support the gluten-free properties of both sorghum and samp. Glycaemic index (GI) calculations showed that

Morama bean flour at a 5% level can lower the glycaemic index (GI) of sorghum porridge from a high GI food to an intermediate GI food. The benefit thereof in an environment where a high GI diet is a real risk factor for obesity, diabetes type 2 and cardiovascular diseases becomes evident.

OPSOMMING

Hierdie studie is onderneem in die lig van die hoë voorkoms van wanvoedingsprobleme soos proteïen-energiewanvoeding (PEW) en diabetes tipe 2 in ontwikkelende lande soos Botswana, en vanweë die wêreldwye belangstelling in onderbenutte en onderontwikkelde oesgewasse.

Moramabone, die saad van *Tylosema esculentum* (fam. Fabaceae) kom natuurlik voor in die droër dele van suider-Afrika, insluitend Botswana, waar dit tot 'n geringe mate van wilde plante geoes word as menslike voedsel. Weens die potensiaal van hierdie gewas is daar toenemende belangstelling om dit as oesgewas te verbou. Ten spyte van sy tradisionele gebruik as voedselbron in Botswana, is baie min egter bekend van sy voedingswaarde, voordele en nadele, en die gebruik daarvan as voedsel, om welke rede hierdie navorsingsprojek onderneem is. Dit het spesifiek ten doel om die skole-voedingsprogram te verbeter met 'n geredelik beskikbare inheemse produk.

Ten einde die uitwerking van verbouing op die gehalte van die produk vas te stel, is Moramabone geoes van wilde plante en van halfwilde plante wat as natuurlike indringers tussen ander aangeplante gewasse in landerye groei. Geen beduidende verskille kon bespeur word nie, wat daarop dui dat verbouingspraktyke nie die gehalte van die produk nadelig beïnvloed nie.

Omdat die rou produk onsmaaklik is, word die bone tradisioneel gerooster. In hierdie studie is vier hittebehandelings toegepas, waarna die produk gemaal is. Eerstens is ‘n sensoriese evaluasie onderneem om die beste sensoriese profiel uit die behandelings vas te stel en tweedens is die invloed van verskillende hittebehandelings op voedingstofsamestelling bepaal. Wat betref die sensoriese profiel het ‘n opgeleide proepaneel gevind dat ‘n hittebehandeling van 150°C vir 20 minute die beste is. Verskillende hittebehandelings het nie 'n beduidende uitwerking op voedingstofsamestelling gehad nie, maar die behandeling by 120°C vir 40 minute het beduidend meer vog bevat.

Vervolgens is die meel met die positiefste sensoriese profiel (150°C vir 20 minute) teen verskillende konsentrasievlakke gevoeg by twee tradisionele disse van Botswana, naamlik sorghumpap en stampmielies-en-bone (*dikgobe*). Hiermee is eerstens vasgestel watter vlak van supplementasie sensories die aanvaarbaarste is vir ‘n fokusgroep bestaande uit sewe Batswana. Die fokusgroep het 'n aanvullingsvlak van 5% as die aanvaarbaarste verkies. Tweedens is die voedingsbydrae (makronutriënte, gluteninhoud en berekende glisemiese indekswaarde) van hierdie 5% supplementasievlak tot die maaltydplan bepaal. Hierdie vlak van toevoeging het die proteïeninhoud met 27 g, en die vetinhoud met 29 g per maaltydplan verhoog, en 'n wesenlike bydrae gelewer tot die magnesium-, sink-, en ysterinhoud.

Vanweë die toename in seliaksiekte in Botswana is die gluteninhoud van Moramaboonmeel ondersoek, aangesien hierdie produk, anders as ander peulgewasse, ‘n hoë prolamieninhoud het. Die resultate het daarop gedui dat Moramaboonmeel in ‘n glutenvrye dieet ingesluit kan word – ‘n eienskap wat verder die glutenvrye aard van sorghum en stampmielies sal ondersteun. Berekeninge van glisemiese indeks (GI) waarde wys dat 'n toevoeging van 5% Moramaboonmeel die GI van sorghumpap van 'n hoë GI-voedsel na 'n intermediêre GI-voedsel wysig. In 'n omgewing waar 'n hoë GI-dieet 'n wesenlike risikofaktor is vir oorgewig, diabetes tipe 2 en kardiovaskulêre siektes, is die voordeel hiervan vanselfsprekend.

MORAMA BEANS

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Introductory perspectives

1.1 Introduction

*Tylosema esculentum (*family Fabaceae*)* ─ colloquially known *as* Morama or Marama Bean in Setswana (Botswana), Braaiboonjie, Maramaboontjie and Elandsboontjie in Afrikaans (Van Wyk & Gericke: 2000: 26), and Gemsbok Bean in English (Smith, 1966:569) ─ is widespread, with large populations in Botswana (around the central Kgalagadi) and Namibia, and smaller populations in the provinces of Limpopo, North-West and Gauteng of South Africa (Verdoorn, 1959; Coetzer & Ross 1977; International Cooperation with Developing Countries Report: 2004:3). It grows in open sand veld and open grass and bush savannah (Amarteifio & Moholo, 1998). The plant is a creeper, it has prostrate branches that grow up to six metres long and its seeds are contained in pods that dehisce when dry. It is adapted to the harsh conditions of Botswana, which are characterised by low rainfall and nutritionally poor soils (Botswana Ministry of Finance & Development Planning, 2003:4). It is a staple food of the Basarwa people ─ Batswana tribe in the Kgalagadi desert (Amarteifio & Moholo, 1998). Figure 1.1 shows the distribution of Morama Bean in southern Africa.

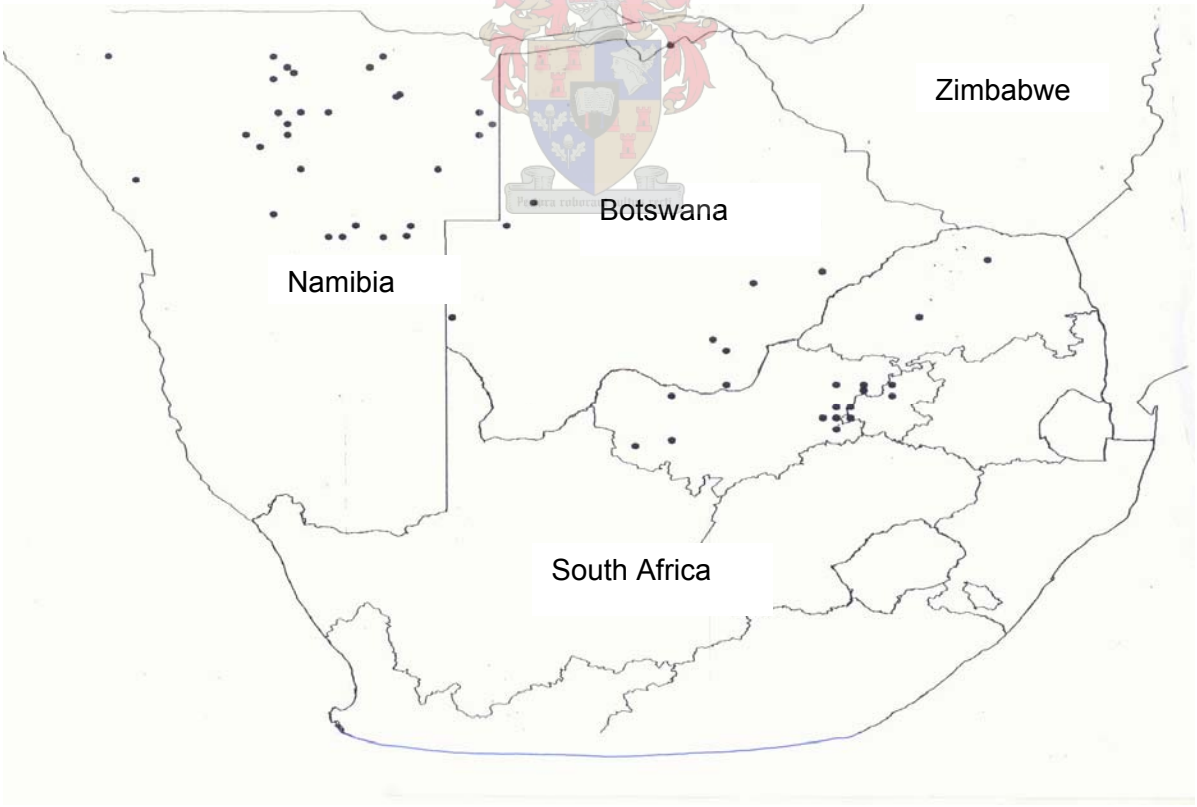

Figure 1.1 Geographical distribution of *Tylosema esculentum* (taken with permission from the PRECIS and ACKDAT data bases of the South African National Biodiversity Institute).

Although Morama has long been identified as a food source (Smith, 1966:225; National Academy of Sciences 1979:3; Keegan & Van Staden, 1981; Hartley, 1997:31; Amarteifio & Moholo, 1998), research on Morama has been more focused on cultivation than on food product development. The raw seeds are hard, and have been described as having a soapy taste. When young, the green beans can be boiled as green vegetables similar to green peas (self observation), while the dry beans are roasted and eaten as a snack. It can also be boiled and eaten as porridge or used as a beverage, like cocoa (Menninger, 1977:101). This bean is seasonally available (June/July) in the local markets in a raw form (self observation) with no nutritional information for the consumers.

Literature reports a wide range of nutrition levels in respect of protein and fat. Amarteifio and Moholo (1998) report that Morama seed contain 34% protein and Hartley (1997:31) reports 30% protein. Hartley (1997:31) further reports 40% fat while Amarteifio and Moholo (1998) report 33,5% fat. These results indicate that Morama Bean is an extremely valuable indigenous food that is high in protein, carbohydrate and fat, and which can help combat malnutrition in the human population. These macronutrients also contribute to the high-energy value of Morama Bean. This plant therefore seems to have a great potential as a food crop

Several reports indicate that the inclusion of pulses (also implying Morama Bean) in the daily diet has many beneficial physiological effects in controlling and preventing various metabolic diseases such as diabetes mellitus, coronary heart diseases and colon cancer (Mazur, Duke, Wahalal, Rasku & Adlercreutz, 1998; Marlett, McBurney, & Slavin, 2002). Currently the role of pulses as therapeutic agent in diets of persons suffering from metabolic disorders is gaining interest (Tharanathan & Mahadevamma, 2003). At a time where the glycaemic response of foods has become very topical, it is of interest to note that dry pulses as a food elicit a low blood glucose response (Thompson, 1988). The factor most contributing to the low glycaemic index of pulses is its physical form. The fibrous coat around beans and seeds and intact plant cell walls act as a physical barrier, slowing down access of digestive enzymes to the starch inside, while protein-starch and fat-starch interactions taking place during cooking also slow down digestion (Brand Miller, Foster-Powell & Colagiuri 1996:30; Vosloo, 2005).

Malnutrition is a global concern and Botswana is faced with these challenges among children and adults. The Botswana Ministry of Finance and Development Planning (2003:316) documented an increase in malnutrition from 0, 5% in 1996 to 2% in 2000. Adequate use of Morama Bean could support a national initiative (as in the case of South Africa) towards the solution of malnutritional problems. Supporting this view, *The natural food hub* [s.a] supports the utilisation of local foods such as Morama Bean. Encouraging consumers to make good choices when purchasing food, this research will also furnish Botswana consumers with a nutritional profile of the Morama Bean. At a time when the demand for protein and energy sources for human and animal consumption is on

the increase and is likely to continue to do so (Kandawa-Schulz, Museler & Naomab, 2002:29), this research and value-added product development using Morama Bean flour is therefore timeous.

This research investigated the nutritional composition (in terms of protein, fat, fibre, moisture, fatty acids and amino acids) and sensory properties of Morama Bean as an essential step for the food industry wishing to embark on food production with Morama Bean flour as an ingredient. Previous information on the development of Morama Bean flour is scant therefore this research has adopted the heat treatment methods that are suitable for roasting peanuts (see Chapter 2). There are already programmes aimed at educating local populations with regard to nutritional benefits of many wild plant foods that exist in their environment (Kuhnlein, 2000) and Morama Bean can be added to these. The nutritional information reported in this research should enhance efforts to promote the wider use of wild foods such as the Morama Bean under investigation.

1.2 Goals and subgoals

The aim of this study is to develop and establish the influence of sampling area and heat treatment during the production on the nutritional composition and sensory attributes of Morama Bean flour.

The subgoals of the research were to

- Develop bean flour from beans systematically collected from five wild localities and two fenced localities in the Kgalagadi area, then subject the collected bean samples to different heat treatments, namely 120 ºC for 40 min, 150 ºC for 30 min, 150 ºC for 25 min and 150 ºC for 20 min (see Chapter 3).
- Analyse the 28 samples (7 localities x 4 heat treatments) for protein, fat, carbohydrate, fibre, moisture, fatty acids and amino acids content (Phase 1, Figure 1.2). Results are reported in Chapter 3.
- Evaluate the variation in nutritional composition of beans from seven different sampling localities (Phase 1, Figure1.2). Results are reported in Chapter 3.
- Evaluate the impact of seven sampling localities wild (1-5) and fenced (1&2) on the nutritional composition of Morama Bean flour with four heat treatments (Phase 1, Figure1.2). Results are reported in Chapter 3.
- Evaluate the sensory attributes of the sample treatments that have proved to show superior nutritional characteristics in order to identify the sensory profile thereof (Phase 2, Figure1.2). Results are reported in Chapter 4.

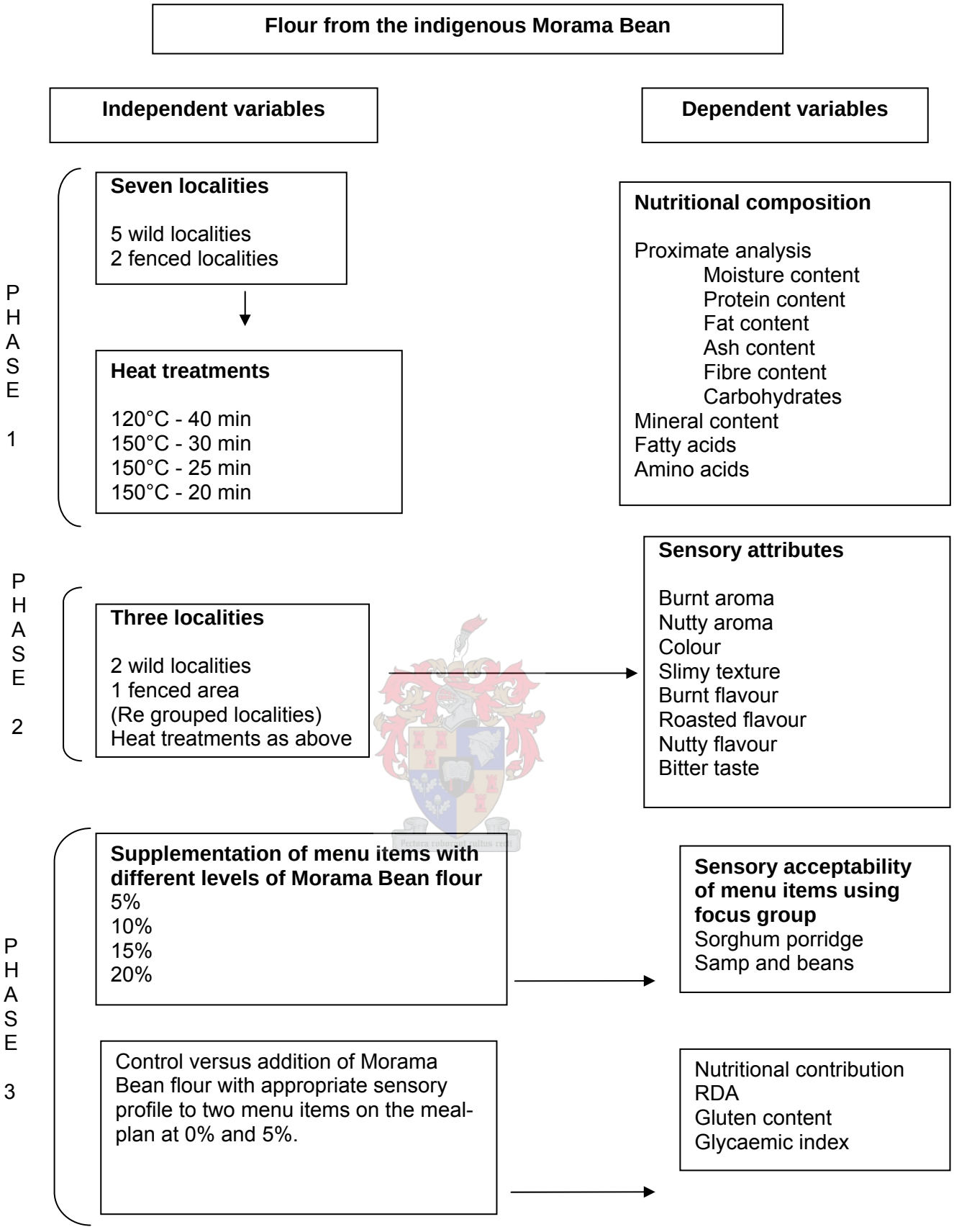

Figure 1.2 Conceptual framework for the independent and dependent variables of the study.

- Evaluate two traditional Botswana dishes, samp & beans and sorghum porridge with different levels of Morama Bean flour (5%, 10%, 15%, and 20%) using a focus group (Phase 3, Figure1.2). Results are reported in Chapter 5.

- Monitor the potential nutritional contribution of Morama Bean flour (5% level) to the meal-plan of Botswana school learners (Phase 3, Figure1.2). Results are reported in Chapter 6.

In view of the scope of the study a conceptual framework was developed (Figure 1.2) which summarise the independent and dependent variables with appropriate detail of each subgoal.

Figure 1.2 shows production of Morama Bean flour from seven different localities by application of four heat treatments. The independent variables of the study for the first subgoals (Phase 1 of study) were therefore seven geographical localities and four heat treatments and the dependent variable was nutritional composition. Having found that there was no significant difference ($p>0.05$) in the nutritional composition between the beans from two fenced localities (F1 and F2) and the five wild localities (W1–W5), the sensory profile of the Morama Bean flour was evaluated after regrouping the seven localities into three groups and applying the same four heat treatments (Phase 2 of the study). The third Phase of the study had the different levels of supplementation with Morama Bean flour (0% and 5%) as the independent variable; the dependent variables were the sensory acceptability and the nutritional contribution of two traditional menu items.

1.3 Outline of the study

The present chapter provides introductory perspectives on the rationale for the study and the goals and subgoals of the study. Chapter 2 presents a review of literature, Chapter 3 reports the results of the nutritional investigation of Morama Bean, while Chapter 4 reports the sensory evaluation of Morama Bean flour. Chapter 5 reports the use of focus group technique for the evaluation of two traditional Botswana dishes enriched with different levels of Morama Bean flour. Chapter 6 reports the results after having monitored the nutritional contribution of Morama Bean to a standard meal-plan. Chapter 7 gives the conclusions and recommendations of the study.

1.4 Format

Chapters 1, 2, 6 and 7 have been written according to the authors' guidelines and technical guidelines for the *Journal of Family Ecology and Consumer Sciences,* while Chapter 3 has been written according to those of *Economic Botany*. Chapters 4 and 5 have been written according to the authors' guidelines for the *Food Quality and Preference Journal*. The thesis therefore represents a compilation of manuscripts where each chapter is an individual entity and some repetition between the chapters has therefore been unavoidable.

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Chapter 2

Literature Review

2.1 Introduction

In the following chapter the taxonomy of the Morama Bean, its habitat and effect of heat treatment will be discussed.

2.2 Taxonomy of Morama Bean.

Morama as a legume belongs to the family Fabaceae, subfamily Caesalpinioidae and genus *Tylosema.* There are four species of *Tylosema* in Africa. *Tylosema esculentum* occurs in Botswana and extends into Zimbabwe, Namibia and South Africa (see figure 1.1). Figure 2.1 shows the taxonomic position of *Tylosema esculentum*.

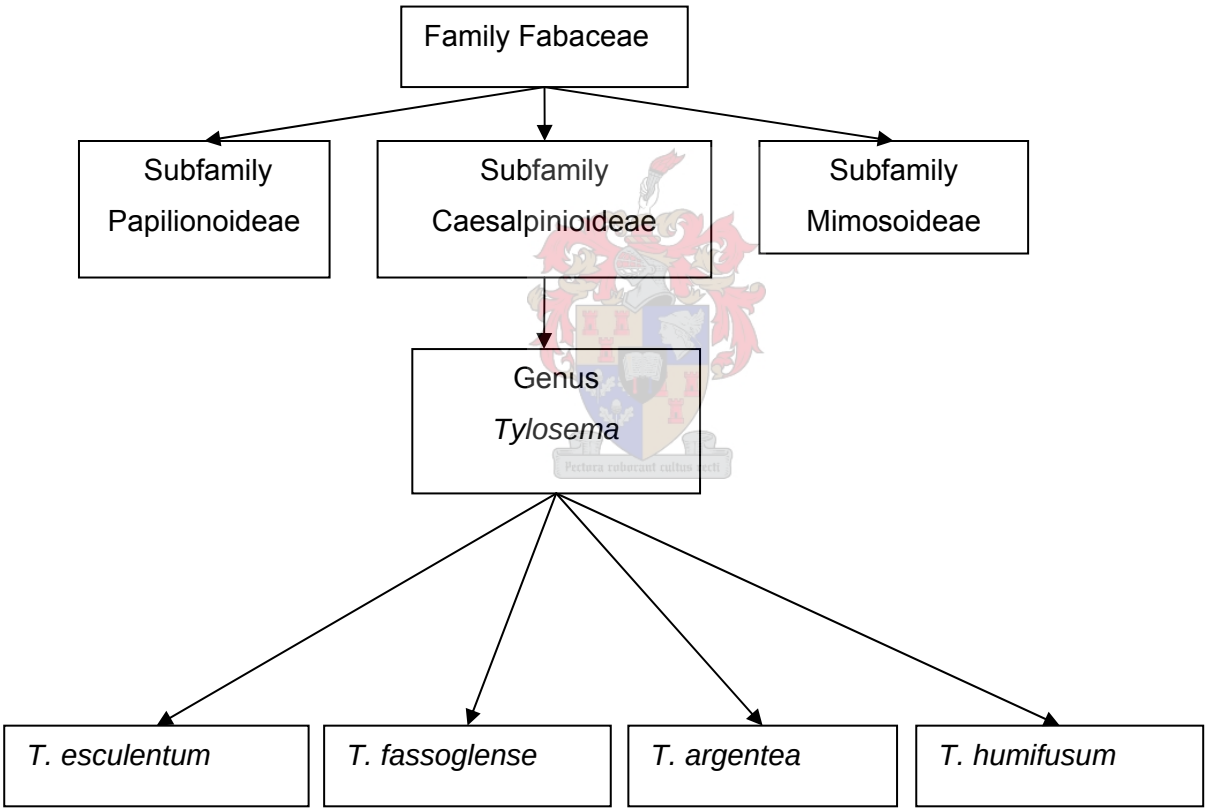

Figure 2.1 Taxonomy of *Tylosema esculentum* (adapted from Hartley, 1997:27).

2.2.1 Habitat

Tylosema esculentum is confined to sandy soils lacking in humus and which are never covered by standing water (Hartley, 1997:29). However, in the Ghanzi area, *T. esculentum* occurs in localities of calcrete and conglomerate rock debris. Francis and Campbell (2003:9) reported that it is being cultivated in Perth, Australia as well as in the United States of America as an experimental crop.

The plant grows in open grass veld where its slender vines can attain lengths of up to 6 m and together form a thick cover over the ground. Between October and March (Coetzer and Ross, 1977) golden yellow clusters of flowers (see Figure 2.2) appear and the fruits ripen between March and April. The pods usually contain two seeds but can produce as many as six seeds which each weigh approximately 2,4 g when mature (see Figure 2.2). The ripe seeds are chestnut brown and spherical, about 15 mm in diameter. The inner flesh, comprising the cotyledons, is firm, cream coloured, oily and without fibers. No reported toxic substances have been detected in any of the seed components (Keegan & Van Staden, 1981). In addition to producing seeds, *T. esculentum* has a large tuber which can weigh up to 10 kg. The base of the leaves and the base of the petioles contain elastic tissue, which enables the leaves to fold close under stress and to orientate the closed leaves so that the radiating surface area is minimised. In winter the parts of the plant above the ground die off and the tuber remains dormant until the next season (National Academy of Sciences, 1979:1).

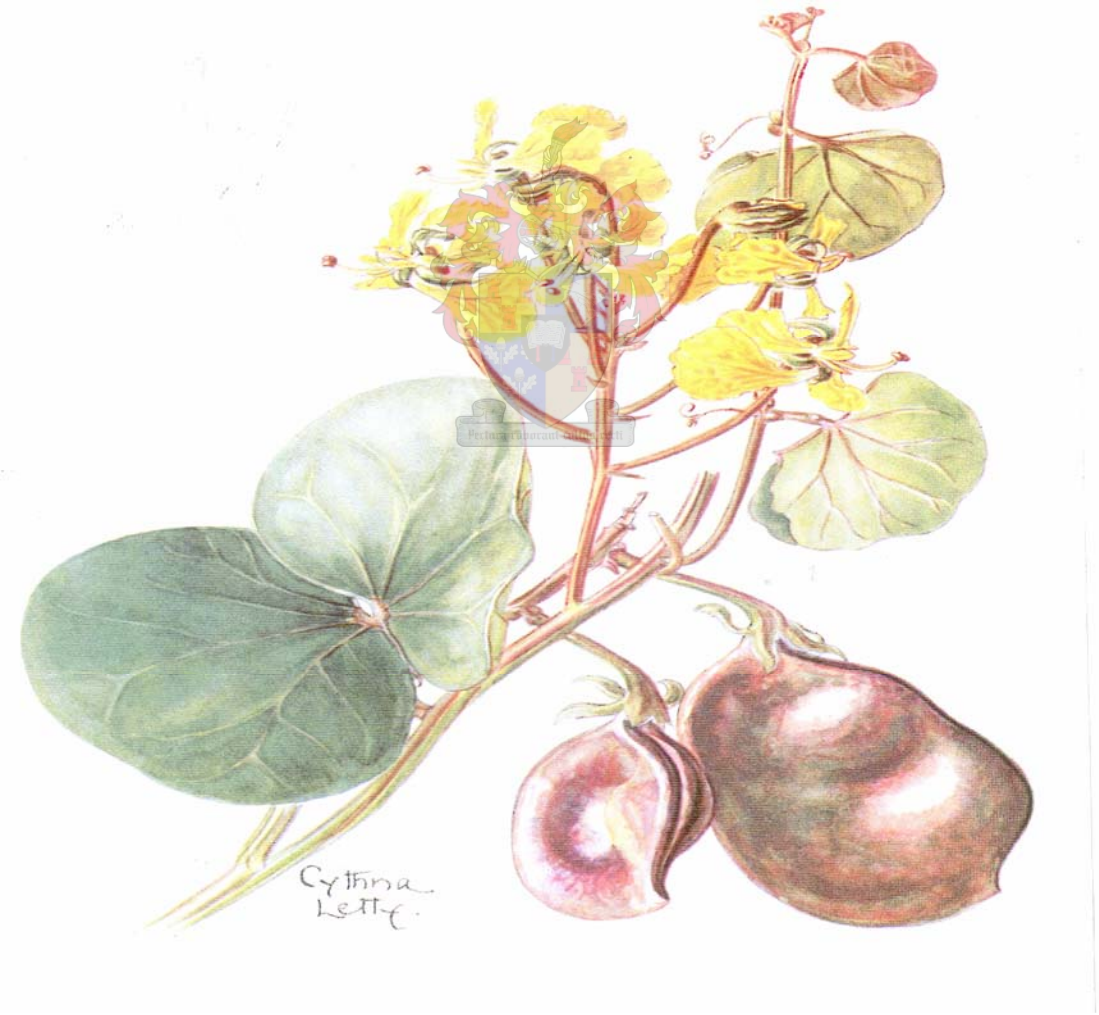

Figure 2.2 Golden yellow flower clusters, leaves and pods of Morama Bean (reproduced with permission of SANBI taken from Flowering Plants of Africa Volume 33: t 1311 (Verdoorn,1959)).

The climate of Botswana is typical of a desert, with temperatures fluctuating widely, and the rains are seasonal and limited. Low rainfall and poor soils are especially found in the Kgalagadi (Botswana Ministry of Finance & Development Planning (BMoFD), 2003:5) where Ghanzi is the main commercial centre of distribution for *T. esculentum* (Hartley, 1997:30). It has temperatures ranging from 15 to 43°C in the hottest months and below 0 to 21°C in the coldest months. The annual rainfall in the Kgalagadi ranges from 300 to 350 mm (BMoFD, 2003:7). The rains occur between October and April, with about 50% falling between January and March.

2.2.2 Fenced localities

At Ghanzi some farmers have cultivated their lands on ground where Morama Bean is indigenous. The lands can be ploughed up to 40 cm deep without damaging the tuber of Morama. The Morama starts to grow after the planted seed has germinated, acting as living mulch, shading out the weeds and limiting evaporation. The Morama Bean plant does not interfere with the yield of maize, beans and melons but do influence the size of pumpkin fruits (International Cooperation with Developing Countries report, 1998–2002:7)

2.2.3 Wild localities

In wild localities the plants survive in leached and infertile soils (National Academy of Sciences: 1979:3). The soils are low in phosphorus (0.008 to 0.12 mg/kg). According to the International Cooperation with Developing Countries Report (1998–2002:7) no detailed studies are available on the vegetation with which Morama is associated. However, over much of the area it grows in open savannah in competition with tall grasses, shrubs and small trees (personal observation).

2.3 Effect of heat treatment

Morama Bean has an unpleasant taste when raw (Hartley 1997:30), therefore heat treatment should be applied, which reduces the water activity in the product and produces changes in sensory attributes (Garrow & James, 1993:337). Cybulska and Doe (2002:41) report that since 1929 it had been recognised that the chemical and microbial stability and thus the shelf life of foods is not directly related to their moisture content but to the property called the water activity. They further report that microbial growth is directly linked to water activity. No microbes can multiply at a water activity below 0,6. Most anti-nutrients, which are common in pulses, are destroyed or reduced by heat treatment. Anti-nutrients reduce the body's ability to access nutrients (Thompson, 1988:123). Roasting is commonly used for heat treatment of nuts including Morama Bean (Bower, Hertel, Oh & Storey 1988). It is typically done in a dry oven at 120 to 180˚C for 15 to 20 minutes as indicated by Peanut Company in Australia (2004). Salunkhe, Chavan, Adsule and Kadam (1992:177–178) report that the roasting of peanuts has no significant effect on the proximate composition and minerals and in the case of Morama the same technique was used for Morama Bean flour.

2.3.1 Anti-nutritional factors in Morama

Anti-nutrients are plant compounds which decrease the nutritional value of plant food, usually by making an essential nutrient unavailable or indigestible when consumed by human or animals (Geo-pie project, 2004) although they have the advantage of lowering the GI as a result of delaying blood glucose response on carbohydrate-containing foods. Bower *et al.* (1988) reports albumins, globulins, prolamines, alkali-soluble and acid-soluble components as the anti-nutritional factors in Morama Bean.

According to Bower *et al.* (1988) the trypsin inhibitor was about 20% of the total seed protein. Ryan cited in Bower *et al.* (1988) reports that the trypsin inhibitor is common in pulses, comprising 5 to 10% of the total protein and can be destroyed by heat. Baking the defatted seed flour at 140°C for 30 minutes decreased its activity in the aqueous protein-extracts by 80% and the saline protein extracts by 50%, giving a decrease of 70% in total trypsin inhibitor activity of the meal.

Bower *et al.* (1988) compare the seed protein in Morama Bean broken down into the constituent proteins with that of soybean as shown in Table 2.1 below. According to Boulter (1977) cited in Bower *et al.* (1988) the presence of the alcohol-soluble protein, prolamine, in a legume seed is unusual, but it is found in Morama Bean, which means it might have some allergic implications with regard to gluten (see the prolamines association with gluten referred to in the draft legislation pertaining to advertising food labelling and marketingof the SA Department of Health, 2002:4).

TABLE 2.1: PROTEIN % COMPOSITION OF MORAMA BEAN COMPARED WITH SOYBEAN

Anti nutrients	Morama Bean	Soybean*
Albumins	23,3	10
Globulins	53	90
Prolamines	15,5	0
Alkali-soluble glutelins	7,7	0
Acid-soluble glutelins	0,5	0

* (Bower et al. 1988)

2.4 Nutritional composition

Research on the nutritional composition of Morama Bean is mostly limited to protein and fat (Table 2.2 and 2.3).

2.4.1 Protein composition

Proteins are composed of long chain amino acids (Ettinger, 2004:38). Twenty-two amino acids exist, of which 12 can be synthesised in the body and as such are called non-essential. The remaining amino acids cannot be synthesised in a sufficient quantity or ratio, or at a rate fast

enough to meet the demands of the body. These are called essential amino acids and include histidine, isoleucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine, as well as arginine for children (Ettinger, 2004:37). These amino acids must be obtained from the diet, whereas the non-essential amino acids are derived from nitrogen and carbon precursors or can be synthesised directly from essential amino acids (Ettinger, 2004:62).

Previous research on the protein content of Morama Bean shows a high concentration (see Table 2.2).

The protein content of Morama Bean ranges between 30 and 42 percent. The Food Composition Tables of the South African Medical Research Council (MRC) (1991) report the protein content of cooked soybean as 37% and peanuts as 26%. Therefore the protein content of Morama Bean equals that of soybeans and peanuts and warrants further research.

TABLE 2.2: PROTEIN CONTENT (%) OF MORAMA BEAN AS REPORTED BY DIFFERENT RESEARCHERS

Researcher	Year	Form	Protein (%)
Keegan & Van Staden	1981	*	30 - 39
Bower *et al.*	1988	*	31,8
Monagham	1995	*	29,6 -41,8
Hartley	1997	w/w	30
Amarteifio & Moholo	1998	*	34,1

* The form (raw or cooked) is not indicated

Soetrisno [s.a] further supports other researchers by stating that pulses such as peas, beans and lentils are high in protein content and have been used as an inexpensive protein in the diets where animal proteins are either unaffordable or are considered detrimental to health by the health-conscious and nutrition-conscious population. Seeds of pulses and other plant protein sources are used as flours in products such as baby formula or in supplementary diets, baked products, pasta or extruded products (Soentrisno [s.a]).

In view of the fact that the protein content of Morama Bean is comparable to that of peanut and soybean, the production of this bean flour will also make a valuable protein contribution to the diet. Blends of cereals and pulses have been reported to have a good protein quality, which comes close to that of meat, milk and other animal proteins (Esminger, Esminger, Konlande & Robson 1993:1286) due to the complementation of amino acids between these two plant sources. Thus Morama Bean products could be used to upgrade the protein quantity and quality of cultural plant diets through protein complementation. These diets mainly contain cereals with low protein content and with limiting amino acids. The limiting amino acid, methionine, in oil seeds (Ettinger, 2004:68)

is complemented by the presence in cereals thereof (Ettinger, 2004:67-68). The same type of complementation is possible with Morama Bean, cereals and milk.

Defatted bean flours (peanut and soy flour) each contain almost 50% protein. Small amounts of these products make major protein contributions when added to cereal flours, which contain only about 8 to 15% protein (Esminger *et al.,* 1993:1286).

2.4.2 Fat Composition

Salunkhe *et al.* (1992:1) remind us that the importance of fats in human nutrition is well recognised. Moreover, fat forms a vital component of many cell constituents. It is an important source of energy and acts as a carrier of fat-soluble vitamins. Fat also contribute significantly as functional ingredient in improving the sensory quality of several processed foods products. Research on Morama Bean shows a high fat concentration (see Table 2.3). Fat content ranges between 32% and 45%. Fat content for soybean is 19% and for peanut is 49%. Latest research reports and reviews of literature also state recent recognition of the important role of certain fatty acids, e.g. oleic acid, linoleic acid (Das, 2001; Leaf, Xiao, Kang & Billman: 2003; Talcott, Passeretti, Duncan & Gorbet, 2005) in combating coronary heart diseases.

TABLE 2.3: FAT CONTENT (%) OF MORAMA BEAN AS REPORTED BY DIFFERENT RESEARCHERS

Researcher	Year	Form	Fat (%)
Keegan & Staden	1981	*	36-43
Bower N, Hertel K, Oh J, Storey R	1988	*	42,2
Monagham	1995	*	32,1-45,3
Hartley	1997	w/w	40
Amarteifio & Moholo	1998	*	33,5

* The form (raw or cooked) is not indicated

w/w= wet weight

Energy contribution of 100 g cooked Morama Bean is 2228,9 kJ (Table 2.4 shows energy values of roasted Morama for protein, carbohydrate and fat per 100 g) of which 56% is from fat, 17% from carbohydrate and 27% from protein (SA Department of Health, 2002: 57).

The roasted Morama Bean is a source of protein (34g per 100 g), a source of iron and phosphorus, and a good source of calcium.

At this stage Morama bean cultivation is so localised that it is only significant for the communities where it occurs naturally, and its significance is increased sustainability of the communities and not for its bulk production.

TABLE 2.4: ENERGY CONTRIBUTION OF ROASTED MORAMA BEAN /100 g

Nutrient	Quantity (g)	Conversion factor*	Total energy (kJ)
Protein	34,1	17	579,7
Carbohydrate	24,1	17	409,7
Fat	33,5	37	1239,5
Total			2228,9

*SA Department of Health, 2002:57

The production of Morama Bean flour will therefore promote the local production of these valuable products. These products are used in different forms as flours, textured flours, concentrates, textured concentrates, isolates and textured isolates.

2.4.3 Fatty acid composition in the diet

Saturated fatty acids (SAFs) lack double bonds between adjacent carbon atoms in the fatty acid chain, while monounsaturated fatty acids (MUFAs) have a single double bond and polyunsaturated fatty acids (PUFAs) have more than one double bond (Ettinger, 2004:54). PUFAs are further subdivided into two classes based on location of the first double bond. The n-3 fatty acids have their first double bond between the third and fourth carbon atom in the chain, whereas n-6 fatty acids have the first double bond between the sixth and seventh carbon atom from the carboxyl end. In the human body, PUFAs cannot be synthesised and are considered as essential fatty acids, which indicates the necessity for them to be obtained from the diet (Ettinger, 2004:55). These fatty acids act as building blocks for biologically active membranes, which surround cells and subcellular particles (Belitz & Groasch, 1987:128).

Bower *et al.* (1988:535) profiled Morama Bean fatty acid composition, which was further researched by Francis and Campbell (2003:9), who also grades Morama as a new high quality oil seed as evidenced by its comparison with canola. The results are shown in Table 2.5.

The oil content of Morama seed is 42% compared to 43% of the canola. Morama Bean in comparison with canola is a rich source of saturated fatty acids (20% as opposed to 6%) and lower in polyunsaturated fatty acids (26% as opposed to 32%). An advatage of plant oils is that they contain no cholesterol (Bouic, 2003). Oleic acid is the most abundant fatty acid in Morama Bean (Francis and Campbell 2003:9). From the view of food oxidation the important lipids are those containing unsaturated fatty acids, like oleic acid, linoleic and linolenic (Schoeman, 2002:103).

Morama contains a high percentage of these oils and thus render them prone to oxidation. However, the polyunsaturated acids and monounsaturated fatty acids such as found in Morama Bean are becoming more popular as the health trend is moving away from the use of saturated fats (which are however also high in Morama (see Table 2.5) to oils containing high levels of monounsaturated and polyunsaturated fatty acids.

TABLE 2.5: A COMPARISON OF THE OIL CONTENT AND FATTY ACIDS OF MORAMA BEAN AND CANOLA

Fatty acid	Morama		Canola
SFA	*	**	**
Myristic	1,3	-	-
Palmitic	13,8	12,8	4,2
Stearic	9,7	7,3	1,8
Arachidic	2,8	-	-
MUFA			
Palmitoleic	1,7	-	-
Oleic	48,5	49,0	59,7
PUFA			
Linoleic	19,2	23,5	21,0
Linolenic	2,0	2,7	11,0
Total SFA	27,6	20,1	6
Total MUFA	50,2	49,0	59,7
Total PUFA	21,2	26,2	32

SFA- Saturated fatty acids
MUFA – Monounsaturated fatty acids
PUFA – Polyunsaturated fatty acids
* Bower et al., 1988
**Francis and Campbell (t2003:9)

Increased consumption of beans have been advocated for their high dietary fibre content and for their hypocholesterolemic and hypoglycemic effects by the National Cancer Institute, the National Heart Association and the National Diabetes Association as reported by Venter and van Eyssen (2001). The fibre content that adds bulk to the food and minimises the feeling of hunger is of great importance in the human diet (Madisa & Tshamekang [s.a] quoting Okigbo 1990).

Apart from aiming to identify the nutritional attributes of a product when developing a food product, sensory evaluation is also essential to investigate the sensory properties of the product.

2.5 Sensory evaluation

Sensory evaluation has been defined as a scientific discipline used to evoke, measure, analyse and interpret reactions to those characteristics of foods and material as they are perceived by the

senses of sight, smell, taste, touch and hearing (Lawless & Heymann, 1999:2). The Sensory Evaluation Division of the Institute of Food Technologists (1981) reports that the most commonly occurring industrial applications are: new product development, product matching, process change, cost reduction and /or selection of a new source of supply, storage stability, product grading or rating, consumer acceptance and /or opinions, consumer preference, panelist selection and training, and correlation of sensory with chemical and physical measurements.

In terms of this study where the sensory profile was developed, descriptive testing was used. Descriptive tests attempt to identify sensory characteristics and quantify them. Panelists are thus selected on their ability to perceive differences between test products and verbalise perceptions. An unstructured vertical or horizontal line with verbal anchors at each end to describe or limit the attribute can be used. For analysis purposes, successive digits are later assigned to each point represented on the scale, usually beginning at the end representing zero intensity. A statistical analysis (e.g. analysis of variance) of the mean intensity scores for each sample is used to determine significant differences among the mean scores for the samples (Sensory Evaluation Division of the Institute of Food Technologists, 1981).

2.6 Conclusions

The literature review clearly shows that the nutritional profile of the Morama Bean is underresearched. Although Morama Bean has long been known as a food source, it has not been documented with other oilseeds. There is an increasing demand for oils with therapeutic or health benefits. Oilseeds rich in essential fatty acids such as Morama Bean need to be researched (Francis & Campbell, 2003:1). The documented nutritional composition indicates that Morama Bean is a high quality food and in view of the potential benefits of Morama Bean as a hypocholesterolemic and hypoglycemic food (trendy properties if consumer needs are considered) additional research is timeous.

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Chapter 3

Nutritional composition

ABSTRACT

The objective of this study was to develop a comparative profile of the nutritional composition of Morama Bean flour roasted at four heat levels. According to these results there was no significant difference ($p>0.05$) in the protein content of the bean roasted at 120°C for 40 min, 150°C for 30 min and 150°C for 25 min. However, the beans roasted at 150°C for 20 min had a significantly ($p\leq0.05$) lower protein content than others. Methionine and cystine are the limiting amino acids as in soybean. Saturated fatty acids detected at the highest concentrations were palmitic acid and stearic acid and the content ranged from 2.99 to 3.38 mg/100 g and 1.45 to 1.62 mg/100 g respectively. The monounsaturated fatty acid detected in the highest concentration was oleic acid (10.38 to 10.99 mg/100 g), while the highest polyunsaturated fatty acid was linoleic acid. The polyunsaturated fatty acids ranged from 7 to 8 mg/100 g. The heat treatment had no significant effect ($p>0.05$) on the ash content, fibre content and carbohydrates. Morama Bean flour was found to be a source of iron, magnesium and zinc. The nutritional composition of roasted Morama Bean demonstrated that Morama Bean is a high quality food.

Keywords: Morama Bean, nutritional composition, proximate analysis, minerals, fatty acids, amino acids.

3.1 INTRODUCTION

*Tylosema esculentum (*family Fabaceae*)* ─ colloquially known *as* Morama or Marama Bean in Setswana (Botswana), Braaiboonjie, Maramaboontjie and Elandsboontjie in Afrikaans (Van Wyk & Gericke: 2000:26), and Gemsbok Bean in English (Smith, 1966:569) ─ is widespread, with large populations in Botswana (around the central Kgalagadi) and Namibia, and smaller populations in the provincesof Limpopo, Nort-West and Gauteng in South Africa (Verdoorn, 1959; Coetzer & Ross 1977; International Cooperation with Developing Countries Report, 2004:3). It grows in open sand veld and open grass and bush savannah (Amarteifio & Moholo, 1998). The plant is a creeper, it has prostrate branches that grow up to six metres long and its seeds are contained in pods that dehisce when dry. It is adapted to the harsh conditions of Botswana, which are characterised by low rainfall and nutritionally poor soils (Verdoorn, 1959; Coetzer & Ross 1977; Botswana Ministry of Finance & Development Planning, 2003:4). It grows wild in the Kgalagadi and is a staple food of the Basarwa people (Amarteifio & Moholo, 1998). Figure 1.1 (see Chapter 1) shows the distribution of Morama Bean in southern Africa.

It is common knowledge that pulses have high protein content and they are an important source of cheap protein in many African countries where animal protein is expensive (Amarteifio & Moholo, 1998; Bower, Hertel, Oh & Storey, 1988; Vadivel & Janardhanan, 2001; Soetrisno, [s.a]; Tharanthan & Mahadevamma, 2003). Siddhuraju, Vijayakumari and Janardhanan (1992) report that plant foods such as cereals and pulses have consistently been listed as the major potential sources of dietary protein for feeding the world of tomorrow and research efforts are being directed to this area to identify and evaluate underexploited food sources.

Although Morama has long been identified as a food source (Smith, 1966:225; National Academy of Sciences 1979:3; Keegan & Van Staden; 1981; Hartley, 1997:31; Amarteifio & Moholo, 1998), research on Morama has been focused on cultivation rather than food product development. The raw seeds are hard, and have been described as having a soapy taste. When young, the green beans can be boiled as green vegetables similar to green peas (self observation), while the dry beans are roasted and eaten as a snack. It can also be boiled and eaten as porridge or used to make a beverage like cocoa (Menninger, 1977:101). This bean is seasonally available (June/July) in local markets in a raw form (self observation) with no nutritional information for the consumers.

Little effort has been devoted to examining the nutritional composition of Morama Bean. The present study was therefore undertaken to compile data on the proximate composition and the mineral, fatty acid and amino acid composition of Morama Bean that had been gathered from wild and fenced (cultivated) localities and exposed to four heat treatments as illustrated in Figure 3.1.

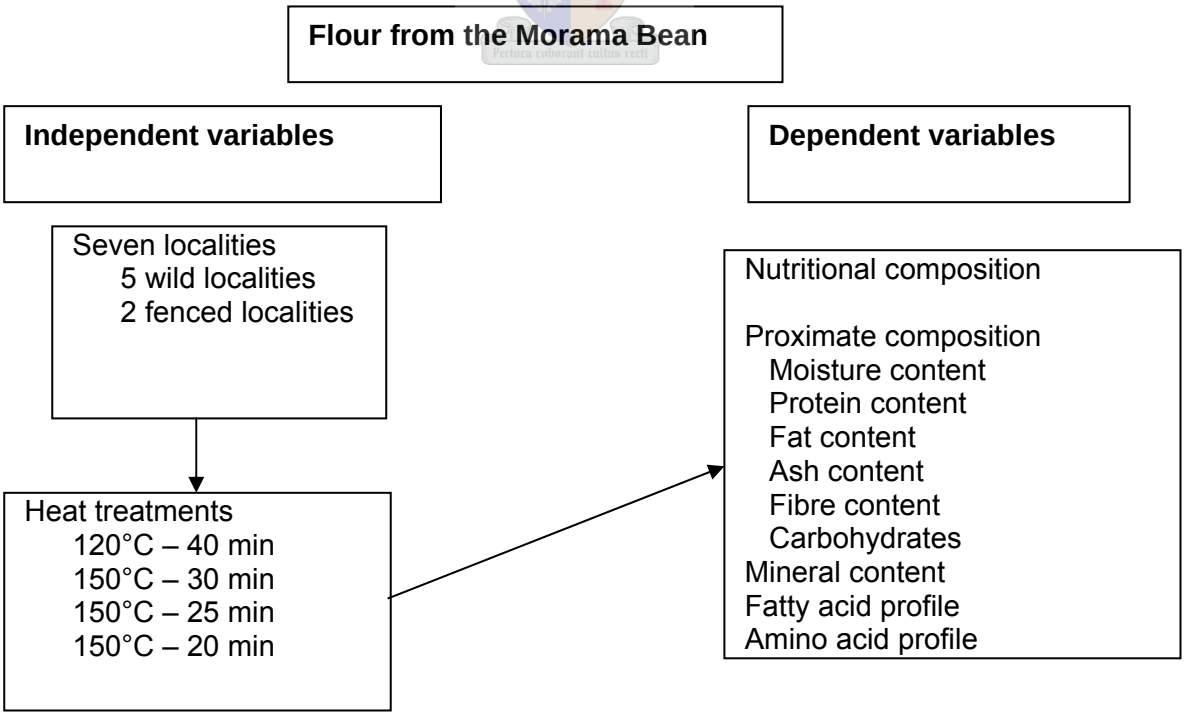

Figure 3.1 Independent and dependent variables for this study (see Chapter1).

3.2 METHODOLOGY

3.2.1 Sampling

Seed specimens for the study were collected in June 2004 from five wild localities and two fenced localities in Jwaneng town, Botswana. The Morama Beans collected had dried and been shed from the pods. The sampling was done by the convenience sampling method in different localities to investigate the effect of wild localities versus fenced localities, as well as heat treatments, on the nutritional value of Morama Bean. A maximum of 4 kg was collected from each site. The land use of the fenced areas is mainly subsistence farming of field crops (for example maize and sorghum) where kraal manure is used as a fertiliser. It could be hypothesised that fenced (being cultivated often and fertilised during cultivation) localities and wild localities (natural growth of indigenous plants) could affect the nutritional composition of Morama Bean. Permission for importing Morama Beans was granted by the Department of Agriculture in Stellenbosch (see Addendum A).

3.2.2 Developent of Morama Bean flour

In June 2004 after collection Morama Beans were heat treated at the National Food Productivity Research Centre in Botswana. The samples were coded as W1 to W5 for samples from wild localities and F1 and F2 for samples from fenced localities. All the samples were wiped to remove dust, weighed and roasted in a pre-heated oven at four different heat treatments. Table 3.1 below shows samples and heat treatments applied.

After roasting, the Morama Bean shell was cracked with a stainless steel garlic crusher, the deshelled beans were packaged in zip lock polythene bags and transported to Stellenbosch where they were ground with a coffee grinder (60 g *Phillips* HR 2109) for two minutes.

The 28 samples (4 treatments x 7 localities) were kept separate during the processing of the bean flour (Table 3.1).

Table 3.1 Morama Beans from different localities (blocks) and heat treatments applied.

Localities (blocks)	W1	W2	W3	W4	W5	F1	F2
120°C 20 min	x	x	x	x	x	x	x
150°C 30 min	x	x	x	x	x	x	x
150°C 25 min	x	x	x	x	x	x	x
150°C 20 min	x	x	x	x	x	x	x

W = wild localities, F = fenced localities

3.3 Research design

The complete randomised block design (Snedecor & Cochran, 1967) was used with four heat treatments that replicate within each of the seven blocks. Blocks consisted of seed specimens collected in June 2004 from five wild localities and two fenced localities (see Section 3.3.1). The nutritional composition data of the 28 samples (7 localities x 4 heat treatments) was analysed statistically and thereafter for the impact of the heat treatments. The nutritional composition of Morama Bean flour was evaluated for the seven sampling sites.

3.4 Chemical analysis

This was a laboratory study where Morama Bean was investigated using the methods of the Association of Official Analytical Chemists (2000). The study used a pre-experimental design where the experiment did not have a control experiment to compare with (Creswell, 1994:130). Each of the seven samples from different localities was heat-treated using four heat treatments and the samples were assigned random numbers and sent for analysis (Addendum B). Analyses for proximate composition, and mineral, fatty acid and amino acid content were conducted in the laboratory of Department of Animal Science, Stellenbosch University.

3.4.1 Proximate analysis

The proximate analysis included moisture, ash, crude protein, crude fat, crude fibre and nitrogen free extracts (digestible carbohydrates). The Morama Bean flour was kept at room temperature during analysis. The percentage of moisture, protein and ash was determined according to the methods of the Association of Official Analytical Chemists (AOAC) (2000). The moisture content was analysed by drying a 2.5 g sample at 100°C for a period of 24 hours. The ash was determined by ashing at 500°C for 5 hours. The protein content was determined according to the Dumas combustion method using a Leco FP-528 method. Fat was analysed using ether extraction according to the AOAC (2000) 920.39 method in the sortex system HT 1043 extraction unit. Fibre was analysed using the fibretec system m 1020 hot extractor. The samples were defatted prior to fibre analysis. The nitrogen free extracts were determined by difference.

3.4.2 Mineral analysis

The elements calcium (Ca), copper (Cu), iron (Fe), magnesium (Mg), manganese (Mn), phosphorus (P), potassium (K), sodium (Na), and zinc (Zn) were determined using ashing of defatted Morama Bean samples. The bean flour samples (2 g) were ashed overnight in a muffle furnace at 550°C. A 6 M hydrochloric acid (HCl) solution was prepared by diluting 500 ml of a 36% (m:m) HCl solution to 1L. After ashing, 5 ml of a 6 M HCl was added to dissolve the cooled sample. Thereafter the samples were put in a water bath until the acid evaporated. After cooling 5 ml 6 M nitric acid (HNO_3) solution was added to the samples, then heated in a water bath and removed after boiling point was reached. The solution was consequently filtered through filter paper into a 100 ml volumetric flask and diluted to volume with deionised water according to the

method described by Giron (1973). Element concentrations were then measured on an ICP-Thermo Jarrel Ash, IRIS (AP).

3.4.3 Fatty acid analysis

The fatty acid content was determined using the same method described by Tichelaar et al. (1998:196-197). The lipids in a 2 g sample were extracted with chloroform/methanol (CM 2:1; v/v) according to a modified method of Folch, Lees and Sloane-Stanley (1957). All the extraction solvents contained 0.01% butylated hydroxytoluene (BHT) as an antioxidant. A polytron mixer (*Kinematica*, type PT 10-35) was used to homogenise the sample within the extraction solvent. Heptadecanoic acid (C17:0) was used as an internal standard to quantify the individual fatty acids. A sub-sample of the extracted lipids was transmethylated for 2 h at 70°C using methanol/sulphuric acid (19:1; v/v) as transmethylating agent. After cooling, the resulting fatty acid methyl esters (FAME) were extracted with water and hexane. The top hexane phase was transferred to a spotting tube and dried under nitrogen.

The FAME was purified by TLC (silica gel 60 plates) and analysed by GLC (Varian Model 3300 equipped with flame ionisation detection) using a 60 m BPX70 capillary column of 0.25 mm internal diameter (SGE, Australia). Gas flow rates were hydrogen, 25 ml/min; and hydrogen carrier gas 2–4 ml/min. Temperature programming was linear at 3°C/min, with an initial temperature of 150°C, a final temperature of 220°C, an injector temperature of 240°C and a detector temperature of 250°C. The FAME in the total lipids was identified by comparison of the retention times to those of standard FAME mixture (Nu-Chek-Prep Inc., Elysian, Minnesota).

3.4.4 Amino acid analysis

The amino acid composition was determined using a modification of the method of Bidlingmeyer, Cohen and Tarvin (1984) on a defatted, dried flour sample using a Waters high-performance liquid chromatography system (1525 HPLC with a binary gradient delivery, 717 auto-sampler and Injector, 1500 column heater, 2487 dual wavelength UV detector) and a Breeze data workstation (Waters, Millford, MA, USA). The flour samples were defatted by solvent extraction according to the method of Lee, Trevino and Chaiyawat (1996). The centrifuged (15 krpm for 5 min) samples were dried under vacuum for 1.5 to 2 h. The pH was adjusted by adding 20 μl solution ethanol:water:triethylamine in the ratio of 2:2:1 and dried for a further 1.5 to 2 h. The resulting sample was derivatised by adding 20 μl derivatising solution of ethanol:water:triethylamine:phenylisothiocyanate in the ratio of 7:1:1:1. This was allowed to react at room temperature for 10 min prior to drying under vacuum (minimum of 3 h). The sample was resuspended in 200 μl of Picotag sample diluent (Waters, Millford, MA, USA) and an 8 μl sub-sample was then injected for separation by HPLC under gradient conditions, where Buffer A was

sodium acetate buffer (pH 6.4) containing 5000 ppm EDTA, 1:2000 triethylamine and 6% acetonitrile. Buffer B was 60% acetonitrile with 5000 ppm EDTA. The data was analysed using Breeze software (Waters, USA).

3.5 RESULTS AND DISCUSSION

Findings of the proximate analysis, and mineral content, fatty acids and amino acids are reported below.

3.5.1 Proximate composition

The statistical analysis showed no significant difference ($p>0.05$) amongst the collection sites (five wild localities and 2 fenced localities), therefore only the effect of heat treatment on the proximate composition was considered and reported in Table 3.2. Mean values for moisture, protein, fat, ash, fibre and the nitrogen free extracts are given below.

TABLE 3.2 MEANS (± STANDARD DEVIATION) FOR PROXIMATE COMPOSITION OFMORAMA BEAN AT DIFFERENT HEAT TREATMENTS (g/100g).

	Moisture	Protein	Fat	Ash	Fibre	NFE*
120°C 40 min	4.24 ± 0.86^{a}	37.02 ± 0.92^{a}	36.60 ± 1.35^{a}	3.19 ± 0.77^{a}	4.59 ± 1.18^{a}	14.36 ± 2.10
150°C 30 min	3.11 ± 0.63^{b}	36.36± 1.11^{ab}	37.16 ± 2.37^{a}	3.04 ± 0.14^{a}	4.52 ± .99^{ab}	15.80 ± 2.20^{a}
150°C 25 min	3.76 ± 0.37^{ab}	36.21 ± 1.11^{ab}	37.50 ±1.04^{a}	2.99 ± 0.15^{a}	4.16 ± 1.49^{ab}	15.37 ± 1.06^{a}
150°C 20 min	3.79 ± 0.34^{ab}	35.81± 0.81^{b}	38.51± 0.68^{a}	3.19 ± 0.52^{a}	3.07 ± 0.73^{b}	15.62 ± 0.89^{a}
LSD	0.70	0.86	1.97	0.58	1.46	1.94

NFE* Nitrogen free extracts
$^{a-b}$ means in the same column with different superscript letters are significantly different ($p\leq0.05$).

The moisture content according to this research ranges from 3% to 4%. There is a significant difference ($p\leq0.05$) between the moisture content of samples treated at 120°C for 40 min and 150°C for 30 min. This corresponds well with a previous study by Bower et al. (1988) where there was a tendency of the flour heated at a high temperature to be low in moisture content.

The protein content ranges from 36 to 37%, which corresponds well with previous reports by Amarteifio and Moholo (1998), Hartley (1997), Monagham and Halloran (1995) and Keegan and Van Staden (1981). There was no significant difference ($p \geq 0.05$) in the protein content of Morama Beans roasted at 120°C for 40 min, 150°C for 25 min and 150°C for 30 min. However, the beans roasted at 150°C for 20 min had a significantly ($p \leq 0.05$) lower protein content than others. There was a tendency for the flour heated at a high temperature for a short time to have slightly lower protein content.

The fat content ranges from 37 to 39%, which corresponds with previous reports by Amarteifio and Moholo (1998), Hartley (1997), Monaghan and Halloran (1995) and Keegan and Van Staden (1981).

The ash content is 3%, which corresponds with that of Amarteifio and Moholo reported in 1998. No significant difference ($p > 0.05$) in ash content between four heat treatments could be found.

The fibre content ranges from 3 to 5%, which corresponds with that of Amarteifio and Moholo (1998:331). The results are also comparable to that of soybean, which varies from 4 to 8% as reported by Carter and Hopper cited in Salunkhe et al. (1992:11). The samples roasted at 120°C for 40 min were significantly higher in fibre content than those roasted at 150°C for 20 min.

The average carbohydrate content of the four treatments (represented as NFE on the table) examined in this study is 15% and the average fibre content is 4%, which together give a total carbohydrate of 19%. There is no significant difference ($p > 0.05$) between the four heat treatments. The results obtained in this study are comparable to those of Bower et al. (1988) who reported an average value of 18.9%.

3.5.2 Mineral content

The mineral content was determined for the elements calcium, copper, iron, magnesium, manganese, phosphorus, potassium, sodium, and zinc in the Morama Bean flour roasted at four different heat treatments, 120°C for 40 min, 150°C for 30 min, 150°C for 25 min, and 150°C for 20 min. The four heat treatments had no significant differential effect ($p > 0.05$) on mineral content except for the element copper. The samples roasted at 150°C for 20 min had a significantly higher ($p \leq 0.05$) copper content than those roasted at 150°C for 30 min. This difference is so small that it is of no practical significance. Literature on the nutritional composition of Morama Bean is scant and no research reports were found showing mineral composition of Morama Bean in full fat flour form. However, the calcium results are within the same range as dried, cooked soybean and dried, cooked haricot beans with values of 102mg/100 g and 70 mg/100 g (SA Medical Research Council, 1991) respectively. The sodium content ranged from 13.2 to 13.4 mg/100 g. This corresponds with Uebersax and Occeña (2003:3533) who report that pulses contain very low

amounts of sodium. The iron content is 2 mg/100 g. This is lower than the iron content of roasted Morama Bean in a study by Amarteifio and Moholo (1998). They reported iron values of 4 g/100 g. The method for determining iron content was not reported in the study, therefore the difference in the iron content values of the two studies cannot be explained. In Botswana iron cookware is commonly used (self observation) and the increase in iron content of Morama Bean could reflect the iron cookware used. Indeed, Park and Brittini (1998) report that iron cookware can cause increased iron in food. Amarteifio and Moholo (1998) further report 776 mg/100 g potassium, 397 mg/100 g phosphorus and 152 mg/100 g calcium. These results are comparable to the results of this study.

TABLE 3.3 MEANS (± STANDARD DEVIATION) FOR MINERAL CONTENT OF MORAMA BEAN FLOUR AT FOUR DIFFERENT HEAT TREATMENTS (g/100 g).

Minerals	Heat treatments				
	120°C for 40 min	150°C for 30 min	150°C for 25 min	150°C for20 min	LSD
Calcium (g)	158.57 ± 9.00[a]	161.43 ± 6.90 [a]	170.00 ± 15.28[a]	170.00 ± 8.16[a]	13.16
Copper (mg)	0.87 ± 0.07 [ab]	0.87 ± 0.03[b]	0.88 ± 0.03 [ab]	0.96 ± 0.13 [a]	0.10
Iron (mg)	2.21 ± 0.12 [a]	2.17 ± 0.11 [a]	2.17 ± 0.26 [a]	2.34 ± 0.36 [a]	0.25
Magnesium (g)	287.14 ± 9.51 [a]	282.86 ± 9.51 [a]	290.00 ± 11.55[a]	291.43 ± 10.69[a]	10.23
Manganese	1.41 ± 0.05 [a]	1.41 ± 0.06 [a]	1.43 ± 0.11 [a]	1.45 ± 0.08 [a]	0.08
Phosphorus	337.14 ± 40.71[a]	360.00 ± 45.09[a]	344.29 ± 41.17[a]	371.43 ± 57.28[a]	57.56
Potassium (g)	697.14 ± 26.28 [a]	702.86 ± 18.90[a]	694.29 ± 18.13[a]	701.43 ± 16.76 [a]	23.88
Sodium (mg)	13.24 ± 0.36 [a]	13.30 ± 0.31 [a]	13.40 ± 0.27 [a]	13.33 ± 0.33 [a]	0.38
Zinc (mg)	3.04 ± 0.13 [a]	3.01 ± 0.10 [a]	2.93 ± 0.15 [a]	2.97 ± 0.16 [a]	0.15

[a-b] means in a row with same superscript are not significantly different .

3.5.3 Fatty acid composition

In Table 3.4 the fatty acid composition is represented quantitatively (g/100 g). According to Enser et al. (1998) the percentage of fatty acids can be misleading especially if treatments only differ in total fatty acid content. The composition of fatty acids in g/100 g samples is useful when calculating the nutritional value of a food portion in terms of the fatty acid profile in relation to total fat – a criterion that is presently increasingly important (Enser et al., 1998). In order to determine this profile the different categories of fatty acids per 100 g needs to be reported.

The means of the total saturated fatty acids range from 5.56 to 6.2 g/100 g. The saturated fatty acids detected in the highest concentrations were palmitic acid (C16:0, 2.99 to 3.38 g/100g) and stearic acid (C18:0, 1.45 to 1.62 g/100 g).

TABLE 3.4 FATTY ACIDS COMPOSITION OF MORAMA BEAN FLOUR (MEANS± STANDARD DEVIATION) AT FOUR HEAT TREATMENTS (g/100 g).

Fatty acids	Heat treatments				
	120ºC for 40 min	150ºC for 30 min	150ºC for25 min	150ºC for 20 min	LSD
C 13:0	0.02 ±0.05 [a]	0.00 ± 0.00 [a]	0.00 ± 0.00 [a]	0.03 ± 0.06[a]	0.04
C 14:0	0.03 ± 0.01[a]	0.02 ± 0.00 [a]	0.03 ± 0.01 [a]	0.02± 0.01 [a]	0.04
C 15:0	0.02 ± 0.01 [a]	0.01 ± 0.00 [a]	0.02 ± 0.00[a]	0.02 ± 0.01 [a]	0.01
C16:0	3.38 ± 0.15[a]	3.32 ± 0.16 [a]	3.36 ± 0.20 [a]	2.99 ± 0.32 [b]	0.21
C 18:0	1.56 ± 0.15 [a]	1.54 ± 0.09 [ab]	1.62 ± 0.09 [a]	1.45 ± 0.13[b]	0.13
C 20:0	0.57 ± 0.08 [a]	0.56 ± 0.04 [a]	0.54 ± 0.04 [a]	0.51 ± 0.06 [a]	0.07
C 21:0	0.04 ± 0.04 [a]	0.03 ± 0.01 [a]	0.03 ± 0.02 [a]	0.04 ± 0.01 [a]	0.04
C 22:0	0.42 ± 0.07 [a]	0.43 ±0.05 [a]	0.39 ± 0.06 [ab]	0.36 ± 0.05 [a]	0.06
C 24:0	0.16 ± 0.34 [a]	0.16 ± 0.03 [a]	0.16 ± 0.01 [a]	0.14 ± 0.02 [a]	0.03
C 16:1	0.16 ± 0.06 [a]	0.13 ± 0.00 [ab]	0.13 ± 0.02 [ab]	0.11 ± 0.02 [b]	0.04
C 18:1(n-9t)	0.03 ± 0.03 [a]	0.01 ± 0.00 [ab]	0.01 ± 0.00[ab]	0.02 ± 0.01 [a]	0.02
C 18:1 (n-9c)	10.74 ± 1.12 [a]	10.90 ± 0.50 [a]	10.99 ± 0.55 [a]	10.38 ± 0.89 [a]	0.89
C 20:1	0.14 ± 0.07 [a]	0.15 ± 0.01 [a]	0.14 ± 0.01 [a]	0.13 ± 0.01 [a]	0.04
C 22:1	0.04 ± 0.06 [a]	0.01 ± 0.00 [a]	0.01 ± 0.01 [a]	0.01 ± 0.00 [a]	0.03
C 18:2 (n-6c)	6.99 ± 1.62 [a]	7.48 ± 0.45 [a]	6.83 ± 1.37 [a]	6.76 ± 0.61 [a]	1.09
C 20:2	0.09 ± 0.08 [a]	0.07 ± 0.02 [a]	0.07 ± 0.03 [a]	0.06 ± 0.01 [a]	0.05
C 18:3 (n-3)	0.03 ± 0.04 [a]	0.01 ± 0.02 [a]	0.01 ± 0.01 [a]	0.00 ±0.00 [a]	0.03
C 20:3 (n-6)	0.03 ± 0.04 [a]	0.04 ± 0.04 [a]	0.02 ± 0.03 [a]	0.01 ± 0.01 [a]	0.04
C 20:3 (n-3)	0.08 ± 0.12 [a]	0.03 ± 0.02 [a]	0.05 ± 0.02 [a]	0.02 ± 0.01 [a]	0.07
C 20:4	0.04 ± 0.05 [a]	0.02 ± 0.00 [a]	0.02 ± 0.03 [a]	0.01 ± 0.00 [a]	0.04
C 20:5	0.07 ± 0.04 [a]	0.04 ± 0.02 [a]	0.06 ± 0.02 [a]	0.04 ± 0.02 [a]	0.03
C 22.6 (n-3)	0.01 ± 0.01 [a]	0.02 ± 0.01 [a]	0.02 ± 0.01 [a]	0.01 ± 0.00 [a]	0.01
Total SFA	6.2	6.07	6.15	5.56	
Total MUFA	11.11	11.20	11.28	10.65	
Total PUFA	7.34	7.71	7.08	6.91	
Total FA	24.65	24.98	24.51	23.12	
PUFA: SFA	1.18	1.27	1.15	1.24	
n6:n3	58.5	125.33	85.63	225.66	

[a-b] Means in the same column with different superscript letters are significantly different from each other (p≤0.05).
SFA = Saturated fatty acids
MUFA = Monounsaturated fatty acids
PUFA = Polyunsaturated fatty acids

The means of the total monounsaturated fatty acids range from 10.65 mg/100 g to 11.28 mg/100 g. The monounsaturated fatty acid in the highest concentration is oleic acid (C18:1) which ranged from 10 g/100 g to 11 g/100 g for the different treatments. According to Schoeman (2002:103) the most beneficial lipids are the monounsaturated fatty acids like oleic acid. It is important to note that food sources with a high content of oleic acid as found in olive oil have cardio-protective effects as opposed to dietary fats that are rich in saturated fatty acids which are associated with increased risk of cardiovascular diseases like stroke and heart attack (Venter & Esyssen, 2001; Hu, Manson & Willet, 2001; Echarte et al. 2004). The means of the total PUFA ranges from 6.91 to 7.71 g/100 g. The PUFA detected in high concentration is the linoleic acid (18:2, n-6), which is currently of high interest (Enser et al. 1998). It is associated with a range of potential health benefits, which include functioning as an anti-carcinogen; aiding in the utilisation of energy for muscle production instead of adipose tissue production; protecting against atherosclerosis and modifying of immune response (Krummel, 2004:879). There was no significant difference ($p>0.05$) in this fatty acid composition between the four heat treatments applied to Morama Bean.

A poor ratio of dietary fatty acids has important human health implications including the development of coronary heart disease, cancer and autoimmune diseases (Anderson 2004:314). The estimated n6:n3 ratio in modern western diets is about 10 – 15:1, whereas in pre-agricultural diets it has been estimated to be between 2 ─ 4:1. The high n6:n3 ratio in western diets stems from excessive consumption of vegetable oil-based fats (Cordian, 1977). The n6:n3 ratio in Morama Bean flour is 1:4, which is in a reversed ratio and lower than the ratio recommended by Anderson (2004, 314) who reports that the recommended dietary ratio of n6:n3 ratio is estimated to be 14 ─ 20:1.

It is well known that the increased intake of SFA contributes to higher risks of heart disease by raising the low-density lipoprotein in the plasma cholesterol, while linoleic acid and α-linolenic acid lower it, thereby decreasing the risk of heart disease (Ettinger, 2004:61). On the other hand stearic acid has no effect on the plasma cholesterol concentrations, although it may contribute to the final stages of coronary heart disease that produce the heart attack (Enser et al. 1998). It is therefore important to scale down SFA intake and maintain the balance by substituting it with PUFA in order to maintain good human nutrition. Raes et al. (2003) report that this can be achieved by calculating the PUFA:SFA ratio that will enable the assessment of the quality of fat in terms of dietary recommended value of ≥ 0.7. The values obtained in this study were higher than 0.7, namely 1.

3.5.4 Amino acid composition

Table 3.5 represents the amino acid composition expressed as g/100 g protein. There was no significant difference ($p>0.05$) in total amino acid of Morama Bean flour roasted at 120°C for 40 min and Morama Bean flour roasted at 150°C for 20 min. The total amino acid for Morama Bean

roasted at 150°C for 30 min and 150°C for 25 min differed significantly (p≤0.05). The amino acid profile for roasted Morama Bean flour results are in agreement with results reported by Bower et al. (1998). Morama Bean appears to be comparable to soybean in essential amino acid content with methionine and cystine being the limiting amino acids (see Table 3.5). Glutamic acid, glycine, aspartate, tyrosine, proline and serine were the major amino acids identified in the roasted Morama Bean flour, ranging from 7.92 to13.39 g/100 g proteins. According to Ettinger (2004:66-70), lack of essential amino acids in the body could hinder synthesis of proteins and lower the body's required level of essential amino acids, which in turn can lead to problems related to digestion, depression and stunted growth. Thus, the result of this study shows that consumption of Morama Bean flour will help in the prevention of malnutrition, especially malnutrition associated with lack of protein intake.

TABLE 3.5 AMINO ACIDS COMPOSITION OF MORAMA BEAN FLOUR (MEANS ± STANDARD DEVIATION AT FOUR DIFFERENT HEAT TREATMENTS) (g/100 g PROTEIN).

Amino acids	120ºC for 40 min	150ºC for 30 min	150ºC for 25 min	150ºC for 20 min	LSD
Glutamic acid	13.39 ± 0.22^{a}	12.69 ± 0.26^{b}	12.93 ± 0.35^{b}	13.28 ± 0.31^{a}	0.33
Serine	6.98 ± 0.16^{a}	6.72 ± 0.17^{b}	6.86 ± 0.19^{ab}	7.01 ± 0.19^{a}	0.22
Glycine	9.65 ± 0.16^{a}	9.40 ± 0.22^{b}	9.55 ± 0.16^{ab}	9.71 ± 0.15^{a}	0.22
Histidine	1.97 ± 0.04^{a}	1.80 ± 0.06^{c}	1.88 ± 0.02^{b}	1.96 ± 0.04^{a}	0.05
Arginine	4.72 ± 0.11^{a}	4.09 ± 0.18^{d}	4.34 ± 0.08^{c}	4.54 ± 0.13^{b}	0.16
Threonine	3.42 ± 0.09^{a}	3.29 ± 0.09^{b}	3.37 ± 0.08^{a}	3.39 ± 0.06^{a}	0.08
Alanine	4.77 ± 0.08^{ab}	4.73 ± 0.16^{ab}	4.70 ± 0.07^{b}	4.82 ± 0.08^{a}	0.12
Proline	7.92 ± 0.08^{ab}	7.80 ± 0.18^{b}	7.85 ± 0.15^{ab}	8.01 ± 0.14^{a}	0.16
Tyrosine	8.04 ± 0.11^{a}	6.73 ± 0.33^{d}	7.46 ± 0.12^{c}	7.73 ± 0.18^{a}	0.25
Valine	4.39 ± 0.21^{a}	4.06 ± 0.37^{a}	4.20 ± 0.25^{a}	4.30 ± 0.31^{a}	0.38
Methonine	0.68 ± 0.03^{a}	0.70 ± 0.02^{a}	0.70 ± 0.02^{a}	0.69 ± 0.03^{a}	0.03
Cystine	0.45 ± 0.03^{a}	0.38 ± 0.01^{c}	0.41 ± 0.03^{b}	0.42 ± 0.04^{ab}	0.03
Isoleucine	3.53 ± 0.23^{a}	3.13 ± 0.38^{a}	3.31 ± 0.29^{a}	3.43 ± 0.32^{a}	0.41
Leucine	5.58 ± 0.07^{a}	5.20 ± 0.30^{b}	5.38 ± 0.12^{ab}	5.46 ± 0.15^{a}	0.23
Aspartate	9.63 ± 0.21^{a}	8.96 ± 0.32^{c}	9.29 ± 0.17^{b}	9.51 ± 0.22^{ab}	0.30
Norleucine	1.21 ± 0.10^{a}	1.20 ± 0.07^{a}	1.26 ± 0.11^{a}	1.29 ± 0.09^{a}	0.10
Phenylalanine	3.43 ± 0.07^{a}	3.09 ± 0.22^{c}	3.25 ± 0.09^{bc}	3.32 ± 0.11^{ab}	0.18
Lysine	4.67 ± 0.15^{a}	3.01 ± 0.36^{c}	3.77 ± 0.20^{b}	4.06 ± 0.27^{b}	0.34
Total	93.97^{a}	86.53^{c}	90.07^{b}	92.47^{ab}	2.44

3.6 CONCLUSIONS

The data on the composition of roasted Morama Bean flour with regard to proximate analysis, minerals, fatty acids and amino acids demonstrated that Morama Bean is a high quality food.

Morama Bean cultivation could prove more valuable than some of the established crops as a source of protein, minerals, carbohydrates, fat and amino acids in the diet of human beings. The n6:n3 ratios of Morama Bean flour showed high values (58.5:225.66) not desirable for human nutrition. This is due to the high values obtained from the n6 fatty acids. Thus more research needs to be undertaken to reduce the n6:n3 ratio of Morama Bean flour either through selection or through genetic manipulation of cultivated plants. The Morama Bean flour in this study is regarded as a suitable addition during formula development, as the nutritional profile of other staple foods could be complemented or enhanced using Morama Bean flour. In view of the fact that Morama Bean flour is regarded as a suitable addition during formula development, it was decided to monitor the nutritional contribution (macro-nutrients and minerals) of Morama Bean to a standard meal-plan (see Chapter 6).

3.7 RECOMMENDATIONS

There is need for further research on the n6:n3 ratio of Morama Bean flour.

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Chapter 4

Effect of different heat treatments on the sensory properties of Morama Bean (Tylosema esculentum) flour

ABSTRACT

The objective of this study was to investigate the effect of heat treatments on the sensory profile of Morama Bean flour. Four heat treatments were applied to Morama Beans and Morama Bean flour was prepared from the beans. The four treatments were evaluated using descriptive sensory analysis. Ten trained panel members identified and defined the sensory attributes. According to these results, samples roasted at 150 °C for 25 min and 150 °C for 20 min had a good sensory profile. Although these treatments were rated on the same part of the scale, there were significant differences ($p \leq 0.05$) for burnt aroma, nutty aroma and burnt flavour, with the sample roasted at 150 °C for 20 min being of a slightly higher quality than the sample roasted at 150 °C for 25 min. The sample roasted at 150 °C for 30 min was the lowest in quality being the result of the high temperature for too long, which had affected the quality of Morama Bean. The high temperature also affected the colour and caused a strong burnt and prominent roasted flavour and bitter taste in this sample. The sample roasted at 120 °C for 40 min had low mean values, indicating that the low temperature will need to be prolonged to have Morama Bean roasted to an acceptable aroma, colour, texture, flavour and taste.

Key words: Morama Bean flour, Descriptive sensory analysis, Heat treatments.

4.1 Introduction

*Tylosema esculentum (*family Fabaceae*)* ─ colloquially known *as* Morama or Marama Bean in Setswana (Botswana), Braaiboonjie, Maramaboontjie, Elandsboontjie in Afrikaans (Van Wyk & Gericke: 2000:26), and Gemsbok Bean in English (Smith, 1966:569) ─ is widespread, with large populations in Botswana (around the central Kgalagadi) and Namibia, and smaller populations in the provinces of Limpopo, North-West and Gauteng in South Africa (Verdoorn, 1959; Coetzer & Ross 1977; International Cooperation with Developing Countries Report: 2004:3). It grows in open sand veld and open grass and bush savannah (Amarteifio & Moholo, 1998). The plant is a creeper, it has prostrate branches that grow up to six metres long and its seeds are contained in pods that dehisce when dry. It is adapted to the harsh conditions of Botswana, which are characterised by low rainfall and nutritionally poor soils (Verdoorn, 1959; Coetzer & Ross 1977; Botswana Ministry of Finance & Development Planning, 2003:4). It grows wild in the Kgalagadi

and is a staple food of the Basarwa people (Amarteifio & Moholo, 1998). Figure 1.1 shows the distribution of Morama Bean in southern Africa.

The raw seeds are hard, and have been described as having a soapy taste. When young, the green beans can be boiled as green vegetables similar to green peas (self observation), while the dry beans are roasted and eaten as a snack. It can also be boiled and eaten as porridge or used as a beverage, like cocoa (Fox & Norwood-Young, 1982:108). In a raw form (self observation) the bean is seasonally available (June /July) in the local markets with no information for the consumers regarding preparation. Roudaut, Dacremont, Colas, Valles-Pamies, and Meste (2002) report that we are living in a society having a large choice of quality food, and the consumers appreciation has become one of the main criteria in food choice as well as nutrition and safety, which in the case of Morama has not been addressed.

Although Morama has long been identified as a food source (Amarteifio & Moholo, 1998; Hartley, 1997:31), research has been more focused on cultivation than on food product development. The studies on the sensory properties of Morama Bean are sparse. In view of the fact that descriptive sensory analysis can be considered as a first step in characterising the sensory attributes of a food product (Moskowitz, 1983, cited in Montouto-Grana, Fernandez-Fernandez, Vazquez-Oderiz & Romero-Rodriguez, 2001), this research addresses a void, namely to develop a sensory profile for Morama Bean flour. Furthermore, due to the fact that flavour, aftertaste and mouth feel are the most important sensory attributes normally influencing consumer purchase behaviour (Meilgaard, Civille & Carr, 1991:5), this research is justified.

In view of future food product development two important criteria to consider when selecting appropriate heat treatments are the impact of the heat treatments and collection area (wild vs fenced) on the nutritional composition and the sensory properties. Flour was subjected to four different heat treatments and thereafter evaluated for a good sensory profile, for application as flour in food formulae.

4.2 Methodology

4.2.1 Sampling

Seed specimens for the study were collected in June 2004 from five wild localities and two fenced localities in Jwaneng town, Botswana. The land use of fenced areas is mainly subsistence farming of field crops where kraal manure is used as a fertiliser. When collected the Morama seeds had already dried and been shed from the pods. The convenience sampling method was used to collect seed specimens for the study. A maximum of 2 kg was collected from each site.

4.2.2 Development of Morama Bean flour for sensory analyses

Having found that there was no significant difference ($p \geq 0.05$) in the nutritional composition between the beans from the five wild localities (W1–W5) and the two fenced localities (F1 and F2) and the Morama Beans from localities W1–W3 were mixed and coded W1, those from the wild localities (W4–W5) were mixed and coded W2 and those from the fenced localities (F1–2) mixed and coded F to develop Morama Bean flour for sensory analysis. All the samples were wiped to remove dust, weighed and roasted in a pre-heated oven at the four different treatments. Table 4.1 below shows treatments applied and localities.

Table 4.1

Morama Beans from different localities and heat treatments applied

Heat treatments		Localities (blocks)		
Temp	Time	W 1	W 2	F
120°C	40 min	x	x	x
150°C	30 min	x	x	x
150°C	25 min	x	x	x
150°C	20 min	x	x	x

After roasting, the Morama Bean shell was cracked with a hammer, and then 25 g of shelled Morama were ground with a coffee grinder (*Braun,* Type 4041, 50-60Hz, 150w, 220-230V) for two minutes (to control the textural/fineness of the flour). The 12 samples (4 heat treatments x 3 localities) were kept separate during the preparation of the bean flour.

4.2.3 Research design

The experimental design consisted of a randomised complete block design with three localities (W1, W2, F) and four heat treatments (120°C for 40 min, 150°C for 30 min, 150°C for 25 min and 150°C for 20 min) replicated in two sessions per locality. While controlling for area, samples from the four heat treatments were served to ten panel members for evaluation in a complete randomised order in two replications.

4.2.4 Statistical analyses

Data were subjected to the appropriate analyses of variance (ANOVA) using SAS version 8.2 Statistical software (SAS, 1999). Shapiro-Wilk tests were performed to test for non-normality (Shapiro & Wilk, 1965).

4.2.5 Sensory analyses

The sensory panel consisted of ten panel members experienced and trained in profiling a wide range of foods and beverages. The panel was further trained using the consensus method as described by Lawless and Heymann (1999). During preliminary sessions, the trained panel identified the sensory properties of the product. During the training session the panellists worked together as a group and discussion was encouraged. A 100 mm unstructured line scale, with the left side of the scale corresponding to the lowest intensity (zero) and the right hand side of the scale corresponding to the highest intensity (100), was used for attribute intensity evaluation. Morama Bean flours prepared from the four heat treatments were used to train the panel on sensory attributes.

The judges agreed on a consensus list of attributes for describing Morama Bean flour, which included burnt aroma, nutty aroma, colour, slimy texture, burnt flavour, roasted flavour, nutty flavour and bitter taste. Attributes and scale anchors for sensory attributes identified by the panel for the Morama Bean flour are given in Table 4.2

Table 4.2

Definitions of sensory attributes for the sensory analysis of Morama Bean flour

Attributes		Definition	Scale anchors*
Aroma	Burnt aroma	Aroma associated with burnt peanuts	None / strong
	Nutty aroma	Aroma associated with peanuts	None /strong
Appearance	Colour	Colour associated with roasted peanuts	Light /dark
Texture	Slimy texture	A sticky texture coating the palate	None /profound
Flavour	Burnt flavour	A flavour associated with a burnt peanut	None / pronounced
	Roasted flavour	A flavour associated with roasted peanuts	None / excessive
	Nutty flavour	Flavour associated with peanuts	None / prominent
Taste	Bitter taste	An aftertaste associated with bitter agents such as caffeine	None / prominent

*** Scale ranges from 0 (minimum) to 100 (maximum) for all attributes**

4.2.6 Sensory evaluation

The ten panellists were seated individually in sensory booths with a florescent light. The samples of Morama Bean flour were served in a randomised order in glass ramekins coded with three digit random codes (Stone & Sidel 1993). The aroma of the samples was immediately assessed after

removing the lid. Colour was assessed after aroma, and the flavour and texture attributes were assessed on an entire sample. Distilled water, unsalted biscuits and apple slices were available for assessors to cleanse their palates between samples when evaluating.

4.3 Results and discussion

The results of the analysis of variance (ANOVA) for the sensory attributes analysed, namely burnt aroma, nutty aroma, colour, slimy texture, burnt flavour, roasted flavour, nutty flavour and bitter taste are presented in Table 4.3. No significant difference was found between localities (W1, W2 and F) ($p > 0.05$). The data from the different localities were pooled to test for the effect of the heat treatment. There was a significant treatment effect for all the attributes evaluated ($p < 0.001$). The whole data set was taken and the outliers were removed until the data had a normal distribution in order to remove interactions between judges and treatment, but these efforts were not successful. Table 4.4 shows means of sensory attributes and the LSD values for all treatments.

Burnt aroma

The four treatments of Morama Bean flour differed significantly ($p \leq 0.05$) with regard to burnt aroma. The samples roasted at 150 °C for 30 min was rated highest with a mean value of 83.81 while the mean value for that roasted at 150 °C for 25 min was 39.36. The sample roasted at 150 °C for 20 min was 27.44 and that roasted at 120 °C for 40 min was rated lowest with mean value of 1.63 (see Table 4.4). The mean value for burnt aroma in sample roasted at 150 °C for 30 min (83.81) indicates that this aroma was very prominent. This treatment was roasted longest, causing flour with a dark colour and a strong prominent burnt aroma. The sample which was roasted for a long time at a low temperature (120 °C for 40 min), had a very low mean value for burnt aroma. This value was in fact so low that it is of no practical significance. Clearly the temperature was not high enough and time not long enough for a burnt flavour to develop.

The Maillard reaction and oxidation of lipids are the most important reactions for the formation of aromas in cooked food (Wu, Kuo & Pan, 2003). According to these researchers interactions between the Maillard reaction and oxidation have received little attention despite the fact that lipids, sugars and amino acids exist in close proximity in most foods. In the case of Morama no published research on this could be accessed. Hee-Nam-Yoon (1996) reported that volatile compounds, most important being 2,5 dimethylpyrazine and 2-methylpyrazine are commonly used as indicators of burnt aroma, which, in the case of Morama, needs to be researched.

Nutty aroma

There was a significant difference ($p \leq 0.05$) between the four heat treatments with regard to nutty aroma. The greatest difference was observed between the sample roasted at 120 °C for 40 min (lowest value namely 8) and the one at 150 °C for 25 min (highest value namely 76). Although the

first sample (120 °C for 40 min) was rated low, it had still been identified as a product with a nutty aroma. In the sample roasted at 150 °C for 30 min the nutty aroma was obscured by the burnt aroma that had developed as a result of the prolonged exposure to high temperature.

Colour

The four treatments differed significantly ($p \leq 0.05$) with regard to colour. The sample roasted at 150 °C for 30 min rated highest with mean value of 90, indicating a dark roasted colour, which was regarded lower in quality. Roasting time and temperature influence the intensity of the brown colour. Although the samples roasted at 150 °C for 25 min and 150 °C for 20 min differed significantly ($p \leq 0.05$) from each other, the difference was minimal in practical terms. The sample roasted at 120 °C for 40 min was rated lowest for colour (mean value = 4.25), significantly ($p \leq 0.05$) lower than the rest of the samples. Again this can be explained by the fact that this product was roasted at a low temperature (120 °C) for a longer time. The heat that developed was not enough for a significant colour change normally brought about by the Maillard reaction and caramelisation.

Slimy texture

The sample roasted at 120 °C for 40 min was significantly different from those roasted at 150 °C for 30 min, at 150 °C for 25 min and at 150 °C for 20 min in respect of slimy texture. Hartley (1997) reports that Morama seed has a slimy texture when raw. It was observed that the sample roasted at 120 °C for 40 min had a mean value of 93 and did therefore not have sufficient heat energy to change the texture of the bean from that of its raw state.

The other heat treatments were rated on the lower part of the scale indicating no slimy texture, and sufficient heat energy was applied to impact on slimy texture. It is speculated that heat treatment should be sufficient to inactivate the enzyme/enzymes or to breakdown the compounds that contribute to this slimy texture. This is a study on its own as no literature could be found to support this hypothesis.

Burnt flavour

There was a significant difference ($p \leq 0.05$) between the four samples with regard to burnt flavour. The sample roasted at 150 °C for 30 min, had a strong burnt flavour as a result of the sample being roasted for a long time (30 min at a high temperature of 150 °C) and was therefore also rated highest with a mean value of 89. Flavour formation in foods is primarily the result of *inter alia*, the Maillard reaction, caramelisation, thermal degradation, oxidation and lipid-Maillard interactions, which, in the case of Morama Beans, need to be researched.

Table 4.3

Analysis of variance (ANOVA) of sensory attributes

ANOVA		Burnt aroma		Nutty aroma		Colour		Slimy Texture		Burnt flavour		Roasted flavour		Nutty flavour		Bitter taste	
Source	DF	MS	P	MS	P	MS	P	MS	P	MS	P	MS	P	MS	P	MS	P
Locality	2	214.6	0.2758	8.7	0.9062	65.3	0.0921	668.9	<.0001	244.3	0.0371	243.0	0.0018	294.9	0.0017	64.9	0.1057
Jugde no	9	1664.3	<.0001	828.3	<.0001	1312.3	<.0001	2564.9	<.0001	1989.4	<.0001	833.7	<.0001	1660.6	<.0001	4481.9	<.0001
Session	3	1021.2	0.006	13.9	0.9250	41.5	0.2058	260.3	<.0001	591.9	<.0001	99.2	0.0483	285.9	0.0004	76.0	0.0498
Judge no * Session	45	390.2	<.0001	152.6	0.0085	219.5	<.0001	319.1	<.0001	267.0	<.0001	162.5	<.0001	75.8	0.0090	107.5	<.0001
Treatment	3	68281.3	<.0001	57259.6	<.0001	75832.4	<.0001	78307.7	<.0001	77427.4	<.0001	70858.3	<.0001	59536.2	<.0001	40531.3	<.0001
Locality** Treatment	6	103.1	0.7104	463.1	<.0001	31.3	0.3286	83.86	<.0001	45.2	0.7105	25.8	0.6477	69.1	0.1602	87.2	0.0077
Judge*** Treatment	27	416.7	0.0003	992.2	<.0001	514.1	<.0001	479.4	<.0001	903.1	<.0001	235.4	<.0001	822.1	<.0001	2487.7	<.0001
Error	144	165.0	-	88.5	-	26.9	-	14.6	-	72.4	-	36.7	-	44.0	-	28.3	-
Total Correlation	239																

DF = degree of freedom

MS = mean square

P = Probability value of F-ratio test

Interaction between main effects

* Indicates interaction between judge number and session

**Indicates interaction between locality and treatment

***Indicates interaction between judge and treatment

Table 4.4

Means of sensory attributes

Sensory Attributes	Scale anchor	120 °C 40 min	150 °C 30 min	150°C 25 min	150 °C 20 min	LSD (p=0.05)
Burnt aroma	None / strong	1.63[d]	83.81[a]	39.36[b]	27.44[c]	4.697
Nutty aroma	None /strong	7.66[d]	63.36[c]	76.11[a]	68.45[b]	3.416
Colour	Light /dark	4.25[d]	90.18[a]	68.57[b]	60.57[c]	1.913
Slimy texture	None /profound	92.67[a]	14.27[c]	18.14[b]	18.39[b]	1.424
Burnt flavour	None / pronounced	1.23[d]	89.04[a]	33.26[b]	27.09[c]	3.131
Roasted flavour	None / excessive	3.22[d]	88.95[a]	57.41[b]	53.97[c]	2.247
Nutty flavour	None / prominent	8.07[c]	64.65[b]	75.54[a]	73.29[a]	2.431
Bitter taste	None / prominent	36.19[b]	75.75[a]	21.13[d]	15.29[c]	2.000

[a - d] Mean values in the same row with the same superscript are not significantly different.

Roasted flavour

The panel found a significant difference ($p \leq 0.05$) in roasted flavour when comparing the four treatments. The sample roasted at 150°C for 30 min was rated highest with a mean value of 88.95 indicating a too prominent roasted flavour according to the scale (see Table 4.4). Although a significant difference ($p \leq 0.05$) in the roasted flavour of the samples roasted at 150 °C for 25 and 20 min were found, their mean values are not far apart (57.41 and 53.97 respectively) and these values indicate that these products were perceived as being medium roasted. The roasted flavour was not regarded as too prominent. The sample roasted at 120 °C for 40 min differed significantly ($p \leq 0.05$) from the other treatments with a mean value of 3.22 which showed that the sample was rated on the lower part of the scale, indicating minimal roasted flavour.

Nutty flavour

There was no significant difference ($p \geq 0.05$) between the samples roasted at 150 °C for 25 min and at 150 °C for 20 min respectively with regard to nutty flavour. Both treatments had an intense nutty flavour. The nutty flavour was dominated by the burnt flavour in the sample roasted at 150 °C for 30 min, hence the product was rated low in nutty flavour intensity. The sample roasted at 120 °C for 40 min had a low nutty flavour (mean value of 8.07) due to the fact that the nutty flavour was not sufficiently developed during the low heat treatment.

Bitter taste

Significant differences in bitter taste between all four heat treatments were found (see Table 4.4). The sample roasted at 120 °C for 40 min differed significantly ($p \leq 0.05$) to those at 150 °C for 30 min, 25 min and 20 min with regard to bitter taste. The samples roasted at 150 °C for 30 min was rated highest with a mean value of 75.75. This was on the highest part of the scale, which was described as a prominent bitter taste. The sample roasted at 150 °C for 20 min – the shortest roasting period at this temperature ─ were rated lowest when evaluating bitter taste, significantly lower ($p \leq 0.05$) than the rest of the samples. The time-temperature intensity was therefore low enough for a minimal degradation effect on the proteins, carbohydrates and fats and therefore little bitter taste was detected. Atwal, Eskin and Vaisey-Genser (1980) report that choline contributes to bitter taste in pulses, which need to be investigated in Morama. During training, panel members speculated that the origins of the bitter flavour might differ. They found the characterisation of these two different bitter flavours difficult.

4.4 Conclusions

The aim of this study was to identify from the four heat treatments and the three localities the Morama Bean flour with a good sensory profile in order to use correct procedures for the development of Morama Bean flour during food product development. According to these results, the samples roasted at 150 °C for 25 min and those at 150 °C for 20 min had a good sensory profile, while those at 150 °C for 30 min was the lowest in quality being the result of the high temperature for a prolonged time, which had affected the quality of Morama Bean. The high temperature in the samples roasted at 150 °C for 30 min also affected the colour and caused a strong burnt flavour, prominent roasted flavour and bitter taste. Those roasted at 120 °C for 40 min had a low mean value for aroma, colour and flavour indicating that the samples at the low temperature will need a longer time to roast. Although the samples roasted at 150 °C for 25 and 20 min were rated on the same part of the scale for burnt aroma, nutty aroma and burnt flavour, there were significant differences ($p \leq 0.05$) with the latter being judged to have a slightly higher quality than the former

4.5 Recommendations

The results of the descriptive sensory analysis showed that the sample roasted at 150°C for 20 min had a good sensory profile. The procedure developed in this study can be applied successfully during food product development.

Since it is speculated that the heat treatment should be sufficient to breakdown the compounds or inactivate the enzyme or enzymes that contribute to slimy texture, further research needs to be conducted in this area.

Torres-Penaranda, Reitmeier, and Wilson, Fehr, and Narvel (1998) report that lipoxygenase is responsible for the off-flavours present in soybean and the genetic removal of the SBL-2 isozyme (which is a lipoxygenase isozyme) has been previously found to reduce the beany, rancid and oily flavours associated with soy products. The presence of lipoxygynase in Morama needs to be researched.

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CHAPTER 5

THE EVALUATION OF TWO TRADITIONAL BOTSWANA DISHES ENRICHED WITH DIFFERENT LEVELS OF MORAMA BEAN FLOUR

Abstract

The aim of this study was to determine the acceptability of sorghum porridge and samp & beans supplemented with Morama Bean flour at different levels. A focus group consisting of seven Batswana (people from Botswana) participants who regularly consume sorghum porridge and samp & beans was used as a sensory tool. A scorecard was developed for each of the products to test the acceptability of the samples supplemented with different levels of Morama Bean flour. These scorecards were used as evaluation tools during the presentation of samples after initial warm-up sessions. A protocol delineating the sequence of questions to be asked in the focus group was designed beforehand and applied for each product. Although the participants did not all know Morama Bean, their preferences regarding acceptable levels of Morama Bean in the products evaluated were similar. The sorghum porridge and samp & beans with Morama Bean flour added at 5% were preferred to the 10%, 15% and 20% levels.

Key words: Morama Bean flour, focus groups, sorghum porridge, samp & beans (*dikgobe).*

4.7 Introduction

*Tylosema esculentum (*family Fabaceae*)* – colloquially known *as* Morama or Marama Bean in Setswana (Botswana), Braaiboonjie, Maramaboontjie, Elandsboontjie in Afrikaans (Van Wyk & Gericke: 2000:26), and Gemsbok Bean in English (Smith, 1966:569) – is widespread, with large populations in Botswana (around the central Kgalagadi) and Namibia, and smaller populations in the provinces of Limpopo, North-Westand Gauteng in South Africa (Verdoorn, 1959; Coetzer & Ross 1977; International Cooperation with Developing Countries Report: 2004:3). It grows in open sand veld and open grass and bush savannah (Amarteifio & Moholo, 1998). The plant is a creeper, it has prostrate branches that grow up to six metres long and its seeds are contained in pods that dehisce when dry. It is adapted to the harsh conditions of Botswana, which are characterised by low rainfall and nutritionally poor soils (Verdoorn, 1959; Coetzer & Ross 1977; Botswana Ministry of Finance & Development Planning, 2003:4). It grows wild in the Kgalagadi and is a staple food of the Basarwa people (Amarteifio & Moholo, 1998) and therefore regarded as a 'food vehicle' for the purpose of nutrition intervention in malnourished communities.

Although Morama Bean has long been identified as a food source (Smith, 1966; National Academy of Sciences 1979; Keegan & Van Staden; 1981; Hartley, 1997; Amarteifio & Moholo, 1998), research on Morama Bean has been more focused on cultivation than on food product development. The raw seeds are hard, and have been described as having a soapy taste. When young, the green beans can be boiled as green vegetables similar to green peas (self observation), while the dry beans are roasted and eaten as a snack. It can also be boiled and eaten as porridge or used as a beverage, like cocoa (Menninger, 1977), while a formula for Morama Bean butter has also been patented (Tebogo Matlhare, Thusanyo Lefatsheng officer, personal communication, 2004), but has never been produced. This bean is seasonally available (June/July) in local markets in a raw form (self observation) with no nutritional information for the consumers.

The nutritional composition of Morama Bean was found to be valuable, with a protein content of 36% and fat content of 39% (see Chapter 3). In view of the fact that protein-energy malnutrition (PEM) is one of the major national public health problems in Botswana (Botswana Ministry of Health, 2003) the inclusion of Morama Bean flour in the diet could help to combat the problem. The researcher is also aware of the fact that Botswana is one of the countries in sub-Saharan Africa most affected by HIV/AIDS (Botswana Ministry of Health, 2003). Thus, in view of the fact that Morama Bean can combat malnourishment, it could also be used as one of the indigenous solutions to malnutrition and its association with HIV/AIDS. Any immune impairment resulting from HIV/AIDS leads to malnutrition (Botswana Ministry of Health, 2003). In response to the Botswana Vision 2016 issued by the government, this research is timely to contribute towards better health for people of Botswana. The target group of 13-year-olds will be the working force by the year 2016 and by developing foods that will improve their health, a contribution towards one of the Vision 2016 objectives of providing adequate nutrition for all citizens can be made (Presidential Task Group, 1997).

In Botswana, secondary school children (13 years and older) spend nine hours in school every day. There is an existing school feeding programme where children are served two meals a day. With specific reference to the school-feeding programme in the Kgosimpe Secondary School, the learners are served sorghum porridge three times a week as breakfast, and samp & beans for lunch once (Boikanyo Moseki, teacher at the above-mentioned school, personal communication). Samp is broken maize kernels which are cooked for an extended period (four to six hours), often with beans, until tender. The standard menu as served at this school was analysed using the software nutritional database programme, *Foodfinder ™ 3* (SA Medical Research Council, 1991), and the results showed (see Chapter 6) that the meal does not meet the Recommended Dietary Allowance (RDA) with regard to protein and fat. Morama Bean can complement this deficiency in the school-feeding programme. These dishes are also served at home. By enriching sorghum and

samp & beans with Morama Bean flour, these foodstuffs could be used as food vehicles to introduce Morama Bean.

In South Africa, food vehicles such as maize flour and bread flour have been granted status as mandatory fortified foodstuffs (SA Department of Health, 2003). Fortification mixes that are used are prescribed, as can be seen in Table 5.1 below. Park, McDowell, Hanson and Yetley (2001) found the fortification of cereals used as food vehicles for the distribution of nutrients to be successful.

Table 5.1

Micronutrient requirements for fortification mix of maize meal (super, special, sifted, unsifted)*

		Micronutrient requirements Per 200 g maize meal Nutritional Goal				Per 1 kg meal Required
Micronutrients	RDA	%RDA	Amount	Retention	Required Addition	Addition
Vitamin A (mcg RE)	800	31%	250	60%	417	2085
Thiamine (mg)	1.40	25%	0.3500	80%	0.4375	2.1875
Riboflavin (mg)	1.60	17%	0.2700	80%	0.3375	1.6875
Niacin (mg)	18	25%	4.5000	90%	5.0000	25.0000
Pyridoxine (mg)	2.00	25%	0.5000	80%	0.6250	3.1250
Folic acid (mg)	0.40	50%	0.2000	50%	0.4000	2.0000
Iron (mg)	14	50%	7.0000	100%	7.0000	35.0000
Zinc (mg)	15	20%	3.0000	100%	3.0000	15.0000

*(SA Department of Health, 2003)

Deliza, Rosenthal and Silva (2003) report that even if a food meets its nutritional requirements, it is unlikely to be accepted by consumers if they do not like the flavour or any other product attribute. Therefore this research aimed at the evaluation of five samples for each of sorghum porridge and samp & beans with Morama Bean flour at different levels, namely 0%, 5%, 10%, 15% and 20%. The dishes without Morama Bean flour are common household menu-items.

4.8 Background on the focus group technique as a sensory tool

The focus group technique is an idea-generating strategy leading to a course of action (Delbecq, de Ven and Gustafson cited in Matthee, 2001). When using this technique the aim is to obtain the whole spectrum of possible opinions from the selected group (Lawless & Heymann, 1999). When using the focus group technique, respondents are offered some topic and are encouraged to discuss it amongst themselves (Silverman, 2001). Focus groups are most effective when exploring responses to well-formulated specific questions (Barnowski et al., 1993 in Deliza et al., 2003). Garber and Boya (2005) report that focus groups are useful for identifying product performance

attributes that are important to consumer needs and influence choice decisions in a given product category.

The focus group technique is qualitative in nature and is used to find information that could not have been accessed in another way. The focus group is useful because discussions within the group tend to allow space in which people can get together and create meaning amongst themselves (Babbie & Mouton 2001). Morgan (1999) report that purposive sampling generates the most productive discussion in the focus groups since the goal in focus groups is to gain insight and understanding by in-depth discussion. Morgan (1999) further states that the participants must be compatible, have some common ground to stand on and be able to talk to each other.

Frankfort-Nachmias and Nachmias (1997) report that the data obtained from a focus group is not representative of the larger population because a very small number of people are used, while Schutte (Senior researcher, Unisearch, Strand, RSA, personal communication, 2004) argues that it is a projection technique − the participants also talk about other people they know, so this covers a fuller range of individuals.

The advantages of the focus group technique are that the facilitator is free to probe, there is a high degree of visual validity, it is a comparatively cheap method to use, the results can be obtained speedily and the researcher can increase the sample or alter the composition without affecting the research process drastically (Krueger, 1988; Morgan, 1999). Furthermore, Stewart and Shamdasani (1990) report that compared to quantitative research, focus groups produce a richer amount of data, because they allow the researcher to ask follow-up questions for clarification, and non-verbal communications can be observed for interpretation of the responses. Compared to personal in-depth interviews, focus group sessions require less time and money, which was within the researchers' limited budget, and yields more facts than personal interviews (Stewart & Shamdasani, 1990).

The focus group method allows participants to explain motivations and reasons for their attitudes, perceptions and preferences and therefore requires the facility of a discussion guide (Deliza et al., 2003). This discussion guide also puts the panel members at ease during the warm-up, which offers a course to follow from the warm-up in order to gather the best information the panelists can offer bearing the goals of the research in mind (Templeton, 1994).

This technique has been used extensively in different localities such as marketing research, nutrition and health education (Auld, Kendall, & Chipman, 1994; Brug, Debie, Assema & Weijts, 1995; Dixey, Sahota, Atwal & Turner, 2001; Lewis & Yetley, 1992). MacFie and Thomson (1994) and the researchers mentioned above have considered the focus group technique as a reliable method.

4.9 Methods

In order to achieve the research objectives, the research followed a particular sequence. Focus group sessions took one hour for each product.

4.9.1 Recruitment of panel members

Seven people aged between 30 and 40 years old ─ six females and one male originally from Botswana and presently studying at the Stellenbosch University, South Africa were recruited. They were people familiar with eating sorghum and samp & beans, which are traditional dishes. Asp (1999) suggests that food habits are a component of culture that makes an important contribution to the food decisions consumers make. However, Morama Bean product was not known to all of them.

4.9.2 Warm-up session

The participants were seated around a table to allow interaction, eye contact and free flow of discussion. The facilitator started the discussion by introducing himself and the general subjects for the discussion. The facilitator took the group through a series of questions on the general use of sorghum and samp & beans, while two assistants took notes. The group members were asked to evaluate and give their opinions on the application of Morama Bean in the products being reported in this research. The following research questions were addressed in the warm-up session:

- How often do you eat sorghum/samp & beans?
- Sketch the typical situation in which you will eat or prepare sorghum/samp & beans.
- Where do people usually eat sorghum/samp & beans other than in their own houses?
- What would for you, be the characteristics of ideal sorghum/samp & beans?

4.9.3 Development of scorecard

After the warm-up session a scorecard was developed for sorghum, and for samp & beans. The scorecard had a rating scale to evaluate the samples on a 9-point scale with 9 used as criterion for ideal sample of sorghum porridge and samp & beans. The following sensory attributes, namely colour, thickness, taste, texture and cooked flavour of the sorghum porridge were regarded as important attributes to be included in the scorecard, while the colour, thickness, taste, mixture (the ratio of samp to beans) and the smell of the samp & beans were regarded as important attributes to be included in the scorecard of the second product.

4.9.4 Development of formula and preparation of sample

Formulae were developed to include approximately 0%, 5%, 10%, 15% and 20% Morama Bean flour in the final cooked products. See Tables 5.2 and Table 5.3 for the different formulations for sorghum and for samp & beans respectively.

Table 5.2

Percentage formulae of sorghum with Morama Bean flour added at four different levels

Ingredients	%	%	%	%	%
Sorghum flour	17	17	16	15	14
Water	83	78	74	70	66
Morama Bean flour	0	5	10	15	20
% Yield	100	100	100	100	100

Table 5.3

Percentage formulae of samp & beans with Morama Bean flour added at four different levels

Ingredients	%	%	%	%	%
Dry samp & beans	22	21	19	19	18
Water	77	73	70	65	61
Salt	1	1	1	1	1
Morama Bean flour	0	5	10	15	20
% Yield	100	100	100	100	100

4.9.5 Method for the preparation of sorghum and samp & beans

For each sample a mixture of ingredients (as per Tables 5.2 and 5.3) was weighed off and mixed in an ovenproof dish, and cooked in a preheated oven (a *Fridgidaire* Electric Stove [Super Cook Master Model] was used) in order to achieve satisfactory temperature control. The mixtures were stirred at intervals to avoid unappetising lumps. Because the two products are quite different in their physical properties, they were prepared differentially: the sorghum porridge was cooked for 30

min at 140°C and stirred at 10 min intervals; the samp & beans dish was cooked for six hours at 100°C and stirred at 30 min intervals.

4.9.6 Presentation of sample

A control sample of sorghum porridge and those with different levels of Morama Bean flour (see Table 5.2) were presented after the warm-up session. The panel discussed these and in the second session samples of samp & beans with different levels of Morama Bean flour were presented. The attributes for each sample were evaluated on a scorecard. The following research questions were addressed during the evaluation of the samples − each sample dealt with separately:

- Let us talk about the sample. How did you find it?
- If the sample that you rated best were available on the market, would you buy it instead of sorghum/samp & beans?
- Will you serve it to your children?
- Do you think your children will eat it?

4.10 Results

Results of the warm-up session and evaluation of the scorecard will be reported in the following sequence.

4.10.1 Information gathered during warm-up session

The information given in the following paragraphs is the opinions of the focus group members pertaining to the general use of sorghum and samp & beans.

4.10.2 Sorghum

Sorghum is eaten every day, for breakfast, lunch or supper. This statement is supported by Kebakile et al. [s.a] (from Botswana), who report that sorghum is the most consumed cereal accounting for 74% of total cereal consumption in peri-urban localities. Kebakile et al. [s.a] further reported that educational level and residential localities influence the consumption of sorghum. Some focus group members referred to sorghum as a ‘must have or must eat’. It is served throughout the country and in Botswana there is no house without sorghum. It can be served for all occasions, including weddings and funerals. It can be bought as a take away as is, or served with meat. The sorghum meal is served to all members of the family. It is regarded as a main meal and not a side dish. For breakfast, it is normally soft or of a dropping consistency, and it is served with milk (sour or fresh) and sugar. When prepared for lunch it is thicker and can be served with side dishes. It can be prepared fermented or non-fermented. It is used in school-feeding

programmes from nursery school to tertiary school. The use of sorghum could be compared to the use of bread in South Africa.

4.10.3 Samp & beans

Samp & beans is commonly eaten as a main dish for lunch or supper. It is not served daily, but once to thrice a week. It is regarded as a full meal and taken without meat or side dishes. Samp & beans can also be served at funerals and weddings. People find samp & beans economical since it expands when cooked and it is considered as a good meal for manual labourers. It can be bought as a take away as is, or with added vegetables. People prefer to make their own mix of samp & beans, as the premix on the market does not include enough beans. The focus group also found that the premix used in this investigation did not include enough beans as can be seen in Figure 5.2, where all the samples were rated low for mixture of samp & beans. Although the SA draft legislation pertaining to the advertising and labelling of foodstuffs requires a food-quantitative ingredient declaration (QUID) for a product that has emphasis in the product name on an ingredient or ingredients, the producers of this product did not apply the QUID declaration. Presently this practice is not illegal, but once the legislation has been promulgated, this package labelling will have to declare percentage of samp & beans respectively. The premix of the South African product used during this research contained 83% samp and 17% beans. In school-feeding programmes the Botswana premix of samp & beans is used and vegetables are added during the cooking process. Oil, a spice-like barbecue salt, beef cubes and vegetables are usually added for additional flavour, while cooking. Sometimes samp & beans is taken with milk.

4.10.4 Evaluation using scorecards

The focus group evaluated the sorghum porridge samples during the first session and samp & beans during the second session. Control samples without Morama Bean flour were available for each of these seven panelists.

4.10.5 Sorghum evaluation

Mean values for the attributes of the sorghum porridge samples were calculated and are summarised in Table 5.4.

Table 5.4

Mean values of sorghum porridge with different levels of Morama Bean flour

Criterion	Ideal sorghum	0%	5%	10%	15%	20%
Brown colour	9	5.8	5.2	5.2	3.5	4.3
Consistency	9	7.0	5.5	6.2	6.5	7.0
Taste	9	7.0	7.2	3.5	3.3	5.7
Texture	9	7.3	5.7	5.8	**7.2**	7.5
Cooked flavour	9	7.7	6.5	4.8	5.2	7.3

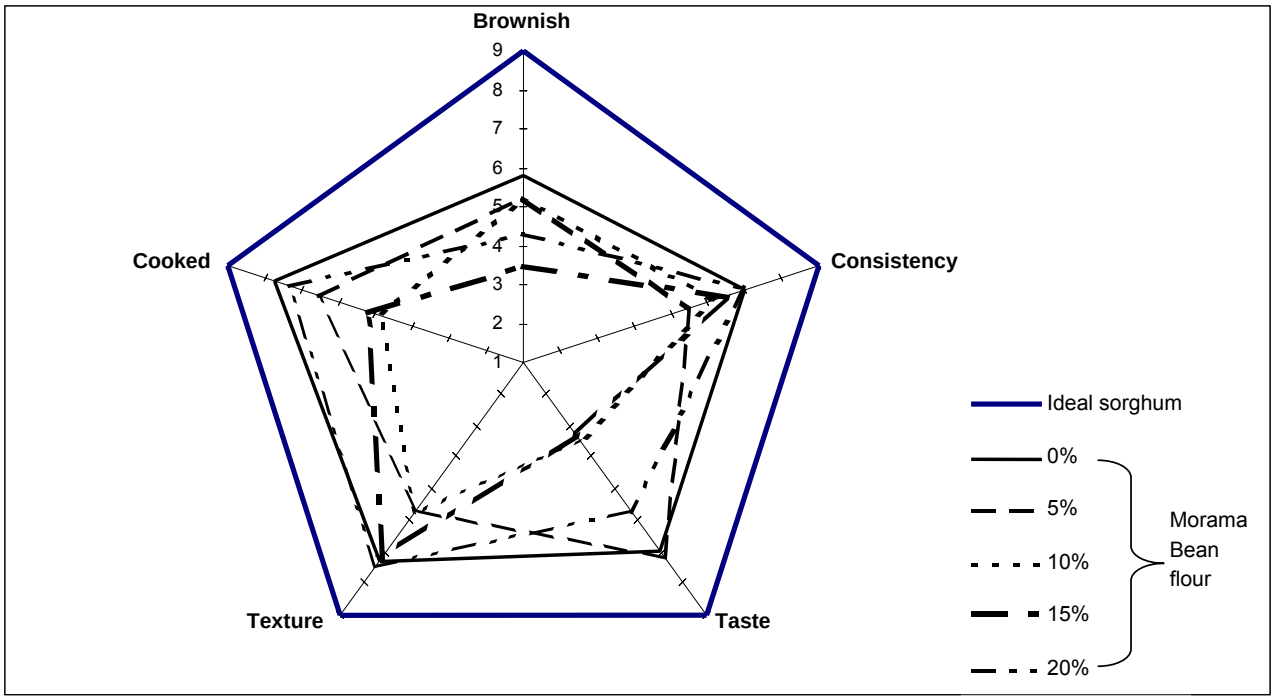

Figure 5.1 Rating of traditional sorghum porridge against sorghum porridge with different levels of Morama Bean flour.

The control sample was rated highest in cooked flavour. Asp (1999) explains that the foods most liked by consumers are those which consumers are familiar with and are considered to be pleasant. Most people preferred the product with 5% Morama Bean flour to all the other samples with the exception of the control. This is also clear from Figure 5.1 where the product with 5% Morama Bean flour was rated highest in taste when compared to the products with 10%, 15% and 20% Morama Bean flour.

Some panel members preferred to add sugar when tasting the sorghum porridge and Morama Bean mixtures. The product with 5% Morama Bean flour could also be served with milk. Panel members felt there was no need to add salt to the sorghum porridge. The consistency of the samples prepared for this session was quite thick and panel members observed that they would prefer porridge with a thinner consistency and softer mouthfeel consistency for breakfast. The panel felt that the colour and taste of the product with 5% Morama Bean flour was acceptable.

According to Figure 5.1 the sample with 20% Morama Bean flour was closer to the ideal sample in thickness, texture and cooked flavour than the 5%, 10% and 15% samples, although the panel felt that this product had a dark colour, and was perceived as being bitter and the taste was not acceptable. Thus, it was regarded to be too different from the sorghum available in the market and they would not buy it, nor did the panel feel that children would eat the product with 20% Morama

Bean flour. However, some panel members felt that the product with 20% Morama Bean flour was not too bitter for adults.

Some of the responses made by the focus group, which were recorded during the discussion, differ from the scorecard responses. Therefore the researchers concluded that the scorecard results could not be relied on. This could be due to the fact that some of the focus group members tried to reach a consensus during the discussion, which is discouraged in focus group sessions.

4.10.6 Samp & beans evaluation

The mean values for all the samp & beans samples were calculated and are summarised in Table 5.5. According to Table 5.5 the focus group rated the sample with 5% Morama Bean flour highest for colour, taste and smell and the panel indicated that they would buy it if available on the market. Asp (1999) reports that according to the Food Marketing Institute Survey, 1998, taste is considered as the most important sensory attribute. The focus group thought that it would be acceptable for children. Samp & beans is regarded as a traditional food and the panel felt it was necessary to stay close to the original formula.

The panel felt that the colour of the sample with 20% Morama Bean flour was excellent but it tasted bitter. Some panel members indicated that the bitterness disappeared after a while and did not linger on the palate. The consistency of the 20% sample was more acceptable than that of the other samples. The product with 20% Morama Bean flour was found to be creamy but too rich for some panel members. The creamy and rich taste would make it difficult for an individual to consume the normal portion of samp & beans. The darker colour of the product with 20% Morama Bean flour gave the appearance of a meaty stew but it did not taste meaty. One could add beef cubes during cooking to add the meaty taste. The panel felt the school children would not find the product with 20% Morama Bean flour acceptable.

Table 5.5

Mean values for samp & beans with different levels of Morama Bean flour

Criterion	Ideal samp & beans	0%	5%	10%	15%	20%
Colour	9	4.0	6.9	5.7	4.6	4.4
Consistency	9	5.1	5.6	5.9	4.9	6.9
Taste	9	7.7	6.6	4.9	3.1	2.9
Mixture	9	3.7	3.9	4.1	5.4	4.3
Smell	9	7.6	7.3	6.4	6.0	5.4

In Figure 5.2 it becomes clear that the sample with 5% Morama Bean flour was closer than the 10%, 15% and 20% samples to the ideal sample in taste, colour and smell. The thickness of the 20% sample was more acceptable than that of the other samples.

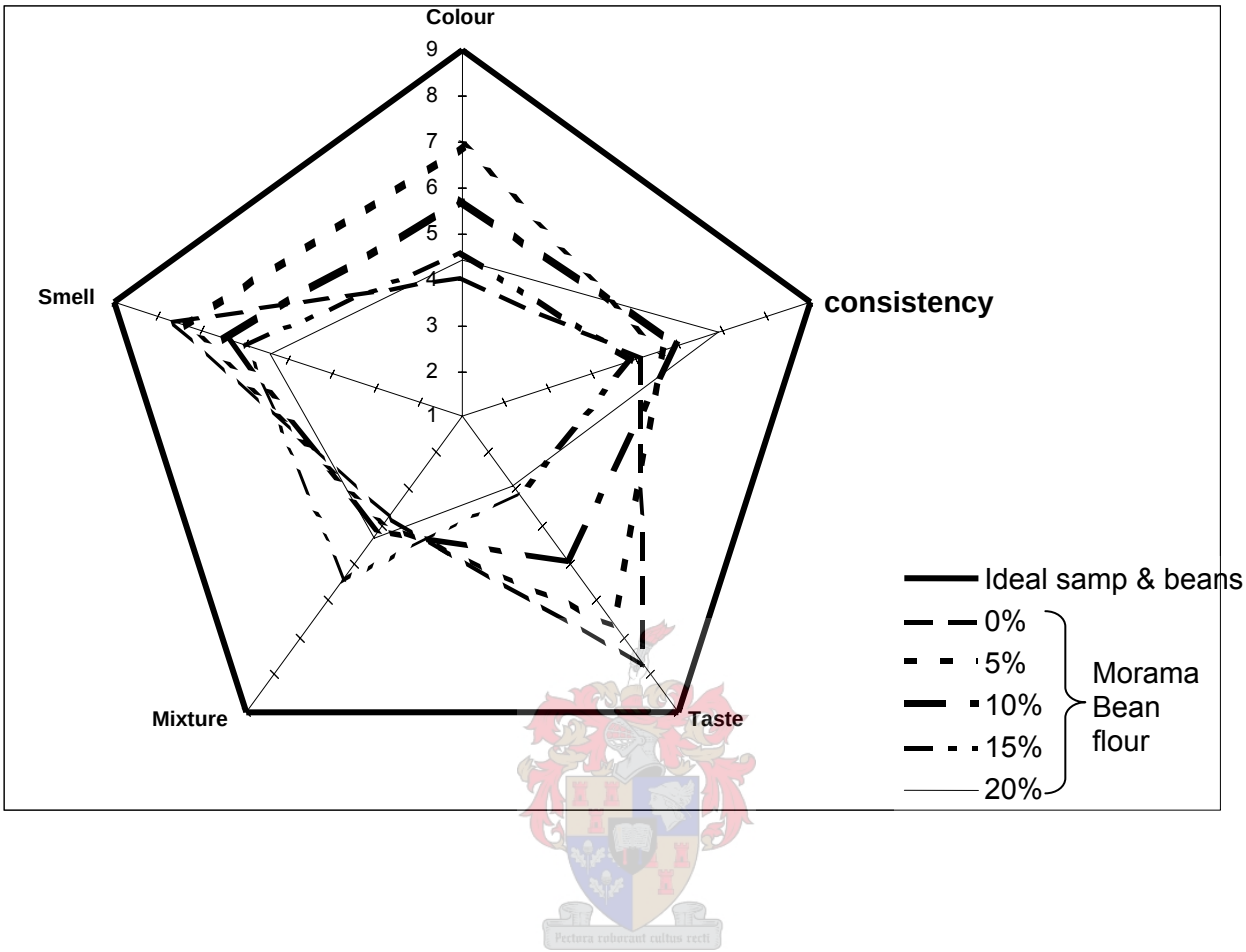

Figure 5.2 Rating of traditional samp & beans against samp & beans with different levels of Morama Bean flour.

4.11 CONCLUSIONS

The focus group interview was a useful tool in evaluating the sensory attributes of sorghum and samp & beans with Morama Bean flour at different levels. The warm-up sessions confirm that sorghum and samp & beans are commonly eaten in Botswana and are good food vehicles for food supplementation or enrichment. In South Africa the fortification of bread flour and maize meal is mandatory (SA Department of Health, 2003). The same can be advocated for sorghum flour in Botswana (for further justification see Chapter 4). Sorghum flour which is used so commonly daily (three times a day), could successfully be fortified with vitamin A, thiamin, riboflavin, nicotinamide, pyridoxine, folic acid, iron and zinc should levels be adapted in view of the possible daily intake to prevent over medication. These are essential nutrients to combat the silent disease rampant amongst the youth of southern Africa (Shetty, 2002). Additionally to this, sorghum porridge

especially could be supplemented with Morama Bean flour, which adds to the fatty acids and amino acids deficient in sorghum porridge.

With regard to the blood glucose response, it should be borne in mind that the Morama Bean flour contains 36% protein and 38% fat which are also factors that lower the glucose response of glyceamic carbohydrates, not only through their physiological effect (Asp & Björck, 1992) but also through the starch-protein and starch fat interactions (Vosloo, 2005) that take place during the cooking. This supplementation will therefore benefit school learners by improving concentration span and delaying hunger pangs (see Chapter 3).

4.12 Recommendations

This study has demonstrated that ideal sorghum porridge and samp & beans with a 5% inclusion level of Morama Bean flour are acceptable. The acceptability was tested by using an adult focus group and therefore the researchers recommend that further consumer studies be conducted using children to get their views on the use of Morama Bean flour in food products as they are the target group for use of samp & beans and sorghum porridge in the school feeding programme. In Botswana, sorghum porridge products e.g. *Morvite* and *Tsabana* are available. They have been fortified with ß-carotene, riboflavin, niacin, pyridoxine, folic acid, cyanocobalamin, ascorbic acid, tocopherol acetate, iron, potassium and zinc. Kebakile et al. [s.a] report that the group aged 15–19 who ate sorghum every day preferred these fortified sorghum products contrary to the adult group used in the investigation. This statement indicates that the focus groups representing the target age group should be used to test the acceptability of traditional foods fortified with Morama bean flour.

Dixey et al. (2001) advise that nutrition education programmes need to allow for greater participation by children and to focus on behaviours, attitudes and values as well as the transfer of knowledge. For this reason the researchers recommend the inclusion of information on the nutritional composition of Morama Bean in nutrition education programmes, the concepts of fortification and food supplementation.

The researcher further recommends more clinical studies on the impact of supplementation and fortification on the nutritional status, and consumer research.

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Chapter 6

Monitoring of the nutritional contribution of Morama Bean to a standard meal-plan

Abstract

In Botswana, secondary school children spend nine hours in school a day. There is an existing school-feeding programme where learners are served two meals a day. The learners are served sorghum porridge three times a week as breakfast, and samp & beans for lunch once a week. Through supplementation of these two traditional menu-items Morama Bean flour offers an opportunity to address malnutritional problems. The first aim of this research was to establish the adequacy of a one-day meal-plan containing *inter alia* sorghum porridge and samp & beans with regard to macronutrients and minerals and the impact of different levels of Morama Bean flour in premixes of these products on the nutritional adequacy of the meal-plan. The second aim was to determine the gluten content. The third aim was to calculate the glycaemic index (GI) of sorghum porridge and samp & beans (*dikgobe* in Setswana) and the impact of 5% Morama Bean flour in premixes on these calculations using an estimated value for Morama Bean. Samp is broken maize kernels which are cooked for an extended period (four to six hours), often with beans, until tender. The determination of the GI of pure Morama Bean is not executable due to high fat and protein value (similar to peanuts). A standard meal-plan for a day was analysed using the software nutritional database programme, *Foodfinder ™ 3* of the South African Medical Research Council and inserting the values for Morama Bean flour obtained in another study in the database. The results showed that the one-day meal-plan without the Morama Bean flour supplementation does not meet the Recommended Dietary Allowance (RDA). By enriching sorghum and samp & beans with Morama Bean flour, the deficiency could be addressed. Sorghum and samp & beans could be used as food vehicles to introduce Morama Bean, which is an indigenous and grossly under-utilised food of Botswana. The nutritional value of the menu-items contained in the meal-plan was significantly improved and it is evident that Morama Bean flour can be used in a strict gluten-free diet. The addition of Morama Bean flour at a 5% level changed the GI of the sorghum porridge from a high GI food to an intermediate GI food. Morama Bean flour at 5% level in a samp & beans premix did not impact on the GI as significantly as in sorghum porridge. However, further studies to evaluate impact of this addition on actual blood glucose response on sorghum porridge and samp & beans is advised. Additionally, fortification with macronutrients such as calcium, iron and B-vitamins is advised. Internationally, fortification status is given to food vehicles such as sorghum and samp in the third world countries where diseases due to lack of micronutrients are rampant.

5.1 Introduction

The nutritional composition of Morama Bean was found to be valuable, with a protein content of 36% and fat content of 39% (see Chapter 3, Section 3.3.1). In view of the fact that protein-energy malnutrition (PEM) is one of the major national public health problems in Botswana (Botswana Ministry of Health, 2003:11; Botswana Ministry of Finance and Development Planning, 2003:315) the inclusion of Morama Bean flour in the diet could help to combat the problem. Madisa and Tshamekang [s.a] report that there is an increasing concern that the use of indigenous foods is declining and the decline has resulted in nutritional deficiencies, especially among children in rural areas. The researcher is also aware of the fact that Botswana is one of the countries in Sub-Saharan Africa most affected by HIV/AIDS. Thus, in view of the fact that Morama Bean can combat malnourishment (see Chapter 3), it could also be used as one of the local solutions to malnutrition and its association with HIV/AIDS. Any immune impairment resulting from HIV/AIDS leads to malnutrition (Botswana Ministry of Health, 2003:17).

The Report of the Botswana Ministry of Health (2003:18) states that poor household food security is a contributing factor to malnutrition. It further reports that available data indicates that for years Botswana has not been able to produce enough food to meet its national requirements (Lado, 2001). Attaining household food security depends on the purchasing power of the household. This means that food insecurity is a problem in the country as 47% of the population lives below the poverty datum line (Botswana Ministry of Health, 2003:18). The inclusion of Morama Bean in the diet could help combat this problem. Food insecurity and malnutrition are higher in female-headed households, which account for 52% of all households as well as for the following groups, namely the disabled, orphans, and rural and urban poor (Botswana Ministry of Health, 2003: 18).

In response to the Botswana Vision 2016 (Presidential Task Group, 1997:1) issued by the government this research is timely to contribute insights towards solution for better health for people of Botswana. The target group of 13-year-olds will be the working force by the year 2016. By developing foods that will improve their health, a good contribution will be made towards one of the Vision-2016 objectives of providing adequate nutrition for all citizens (Presidential Task Group, 1997:71).

Currently the role of dry pulses as therapeutic agents in diets of persons suffering from metabolic disorders is gaining interest (Tharanathan & Mahadevamma, 2003). At the time where the glycaemic response of foods has become very topical, it is of interest to note that dry pulses elicit a low blood glucose response (Thompson, 1988). Morama Bean is classified as a legume and the same low blood glucose response is likely. With specific reference to the meal-plan, which consists of menu-items such as bread and peanut butter with an apple for breakfast, and samp & beans for lunch (see Chapter 5) prepared from a premix with 83% samp and 17% beans as part of a school feeding programme, sorghum porridge, with milk and sugar for supper, it is questioned

whether the meal-plan is nutritionally adequate, especially for learners. Additional to the findings pertaining to nutrients that were reported in Chapter 3, it should also be borne in mind that both sorghum and samp have high glycaemic indexes – respectively 80 and 91 (Steenkamp & Delport, 2002:72) – which means that these two products, being used as main ingredient for three or four menus per week, will release energy of school learners fast with the corresponding deleterious effects. Ultimately, high GI foods result in decreased concentration span, and may in the long run, affect performance, overall academic achievement and pose health risks. Pawlak, Kushner and Ludwig (2004) argue that many of the studies on the effect of GI on humans have confounding factors such as fibre, energy density and palatability, and therefore aimed at investigating the independent effect of GI on animals. They found that high GI-food resulted, *inter alia*, in higher body fat and less lean body mass. Supporting evidence pertaining to health risks of high GI-foods in the field of human nutrition is growing (Vosloo, 2005).

When sorghum porridge and samp & beans are supplemented with Morama Bean flour in premixes the glycaemic index of the products can be expected to decrease – a physiological effect of fat and protein explained by Asp and Björck (1992) and through nutrient interactions between lipids and starch and proteins and starch (Vosloo, 2005).

This study aimed at monitoring the nutritional contribution of the addition of Morama Bean flour as a premix to sorghum porridge and samp & beans within a complete meal-plan using 5% of Morama Bean flour on macronutrients and minerals, as well as on the gluten content and estimated value of the glycaemic index. For the purpose of this study the following operational definition was formulated for nutritional contribution (see Figure 6.1).

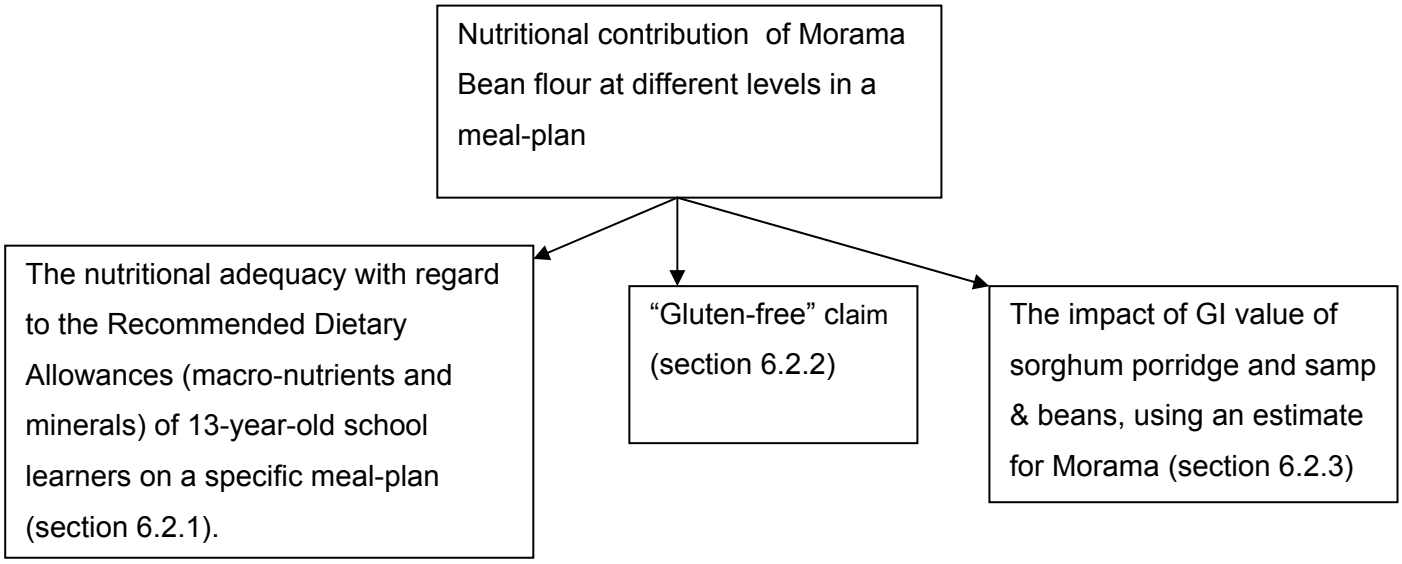

Figure 6.1 Operationalising "nutritional contribution" of Morama Bean flour in this study

5.2 Methodology

Nutritional contribution with regard to this study is determined in three aspects. Firstly the nutritional adequacy of the menu-items in the one-day meal-plan in terms of the RDA for 13-year-olds. Secondly the gluten content was determined. Thirdly the glyceamic index was calculated with Morama bean supplementation at 0% and 5%.

Botswana uses the US Department of Agriculture (USDA) Food Guide Pyramid (Earl, 2004:376) to monitor population diet which is not quantifiable and therefore was not suitable for this study.

5.2.1 Measuring the nutritional adequacy of a meal-plan

The nutritional database programme *Foodfinder* ^{TM} 3 was used to analyse the contribution of the standard non-enriched sample and those samples that were supplemented with Morama Bean flour at 0 and 5%, levels. The target group was 13-years-old and over individuals. All values were available on this database with the exception of Morama Bean, which was inserted with a view to this monitoring phase of the research. The Morama Bean data were available from the analyses done and reported in Chapter 3. For the monitoring of the effect of different levels of Morama Bean flour (0 and 5%) on the estimated GI, and on macronutrients and the minerals, the ingredients were kept constant.

The information gained from the Kgosimpe School reflects the normal meal-plans for a 14-week period in Addendum C. (Boikanyo Moseki, teacher at the above-mentioned school, personal communication, 2005). For brevity an extract for three weeks is reported (Table 6.1).

6.2.1.1 Selection of menu-items from the meal-plan

Two traditional items were selected from the plan in Table 6.1, namely sorghum porridge which appears on the above meal-plan thrice – every breakfast on Mondays, Wednesdays and Fridays, and samp & beans, which appears once per week, but is also commonly eaten at home and also regarded as a traditional Botswana food. A one-day meal-plan was completed by adding a commonly eaten supper dish (sorghum porridge) to the school menu for Tuesday (see Table 6.1).

6.2.1.2 Formula for the two traditional dishes

A formula was developed to include approximately 0% and 5% Morama Bean flour in the final cooked product. See Tables 6.2 and 6.3 for the different formulations for sorghum porridge and for samp & beans.

TABLE 6.1 KGOSIMPE SECONDARY SCHOOL SECOND TERM MENUS

Weeks		1	2	3
Monday	Breakfast	400 g Sorghum porridge	400 g Sorghum porridge	400 g Sorghum porridge
	Lunch	400 g Mealie meal porridge 100 g Meat 250 ml Orange squash	400 g Mealie meal porridge, 100 g Meat 250 ml Orange squash	400 g Mealie meal porridge,100 g meat 250 ml Orange squash
Tuesday	Breakfast	100 g Bread, 25 g peanut butter 250 ml Tea	100 g Bread,25 g peanut butter 250 ml Tea	100 g Bread, 25 g peanut butter 250 ml Tea
	Lunch	400 g Samp & beans Apple	400 g Samp & beans Apple	400 g Samp & beans Apple
Wednesday	Breakfast	400 g Sorghum porridge	400 g Sorghum porridge	400 g Sorghum porridge
	Lunch	100 g Chicken 400 g Rice 50 g Cole slaw	100 g Chicken 400 g Rice 50 g Cole slaw	100 g Chicken 400 g Rice 50 g Cole slaw
Thursday	Breakfast	100 g Bread jam 250 ml Tea	100 g Bread jam 250 ml Tea	100 g Bread jam 250 ml Tea
	Lunch	400 g Mealie meal porridge 50 g Cooked cabbage 250 ml Orange squash	400 g Mealie meal porridge 50 g Cooked cabbage 250 ml Orange squash	400 g mealie meal porridge 50 g Cooked cabbage 250 ml Orange squash
Friday	Breakfast	400 g Sorghum porridge	400 g Sorghum porridge	400 g Sorghum porridge
	Lunch	400 g Mealie rice 100 g Beef stew Apple	400 g Mealie rice 100 g Beef stew Apple	400 g Mealie rice 100 g Beef stew Apple

TABLE 6.2 PERCENTAGE FORMULAE OF SORGHUM AND SAMP & BEANS WITH MORAMA BEAN FLOUR ADDED AT TWO DIFFERENT LEVELS

	Sorghum porridge		Samp & beans	
Morama Bean flour	**0%**	**5%**	**0%**	**5%**
Sorghum flour	17	17	-	-
Dry samp & beans	-	-	22	21
Water	83	78	77	73
Salt	-	-	1	1
% Yield	100	100	100	100

6.2.1.3 Method for the preparation of sorghum and samp and beans

For each sample a mixture of ingredients (as per Table 6.2) was weighed off and mixed in an ovenproof dish, and cooked in a preheated oven (a *Fridgidaire* Electric Stove [Super Cook Master Model] was used) in order to achieve satisfactory temperature control. The mixtures were stirred at intervals to avoid unappetising lumps. Because the two products are quite different in their physical properties, they were prepared differentially: the sorghum porridge was cooked for 30 min at 140°C and stirred at 10 min intervals; the samp & beans dish was cooked for six hours at 100°C and stirred at 30 min intervals.

5.2.2 The determination of the gluten content

With regard to "gluten-free" claim it is already known that sorghum and samp & beans are free from gluten (Steinman, Food allergist, personal communication, 2005) but due to the fact that Morama Bean contains high percentage prolamines (see Chapter 2, Table 2.1), it was decided to test Morama Bean for gluten content (SA Department of Health, 2002:14) in view of the gluten intolerant individuals and persons suffering from celiac disease.

5.2.3 Calculation of the glycaemic index

With regard to the glycaemic index the estimated GI value of Morama Bean is taken (with dried, cooked soy as reference value, namely, 34) and the impact of the 5% addition level of Morama Bean flour was calculated. This reference value was decided on, despite compositional differences between roasted Morama Bean flour and cooked soy bean (see Table 6.3). During this research the actual glycaemic index of Morama Bean could not be obtained from a reputable laboratory due to the high fat and protein content which makes testing, as for peanuts not feasible (see Table 6.3).

TABLE 6.3: MORAMA BEAN, PEANUTS AND SOY: MACRO NUTRIENT PERCENTAGE COMPOSITION AND GI

Food product	Prot	CHO	Fat	Moisture	GI
Morama, roasted*	36	16	38	4	Unknown
Peanut, roasted, unsalted**	26	10	49	2	Unknown
Soy, dried, cooked **	16	5	9	63	34

*See Chapter 3

** SA Medical Research Council Foodfinder *TM3*

GI is defined as the blood glucose response of carbohydrate foods and is defined as the incremental area under the blood glucose response curve of a 50 g carbohydrate portion of a test food expressed as a percentage of the response of the same amount of carbohydrate from pure glucose taken by the same subject (SA Department of Health, 2002:10). Vosloo (2005); Nishumune et al. (1991); Anderson(1997) and Wolever (1999) give the same definition.

5.3 RESULTS

5.3.1 Nutritional adequacy

In Table 6.4 contribution of Morama Bean flour regarding the macronutrients and minerals to the standard meal-plan (see Section 6.2.1) was monitored against the Recommended Dietary Allowance given in Foodfinder^{TM}3 database (SA Medical Research Council, 1991). (See Addendum D for Foodfinder^{TM}3 results).

Protein

When Morama Bean flour was added to a standard meal containing sorghum porridge and samp & beans, the contribution of protein to the RDA was raised from 40,6 g to 67,4 g at 5% level. The 5% level was acceptable in the focus group (see Chapter 5) and it contributes 146,52% of the RDA for individuals 13 years and above. This clearly shows that addition of Morama Bean flour to the diet can contribute to the protein intake. It should however be borne in mind that excessive intakes of protein can also have an impact on nutritional status as a high protein intake can interfere with calcium metabolism (Spear,2004:290) especially if the animal protein is taken with plant protein. Enriching the meals with Morama Bean at 5% will effectively improve the protein content by 38% and improve the protein quality as well (due to complementation).

Fat

The Morama Bean flour increased the standard meal energy value of total fat from 13,77% to 25,35%, which is within the WHO recommended value of 15-30% energy.It is important to note

that this is a plant source and does not contain cholesterol (Bouic, 2003:40). The saturated fatty acids (SFA) content is 24, 20%. The polyunsaturated fatty acids (PUFA) value has been reduced by the addition of Morama Bean flour from 4,50% to 3,42%. Energy-carbohydrate value has been reduced from 73,61% to 59,79% which is within the recommended range.

TABLE 6.4 NUTRITIONAL ADEQUACY OF 5% SUPPLEMENTATION OF MORAMA BEAN FLOUR IN A 1-DAY MEAL-PLAN CONTRIBUTION TO RDA

Nutrient	Recommended Dietary Allowance (RDA) for individuals 13 years and older*	Contribution of standard meal without Morama to RDA	Contribution of standard meal with sorghum and samp and beans with Morama flour to RDA (5% level)
Protein (g)	46	40.6	67.4
Fat (%)	15-30	13.77	25.35
Carbohydrate (%)	55-75	73.61	59.79
Calcium (mg)	1200	254	381
Phosphorus (mg)	1200	709	988
Potassium (mg)	-	1572	2098
Magnesium (mg)	280	306	524
Sodium (mg)	-	1046	1056
Copper (mg)	2	1.33	2.05
Iron (mg)	10.5	8.8	10.5
Zinc (mg)	12	6.14	8.36
Manganese (mcg)	3500	2872	2873

*Foodfinder™3 (SA Medical Research Council, 1991)

Calcium

The 5% level of Morama Bean added to the standard meal increases the calcium from 254 mg to 381 mg, but this is still below the Recommended Dietary Allowance. Obviously higher levels of addition of Morama Bean flour will contribute more to the RDA.

Dietary surveys have consistently shown that calcium and iron is marginal in adolescents' diets due to poor food choices (Spear, 2002). During the adolescent stage calcium needs are greater since 45% of the skeletal mass is added during this stage (Spear, 2002). The inclusion of Morama Bean flour in the target group and the whole population diet is encouraged to help meet these deficiencies.

Phosphorus

The Recommended Dietary Allowance of phosphorus is 1200 mg, the standard meal contributes 709 mg and the 5 % Morama Bean flour supplementation to the two menu-items increases the value to 988 mg. Anderson (2000:129) reports that dry pulses are good sources of phosphorus also true for Morama Bean.

Iron

The iron level of the standard meal-plan increased from 8,8 mg to 10,5 mg with Morama Bean added at 5% level. Spear (2002) reports that iron intakes of adolescents with normal dietary patterns are between 12,5 and 14,2 mg/day for girls and 13,6 to 18,0 mg/day for boys.

Magnesium

The standard meal contributed 306 mg and the addition of Morama Bean flour at 5% level increased the value to 524 mg. Thus, supplementing the meal-plan with 5% Morama Bean flour made a significant contribution to meeting the RDA for magnesium.

Zinc

The standard meal-plan contributed 6,14 mg of zinc and the 5% addition of Morama bean contributed 8,36 mg. In the case of South Africa, zinc is used in fortification mixes which is proof of its importance in the diets of malnourished individuals. Although zinc content of the meal-plan supplemented with 5% Morama Bean flour for two traditional menu-items does not meet the Recommended Dietary Allowance, the results show that it makes a significant contribution to the diet. Shankar and Prasad (1998) report that zinc is critical for normal immune function and physical growth. Zinc is also essential for growth and sexual maturation (Spear, 2002).

5.3.2 Gluten- free claim

According to the allergen test report (Steinman, 2005 see ─ Addendum E), Morama Bean flour can make a gluten-free claim. Morama Bean flour contains <1.5ppm of gluten. This means that Morama Bean flour will not aggravate the symptoms of people suffering from celiac disease.

5.3.3 The impact of Morama Bean flour on estimated GI value

Table 6.5A shows that the GI of sorghum porridge without Morama Bean flour is ~70. This value means that this dish has a high GI which can easily release energy and therefore not suitable for learners who need sustained energy levels. The addition of Morama Bean flour lowers the GI of sorghum porridge when added at 5% to that of an itermediate GI food. In Table 6.5B the GI of samp & beans without Morama Bean flour is high. Although the GI of the dish with 5% Morama Bean flour addition does not change the GI of the dish to a lower GI category, there is evidence

that Morama Bean flour can lower the GI of the dish. The GI of the dish without Morama Bean flour is ~86 while the GI of the dish with Morama Bean flour at the 5% level of addition is ~83.

In view of the fact that the addition of Morama Bean flour lowers the GI of the Standard menu-plan, further research on the contribution of Morama Bean flour at different levels of these traditional foods to the GI is suggested.

TABLE 6.5A CALCULATIONS OF THE GI OF SORGHUM PORRIDGE WITHOUT MORAMA BEAN AND WITH MORAMA BEAN FLOUR AT DIFFERENT LEVELS

Ingredient	**Mass**	**Glycaemic carbohydrate /100 g for dish**	**Glycaemic carbohydrate /100 g for each ingredient with regard to amount of the ingredient**	**GI of each ingredient**	**Contribution of each ingredient to the GI of the dish**	**% Contribution of the ingredient to the GI of the dish / Glycemic load of the particular ingredient**
Sorghum porridge without Morama Bean flour						
Sorghum flour	125	22	27,5	80	38,26	54,7
Sugar	25	100	25	67	**29,13**	41,6
Milk	100	5	5	30	2,6	3,7
Total CHO in the dish			57,5	GI	69,99- 70	100
Sorghum porridge with Morama Bean flour @ 5%						
Sorghum flour	125	22	27,5	80	35,13	52,39
Morama Bean flour	32	16	5,12	34*	2,78	4,15
Sugar	25	100	25	67	26,75	39,89
Milk	100	5	5	30	2,40	3,58
Total (0 %)			62,62	GI	67,06	100,01

TABLE 6.5B CALCULATIONS OF THE GI OF SAMP & BEANS WITHOUT MORAMA BEAN AND WITH MORAMA BEAN FLOUR AT DIFFERENT LEVELS

Ingredient	Mass	Glycemic carbohydrate /100 g for dish	Glycemic carbohydrate /100 g for each ingredient with regard to amount of the ingredient	GI of each ingredient	Contribution of each ingredient to the GI of the dish	% Contribution of the ingredient to the GI of the dish / Glycemic load of the particular ingredient
Samp & beans without Moramam Bean flour						
Samp	103,75	86	89,23	**91**	83,81	97,78
Beans	21,25	36	7,65	24	1.90	2,22
Total (0%)			96,88	GI	85,71	100
Samp & beans with Morama Bean flour@ 5%						
Samp	103,75	86	89,23	91	80,75	96,32
Beans	21,25	36	7,65	24	1,83	2,18
Morama Bean flour	23	16	3,68	34	1,24	1,48
Total (5%)			100,56	GI	83,3	99,98

During food product development additions to a food formulation should be considered separately when the impact of the formula on blood glucose response is a consideration (Vosloo, 2005). The glycaemic index of Morama Bean flour has been assumed. This assumption is a very conservative theoretical estimate of the impact of Morama Bean flour on GI of sorghum porridge, provided it is added in a premix formulation to water before, and not after cooking, this being the reason why the concept of premix is stipulated. This procedure ensures nutrient interaction, which together with physiological action of protein and fat on GI will also contribute to the lowering effect of Morama Bean flour. Actual blood glucose response testing could produce unanticipated results – it is hypothesised that the blood glucose response will be lower than estimated.

In the formulae for sorghum porridge, the one without Morama Bean flour and the one with the 5% level of addition of Morama Bean flour, the ingredients that mainly contribute to Morama Bean flour and the sugar also contributes to the lowering effect of the GI on these formulae.

5.4 Conclusions

The aim of this research was to monitor the impact of the nutritional contribution of Morama Bean flour to sorghum porridge and samp & beans using 5% level of Morama Bean flour. Based on the information obtained in the study, it can be concluded that Morama Bean flour can be used to enrich sorghum flour and samp & beans premixes. Inclusion of Morama Bean flour in school-feeding programmes and the diet of the rest of the community offer an opportunity to address malnutritional problems.

Morama Bean flour can make a gluten-free claim and can be included in strict gluten-free diets to help decrease the risk of developing serious preventable health conditions for gluten-sensitive individuals.

The results show that Morama Bean flour can lower the GI of sorghum porridge from a high GI-food to an intermediate GI-food. In view of the fact that consumption of a high GI-diet affects body composition and poses a risk factor for diabetes and cardiovascular diseases in human beings Morama Bean flour addition to the diet is important. With regard to the blood glucose response, it should be borne in mind that the Morama Bean flour contains 36% protein and 38% fat which are also nutritional factors that lower the glucose response of glyceamic carbohydrates, not only through their physiological effect (Asp & Björck, 1992) but also through the starch-protein and starch-fat interactions (Vosloo, 2005) that take place during cooking. This supplementation will benefit school learners by improving concentration span and delaying hunger pangs, while the benefits to a diabetic-prone population is evident.

As Morama Bean is not contemplated in isolation but used as part of food formulation, the actual impact of 5% level of addition on blood glucose response used for conducting GI can be established during further research in laboratories equipped with the appropriate infrastructure and know-how. Presently no accredited laboratories are available in SA, though there are laboratories with the expertise.

5.5 Recommendations

It is advocated that in the areas where Morama Bean is an indigenous plant, it should be cultivated with a view to product development for premixing in traditional dishes. Before progress with cultivation programmes is made, consumer testing on the target market should be done to establish if the supplementation is acceptable.

There is need for further research on the GI of Morama Bean flour. From estimations made, the study results show that Morama Bean flour can lower the GI of sorghum porridge from a high GI-food to an intermediate GI-food. In view of the fact that consumption of the high GI diet affects body composition and is a risk factor for diabetes and cardiovascular diseases in human beings,

addition of Morama Bean flour to the diet is beneficial. A nutrition intervention study is recommended and should the results be positive, advocacy of supplementation at policy level is advised.

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Chapter 7

Conclusions and recommendations

6.1 Conclusions

The main aim of the study was to establish the influence that geographical location (sampling areas) have on the nutritional composition of Morama Bean flour during its production, as well as the effect of heat treatment at varying temperatures (120°C for 40 min, 150°C for 30min, 150°C for 25 min and 150°C for 20 min). A sensory profile was drawn for the samples with the four heat treatments. The sample with the most desirable sensory properties was identified and used for the consecutive studies. Further studies entailed that 5%, 10%, 15% and 20% Morama Bean was added to two traditional Botswana menu-items, namely sorghum porridge and samp & beans. A focus group was used to establish the consumer acceptability of the five samples.

The geographical location and the four heat treatments of the Morama Bean and the Morama Bean flour did not show any significant difference ($p>0.05$) in the nutritional composition with regard to proximate analysis (moisture, proteins, fat, ash, fibre and nitrogen-free extracts). The nutritional composition of Morama Bean showed that it can be an invaluable food supplement for secondary school learners (see Chapter 6).

The 38% fat content signifies a concentrated source of energy. Other important lipid components of Morama Bean flour are linoleic acid, which is an integral part of membrane phospholipids and a precursor to arachidonic acid; oleic acid, which has a cardio-protective property; and palmitic acid, which is a saturated fatty acid known to reduce cholesterol levels in the body in spite of the fact that it is a saturated fatty acid (see Chapter 3).

As a source of protein (36%), Morama Bean flour can be added to food premixes to raise protein levels of most standard meals, e.g. 5% Morama Bean flour added to a standard meal of 100 g cooked sorghum porridge and 100 g cooked samp & beans will raise the protein level from 26 g to 45 g, though this does not meet the Recommended Dietary Allowance (RDA) of 56 g which is recommended by the SA Department of Health (2004:), but it does drastically improve the quality (adds variety of amino acids to the diet) and the quantity of protein in the diet of school learners in a developing country like Botswana (see Chapter 6).

Minerals present in Morama Bean flour (calcium, iron, magnesium, phosphorus, and zinc) add significantly to the mineral content of the diet. Dietary surveys have consistently shown that calcium and iron are marginal in the diets of adolescents due to poor food choices. During the adolescent stage calcium needs are greater since 45% of the skeletal mass is added in this stage, therefore the inclusion of Morama Bean flour is necessary. It is important to note that zinc is

essential for growth and sexual maturation, which is needed by the target group. The inclusion of Morama Bean flour in diets should be accompanied by animal products to improve the bioavailability of the zinc and iron in the body. Like other pulses Morama Bean flour is a good source of phosphorus.

A trained panel (see Chapter 4) described the sensory profile of Morama Bean flour. The descriptors were burnt aroma, nutty aroma, colour, slimy texture, burnt flavour, roasted flavour and bitter taste. The highest quality was found in the sample roasted at 150°C for 20 min. The lowest quality was found in the sample roasted at 150°C for 30 min, a result of high temperature for a long time. The sample roasted at 120°C for 40 min also had a low mean value especially for burnt aroma, nutty aroma, colour, burnt flavour, roasted flavour and nutty flavour, indicating the beans treated at the low temperature will need a longer time to have a better quality of roasted Morama Bean flour, whilst the sample roasted at 150°C for 25 min was less favourable than the one roasted at 150°C for 20 min, but still favourable.

The focus group used in this study (see Chapter 5) preferred samples of sorghum porridge, and samp & beans with 5% Morama Bean flour added to it, though it has obviously a lower contribution to the RDA than the other additions of Morama Bean flour (10%, 15% and 20%). However, the focus group did not represent the target market and it is essential that consumers who provide data regarding acceptability, should be qualified to do so, that is, they should present the target market (Stone, 2005).

With regard to the investigations of the nutritional contribution of Morama Bean to a standard meal-plan (see Chapter 6), these research findings showed that the one-day meal-plan with Morama Bean does contribute significantly to the RDA where proteins, fats and minerals are concerned and the conclusion is finally made that Morama Bean flour could complement the deficiency in Batswana diets generally and in school feeding programmes specifically.

6.2 Recommendations

The optimum temperature for the production of Morama Bean flour was 150°C for 20 min. It is therefore recommended that this temperature be used in the production of Morama Bean flour as this treatment had the most positive sensory profile.

The documented nutritional composition indicates that Morama Bean is a high quality food (see Chapter 3). The study revealed that Morama Bean flour added at 5% to a standard meal-plan consisting of sorghum porridge, and samp & beans significantly improved the protein content of the meal from 40,6 g to 67,4 g. It is therefore recommended that Morama Bean flour be added to a standard meal-plan. In view of the potential benefits of Morama bean as a hypocholesterolemic and glucose controlling food (trendy properties if consumer needs are kept in mind), it should be

considered in premix formulae as a food supplement in the secondary school feeding programmes specifically and for commercial marketing to the general consumer in Botswana, especially if it is borne in mind that it is an indigenous food that will contribute to a sustainable livelihood.

The findings (Chapter 5) have demonstrated that ideal sorghum porridge and samp & beans with 5% inclusion level of Morama Bean flour are acceptable. The acceptability was tested by using an adult focus group and therefore the researchers recommend that further consumer studies be conducted using children to get their views on the use of Morama Bean flour in food products as they are the target group for the use of samp & beans and sorghum porridge in school feeding programmes and therefore best qualified (Stone, 2005). Dixey *et al.* (2001) advise that nutrition education programmes are needed to allow for greater participation by children and to focus on behaviours, attitudes and values as well as the transfer of knowledge. For this reason the researchers recommend the inclusion of knowledge in nutrition education programmes on the nutritional composition of Morama Bean flour and on the fact that Morama Bean supplementation delay hunger pangs and prevent certain diseases for them to understand the importance of supplementated premixes of sorghum porridge and samp & beans with Morama Bean flour.

From estimations made, the study results (see chapter 6) show that Morama Bean flour can lower the GI of sorghum from a high GI-food to an intermediate GI-food. In view of the fact that consumption of the high GI diet affects body composition and is a risk factor for diabetes and cardiovascular diseases in human beings, addition of Morama Bean flour to diet is beneficial. A nutrition intervention study is recommended and should the results be positive, advocacy of supplementation at policy level is advised.

During this research (see Chapter 6), the actual glycaemic index of Morama Bean was not obtained from a reputable laboratory. The high fat and the protein content makes testing not feasible, as is also the case with peanuts. Therefore determination of the impact of the different levels of Morama Bean flour in the said premixes on insulin response, blood glucose response and on the profile of appropriate blood lipids, is advised.

With regard to the blood glucose response, it should be borne in mind that Morama Bean flour contains 36% protein and 38% fat, which are also factors that lower the glucose response of glycaemic carbohydrates, not only through their physiological effect (Asp and Bjőrck, 1992), but also through the starch-protein and starch-fat interactions (Vosloo, 2005) that take place during the cooking. In view of the nutrient (e.g. starch-protein) interactions that take place during cooking (Vosloo, 2005) it is advised that a premix-approach and not an add-on (as when adding sugar to porridge for instance) is used to get optimum benefit from the additions. The supplementation will benefit the school learners by improving concentration span and delaying hunger pangs, while the benefit for a diabetic prone community is quite evident.

The researchers therefore advocate that, where Morama bean grows indigenous, it should be cultivated with a view to produce Morama Bean as a premix for traditional dishes. Before advances are made, further research on cultivation programmes, and consumer testing of Morama Bean flour as a food supplement is advised.

It is worth noting that the study did not cover all the relevant aspects of nutritional analysis for Morama Bean. Anti-nutrients and vitamins, which are critical in pulses like Morama, were not studied and that further research is advised.

The nutritional information reported in this research should enhance efforts to promote the wider use of wild plant foods like Morama Bean as part of a broader programme aimed at educating local populations with regard to nutritional benefits of the many wild plant foods that exist in their environment.

6.3 References

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ADDENDUM A

DEPARTMENT: AGRICULTURE
REPUBLIC OF SOUTH AFRICA

SAAFQIS (South African Agricultural Food, Quarantine and Inspection Services)
Private Bag X5015, Stellenbosch 7599
Plant Quarantine Station, Polkadraai Avenue, Stellenbosch

From: Ms A. Mkutshulwa
Tel: 021-8091669 • **Fax:** 021-8832570 • **e-mail:** angelinem@nda.agric.za
Enquiries: Angeline Mkutshulwa • **Ref:** 14/2/2/1-Univ. of Stellenbosch

University of Stellenbosch
Private Bag X1
MATIELAND
7608

2004/09/22

Attention: Ms Yvonne Mmonatau

NOTIFICATION: RECEIPT OF IMPORTED PLANT MATERIAL

DATE:	PERMIT NO.:	PHYTO. CERT. NO.:
2004-09-15	P0012990	None

ORIGIN:	Botswana

CROP	I NO.	VARIETY/CULTIVAR	QUANTITY
Tylosema sp.	I 7393	Morama Bean	30 kg

CONDITION OF MATERIAL ON ARRIVAL	Material arrived in a good condition. *Psocoptera* (book lice) were found but not of quarantine importance. No phytosanitary certificate.
COMMENTS	Material released to the importer for laboratory experiment and to be destroyed afterwards.

SENIOR MANAGER: SAAFQIS

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ADDENDUM B

Randomised samples for analysising 28 samples (7 localities x 4 heat treatments)

Sample	Area x Treatment
1	W2A
2	W5C
3	W2D
4	F2B
5	W2B
6	W1A
7	W3C
8	F1A
9	W4A
10	F1D
11	W1C
12	F1C
13	W3A
14	W3B
15	W2C
16	F2A
17	W4D
18	W5D
19	W5B
20	F2D
21	F2C
22	W4B
23	W4C
24	W5A
25	W1B
26	F1B
27	W3D
28	W1D

Key: W - Wild localities; F - Fenced localities

A - (120 ˚C for 40 min)

B - (150 ˚C for 30 min)

C - (150 ˚C for 25 min)

D - (150 ˚C for 20 min)

ADDENDUM C

SECOND TERM MENU 10/05-12/08/2005

		MONDAY		TEUSDAY		WEDNESDAY		THURSDAY		FRIDAY	
WEEK	DATE	BREAK	LUNCH	BREAK	LUNCH	BREAK	LUNCH	BREAK	LUNCH	BREAK	LUNCH
1	10-13/505			BREAD BUTTER TEA	SAMP BEANS APPLE	PORRIDGE	CHICKEN RICE SOUP SALAD	BREAD BUTTER TEA	M/MEAL CBBAGE DRINK	PORRIDGE	M/RICE S/BEEF APPLE
2	16-20/505	PORRIDGE	M/MEAL MEAT SOUP DINK	BREAD BUTTER TEA	SAMP BEANS APPLE	PORRIDGE	CHICKEN RICE SOUP SALAD	BREAD BUTTER TEA	M/MEAL CBBAGE DRINK	PORRIDGE	M/RICE S/BEEF APPLE
3	23-27/505	PORRIDGE	M/MEAL MEAT SOUP DINK	BREAD BUTTER TEA	SAMP BEANS APPLE	PORRIDGE	CHICKEN RICE SOUP SALAD	BREAD BUTTER TEA	M/MEAL CBBAGE DRINK	PORRIDGE	M/RICE S/BEEF APPLE
4	30-03/605	PORRIDGE	M/MEAL MEAT SOUP DINK	BREAD BUTTER TEA	SAMP BEANS APPLE	PORRIDGE	CHICKEN RICE SOUP SALAD			PORRIDGE	M/RICE S/BEEF APPLE
5	06-10/605	PORRIDGE	M/MEAL MEAT SOUP DINK	BREAD BUTTER TEA	SAMP BEANS APPLE	PORRIDGE	CHICKEN RICE SOUP SALAD	BREAD BUTTER TEA	M/MEAL CBBAGE DRINK		M/RICE S/BEEF APPLE
6	13-17/605	PORRIDGE	M/MEAL MEAT SOUP DINK	BREAD BUTTER TEA	SAMP BEANS APPLE	PORRIDGE	CHICKEN RICE SOUP SALAD	BREAD BUTTER TEA	M/MEAL CBBAGE DRINK	PORRIDGE	M/RICE S/BEEF APPLE
7	20-24/605	PORRIDGE	M/MEAL MEAT SOUP DINK	BREAD BUTTER TEA	SAMP BEANS APPLE	PORRIDGE	CHICKEN RICE SOUP SALAD	BREAD BUTTER TEA	M/MEAL CBBAGE DRINK	PORRIDGE	M/RICE S/BEEF APPLE
8	27-01/705	PORRIDGE	M/MEAL MEAT SOUP DINK	BREAD BUTTER TEA	SAMP BEANS APPLE	PORRIDGE	CHICKEN RICE SOUP SALAD	BREAD BUTTER TEA	M/MEAL CBBAGE DRINK		
9	04-08/705	PORRIDGE	M/MEAL MEAT SOUP DINK	BREAD BUTTER TEA	SAMP BEANS APPLE	PORRIDGE	CHICKEN RICE SOUP SALAD	BREAD BUTTER TEA	M/MEAL CBBAGE DRINK	PORRIDGE	M/RICE S/BEEF APPLE
10	11-15/705	PORRIDGE	M/MEAL MEAT SOUP DINK	BREAD BUTTER TEA	SAMP BEANS APPLE	PORRIDGE	CHICKEN RICE SOUP SALAD	BREAD BUTTER TEA	M/MEAL CBBAGE DRINK	PORRIDGE	M/RICE S/BEEF APPLE
11	18-22/705										
12	25-29/705	PORRIDGE	M/MEAL MEAT SOUP DINK	BREAD BUTTER TEA	SAMP BEANS APPLE	PORRIDGE	CHICKEN RICE SOUP SALAD	BREAD BUTTER TEA	M/MEAL CBBAGE DRINK	PORRIDGE	M/RICE S/BEEF APPLE
13	01-0508/05	PORRIDGE	M/MEAL MEAT SOUP DINK	BREAD BUTTER TEA	SAMP BEANS APPLE	PORRIDGE	CHICKEN RICE SOUP SALAD	BREAD BUTTER TEA	M/MEAL CBBAGE DRINK	PORRIDGE	M/RICE S/BEEF APPLE
14	08-12/8/05	PORRIDGE	M/MEAL MEAT SOUP DINK	BREAD BUTTER TEA	SAMP BEANS APPLE	PORRIDGE	CHICKEN RICE SOUP SALAD	BREAD BUTTER TEA	M/MEAL CBBAGE DRINK		

ADDENDUM D

MRC FOODFINDER 3

Meal Analysis - Standard RDA

Name: Yvonne Mmonatau
Code:
ID Number:
Gender: Female
Age: 13.0

Daily on 2005/09/14
100 n/a g of Bread/rolls, Brown (100.00g)
25 n/a g of Peanut Butter; Smooth Style (25.00g)
250 n/a g of Tea, Rooibos, Brewed (250.00g)
100 n/a g of Apple, Golden Delicious, Raw (100.00g)
400 n/a g of Maltabella, Cooked (400.00g)
25 n/a g of Sugar, White, Granulated (25.00g)
100 n/a g of Milk, Full Fat / Whole, Uht (100.00g)
400 n/a g of Samp And Beans, 1:1 (400.00g)
1 n/a g of Salt, Table (1.00g)

Macronutrients

Description	Amount	RDA	RDA %	
Moisture (g)	1100.0			
Energy (kJ)	5454	9205.00	59.25%	
Nitrogen (g)	0.53			
Total protein (g)	40.6	46.00	88.26%	
Plant protein (g)	37.4			
Animal protein (g)	3.2			
Total fat (g)	20.3			
Carbohydrate, avail. (g)	208.0			
Starch (g)	0.0			
Glucose (g)	2.7			
Fructose (g)	7.0			
Galactose (g)	0.0			
Sucrose (g)	28.3			
Maltose (g)	0.0			
Lactose (g)	4.8			
Total sugars (g)	43.3			
Added sugar (g)	25.9			
Total dietary fibre (g)	28.2			
Insoluble dietary fibre (g)	1.5			*
Soluble dietary fibre (g)	1.0			*
Ash (g)	4.2			
Non-starch polysaccharides (g)	2.4			
Insoluble NSP (g)	1.4			*
Soluble NSP (g)	1.0			*
Lignin (g)	0.1			*

Minerals

Description	Amount	RDA	RDA %	
Ca (mg)	254	1200.00	21.17%	
Fe (mg)	8.8	15.00	58.67%	
Haem iron (mg)	0.0			*

Minerals

Description	Amount	RDA	RDA %	
Non-haem iron (mg)	0.4			*
Mg (mg)	306	280.00	109.29%	
P (mg)	709	1200.00	59.08%	
K (mg)	1572			
Na (mg)	1046			
Cl (mg)	119			
Zn (mg)	6.14	12.00	51.17%	
Cu (mg)	1.33	2.00	66.50%	#
Cr (mcg)	1.9	125.00	1.52%	#
Se (mcg)	2.5	45.00	5.33%	
Mn (mcg)	2872	3500.00	82.06%	#
I (mcg)	3	150.00	2.00%	*
B (mcg)	296			*
F (mcg)	24			*
Si (mcg)	561			*

Vitamins

Description	Amount	RDA	RDA %	
Vitamin A (RE) (mcg)	43	800.00	5.38%	
Retinol (mcg)	37			
Total carotenoids (mcg)	36			
B-Carotene (mcg)	30			*
A-Carotene (mcg)	0			*
Cryptoxanthin (mcg)	11			*
Thiamin (mg)	0.73	1.10	65.45%	
Riboflavin (mg)	0.40	1.30	30.77%	
Niacin (mg)	9.8	15.00	65.33%	
Vitamin B6 (mg)	0.614	1.40	43.86%	
Folate (mcg)	332	150.00	221.33%	
Vitamin B12 (mcg)	0.4	2.00	20.00%	
Pantothenate (mg)	1.58	5.50	28.73%	#
Biotin (mcg)	7.7	65.00	11.85%	#
Vitamin C (mg)	8	50.00	16.00%	
Vitamin D (mcg)	0.03	10.00	0.30%	
Vitamin E (mg)	1.68	8.00	21.00%	
A-Tocopherol (mg)	0.14			*
B-Tocopherol (mg)	0.00			*
D-Tocopherol (mg)	0.00			*
G-Tocopherol (mg)	0.00			*
A-Tocotrienol (mg)	0.00			*
B-Tocotrienol (mg)	0.00			*
D-Tocotrienol (mg)	0.00			*
G-Tocotrienol (mg)	0.00			*
Lycopene (mcg)	0			*
Lutein (mcg)	19			*
Vitamin K (mcg)	4.87	45.00	10.82%	*

Fatty acids & cholesterol

Description	Amount	RDA	RDA %	
Saturated FA (g)	5.22			
Mono-unsaturated FA (g)	6.79			
Polyunsaturated FA (g)	6.63			
Single trans FA (g)	0.00			*
Double trans FA (g)	0.00			*
Total trans FA (g)	0.00			*

Fatty acids & cholesterol

Description	Amount	RDA	RDA %	
Cholesterol (mg)	10			
C4:0 (g)	0.11			
C6:0 (g)	0.07			
C8:0 (g)	0.04			
C10:0 (g)	0.09			
C12:0 (g)	0.10			
C13:0 (g)	0.00			*
C14:0 (g)	0.42			
C15:0 (g)	0.00			*
C16:0 (g)	2.60			
C17:0 (g)	0.00			*
C18:0 (g)	0.92			
C20:0 (g)	0.20			
C21:0 (g)	0.00			*
C22:0 (g)	0.40			
C23:0 (g)	0.00			*
C24:0 (g)	0.16			
C10:1 (g)	0.00			*
C12:1 (g)	0.00			*
C14:1 (g)	0.03			
C15:1 (g)	0.00			*
C16:1 (g)	0.05			
C17:1 (g)	0.00			*
C18:1 (g)	6.41			
C20:1 (g)	0.13			
C22:1 (g)	0.05			
C23:1 (g)	0.00			*
C24:1 (g)	0.00			*
C18:2 (g)	5.76			
C18:3 (g)	0.12			
C18:4 (g)	0.00			
C20:2 (g)	0.00			*
C20:4 (g)	0.00			
C20:5 (g)	0.00			
C22:2 (g)	0.00			*
C22:3 (g)	0.00			*
C22:4 (g)	0.00			*
C22:5 (g)	0.00			
C22:6 (g)	0.00			
C24:6 (g)	0.00			*
C20:3 (g)	0.000			

Amino Acids

Description	Amount	RDA	RDA %
Isoleucine (g)	1.620		
Leucine (g)	3.506		
Lysine (g)	1.802		
Methionine (g)	0.651		
Phenylalanine (g)	2.034		
Threonine (g)	1.446		
Tryptophan (g)	0.438		
Valine (g)	1.983		
Arginine (g)	2.356		
Histidine (g)	1.019		

Amino Acids

Description	Amount	RDA	RDA %
Cystine (g)	0.038		
Tyrosine (g)	0.152		
Alanine (g)	0.130		
Aspartic acid (g)	0.286		
Glutamic acid (g)	0.727		
Glycine (g)	0.079		
Proline (g)	0.317		
Serine (g)	0.194		
Hydroxyproline (g)	0.000		

Other components

Description	Amount	RDA	RDA %
Alcohol (g)	0.0		*
Phytate (mg)	63		*
Malic acid (mg)	439		*
Citric acid (mg)	228		*
Tartaric acid (mg)	0		*
Oxalic acid (mg)	1		*
Caffeine (mg)	0		*
Tannins (mg)	0		

Energy Calculations

Description	Amount	Prudent Guideline
%Energy - Protein	12.64%	+/- 15%E
%Energy - Fat	13.77%	< 30%E
%Energy - Saturated SFA	3.54%	< 10%E
%Energy - Mono-unsaturated MUFA	4.60%	+ 10%E
%Energy - Polyunsaturated PUFA	4.50%	~ 10%E
%Energy - Carbohydrate	73.61%	+/- 55%E
%Energy - Alcohol	0.00%	-

Legend

* - There are many missing or no values for these Nutrients.
Please consult the FoodFinder3 Manual -> Reports/Analysis: Meal Analysis.
- Estimated safe and adequate daily dietary intake (value is the mean of the range)
= - RDA = Recommended Dietary Allowance
+ - RDA % = Percentage of the Recommended Dietary Allowance

MRC FOODFINDER 3

Meal Analysis - Standard RDA

Name: Yvonne Mmonatau
Code:
ID Number:
Gender: Female
Age: 13.0

Daily on 2005/09/14
100 n/a g of Bread/rolls, Brown (100.00g)
25 n/a g of Peanut Butter; Smooth Style (25.00g)
250 n/a g of Tea, Rooibos, Brewed (250.00g)
100 n/a g of Apple, Golden Delicious, Raw (100.00g)
400 n/a g of Maltabella, Cooked (400.00g)
25 n/a g of Sugar, White, Granulated (25.00g)
100 n/a g of Milk, Full Fat / Whole, Uht (100.00g)
400 n/a g of Samp And Beans, 1:1 (400.00g)
1 n/a g of Salt, Table (1.00g)
75 n/a g of morama bean (75.00g)

Macronutrients

Description	Amount	RDA	RDA %	
Moisture (g)	1102.8			
Energy (kJ)	7178	9205.00	77.98%	
Nitrogen (g)	0.53			
Total protein (g)	67.4	46.00	146.52%	
Plant protein (g)	64.2			
Animal protein (g)	3.2			
Total fat (g)	49.2			
Carbohydrate, avail. (g)	222.0			
Starch (g)	0.0			
Glucose (g)	2.7			
Fructose (g)	7.0			
Galactose (g)	0.0			
Sucrose (g)	28.3			
Maltose (g)	0.0			
Lactose (g)	4.8			
Total sugars (g)	43.3			
Added sugar (g)	25.9			
Total dietary fibre (g)	30.5			
Insoluble dietary fibre (g)	1.5			*
Soluble dietary fibre (g)	1.0			*
Ash (g)	6.6			
Non-starch polysaccharides (g)	2.4			
Insoluble NSP (g)	1.4			*
Soluble NSP (g)	1.0			*
Lignin (g)	0.1			*

Minerals

Description	Amount	RDA	RDA %
Ca (mg)	381	1200.00	31.75%
Fe (mg)	10.5	15.00	70.00%

Minerals

Description	Amount	RDA	RDA %	
Haem iron (mg)	0.0			*
Non-haem iron (mg)	0.4			*
Mg (mg)	524	280.00	187.14%	
P (mg)	988	1200.00	82.33%	
K (mg)	2098			
Na (mg)	1056			
Cl (mg)	119			
Zn (mg)	8.36	12.00	69.67%	
Cu (mg)	2.05	2.00	102.50%	#
Cr (mcg)	1.9	125.00	1.52%	#
Se (mcg)	2.5	45.00	5.33%	
Mn (mcg)	2873	3500.00	82.09%	#
I (mcg)	3	150.00	2.00%	*
B (mcg)	296			*
F (mcg)	24			*
Si (mcg)	561			*

Vitamins

Description	Amount	RDA	RDA %	
Vitamin A (RE) (mcg)	43	800.00	5.38%	
Retinol (mcg)	37			
Total carotenoids (mcg)	36			
B-Carotene (mcg)	30			*
A-Carotene (mcg)	0			*
Cryptoxanthin (mcg)	11			*
Thiamin (mg)	0.73	1.10	65.45%	
Riboflavin (mg)	0.40	1.30	30.77%	
Niacin (mg)	9.8	15.00	65.33%	
Vitamin B6 (mg)	0.614	1.40	43.86%	
Folate (mcg)	332	150.00	221.33%	
Vitamin B12 (mcg)	0.4	2.00	20.00%	
Pantothenate (mg)	1.58	5.50	28.73%	#
Biotin (mcg)	7.7	65.00	11.85%	#
Vitamin C (mg)	8	50.00	16.00%	
Vitamin D (mcg)	0.03	10.00	0.30%	
Vitamin E (mg)	1.68	8.00	21.00%	
A-Tocopherol (mg)	0.14			*
B-Tocopherol (mg)	0.00			*
D-Tocopherol (mg)	0.00			*
G-Tocopherol (mg)	0.00			*
A-Tocotrienol (mg)	0.00			*
B-Tocotrienol (mg)	0.00			*
D-Tocotrienol (mg)	0.00			*
G-Tocotrienol (mg)	0.00			*
Lycopene (mcg)	0			*
Lutein (mcg)	19			*
Vitamin K (mcg)	4.87	45.00	10.82%	

Fatty acids & cholesterol

Description	Amount	RDA	RDA %	
Saturated FA (g)	46.96			
Mono-unsaturated FA (g)	86.80			
Polyunsaturated FA (g)	6.63			*
Single trans FA (g)	0.00			*
Double trans FA (g)	0.00			

Fatty acids & cholesterol

Description	Amount	RDA	RDA %	
Total trans FA (g)	0.00			*
Cholesterol (mg)	10			
C4:0 (g)	0.11			
C6:0 (g)	0.07			
C8:0 (g)	0.04			
C10:0 (g)	0.09			
C12:0 (g)	0.10			
C13:0 (g)	0.02			*
C14:0 (g)	0.42			
C15:0 (g)	1.09			*
C16:0 (g)	4.84			
C17:0 (g)	0.00			*
C18:0 (g)	2.00			
C20:0 (g)	0.59			
C21:0 (g)	0.03			*
C22:0 (g)	0.67			
C23:0 (g)	0.00			*
C24:0 (g)	0.27			
C10:1 (g)	0.00			*
C12:1 (g)	0.00			*
C14:1 (g)	0.03			
C15:1 (g)	0.00			*
C16:1 (g)	0.13			
C17:1 (g)	0.00			*
C18:1 (g)	14.20			
C20:1 (g)	0.23			
C22:1 (g)	0.05			
C23:1 (g)	0.00			*
C24:1 (g)	0.08			*
C18:2 (g)	10.83			
C18:3 (g)	0.12			
C18:4 (g)	0.00			
C20:2 (g)	0.05			*
C20:4 (g)	0.00			
C20:5 (g)	0.00			
C22:2 (g)	0.00			*
C22:3 (g)	0.00			*
C22:4 (g)	0.00			*
C22:5 (g)	0.06			
C22:6 (g)	0.11			
C24:6 (g)	0.00			*
C20:3 (g)	0.008			

Amino Acids

Description	Amount	RDA	RDA %
Isoleucine (g)	1.620		
Leucine (g)	3.506		
Lysine (g)	1.802		
Methionine (g)	1.168		
Phenylalanine (g)	4.524		
Threonine (g)	3.988		
Tryptophan (g)	0.438		
Valine (g)	5.208		
Arginine (g)	5.761		

Amino Acids

Description	Amount	RDA	RDA %
Histidine (g)	2.489		
Cystine (g)	0.353		
Tyrosine (g)	5.942		
Alanine (g)	3.745		
Aspartic acid (g)	7.419		
Glutamic acid (g)	10.680		
Glycine (g)	7.362		
Proline (g)	6.325		
Serine (g)	5.452		
Hydroxyproline (g)	0.000		

Other components

Description	Amount	RDA	RDA %
Alcohol (g)	0.0		*
Phytate (mg)	63		*
Malic acid (mg)	439		*
Citric acid (mg)	228		*
Tartaric acid (mg)	0		*
Oxalic acid (mg)	1		*
Caffeine (mg)	0		*
Tannins (mg)	0		

Energy Calculations

Description	Amount	Prudent Guideline
%Energy - Protein	15.96%	+/- 15%E
%Energy - Fat	25.35%	< 30%E
%Energy - Saturated SFA	24.20%	< 10%E
%Energy - Mono-unsaturated MUFA	44.74%	+ 10%E
%Energy - Polyunsaturated PUFA	3.42%	~ 10%E
%Energy - Carbohydrate	59.79%	+/- 55%E
%Energy - Alcohol	0.00%	-

Legend

* - There are many missing or no values for these Nutrients.
Please consult the FoodFinder3 Manual -> Reports/Analysis: Meal Analysis.
- Estimated safe and adequate daily dietary intake (value is the mean of the range)
= - RDA = Recommended Dietary Allowance
+ - RDA % = Percentage of the Recommended Dietary Allowance

ADDENDUM E

F · A · C · T · S

Food & Allergy Consulting & Testing Services

ALLERGEN TEST REPORT

To:	Stellenbosch University	**Date:**	8 August 2005
		No. of pages:	3
For attention:	Charlyn Vosloo	**Enquiries:**	Dr. H.A. Steinman
		Test report no.:	**US050808/0020**

Herewith the test results for test report **US050808/0020** as requested.

Please note that:

1. The samples were analysed on 06 August 2005.
2. Test results relate only to samples tested.
3. One (1) sample of each product delivered, was homogenized and tested once using the ELISA testing method.
4. Lower detection limit: 1.5ppm gliadin.
5. Due to the deterioration of the samples, perishable samples are not stored for future enquiries, whereas non-perishables will be stored for a period of 30 days after testing has been conducted.
6. This report may not be reproduced, except in full. When only certain pages or sections of the full report are reproduced, written permission must be given by F.A.C.T.S.

Kind regards,

Dr. Harris Steinman
On behalf of F.A.C.T.S.

F · A · C · T · S

Food & Allergy Consulting & Testing Services

THE FOLLOWING TESTS YIELDED THE FOLLOWING RESULTS:

TEST RESULTS: *Gluten*
Morama bean flour - Raw
Simple 1: GL0143 < 1.5 ppm
Comment: Allergen within legislated limit for Gluten-free claim.

TEST RESULTS: *Gluten*
Morama bean flour - Roasted
Simple 1: GL0144 < 1.5 ppm
Comment: Allergen within legislated limit for Gluten-free claim.

DATA INTERPRETATION: *Gluten* Claims

Currently, in the Codex Standard for gluten-free food, the term "gluten-free" is defined as follows:
"In accordance with this standard "gluten free" means, that the total amount of the used gluten of wheat, rye, barley and oat in the products or those crossed species in food or ingredients is not more than 200 ppm (mg/kg) on the dry substance basis".

CONCLUSIVE REMARKS:

1. This product complies with the draft South African legislation of 200ppm for a gluten-free claim. It also complies with the imminent South African labeling legislation, which requires that gluten in products fall below the threshold of 20ppm to be eligible to carry the gluten-free claim.

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Food & Allergy Consulting & Testing Services

ALLERGEN TEST REPORT

INVOICE NUMBER:	N/A
DATE OF RECEIPT:	04-08-2005
CUSTOMER:	Stellenbosch University
SENDER:	Charlyn Vosloo
CUSTOMER ORDER NUMBER:	
TEST REPORT NUMBER:	US050808/0020
ALLERGEN TEST DESCRIPTION:	QUANTITATIVE GLUTEN

DATA INTERPRETATION

ALLERGEN BACKGROUND: GLUTEN

Detection of gluten in foodstuffs plays an essential role in the quality control and selection of foods for individuals with gluten-sensitive enteropathy (Celiac disease) and gluten allergy. Allergy to gluten can be fatal, although a range in severity of reactions occurs in response to varying doses. Invariably, it can have an enormous effect on the quality of life of the individual.

Coeliac disease is a permanent hereditary disorder of the immune system. Whenever gluten prolamins found in wheat (gliadins), barley (hordeins) and rye (secalins) are ingested, damage is done to the small intestine, resulting in a range of symptoms. It has been reported that as little as 29ppm of ingested gluten can trigger symptoms. The only treatment for this disease is the strict avoidance of gluten found in wheat, rye and barley.