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FOOD DEVELOPMENT CENTRE
Growing Opportunities in Food

Final Report on

DEVELOPMENT OF SNACK FOODS USING MANITOBA GROWN DRY BEANS (Project # 3322)

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EXECUTIVE SUMMARY

The purpose of this study was to assess the processing potential of Manitoba grown dry field beans in roasted snacks application. The study focused on identifying popular dry bean cultivar(s), and the suitable processing technologies for obtaining roasted bean snacks. The process was developed and optimized for the selected varieties.

A major element of the research was the extensive evaluation of 111 varieties of dry field beans from nine market classes (Navy, Pinto, Black, Small red, Great northern, Pink, Cranberry, Light kidney and White dark kidney) obtained from the Agriculture and Agri-Food Canada (AAFC) at Morden Research Centre, Manitoba. The beans were analyzed for protein, moisture contents and water holding capacity to characterize differences in nutrient composition and functionality. The protein content, water holding capacity and moisture content of the dry field beans ranged from 19.82 to 29.48%; 1.01 to 2.58 mL/g and 8.56 to 14.80%, respectively.

Nine popular bean varieties (Carmen, CDC Jet, Pintoba, Windbreaker, Envoy, Earlired, R0G 8O2, Beryl and Cran 09) were selected for the development of roasted bean snacks. FDC evaluated different pre-treatment and processing technologies. Pre-treatments included soak in solutions of salt and sugar to influence the textural quality attributes.

The conclusions from this study are summarized below:

- Prototype roasted bean snacks were successfully produced using Manitoba grown dry field beans. The products obtained exhibited relatively consistent sensory and physical properties.
- The developed process involved soaking, cooking/blanching, seasoning and roasting to obtain the snack. The moisture gained following a 24h soaking was generally between 40% and 54%. The moisture content of the roasted bean snacks were less than 7%.
- The beans were roasted at high temperatures (170°C) for 27-34 min, depending on the variety. Sensory properties of roasted bean snacks were highly rated by a team of trained FDC panellists with an above average preference for all the snacks. Roasted

bean snacks offer healthy and nutritious alternatives to commonly retailed roasted corn and peanuts snacks.

- The processing techniques used to develop the bean snacks could revitalize the utilization and consumption of dry field beans by health conscious consumers. The dry field bean varieties have potential in developing healthy and tasty roasted bean snacks. Also, their colour could find application in the ingredient industry.
- Roasting improved the appearance and palatability, as the beany flavours were considerably acceptable for the panellists. The developed snacks can be used as allergen-free ingredient to target the well positioned market trend. Considering the health benefits of the beans, process and product developers could include the snacks in formulations to achieve nutrient balance and health claims.
- Preliminary trials on application of the bean snacks as potential ingredients in energy bars and granola/trail mixes were considered.
- Chemical analysis of the roasted snacks is recommended to generate information for proper labelling and possible nutrient/health claim in the future.
- The project provided information on the feasibility of developing roasted bean snack. Further study on the technical aspect, such as retaining the seed structure through the process stages could be addressed in future breeding trials to increase the opportunities for the dry field beans. The implementation of a HACCP plan is recommended for commercial production of the snacks.

The presentations made at the 2011 MPGA summer tour of pulse research fields and specific FDC events were keys to disseminating information on potential commercialization opportunities and health benefits of consuming pulses in general. The joint research by FDC and AAFC to develop snack foods using Manitoba grown dry field beans was funded by the Manitoba Pulse Growers Association (MPGA) Inc.

Background

The project on the development of snack foods using Manitoba grown dry field beans was jointly initiated by the Food Development Centre (FDC) and the Agriculture and Agri-Food Canada (AAFC) Morden Research Centre in Manitoba. The project was exclusively funded by the Manitoba Pulse Growers Association (MPGA) Inc. This study aimed to add value to Manitoba grown dry field beans through processing into snack foods using the different marketing class(es) and cultivar(s). Development of snack foods from Manitoba grown dry beans would benefit growers, processors and health-conscious consumers in Canada, specifically in Manitoba.

In commencing the project, popular market classes and corresponding varieties of dry field beans were obtained from AAFC. The report summarizes the research activities performed in developing healthy nutritious snacks from dry field beans. The presentations at the 2011 MPGA summer tour of pulse research fields and specific FDC events were keys to disseminating information on potential commercialization opportunities and health benefits of consuming pulses in general.

The bean varieties or length of storage affected processing, while soaking and thermal processes were key technical steps. Process challenges that involved the degree of moisture uptake or splitting/blooming were unique to some varieties. Such features made it difficult to achieve the acceptable texture and appearance.

The processing techniques used to develop the bean snacks could revitalize the utilization and consumption of dry field beans by health conscious consumers. Considering the health benefits of the beans snacks, process and product developers could include them in formulations to achieve nutrient balance and health claims. This research highlighted a potential application of bean snacks in energy bars and granola/trail mixes. The prototypes were displayed at the 2011 MPGA Summer Field Day but the results will not be discussed in this report. The snacks offer healthy and nutritious alternatives to commonly retailed roasted corn and peanuts snacks.

FDC's laboratories and pilot plant facilities provide the necessary flexibility to conduct a wide variety of research and development projects in cereal grains and oilseeds, fruits and vegetables, bakery, beverages, meat, and extruded products. FDC's personnel have expertise in many processing technologies and product development including membrane filtration, supercritical fluid extraction, spray drying, freeze-drying, blanching, extrusion, drum drying, modified atmosphere packaging, pasteurization, retort processing, fermentation, product formulation, sensory evaluation and shelf-life studies.

Development of Bean Snacks

1.0 INTRODUCTION

Approximately 4.0 to 4.5 million tonnes of pulses are produced annually in Canada. Pulses are consumed for their balanced nutrient profile. Dry field beans are harvested at physiological maturity. In the commodity markets, dry field beans are classified according to the established seed characteristics, which may not correlate with certain desirable application qualities. Research is ongoing to evaluate several bean classes for specific agronomic characteristics, such as yield per acre and resistance to diseases and insects before being released into commercial farms. However, several environmental, agronomical factors and inherent seed characteristics influence the quality of the beans.

An important selection criterion for commercialization of dry beans is based on the expected yield per acre. The yield is a measure of the expected output based on a given amount of planted material. The value is a measure of the dry beans production from the farm. In the commodity markets, these established properties may not reflect process capabilities and desired consumer qualities. The potential of dry beans for specific food applications are hardly factored into the selection process in the commodity market. This could create challenges in the developing potential nutritious products from dry beans.

Dry beans are high in protein, fibre, complex carbohydrates, minerals and antioxidants. To tap into the functional, nutraceutical, and heart-health benefits of dry beans, there is a need to investigate the relationship between the agronomic quality and nutritional/functional quality of dry bean cultivars to expand the product application. Dry beans are ideal ingredients to incorporate into food products because of their nutritional and functional properties. Beans have been clinically proven to contain health-promoting ingredients that lower cholesterol, prevent cancer and enhance digestion. Currently, there is limited knowledge and information on the relationship between assessed field selection criteria and processing potential in roasted snacks application. However, the use of pulse flours in product application is on the rise.

This report, which is divided into two main phases, outlines the development of snack foods using Manitoba grown dry beans. The first phase involves a selection of popular varieties from dry bean market classes in April 2010. The goal was to objectively identify varieties with potential functional properties suitable for ingredient processing and prototype development into pulse based snacks. The second phase describes the development of a process for the production of roasted bean snacks using selected varieties.

2.0 PROJECT DESCRIPTION

This study aimed to add value to Manitoba grown dry field beans from the different marketing class(es) and cultivar(s) through the development of processes needed to obtain snacks. The development of snack foods from Manitoba grown dry beans would benefit growers, processors and health-conscious consumers.

Initial research work done at FDC created powdered material by grinding the beans into flour. The flour samples were analyzed for protein, moisture, colour and water holding capacity to characterize the differences in the nutrient composition and functionality. The high protein content of beans makes them an excellent source of nutritional components which contributes to great healthy snack foods.

The research reviewed mutually dependent components and properties in order to utilize dry field beans as snack foods used by consumers to address food choices. Food products and ingredients that deliver unique sensory attributes and functional characteristics are in demand by food processors and end users alike.

Nine bean varieties, namely Carmen, CDC Jet, Pintoba, Windbreaker, Envoy, Earlired, R0G 8O2, Beryl and Cran 09, were selected for the further research.

3.0 PROJECT OBJECTIVES

The project objective was to develop snacks from dry field beans that would feed into the eating habits of consumers seeking alternatives to unhealthy non-pulse based snacks. In addition, the project was to identify the most suitable varieties from the assembled marketing classes. Generally, the research was outlined to:

a) Evaluate the potential use of different marketing class(es) and cultivar(s) of dry beans in snack food applications;
b) Evaluate quality attributes in terms of sensory and nutritional information;
c) Identify popular cultivar(s) and seed size(s) with acceptable textural properties suitable for snack applications;
d) Document results to growers and processors at MPGA meetings and/or other forums to facilitate marketing and transfer of information to industry; and
e) Increase public awareness of the nutritional, functional and health benefits of Manitoba grown dry beans in product applications.

4.0 WORK OUTLINE

The project started with physical and chemical evaluation of over 100 varieties of dry field beans. Selecting the varieties for further development proved difficult because of similarities in protein content and water binding capacity. The project to formulate bean snacks using the capabilities at FDC involved the following:

- Reviewing snack processing technique to optimize the process and quality;
- Designing a process flow and identifying suitable equipment;
- Evaluating different pre-treatment and processing technologies against the dry field beans for obtaining suitable product quality;
- Assessing the process flow for improved product quality; and
- Developing a process for producing the bean snacks.

5.0 MATERIALS AND METHODS

5.1 Ingredients

In the first phase of the research a total of 111 varieties of dry field beans from nine identified market classes (Navy, Pinto, Black, Small red, Great Northern, Pink, Cranberry, Light kidney and White dark kidney) were obtained from AAFC Morden Research Centre in Manitoba. These samples were delivered with crop information such as seed size, yield and seed weight following screening and evaluation for desired field quality characteristics by AAFC

scientist/agronomist. The beans were received and stored in food grade pails at room temperature at FDC in Portage la Prairie, Manitoba until further processing.

The beans were milled with a Perten Lab mill 3600, model 090128, rpm 1720, equipped with discs type 5 (fine grind). The seeds/flours were analyzed for physical, chemical and functional properties such as moisture, protein and water binding capacity. Objective colour measurements were taken but are not discussed in this report. In the final phase, the research specifically focused on the following varieties namely Carmen, CDC Jet, Pintoba, Windbreaker, Envoy, Earlired, R0G 8O2, Beryl and Cran 09.

Additional ingredients used during the process/product development were sourced from commercial retail outlets. The ingredients included:

Salt**:** Sea salt (Baleine, coarse crystals (Lot # LA101880142) was used for texture modification and as a flavouring/seasoning agent to enhance the flavour profile of beans.

Sugar**:** Fine granulated sugar (Rogers, Dawn Foods) was used for texture modification and as a flavouring agent to enhance the flavour profile of beans.

Oil**:** Soybean oil (Lot # 3063420) was used as an adhering agent. Using oil in the process improves the appearance, texture and mouthfeel.

Indian Masala**:** A flavourful blend of garam masala and other spices was used as seasoning. It improved the appearance, texture and mouthfeel.

5.2 Physical, Chemical and Sensory Measurements

A. *Water activity* was analyzed using method MFLP-66, Aqualab model 4TE from Decagon Devices, Inc.

B. *Moisture content* was measured with the rapid moisture analyzer (model IR-30) using infrared technology for drying at 130°C.

C. *Colour* was measured using Minolta Chroma meter (model CR-400, Konica Minolta Sensing Inc.). The colour data are numeric values expressed as L*, a* and b* representing

lightness, redness and yellowness respectively. The lightness (L*) spans from black to white; red - green (a*) and yellow - blue (b*) colour values. The colour was measured on the bean flour placed in the sample cup for measurement.

D. *The nitrogen* content was quantitatively measured by Dumas method and converted to crude protein content (dry weight) using nitrogen factor of 6.25 by an external laboratory.

E. *Water hydration capacity* (WHC) is defined by the American Association of Cereal Chemists (AACC) as "the maximum amount of water that 1 g material will imbibe and retain under low-speed centrifugation". According to the AACC, this method applies to protein flours, concentrates and isolates of vegetable or animal origin that consist of native, modified or denatured protein. Characterization of WHC of the fibre matrix is essential to understand the perceived health response to fibre in the diet, specifically during gut transit (Robertson et al., 2000[1]).

Approximate WHC was determined by a modified version of AACC Method 56-30 (formerly 88-04). Single measure was conducted for each variety as follows: flour samples (3 g) were weighed into 30-mL centrifuge tubes. Distilled de-ionized water (30 mL) was added to the tubes, followed by mixing to a homogeneous mixture. The mixture was held for 1 h at room temperature. After time elapsed, the tubes were centrifuged for 5 min at 2100 rpm (Thermo Scientific Sorvall Evolution RC Super speed Centrifuge, Thermo Fisher Scientific Inc., Waltham, MA). The supernatant was discarded and tubes were inverted on a paper towel for 20 sec. The tubes were weighed to determine the combined mass of tube and hydrated pellet. The WHC was recorded in ml/g where, D is the mass of centrifuge tube and sample after decanting (g); B the sample mass (g); and E the tarr mass of centrifuge tube (g).

$$WHC\left(\frac{mL}{g}\right) = ((D-E) - B)/B$$

[1] Robertson, J.A.; Monredon, F.D.; Dysseler, P.; Guillon, F.; Amadò, R.; Thibault, J-F. (2000). Hydration properties of dietary fibre and resistant starch: a European collaborative study. Lebensm.-Wiss. u.-Technol. 33(2): 72-79.

F. *Sensory assessors* from FDC staff with training on snack profiling were requested to evaluate and score on quality attributes such as appearance, texture, flavour, aftertaste and overall acceptability. Eight to twelve panellists assessed the prototypes for quality attributes. The panellists tasted the products and provided inputs that accelerated the decision making process. The final prototypes were rated for desired attributes on a scale of 1 (unacceptable/undesirable) to 7 (acceptable/desirable). Additional comments were provided on the noted attributes.

G. *Analyses*: the protein, moisture and water binding capacity data was analyzed using SPSS Statistical Software (Somers, NY), also known as Predictive Analytics Software (PASW). The protein content and WHC was subjected to Analysis of Variance (ANOVA) by the marketing classes. The test for differences was determined with Scheffe, at an alpha value of 0.05.

5.3 Product and Process Development

The research reviewed bean material from 2009 to 2012 harvest and then completed the work using the later harvest. Bean varieties from 2010 harvest were used in the preliminary study. The project was completed with 2012 harvest. A suitable processing technology was developed to process healthy roasted snacks from dry field beans obtained from AAFC. Based on the information acquired, a total of nine varieties were selected from various market classes for the second phase. The quality and sensory effect of the end product were assessed. The results from the bench top experiments were transferred to the final process in the development of a prototype snack. Figure 1 describes the basic process flow developed for the prototype.

5.3.1 Soaking

Beans varieties (Carmen, CDC Jet, Pintoba, Windbreaker, Envoy, Earlired, R0G 8O2, Beryl and Cran 09) were weighed and soaked with water (ambient approx. 10-26°C) at a ratio of 1:3 (beans to water). The beans were hydrated for the first 5 – 7 h at room temperature and transferred to 7°C in order to avoid any possible fermentation associated with a longer soak time (usually 24 h).

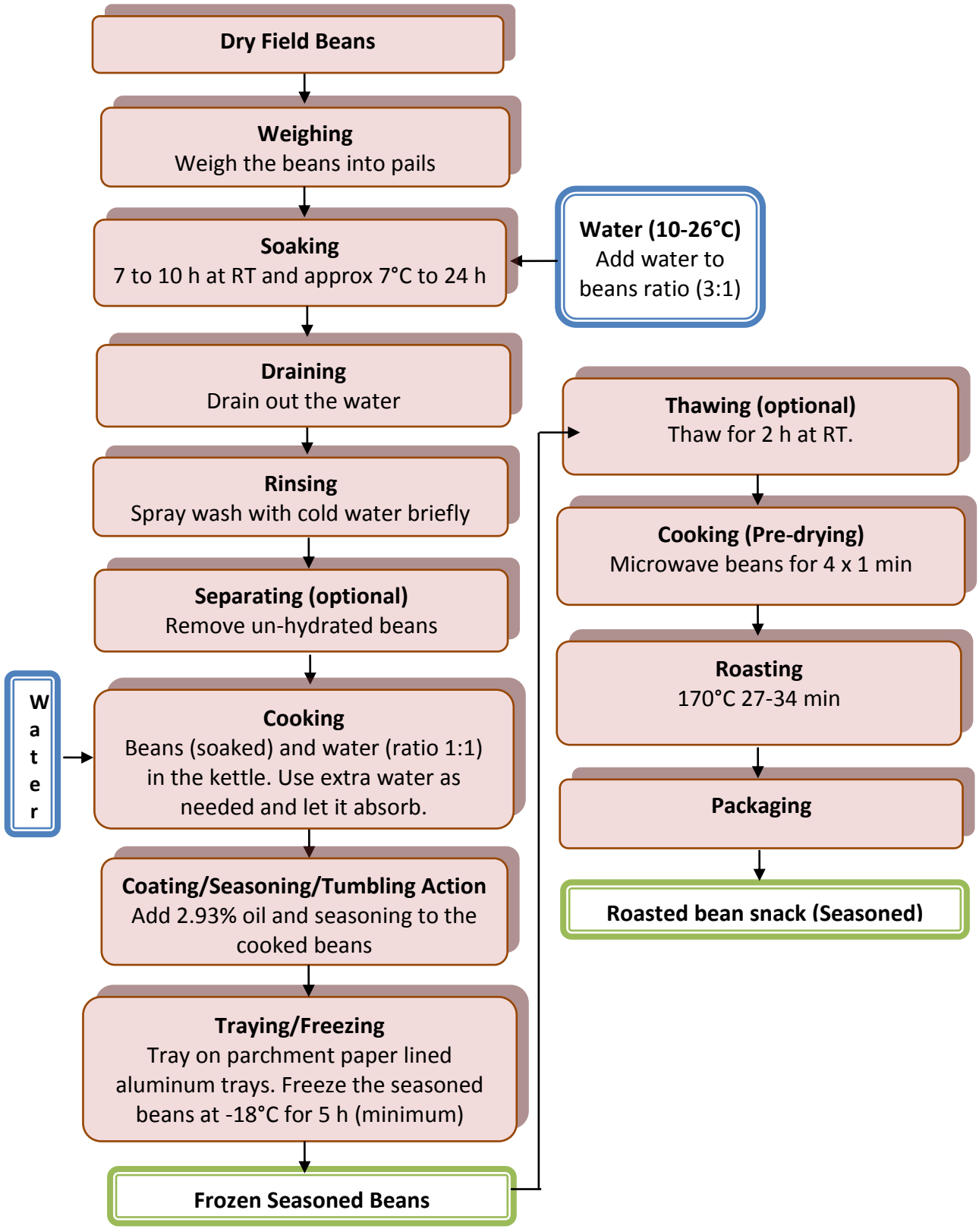

Figure 1: The recommended process flow *(RT denotes room temperature)*

5.3.2 Cooking

In developing the methodology, suitable cooking methods like steam and water blanching were investigated. Beans were cooked using the electric kettle (Cleaveland Electric kettle; model KET-12-T; Cleveland Range Ltd, Toronto, Canada).

5.3.3 Roasting

Prior to roasting, cooked frozen beans were either spread on Teflon trays to thaw or thawed by a quick dip in cold water followed by hot water and drained. The beans were either dried to approx. 10-12% moisture content in the Hobart oven at 65°C or roasted directly from frozen state. The effect of added salt in the soaking stage was evaluated in roasted beans. Roasting was carried out at 120-170°C in either the Hobart oven or in a cabinet oven for 15-34 min. The temperature and time selections were based on preliminary study trials.

5.3.4 Flavour ingredient selection

Laboratory trials were conducted to identify an appropriate seasoning/blend to flavour the bean snacks. The seasoning ingredients of Indian Masala and ground sugar-tapioca starch mix (1:1 ratio) were used at 5% cooked bean weight. The sugar-starch mix was eliminated in the final trials. Soy oil (2.93% of cooked bean weight) was used as an adhering agent. Seasoned beans were spread on aluminum trays lined with parchment paper and roasted at 170°C. The weight loss seasoned roasted beans ranged from 52 to 73 %.

6.0 RESULTS AND DISCUSSION

In the first phase, the study screened 111 varieties of dry beans for key nutrient (protein), functional properties (water binding capacity) and moisture content. Based on the results (Appendices A-E), the range of protein content was 19.82 to 29.48%, with the highest content in Navy bean (Na06-005, medium size) and lowest content (19.82%) in Pinto bean (13-8-1, large size).

Similarly, the water holding capacity showed a wide range of 1.01 to 2.58 mL/g in dry field beans. The highest content was in Small Red GS780, medium size bean; and lowest content in

Navy bean (GTS561, medium size). The moisture content of the dry field beans ranged from 8.56 to 14.80%. The highest moisture content in dry field beans was Cranberry (Etna, large size) and lowest content (8.56%) in Navy bean (DJ091010, large size).

Generally, there seemed to be differences in the protein content within the classes/varieties. Significant differences existed between Navy and Pinto beans ($p = 0.004$). The WHC showed significant differences between Navy, Pinto, Cranberry, Small Red; Black and Cranberry; Great Northern and Cranberry; and Cranberry and Pink. The variation could be caused by environmental factors but without replicates, statistical analyses could not be performed. Hence, they were not used as guide in the selection of specific varieties. The AAFC and FDC scientists proceeded with popular cultivars and representation of the market classes. The selected varieties used for continuing the project were used in developing the roasted bean snacks.

In a study carried out on nine classes of dry field beans, the protein content, moisture content, and water holding capacity were compared to the subjective quality assessed at harvest. The preliminary results indicated that the relationship perceived between dry field bean quality at harvest (such as 1000 seed weight, seed size and seed quality), and nutrient/functional quality (as measured by protein content and water holding capacity) showed a weak to no correlation between the variables. The field quality of some classes of dry field beans did not show a direct relation with the protein content and the water binding capacity. The results show the need for better objective and quick assessment tool in place of the current practice.

The beans were milled into flour and assessed for product development potentials. The functionality of the flours presented technical challenges in the tested applications such as cookies and crackers in the absence of non pulse base flours. The product application required a high proportion of fat, salt or sugar ingredients which diluted the health benefits of the snacks. Also, the amounts of the bean flours were relatively inadequate for extensive trials.

Taking into account the similarity in protein/nutrient content among the varieties and marketing classes, potential application of the flour without the use of an elevated amount of salt, fat or sugar is limited besides extrusion. However, the sample size was inadequate for

extrusion trials. The research then focused on using the whole bean seeds in a snack application. The process demonstrated feasible potential for dry field beans.

Typical processes used to develop snacks from whole bean seeds include pre-treatments and subsequently boiling and roasting. Soaking in solutions of salt and sugar to infuse the flavours hardened or softened the matrix and affected the textural quality attributes.

During the soak, the ROG 802 and Pintoba variety beans gained over 89% in weight after 24 h soaking followed by Earlired (79.4%), Cran-09 (77.0%) and Windbreaker (60.4%). The CDC Jet had the lowest percentage of weight gain at 48.1%. The appearance of some bean varieties after soaking is shown in Figure 2. The moisture gained following soaking was generally between 40% and 54%. CDC Jet, ROG 802 and Earlired varieties appeared to be split due to hydration. Unlike other varieties of beans, the natural colour of the CDC Jet variety beans changed from black to dark purplish black.

In selecting the cooking technology, suitable cooking methods, like steam and water blanching, were investigated. In addition, the specific process approach that would suit the bean varieties was defined. As shown in Figure 3, steam blanching with a lid resulted in fully cooked beans as opposed to cooking without a lid. Water blanched beans were slightly more moist than the beans that were cooked by steam blanching (uncovered). Water blanching the beans was recommended and used in additional trials. The varieties of hydrated beans were cooked with prepared solutions of: water only (as a control), water with 5% salt, and water with 5% sugar at 1:2 ratio (hydrated beans to water) as infusion solutions. The cooked samples were packed and held frozen for further processing.

Figure 2: Appearance of the beans after soaking.

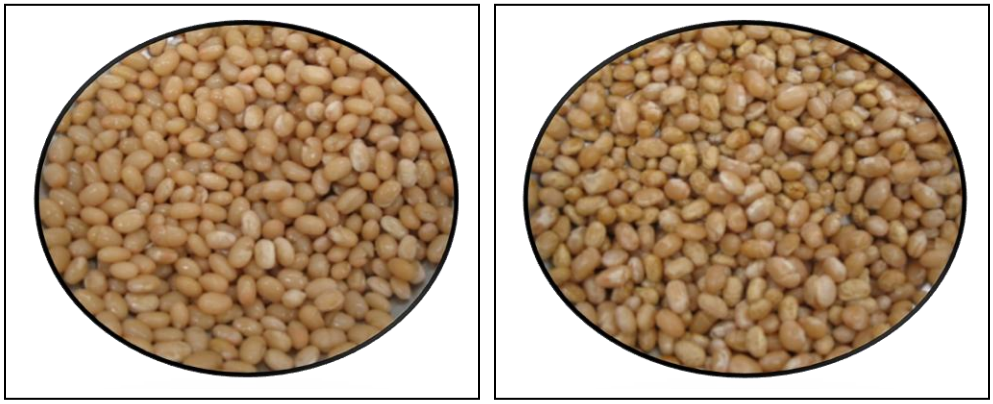

Figure 3: Appearances of steam blanched beans with (left) and without (right) the use of a lid during cooking.

Weight gained (%) by the beans during cooking ranged from 26-55% (control), 21-47% (salt) and sugar 27-55% (sugar) depending on the bean variety. The added salt in the cooking solution slightly lowered the weight gain compared to control and sugar cooked beans. Based on visual observation, the beans cooked with salt solution maintained an intact structure, whereas water or sugar infused beans were rated mushier in texture than salt. The Cran 09 variety was delicate to manipulate in the cooked state compared to other varieties. Also, it cooked slightly faster and had the tendency to overcook, resulting in clustered mass.

In the final cooking process design, water was added to the pre-soaked beans in the electric kettle at 1:1 ratio of beans to water. The kettle was then covered prior to cooking. The beans were cooked for 40-60 min (electric kettle, set at position 7). Depending on the bean type, extra water was added to obtain a full cook. The appearance of the soaked and cooked Cran 09, Pintoba and CDC Jet respectively are shown in Figure 4. The skin colour of the beans leached into the cooking water and affected the overall appearance. CDC Jet lost its vibrant shinny black colour after cooking.

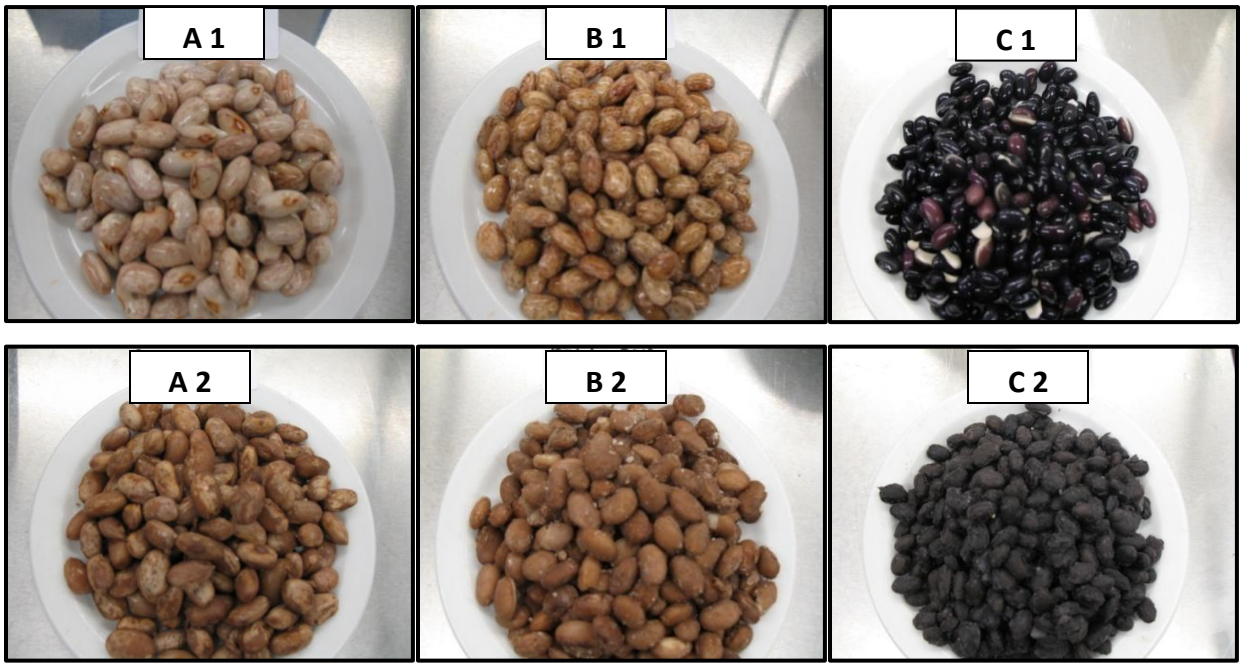

Figure 4: Appearance of Cran 09 (A 1), Pintoba (B 1) and CDC Jet (C 1) after soaking; and cooked Cran 09 (A 2), Pintoba (B 2) and CDC Jet (C 2).

In addition, Beryl and Envoy had considerably lower success rating in achieving fully hydrated batches compared to the other varieties. After 24h soak, hard beans (considered with less than 15% moisture content) were mechanically separated through a screen. Beryl and Envoy varieties cooked faster than other bean varieties but were hardly able to retain their integrity (Figure 5).

Figure 5: The appearance of cooking challenges associated with cooking of beans: the fully hydrated (A), un-hydrated (B) and cooked (C) Beryl varieties.

The sugar infused beans were better than the salt infused beans in terms of texture and flavour. Depending on the variety of beans, the appearance of sugar infused (cooked) were comparable with control (cooked) beans but slightly harder than the control. Overall, water/sugar solution could be used to cook beans based on the desired outcome.

Texture and taste are important snack product qualities that considerably influence consumer acceptability. Desired food quality, which include various attributes are linked to the physiochemical matrix. The food matrix can be influenced by the processing conditions (time temperature)[2]. The diverse factors that affect quality basically challenge the processes that would influence the physiochemical matrix.

Hence, it was important to understand the effect of the selected process on product properties. The main desirable quality of the bean snack is texture followed by flavour and colour. Texture development in the beans is due to gelatinization of starch and non starchy polysaccharides (softened), then hardening of the structure. The evaporation of water from the matrix impacts the texture. The texture developed before and during roasting was found important to sensory quality. Roasting of snacks is generally performed using hot air or oil at high temperature. Depending on size and structural components, under or over roasting can be an issue. Inadequate temperature/time combinations during roasting affected the appearance and acceptability of bean snacks in the preliminary trials. This study later demonstrated that under

[2] Luning, PA and Marcelis, WJ 2006. A techno-managerial approach in food quality management research. Trends in Food Science and Technology, 17 (7), 378-385.

the roasting conditions used, higher temperature (120-170°C) had considerable positive impact on most varieties. Overall, the bean cultivars/varieties had similar responses to the selected thermal treatment and roasting (170°C).

In roasting trials to develop the colour, the improper temperature/time combination left a lingering bitter flavour on some varieties. The outcome could be attributed to the highly localised surface heat. Fully opened structure in some roasted bean varieties makes them subject to further structural disintegration during packaging. The noted observation was the main reason that the seasoning application stage preceded the roasting.

Cooked beans infused with or with no salt/sugar were roasted in frozen or thawed state. Roasting was carried out at 170°C in the Hobart oven. It was observed that the frozen or thawed roasted beans had similar textural properties (Figure 6). However, frozen beans had lesser splits/open structure than the pre-dried or thawed samples. The cooked salt infused beans were not mushier than sugar or control beans. This enhanced the moisture removal during roasting and impacted airiness. After roasting, all salt infused roasted beans were found harder and superior in colour to the sugar infused beans (Table 1).

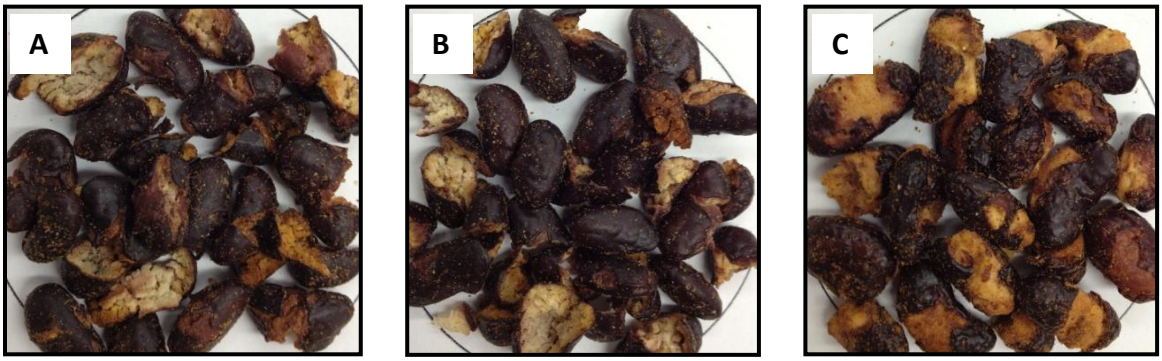

Figure 6: Appearance of roasted beans that were A) pre-dried prior to roasting; B) thawed; and C) roasted from frozen state.

Panellist evaluated the samples for texture and flavour on a scale of 1 to 5 during the development stages. The roasted bean snacks were rated above 3.0 except for Cran 09, R0G 8O2 and CDC Jet. The low ratings were associated with roasted salt infused beans, which were

harder. Panellists liked the crispiness and crunchiness of the unsalted sample as it was easier to chew than the salt containing beans.

Air dried beans shrunk slightly to an acceptable appearance. Roasting from the frozen state maintained the size (soaked bean size) or even larger, and produced lighter and airy texture beans with highly visible splits. Also, the split structure held some seasoning within the openings. However, microwaving prior to roasting resulted in manageable structure within most varieties. Hence, it was introduced in the process used for producing roasted bean snacks.

Table 1: Texture and flavour ratings; and comments on roasted bean samples that were infused with only water (control), salt or sugar samples. Ratings were based on a five point scale, where 5 = like extremely and 1 = dislike extremely.

Variety	Treatment type	Texture	Flavour	Comments
Pintoba	Control	4.00	4.00	Good texture, crispier
	Salt	3.00	3.00	Slightly harder, too salty
	Sugar	4.00	4.00	Slightly harder, mild sweetness
Windbreaker	Control	4.50	4.50	Good texture, crispier than Pintoba
	Salt	3.00	3.00	Slightly harder, too salty
	Sugar	4.20	4.20	Slightly harder, mild sweetness
Cran 09	Control	4.80	4.80	Better appearance, crispiest
	Salt	2.50	3.00	Slightly harder, too salty
	Sugar	4.50	4.50	Slightly harder, mild sweetness
Earlired	Control	4.00	4.00	Good flavour and crunchiness
	Salt	3.50	3.50	Slightly harder, too salty
	Sugar	3.50	3.50	Slightly harder, mild sweetness
ROG 8O2	Control	4.80	4.80	Better appearance, crispiest
	Salt	2.50	2.50	Slightly harder, too salty
	Sugar	4.50	4.50	Slightly harder, mild sweetness
CDC Jet	Control	4.50	4.50	Good crunchiness
	Salt	2.50	2.50	Hardest to bite, too salty
	Sugar	4.20	4.20	Slightly harder, mild sweetness

During the seasoning trials, several seasoning types were reviewed from previous supplier libraries. They commenced the selection and elimination process. Finally, they were narrowed down to a blend of starch-sugar mix and store purchased Indian Masala. Starch generally has a bland taste which did not support the masking of the beany flavour. But the sugar was expected

to mellow out the flavour and was noted in some preliminary trials. Panellist quickly discovered that the added starch and sugar mix contributed raw or uncooked flavour. The panellists noted that starch-sugar seasoning displayed a whitish unacceptable appearance and unpleasant starchy taste notes. Hence, Indian Masala seasoning was used in all trials. Indian Masala seasoning complimented the bean flavour. Based on the panellists' comments, Indian Masala was used further in the remaining trials.

In order to assess the process feasibility of the seasoning, the seasoning was applied on samples before freezing (prior to roasting) and on the roasted beans. When applied to roasted beans, the use of suitable/non-water based adhesion products would help retain the textural properties. The use of oil was identified and optimized at a high usage level of 3.5%. Hence, the seasoning was applied prior to roasting.

Cooked beans were roasted immediately after seasoning with oil and Indian Masala and mixed gently and manually. It was observed that tumbling of the cooked beans using a mechanical means resulted in mushier beans; hence it was not recommended in further trials.

Finally, the beans were processed for sensory evaluation. The trials identified soaking, cooking, seasoning, freezing and roasting as suitable processes to develop the roasted bean snacks. The appearance of nine varieties of bean snacks roasted from the frozen state is shown in Figure 7. In Figure 8, the appearance of the thawed roasted bean snacks are shown. The degree of split or structural disintegration varied considerably in the samples. The snack colour was highly acceptable singularly or in combinations to create interesting visuals. However, regardless of variety of beans, and temperature and time, the beans lost their structural integrity following roasting.

The moisture content in the roasted bean snacks was relatively low in both processes. Moisture values for bean snacks that were roasted following thawing ranged from 0.97 to 6.67%, while bean snacks roasted from the frozen state ranged from 1.50 to 4.95%. Based on the values obtained (Table 2), the snacks have the potential for an extended shelf-life.

Figure 7: Appearance of roasted bean snacks from selected varieties from frozen state. The samples listed from A to I are: Earlired, Carmen, Envoy, R0G 8O2, Windbreaker, CDC Jet, Beryl, Pintoba and Cran 09, respectively.

Figure 8: Appearance of roasted (thawed) bean snacks from selected varieties. The samples listed from A to H are: Earlired, Carmen, Envoy, R0G 8O2, Windbreaker, CDC Jet, Beryl, and Pintoba, respectively.

Table 2: Moisture contents (%) of roasted bean snacks.

Bean varieties	Moisture content (%)	
	Roasted frozen	*Roasted thawed*
Earlired	4.69	4.51
Carman	2.37	1.59
Envoy	1.75	4.43
ROG 802	2.12	5.39
Windbreaker	4.04	1.99
CDC Jet	3.01	3.97
Beryl	4.95	6.67
Pintoba	4.94	0.97
Cran 09	1.50	n/a

6.1 Sensory characteristics

Assessment of sensory characteristics is frequently used to evaluate consumer acceptability of food products. Examining the acceptability of the roasted beans by the panel is important in determining the consumer willingness to purchase a product. Sensory was used to subjectively evaluate the roasted beans during development and on the final product to generate and rate descriptive attributes. Details provided are specific to the bean snacks that were successfully developed in the project. Generally, the texture and flavour (absence of a beany flavour) influenced the acceptance of bean snacks. Roasted beans that were light and very airy in texture were disliked by the panellists due to lacking the ability to masticate.

Sensory evaluation of the thawed-roasted bean snacks in Figure 9 shows the rated acceptability of the varieties of roasted beans. The rated characteristics were: appearance, flavour, aftertaste, texture and overall acceptability. On a scale of 1 (unacceptable/undesirable) to 7 (acceptable/desirable), the varieties had above average scores. The varieties with the most rounded ratings were Earlired, Carmen, Envoy, R0G 8O2, Windbreaker, CDC Jet and Beryl. Cran 09 could be considered to be on the borderline and Pintoba was least acceptable by the panellists. The important comments that were shared by the panel on associated rating emphasized on textural aspects. The shared details provided insight into the possible explanation for the rated values obtained (Table 3).

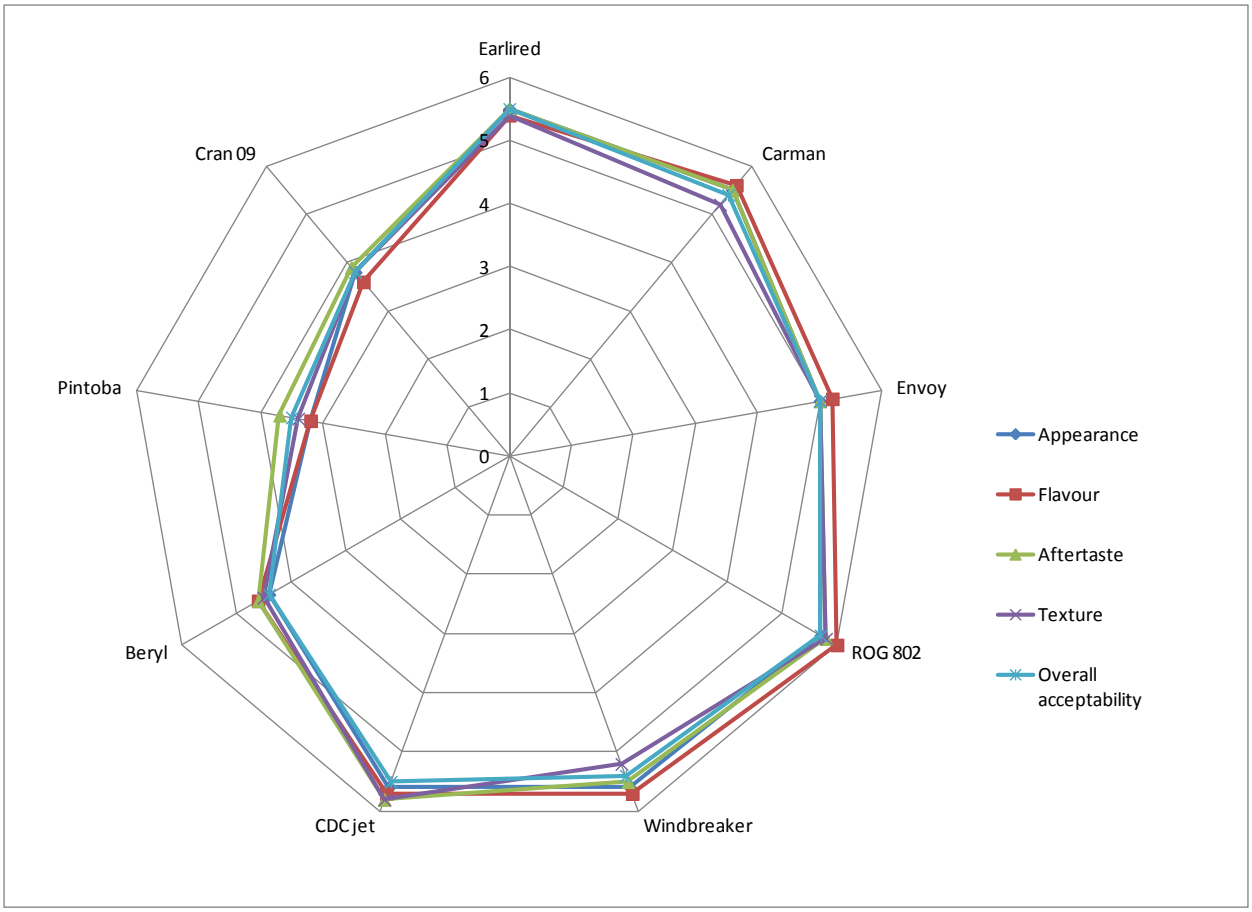

Figure 9: The sensory profile of frozen-roasted bean snacks.

Table 3: Panellists' comments noted during the sensory evaluation of the frozen-roasted bean snacks.

Beans varieties	Comments
Earlired	Few airy and hard pieces; crispy; airy texture; slightly beany flavour
Carman	Powdery; crispy; airy texture; slight beany flavour
Envoy	Few powdery and hard pieces; crispy; lacks bean structure; slightly burnt taste; strong beany flavour
R0G 8O2	Good flavour; best sample; harder; poor appearance, very crunchy; beany/little flabour
Windbreaker	Beany. Good flavour; few hard pieces; crispy not crunchy; milky flavour; very light
CDC Jet	Harder; best sample;
Beryl	Too crunchy, beany, very crispy, very hard; worst; poor flavour; harder
Pintoba	Powdery; bitter flavour;
Cran 09	Over cooked; very powdery; open, slightly burnt; crunchy

Sensory evaluation of the thawed-roasted bean snack in Figure 10 shows the rated acceptability of the varieties of roasted beans. The characteristics were: appearance, flavour, aftertaste, texture and overall acceptability. On a scale of 1 (unacceptable/undesirable) to 7 (acceptable/ desirable), the varieties had above average scores. The varieties with the most rounded ratings were Earlired, Carmen, Envoy, Windbreaker and CDC Jet. Beryl is considered to be on the borderline acceptability. The least acceptable varieties were Pintoba and R0G 8O2. The comments from the panellists are indications on how they possibly rated values obtained (Table 4).

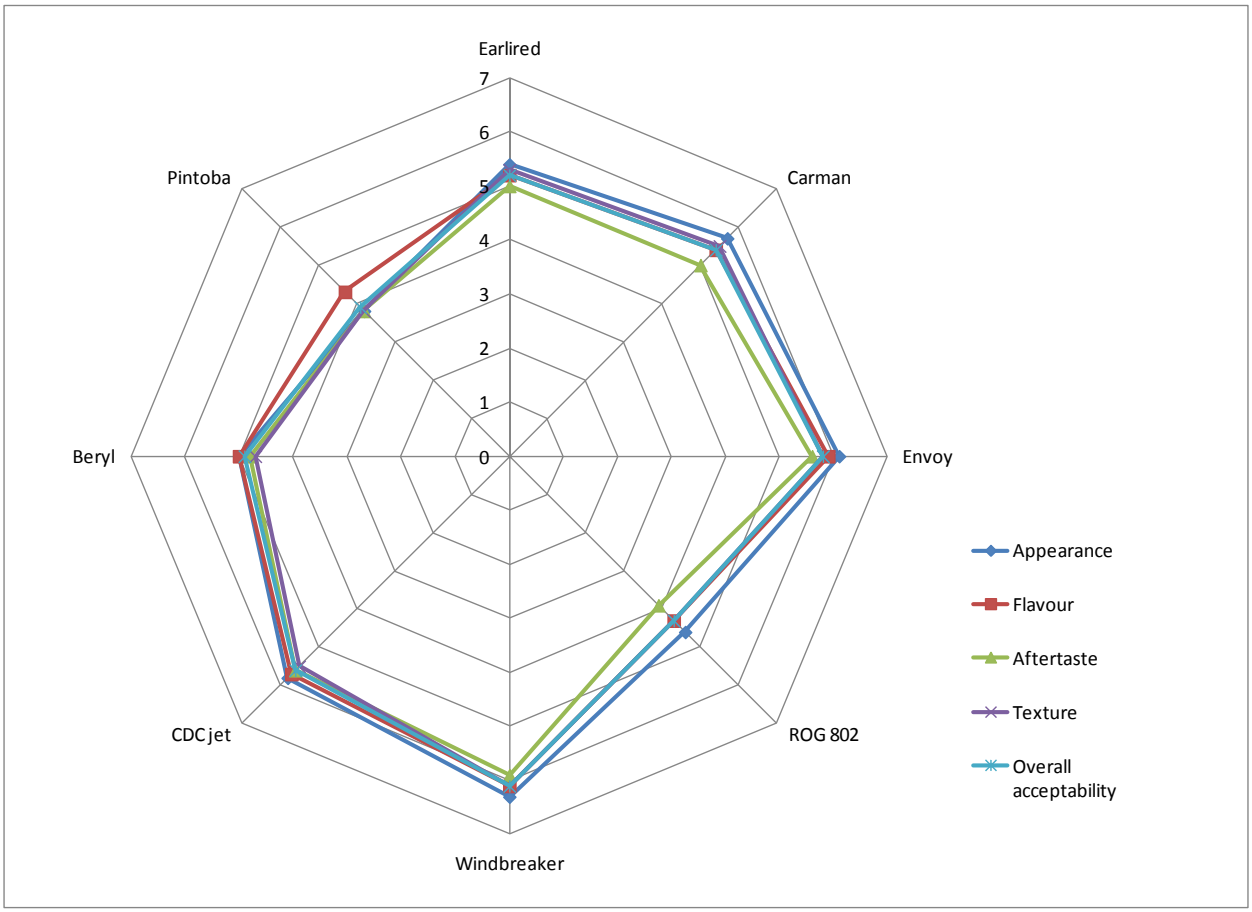

Figure 10: The sensory profile of thawed-roasted bean snacks.

Table 4: Panellists' comments noted during the sensory evaluation of the thawed-roasted bean snacks.

Beans varieties	Comments
Earlired	Good flavour; no beany flavour; hard texture
Carman	Crumbles and breakdown easily,, little beany flavour, light texture; slightly salty
Envoy	Breakdown too easily; crispy, dislike the size for snack; less beany; milky flavour
R0G 8O2	Does not breakdown well, slightly harder
Windbreaker	Looks like roasted peanuts; very crispy; good texture, the best, slightly beany; slightly burnt flavour
CDC Jet	Not as hard as R0G 8O2; unopened pieces are hard; dark;
Beryl	Less dried or not fully cooked; very beany; dry cracked appearance; hard and flaky
Pintoba	Bitter flavour; hardness affects overall quality; burnt after taste; beany
Cran 09	**

** Sample unavailable

The frozen-roasted beans had better overall rating for the varieties compared to thawed-roasted. The roasting from frozen state was more manageable than the thawing followed by roasting. Also, the frozen process would be easier to transfer to scale-up or potential clients.

The acceptable textural properties of the snacks can be attributed to the low moisture content. Quality control checks for moisture content (%) and water activity were performed on finished product. Accepted moisture content and water activity levels were ≤ 11% and ≤ 0.60, respectively.

6.2 Quality control guidelines

The developed processes involved soaking, cooking/blanching, seasoning and roasting to obtain the snack. The seasoned beans were roasted at high temperatures (170°C) for 27-34 min that could substantially reduced microbial load to an acceptable level. Utilizing seasoning mix after roasting in future could potentially increase microbial load. This should be controlled to ensure a quality safe of finished product. From a food safety perspective, quality guidelines for microbial levels in ready-to-eat food should apply. To ensure food product safety, the implementation of a HACCP plan is recommended.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Prototype roasted bean snacks can be produced using Manitoba grown dry field beans. The products obtained exhibited relatively consistent sensory and physical properties. Please note that the developed bean snacks are prototype products and changes to the processes might occur during scale-up. This might affect the final product quality.

Most of the nine dry field bean varieties (Carmen, CDC Jet, Pintoba, Windbreaker, Envoy, Earlired, R0G 8O2, Beryl and Cran 09) assessed have potential in developing healthy and tasty roasted bean snacks. Also, their colour could find application in the ingredient industry. Seasoning improved the appearance and palatability after roasting, as beany flavours were considerably tolerated during sensory.

The developed snacks can be considered low in fat in addition to other healthy components in pulses. As an allergen free product, the target group could be well positioned on the market.

Given that beans are nutrient dense, chemical analysis of the roasted snacks is recommended to generate information for proper labelling and possible nutrient/health claim in the future.

Further work would be required to scale-up and packaged the prototype bean snacks for consumer testing. The seasoning ingredients can be investigated further to attract larger consumer group. The shelf-life of the bean snacks in the preferred packaging should be studied.

Appendices

Appendix A: The marketing classes, varieties, sizes, moisture (%) and protein (%) contents; and water holding capacity (WHC) for 2009 regional trials.

Class	*Variety*	*Size*	*MC (%)c*	*Protein (%)*	*WHC (ml/g)*
Black	*CDC Jet	Small	10.93	27.17	1.24
Black	BK05-009	Small	10.43	26.60	1.17
Navy	Galley	Small	10.98	26.58	1.24
Navy	Cargo	Small	10.85	26.39	1.13
Navy	HR177	Small	10.03	26.16	1.10
Navy	*Envoy	Small	10.32	26.05	1.03
Navy	Lightning	Small	10.29	25.96	1.09
Black	8580963	Small	11.08	25.65	1.12
Navy	N252185	Small	10.03	25.60	1.23
Navy	HY4181	Small	9.97	25.59	1.11
Navy	DJ091010	Small	8.56	25.56	1.27
Navy	AC Cruiser	Small	10.24	25.55	1.26
Navy	H96048	Small	10.83	25.34	1.20
Navy	GTS 549	Small	9.77	25.18	1.15
Navy	5061	Small	10.36	25.18	1.18
Navy	T10601	Small	10.02	24.58	1.30
Black	Shania	Small	10.35	24.44	1.22
Navy	2098	Small	10.63	24.44	1.19
Navy	T9903	Small	9.73	24.28	1.22
Navy	H96204	Small	10.74	23.86	1.14
Navy	T9905	Small	10.86	23.59	1.24
Black	5222	Small	9.82	23.18	1.28
Navy	OAC 05-1	Small	10.20	22.91	1.09
Black	Eclipse	Small	9.88	22.81	1.49
Black	6252	Small	11.54	22.72	1.31
Black	5226	Small	10.24	22.49	1.31
Black	Black Violet	Small	11.28	22.20	1.31
Black	BK04-001	Small	9.77	21.42	2.33

Appendix B: The marketing classes, varieties, sizes, moisture (%) and protein contents (%); and water holding capacity (WHC, mL/g) of 2009 wide row COOP A trials.

Class	***Variety***	***Size***	***MC (%)c***	***Protein (%)***	***WHC (ml/g)***
Navy	NA06-005	Medium	11.32	29.48	1.10
Navy	NA06-002	Medium	10.39	28.61	1.08
Black	*CDC Jet	Medium	10.20	28.08	1.16
Black	GS 701	Medium	10.24	27.93	1.14
Navy	W2484-RR75268	Medium	10.89	27.26	1.12
Black	H72-1	Medium	10.26	27.20	1.33
Navy	W2651-80393	Medium	10.38	27.13	1.13
Navy	GTS562	Medium	11.11	26.98	1.28
Navy	GTS 570	Medium	10.18	26.83	1.08
Navy	H3450-86286	Medium	10.32	26.74	1.13
Navy	NA06-007	Medium	10.85	26.69	1.06
Navy	*Envoy	Medium	10.50	26.45	1.05
Black	GS 1302	Medium	10.32	26.38	1.12
Black	H3450-90274	Medium	10.56	26.23	1.44
Black	*AC Harblack	Medium	10.76	26.15	1.18
Navy	T68469	Medium	10.30	26.10	1.30
Navy	GTS561	Medium	10.56	26.06	1.01
Navy	H3450-90293	Medium	9.80	25.90	1.18
Navy	H68-1	Medium	10.14	25.76	1.15
Navy	NA06-003	Medium	10.13	25.56	1.20
Black	Loreto	Medium	9.64	25.29	1.16
Black	H68-4	Medium	9.79	25.23	1.22
Navy	T67106	Medium	10.45	25.08	1.20
Navy	H73-2	Medium	10.67	24.95	1.14
Navy	03019	Medium	10.13	24.86	1.07
Navy	T10704	Medium	10.14	24.74	1.18
Navy	*T9903	Medium	10.62	24.40	1.11
Navy	T68442	Medium	10.53	23.65	1.09
Navy	02084	Medium	10.34	23.53	1.87

Appendix C: The marketing classes, varieties, sizes, moisture (%) and protein (%) contents; and water holding capacity (WHC in mL/g) for 2009 wide row COOP A trials.

Class	***Variety***	***Size***	***MC (%)c***	***Protein (%)***	***WHC (ml/g)***
Great Northern	8-3-4	Large	11.10	27.45	1.24
Great Northern	8-11-1	Large	10.68	27.22	1.07
Great Northern	Orion	Large	11.31	25.71	1.68
Great Northern	9-6-2	Large	10.97	25.61	1.08
Small red	47-3-3	Large	10.93	25.54	1.55
Pinto	11-2-2	Large	10.93	25.47	1.67
Great Northern	*Beryl	Large	11.06	25.13	1.48
Pinto	COB 2828-99	Large	11.08	24.85	1.47
Pinto Small red	*AC Earlired	Large	10.51	24.84	1.53
Pinto	Durango	Large	10.89	24.63	1.34
Pinto	COB 2824-99	Large	11.05	24.60	1.37
Great Northern	13-10-1	Large	10.87	24.37	1.40
Pinto	*Maverick	Large	11.70	24.20	1.33
Pinto	8-2-3	Large	10.33	23.33	1.23
Small red	5-7-1	Large	10.68	22.68	1.47
Pinto	Baja	Large	11.41	22.61	1.47
Small red	48-1-1	Large	11.25	22.54	1.21
Pinto	La Paz	Large	10.72	22.40	1.52
Pinto	11-8-2	Large	10.44	22.12	1.82
Pinto	Sonora	Large	11.04	21.88	1.33
Pinto	0868	Large	9.71	21.51	1.44
Small red	7-4-2	Large	11.10	21.50	1.90
Pinto	13-8-1	Large	11.44	19.82	1.27

Appendix D: The marketing classes, varieties, sizes, moisture (%) and protein (%) contents; and water holding capacity (WHC, mL/g) for 2009 regional trials.

Class	***Variety***	***Size***	***MC (%)c***	***Protein (%)***	***WHC (ml/g)***
Cranberry	*Cran 09	Large	10.55	24.54	2.01
Cranberry	Etna	Large	14.80	24.28	2.16
Cranberry	BD1003	Large	10.14	26.14	2.02
Light Kidney	*Pink Panther	Large	10.22	26.22	1.48
Light Kidney	Foxfire	Large	10.65	27.01	1.80
White/Dark Kidney	*GTS 402	Large	10.45	24.72	1.48
White/Dark Kidney	GTS 401	Large	10.51	24.66	1.59
White/Dark Kidney	R0G 802 (DK)	Large	10.12	27.70	1.57

Appendix E: The marketing classes, varieties, sizes, moisture (%) and protein (%) contents; and water holding capacity (WHC, mL/g) for 2009 regional trials.

Class	***Variety***	***Size***	***MC (%)c***	***Protein (%)***	***WHC (ml/g)***
Pinto	Winmor	Medium	10.58	27.80	1.73
Pinto	Pintoba	Medium	10.60	26.01	1.01
Small red	GS780	Medium	10.62	25.87	2.58
Great Northern	99136	Medium	10.64	25.73	1.11
Great Northern	99118	Medium	11.07	25.05	1.05
Pinto	Windbreaker	Medium	10.78	24.95	1.55
Great Northern	Gemini	Medium	10.54	24.85	1.13
Pinto	ND-307	Medium	11.12	24.83	1.95
Small red	*AC Earlired	Medium	10.53	24.76	1.66
Pinto	Medicine Hat	Medium	10.27	24.67	1.59
Pinto	Island	Medium	10.66	24.56	1.52
Great Northern	*Beryl R	Medium	10.43	24.38	1.60
Small red	SR05-008	Medium	11.17	24.14	1.31
Pinto	6203	Medium	10.60	23.98	1.31
Pinto	6189	Medium	10.34	23.90	1.61
Pinto	P239222	Medium	10.63	23.84	1.75
Pink	R0G 922	Medium	10.89	23.66	1.22
Pinto	Stampede	Medium	11.37	23.55	1.90
Pink	*Pink Floyd	Medium	10.37	23.16	1.96
Pinto	1223	Medium	10.64	22.85	1.35
Pinto	P35161	Medium	10.26	22.75	1.68
Pinto	*Maverick	Medium	11.09	22.61	1.54
Pinto	Mariah	Medium	11.01	22.06	1.70

Field Day for Demonstration of value-added bean based products

The Manitoba Pulse Growers' Association (MPGA) approached FDC to participate in the Annual Summer Field Trip in 2011. FDC made a presentation on value-added opportunities for beans to growers/guests. FDC showcased a bean snack (energy bar) developed with the roasted beans, which was well received.

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