Agricultural Innovation Program
Research Project Final Report
Contribution Agreement - Vote 10 Funding

Project Title:	Development of a Designer Soybean Testing Methodology Activity 1: Development of Lexicon & Tasting Panels
Start Date (yyyy-mm-dd):	2012-04-01
Expected End Date (yyyy-mm-dd):	2013-03-31
Actual End Date (yyyy-mm-dd):	2013-03-31
Principal Investigator (PI):	Sevita International – Jim McCullagh

Short Executive Summary of report:

ECODA's major soybean industry partner, Sevita International, exports a wide range of soybean varieties to Japan for the production of soymilk and tofu. Each Japanese customer has a different formulation, process and style of product and, therefore, different soybean varieties work better for some customers than others.
To maintain consistency across variety evaluations throughout the project, the Guelph Food Technology Centre (GFTC) developed standard processes to make soymilk and tofu as well as a scoring system to rate soybean varieties.
Throughout the development process, quality control specialists from various food companies, based in Japan, visited GFTC and contributed their expertise, preferred methodology, evaluation terminology and techniques.
The activity resulted in a standardized production process for both, soymilk and tofu, as well as a list of terms that describes the attributes of the end products (i.e. a lexicon).

A. Research Progress and Accomplishments (to date in relation to expected milestones and deliverables / outputs)

- Include brief summary of:
  - Introduction, literature review, objectives, milestones and deliverables / outputs.
  - Approach / methodology (summary by objectives).
- Include results and discussion (overview by objectives and milestones), next steps and references.

Introduction
The Guelph Food Technology Centre (GFTC) used a combination of literature searches, individual expertise, professional consultation and feedback provided by Sevita International and the Japanese collaborators to develop a standardized process for making both, soymilk and tofu, as well as the lexicon required for evaluating the end products using a trained sensory panel.

Introduction to Japanese Collaborators
Each of the Japanese companies has conducted a vast amount of research in soymilk and tofu production in the past and has developed a strong understanding of the Japanese palate. The representatives from each of these companies are highly respected in Japan as specialists in their fields. These representatives provided invaluable feedback on processing techniques that were used in this study and facilitated a comparison between the GFTC developed lexicon and their own Japanese quality control lexicons.

Objectives
- Create a sensory evaluation lexicon for both soymilk and tofu products.
- Translate the lexicon into Japanese.
- Validate the lexicon via Japanese quality control.
- Validate the lexicon through sensory evaluations.

Deliverables

- A sensory evaluation lexicon as well as a summary of findings.

Methodology – Soymilk Process Development

Two varieties of Japanese soymilk were provided to the GFTC by Sevita International for the purpose of sensory evaluations and comparison to GFTC made soymilk during production trials. The imported soymilk varieties were:

- Kinusayaka (Blue Tetra Pak)
- DH530 (White Tetra Pak)

Soymilk producers have different opinions on the issue of whether or not to remove the soybean seed coats prior to processing. The process used to remove the seat coats is called dehulling. The first attempt to make soymilk at the GFTC was with whole, soaked beans. Samples from this first attempt were found to be very different from the Japanese soymilk samples.

Although dehulling requires an additional operation and more time, many soymilk producers maintain that dehulling improves the soymilk flavour by extinguishing a 'green flavour' component and a subtly bitter component from the hull. The soymilk quality control specialist confirmed this by indicating that the hilum is a source of Saponin A and, thus, if the hilum is not removed from the bean, the result is a bitter taste in the soymilk. Based on this information as well as the fact that the Japanese soymilk samples were made from dehulled beans, the decision was made to dry dehull the beans prior to processing.

The soymilk quality control specialist also advised that dehulled beans are not soaked. Dehulled beans are added into a mill with 93°C water simultaneously and so this process was followed as suggested. The major advantage of not soaking beans is shortening the processing time. The hot water is used to inactivate the lipoxygenase enzyme released during milling.

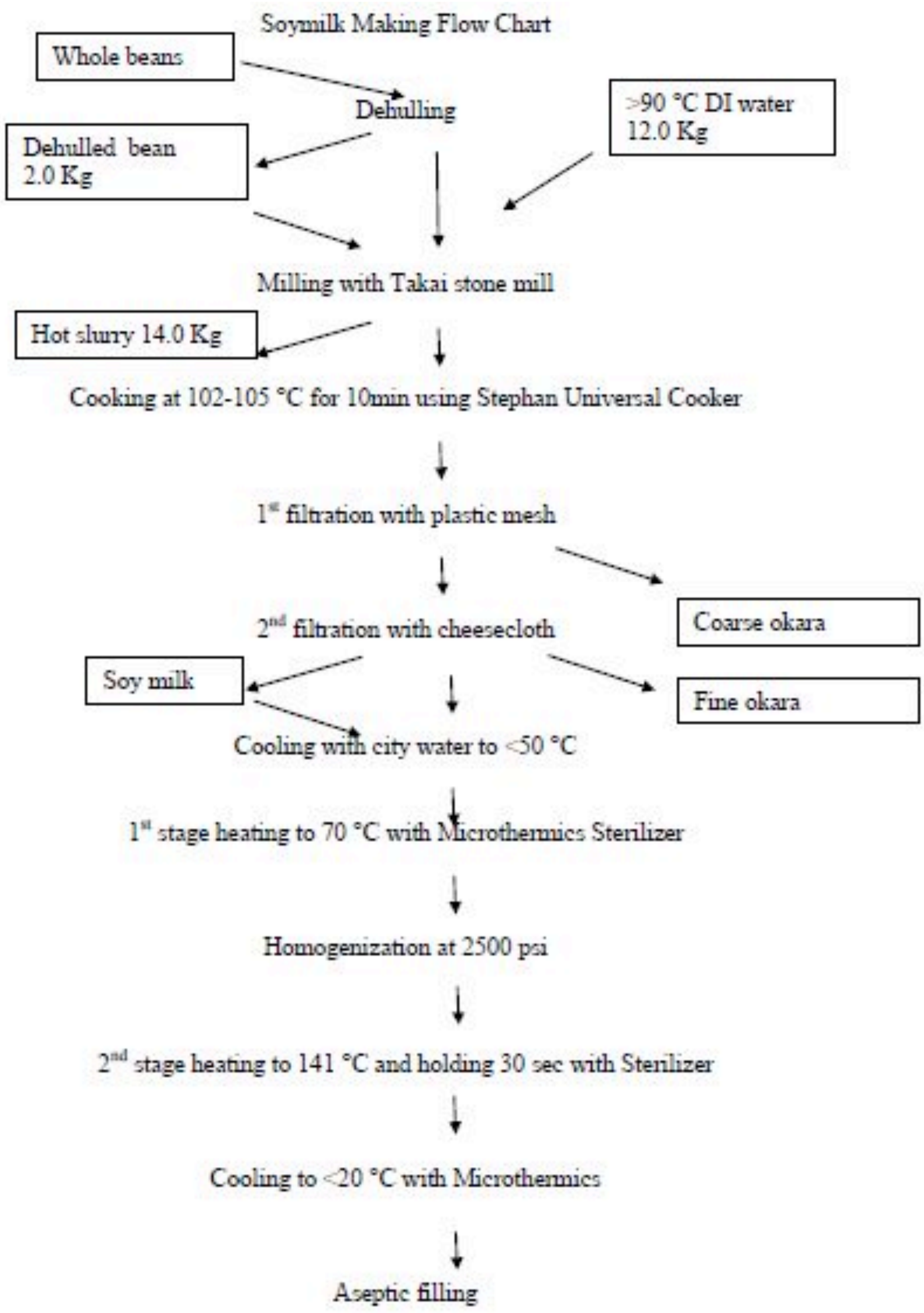
Once the beans were milled, the slurry was transferred to the Stephan Universal Cooker as quickly as possible. The slurry was cooked with jacked steam and the product temperature was held at 102-105°C for ten minutes. Cooking time and temperature are key to successful soymilk production and each soymilk producer has their own time-temperature parameters. These cooking parameters were determined based on the consideration of adequate heat to inactivate soybean trypsin inhibitors, without generating a burned flavour in the product.

Soymilk can be extracted from the slurry before or after cooking, cold or hot. In Japan, the soymilk is always extracted hot after cooking. Heating lowers the soymilk viscosity, which is thought to facilitate extraction and give higher yields of protein and solids. Therefore, the soymilk was extracted by a two-stage filtration at high temperature. The cooked slurry was first poured into a plastic mesh filter at about 90-95°C and coarse okara was retained. The filtrate was then transferred and filtered by a cheesecloth bag at ~ 80°C. The soymilk was collected in a pail and put in cold water bath to cool to below 50°C. The soymilk produced in this stage is not stable and is, thus, subjected to fat separation (i.e. it will develop a layer of fat upon storage).

The soymilk was then pumped into a HTST (high temperature short time) / UHT (ultra-high temperature) sterilizer (Microthermics) to heat continuously to 70°C. It was homogenized by a two-stage homogenizer at (2000psi 1st stage and 500psi 2nd stage) at this temperature. Homegenization breaks the fat globules and okara particles and gives the soymilk a creamier, more uniform consistency (Shurtleff & Aoyagi, 1990).

The soymilk was further heated up to sterilization temperature. The temperature used at the GFTC was 141°C and held for 30 seconds, as this was the standard practice for sterilization at GFTC to meet human consumption requirements. The soymilk quality control specialist suggested, that this was an appropriate temperature for sterilization however their company utilizes a temperature of 150°C and held for five seconds, which provides similar results. The soymilk is then cooled to <20°C using microthermics. The sterile soymilk was filled in glass bottles under aseptic conditions. Refer to Figure 1: Process for making soymilk at GFTC.

Figure 1: Process for making soymilk at GFTC.



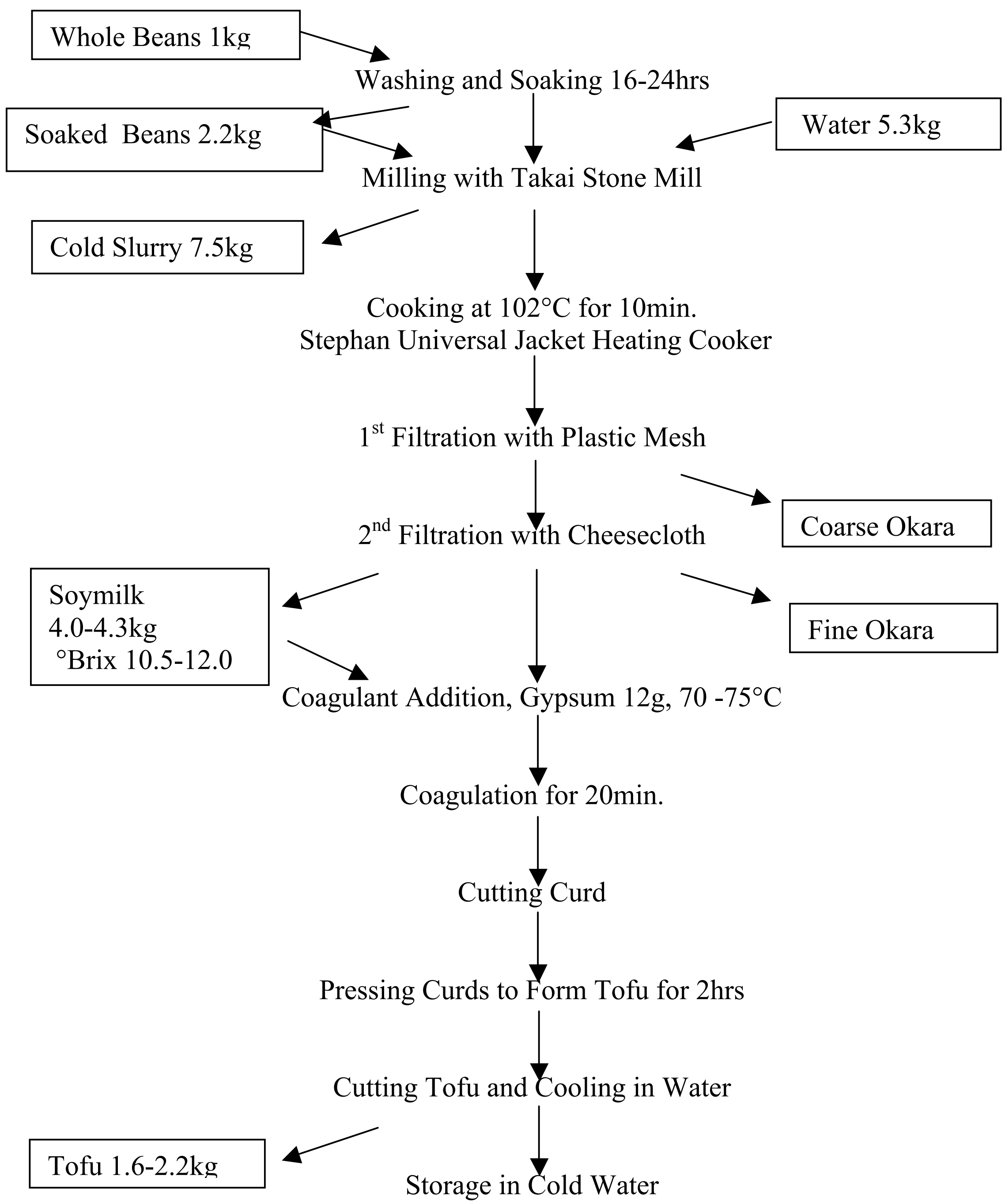
Methodology – Tofu Process Development

The production of tofu consists of two main steps:
(1) the preparation of soymilk; and
(2) the coagulation of this soymilk to form curds, which are then pressed to form tofu cakes.
Although soybeans were dehulled for the soy milk production, whole beans are generally used for tofu production in Japan (Shurtleff & Aoyagi, 1990). Therefore, whole beans were used for tofu production.
One kilogram of whole beans was soaked in about three times their weight of tap water at the ambient temperature the day before processing. One of the tofu quality control specialist contributed, that one can tell when a bean has soaked enough by separating its halves: if the inside of each half is dented in/dimpled, premium soaking time has been achieved; if the halves are flat, it indicates that the beans may have been over-soaked. After soaking, the beans weigh about 2.2 times their original weight (i.e. they absorb approximately 1.2 times their weight in water). The soaked beans were rinsed with cold tap water. Cold water is also added to beans to make 7.5kg of total weight. The beans and water were gravity fed to the Takai stone mill to grind them into cold slurry. The slurry was transferred to the Stephan Cooker immediately. Cooking was done in the scraped surface kettle (Stephan Cooker) at 102°C for 10 minutes. As the cooking temperature increased up to 100°C, there were increases in tofu solid yield, substantial increases in the coagulation factor and tofu bulk yield, and a dramatic increase in the tofu firmness. One of the key functions of cooking the soy slurry is to inactivate most of the soybean trypsin inhibitors (STI), substances in raw soybeans which inhibit growth in animals and can cause enlargement of the pancreas (Shurtleff & Aoyagi, 1990).
The cooked slurry was transferred to a plastic screen (425µm or US Mesh 40) for the first filtration without cooling. Gentle stirring was applied to enhance filtering. The filtrate was then filtered with a fine-weave straining bag with gentle pressing. The latter filters out the very fine okara. The filtrations are completed within 15 minutes and the filtered soymilk temperature was about 73- 75°C before being mixed with the coagulant. The okara was not washed with additional water due to the small batch operation and yield was not the focus of the trials. During the soymilk extraction process, the soymilk was kept from cooling too much; this facilitates subsequent coagulation.
Coagulation of the soymilk is the most important step in the tofu making process and also the most difficult to master, since it depends on the complex interrelationship of different variables: variety and percentage of protein in the soybeans used, the slurry cooking temperature, the soymilk volume and the coagulation temperature, the coagulant type, amount and method of mixing as well as the coagulation time. The proper regulation of all these related factors greatly affects both the yield and the quality of the resulting tofu. In order to evaluate the sensory quality of different varieties, all the tofu products were processed in the standard method described in Figure 2 (Process for making tofu at GFTC). Trials were done using both gypsum (calcium sulfate) and nigari (magnesium sulfate). Gypsum was chosen as the coagulant, because its coagulation is less affected by mixing methods compared with nigari. Furthermore, gypsum was found to deliver more consistency in the tofu texture in this study. The amount of coagulant was determined by trials as well. Twelve grams of gypsum were dispersed in 100ml warm water prior to coagulation. The hot soymilk (70-75°C) was poured down all at once to the gypsum suspension to allow turbulent mixing and was immediately stirred vigorously by a paddle. The mixture was set aside still to allow coagulation for 20 minutes.
The curd was cut with a knife into cubes, then stirred and ladled into the cloth-lined forming boxes (18×12.5cm) without removal of the whey. The edges of the cloths were folded over the top of the curd and a lid was placed atop the cloths. A standard five pound weight was place on the lid. The pressure on the curd was about $10g/cm^2$. The pressing was held for two hours. Well-pressed tofu does not stick to the cloth and the cloth can be removed without breaking the tofu. The tofu was cut into halves and placed in cool tap water.

Tofu storage

All the tofu products were stored in cold water at refrigeration temperature (4°C). The water was replaced every day prior to the sensory evaluation. The tofu products were used for sensory studies within three days after production.

Figure 2: Process for making tofu at GFTC.



Methodology – Lexicon Development

Selection of soymilk attributes, to be used for training panellists, was based upon a literature search (Civille et al. 1996, Day N'Kouka et al. 2004, Meilgaard 2007, Russel et al. 2006 and Torres-Penaranda et al. 1998) and the evaluation of the soymilk varieties by the GFTC, as well as from feedback provided by Sevita International and the Japanese collaborators. Table 1 below summarizes and defines the selected attributes for soymilk evaluation.

Table 1. Attribute and attribute definitions for soymilk evaluation.

Attribute	**Definition**
Raw green	aromatic characteristics of freshly cut green beans
Cooked bean	aromatic characteristics of cooked beans or soy beans
Sweet	taste on the tongue stimulated by sugars
Bitter	taste on tongue stimulated by solutions of caffeine, quinine and certain other alkaloids
Astringent	the chemical feeling factor on the tongue or other skin surfaces of the oral cavity described as puckering/drying and associated with tannins or alum

Selection of tofu attributes, to be used for training panellists, was based upon a literature search (Civille et al. 1996, Meilgaard 2007, Russel et al. 2006 and Torres-Penaranda et al. 1998) and the evaluation of the tofu varieties by the GFTC, as well as from feedback provided by the Sevita International and the Japanese collaborators. Table 2 below summarizes and defines the selected attributes for tofu evaluation.

Table 2. Attribute and attribute definitions for tofu evaluation.

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Cooked bean	aromatic characteristics beans or soybeans
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Results and Discussion - Soymilk

Upon the soymilk specialist's visit to the GFTC, contributions were made to the soymilk production process as discussed above. Confirmation was given that the lexicon chosen was similar to what the scientists at the Japanese company use when evaluating soymilk. A recommendation was also made from the soymilk quality control specialist regarding additional lexicon words to be used for future projects. These words included: beany, chalky and lightness (fullness). The description of the new lexicon words was as follows:

- beany – the taste of a raw soybean
- chalky – powdery (both: a taste and texture), similar mouth feel as milk of magnesia
- lightness – described as watery, the opposite of dense

Results and Discussion - Tofu

Tofu production varies greatly in Japan. Processing times, techniques and coagulants are all factors which fluctuate from company to company. For this activity, a standardized process was chosen because it was the most controllable process, resulting in the least production based variation between varieties used. It was necessary to control variation in processing to maintain consistency across sensory evaluations and component analysis necessary for Activities 2 and 3 in the AIP project. Although the GFTC was unable to follow all recommendations from the Japanese quality control specialists, the suggestions were noted for future use.

Suggestions from one tofu company specialist included:

- Gypsum is used for processing at higher temperatures for faster processing, the resulting flavour is clean. This coagulant is common to processors in the Kyoto region. Nigari is used for processing at lower temperatures for slower processing, the resulting flavour is sweet. This coagulant is common to processors in the Tokyo region. Although both coagulants are common in Japan, nigari is the preferred coagulant for many tofu companies.
- Tofu taste changes over time and storage plays a role in this. If the water is replaced daily, some of the taste will be rinsed away over time. This is especially true for the taste contributed by the coagulants.

Suggestions from the second tofu company specialist included:

- Grinding of the soybeans must be done on a fine stone or small steel-toothed type of mill to ensure the end product is fine and does not allow large particulate matter to pass through, ensuring the maximum amount of protein stays within the soymilk and does not go into the okara.
- The Brix test must indicate a result of 11.5 or higher, otherwise too much protein is being lost in the okara.

Conclusions and Next Steps

The established processes and lexicons are acceptable for use of evaluating soymilk and tofu.
Moving forward, the GFTC will be incorporating the above suggestions from the Japanese collaborators into their soymilk and tofu production to refine their techniques.

References

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Shurtleff W. and Aoyagi A. 1990, Tofu & Soymilk Production – The book of tofu, vol. II, Soyfoods Center, David.R. Erickson, editor 1995, Practical Handbook of Soybean Processing and Utilization, AOCS Press

Torres-Penaranda A.V., Reitmeier C.A., Wilson L.A., Fehr W.R. and Narvel J.M. 1998. Sensory Evaluation: Sensory characteristics of soymilk and tofu from lipoxygenase-free and normal soybeans. Journal of Food Science. 63: 1084-1087.

B (I). Funded Collaborators (Co-PI, AAFC, other federal scientists)

- Include the name of scientist / organization.

GFTC:
Xin Hu**,** Nadia Brunello-Rimando **,** Karen McPhee

Japanese Collaborators:
Confidential

Sevita International:
David Hendrick, John Hendrick, Stacey Simpkin, Jim McCullagh, Mark MacDuff

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University of Ottawa:
D. John T. Arnason, Ammar Saleem, Rui Liu

B (II). Acknowledgement of non-funded collaborators (who provide support, e.g. access to other laboratory or other facilities and equipment input / advice / guidance / assistance, etc).

- For research supported by targeted funding programs, list any collaborators who are receiving Contribution Vote 10 funds (e.g., university and industry collaborators). In addition, please list separately the participants who support your project but are not receiving any funding through the program.
- Include name of scientist / organization.

University of Guelph: Lisa Duizer, Alison Duncan, Department of Human Health and Nutritional Sciences

C. Variance Report (if applicable, describe how the work differs from the proposed research)

- Include changes to objectives and project work plan / budget, changes to the team, other constraints.

- No changes to the objectives or project work plan.
- This activity was completed under budget.

D. Impact Assessment (if applicable, describe how the variance factors above will impact project continuation)

- Include changes to the objectives, changes to the project work plan / budget, changes to performance (i.e. meeting targets).

- The variance factors did not impact the objectives of the work plan.
- This variance factors affected the budget primarily as:
  1) The Japanese sourced materials, required for the activity, were provided free of charge, accepting payment for shipment costs only and
  2) the Japanese collaborators did not accept full payment for their time and travel.

E. Achievements (include only those related to this project)

- Include innovations, publications / conferences, technology transfer, capacity building, success stories, media, recognition and other outputs.

Achievements resulting from this project include:

- The development of a standardized production protocol for soymilk.
- The development of a standardized production protocol for tofu.
- The development of a lexicon for evaluating and quantifying taste attributes in soymilk.
- The development of a lexicon for evaluating and quantifying taste attributes in tofu.

F. Lessons learned (self-evaluation of project)
Production protocols and quality control can vary greatly between companies within Japan. Each company has their own preferred method of production for soymilk/tofu, using different temperatures, processing times, coagulants and packaging techniques. Although quality control techniques and terminology are similar, soybean variety preference may vary greatly, this may be due to the variation in processing techniques or it may be simply reliant on individual preference.

Jim McCullagh	**May 31 2013**	
PI Name	**Date**	**Signature**

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