Linum usitatissimum as a Nutraceutical and its Use in Food Products

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Abstract

Fortification, the process of food modification for providing beneficial health effects, has potential as a method of increasing human consumption of various forms of *Linum usitatissimum* (common flax). Flax has potential as a fortifier in commercial and home goods and products, because flaxseed is known to be remarkably beneficial to human health, and has significant and increasing availability. Flax has a high amount of dietary fiber, has strong antioxidant properties, and is the most widely available botanical source of α-Linolenic acid, an omega-3 fatty acid. Common flax has also been found to have several beneficial bioactive properties. Such valuable qualities of flax are promising to the development of food products that are beneficial to human health.

This research investigates the uses of flax as a component in food products. Three products were developed with a milled flaxseed substitute for flour, and thirty-five subjects rated the products against control products for likeability and sensory qualities. Study results showed that adults have a medium range of declared knowledge of the benefits of flax and a medium willingness to include flax products in their diets. The flax products retained benefits through baking and received high acceptability ratings. Surveyed adults were found to have a general preference for the flax products. The flax additive was found to be insignificant or beneficial to product flavor and aroma, and female and younger subjects were determined to have greater acceptability of flax and more declared knowledge of flax benefits. This demonstrates that especially to those groups, fortifiers such as milled flax and flaxseed hold potential as natural and simple additives to foods and other edible products.

Introduction

Fortification is a process of food modification for the purpose of providing beneficial health effects for consumers. Even though the public generally has little knowledge about fortified products, an abundance of those products exists in mainstream supermarkets across the United States. One notable example is vitamin D, which is added to staple foods in order to avoid disease caused by the vitamin's deficiency. Milk and other dairy products are among the most common products fortified with the vitamin. Several beneficial fortifiers are commonly used in products and are less well-known by the public, including fluoride, folic acid, and niacin.

Common flax, the seed from *Linum usitatissimum*, contains nutrients and other substances that have been shown to be beneficial to human health (Dupasquier, et al. 2007). It is useful in whole solid (flax seed), ground solid (milled flax seed), and liquid (flaxseed oil) forms, and these beneficial components include omega-3 (ω-3) fatty acids and dietary fiber (Dahl, et al., 2005). Another benefit of flax is its high amount of the lignan secoisolariciresinol diglucoside (SDG). Flax is the richest known source of lignans, which work as antioxidants (Dahl, et al., 2005). Flax has been found to possess numerous qualities that benefit humans, including anti-arrhythmic (Ander et al., 2004), anti-atherogenic (Dupasquier et al. 2007, 2006), and anti-inflammatory qualities (Dupasquier et al., 2007), in addition to improving vascular function (Dupasquier et al., 2006).

Omega-3 fatty acids are essential for the human body and are one of the leading substances sought for their functional properties (Starling 2009). Flax is a notable source of the ω-3 alpha-linolenic acid (ALA) with the acid composing around 56 percent of flaxseed oil by mass. It should be noted that other substances may be better tools for obtaining ω-3 fatty acids, including the seed oil of the kiwi fruit, which is 63 percent ALA, and fish oils, which contain the longer chain ω-3s EPA and DHA. ALA in flax and kiwi fruit is metabolized by humans into EPA and DHA, but the process is inefficient and

possibly impaired with aging (Gerster 1998). However, dietary compliance for fish supplementation is often an issue due to concerns about environmental toxins and palatability (Gebauer, et al. 2006). As well, no matter how beneficial a product is for health, if the general population will not ingest it, the product will never provide the expected benefits.

For functional food and clinical trial use, baked products are suitable. Adding thirty grams of flax to a baked product is simple and yet difficult for consumers to detect. As well, baked products are ideal as they are widely consumed, can be manufactured and frozen until needed, require little preparation after thawing, and can be readily transported. Flax incorporated into baked products in amounts that provide health benefits will most probably increase sales as long as the products have aroma and flavor characteristics similar to those without the flax seed. (Verbeke 2006).

Another characteristic of baked goods is that the baking process does not reduce the amount of ALA in the flax within. It has been reported that there is no significant difference in the ALA content of plain muffin mixes containing ground flaxseed (28.5% of total ingredients by weight before baking) baked at 178 °C for 2 hours compared to the unbaked muffin mix. Therefore, the baking process does not appear to affect the amount of ALA present in the final product (Chen et al., 1994). As well, the baking process was found to not affect the amount of SDG (Muir et al., 1996). Milled flax is suitable, as it has less detectable texture than ground flax, and is more stable than flaxseed oil under high temperatures.

Flavoring additions to flax products can decrease consumer detection of the unusual flavors or textures associated with flax. They can also provide variety in product selection which can positively influence compliance. However, the choice of flavoring, the amount present, and the matrix used for delivery are also important (Aliani et al., 2011).

Taste and aroma can prove to be difficult obstacles in the development of a functional and acceptable product, as high ALA content increases susceptibility for oxidative rancidity, which negatively affects the taste and aroma of the product (Aliani et al., 2011). Low levels of flax addition may be suitable. Alpaslan and Hayta (2006) found that a bagel-type product with 5% flaxseed incorporated as part of the flour showed no significant flavor or overall acceptability differences compared to the wheat flour control. The highest taste and aroma acceptance scores were found for yeast bread with a substitution of 15% flaxseed with flour tested at percentages up to 25% (Mentes, Bakkalbasi, & Ercan, 2008).

Objective

This research investigates the uses of milled flax as a component in baked food products, and evaluates the general recognition of the benefits of flax and the acceptance of flax fortification by the subjects in the study. In addition, it includes a subjective evaluation of taste of the finished products. The larger objective of this study is to evaluate the potency and appeal for products containing a flax product as a fortifier.

Methods & Materials

Thirty-five human participants were drawn from New York suburban communities for participation in taste evaluation. Participants were primarily male (52.9%) and Caucasian/white (%). As part of the questionnaire, the subjects were asked basic demographic data such as age, race, and gender. Additionally, they were also asked how familiar they were with the nutritional benefits of flax and how willing they would be to adapt their diet to include flax on a regular basis.

Along with a general information sheet, six scale sheets each containing fifteen scales were set in front of each participant. In turn, six food samples constituting whole wheat rolls, orange-blueberry muffins topped with pecans, and cheddar-herb biscuits, each with and without added flax. Participants made one mark on each of the fifteen scales for each of the six samples (one for each sample) to indicate the intensities of various aspects of the overall flavor ranging on a relative hedonic scale from "not detectable" to "fully detectable" and to indicate the desirability of the product to them. Samples were tasted in consistent order and water was used by each participant as a palette cleanser between each of the six samples.

The difference or lack thereof between the two ratings for each sample food (one with the flax additive and one without) was used to judge the magnitude of the impact that the addition of flax had on the products' taste, desirability, and other qualities.

The length of the trials differed depending on the size of the group. Group sessions lasted from twenty to thirty minutes, while individual sessions were estimated to be as short as eight minutes. The thirty-five participants each completed six scale forms, amounting in a data pool of 245 taste ratings. The scores recorded by participants for products including flax were compared to those recorded without flax via statistical spreadsheet documentation.

Results

Likability of products on average never exceeded 8.1 or fell under 7 on the hedonic scale. Subjects on average rated flax product likability a 7.56 and control product likability a 7.43 on the 9-point scale. The difference between rated likability averaged -0.12 units of the hedonic scale, with flax products having a slightly higher rated likability (Fig 1).

	flax (mean)	control (mean)	δs (mean)
Question 1	8.03922	7.86275	-0.17647
Question 2	7.735294	7.754902	0.019608
Question 3	7.578431	7.509804	-0.068627
Question 4	7.54902	7.32353	-0.22549
Question 5	7.27451	7.137255	-0.137255
Question 6	7.16667	7.01961	-0.14706
Mean	7.55719	7.43464	-0.12255

Figure 1 –

The average change in perceived values (δs) is shown here in the third column.

One of the clearest trends in how participants rated the likability of the products (in the first six questions) was in decreasing scores as they answered the questions (Fig. 2). This does not appear to be as significant as the fact that the foods containing flax were rated just as highly, and in most cases, higher than the control products.

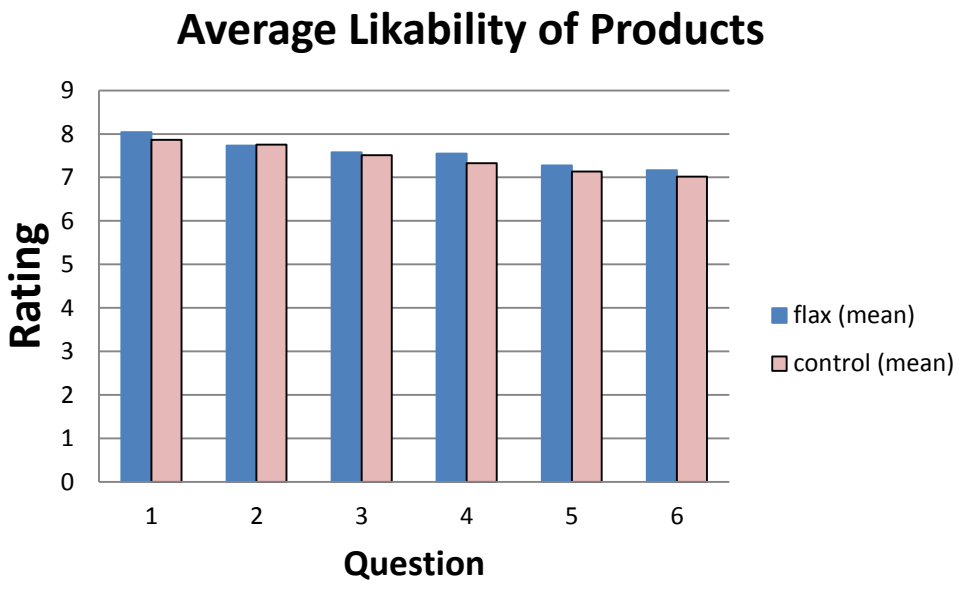

Figure 2 –

Subjects' ratings of the six sampled food products. This chart is a visual description of the numerical values shown in Figure 1. This chart uses an average of all the food products tested.

Clear trends were evident upon evaluation of participant's ages and genders in relation to their declared knowledge of flax and their declared abilility to accept flax products in their diets. Younger participants had more declared knowledge and greater declared acceptability, as can be seen especially in the first quarter of the graphs charting age (Figs. 3 and 4).

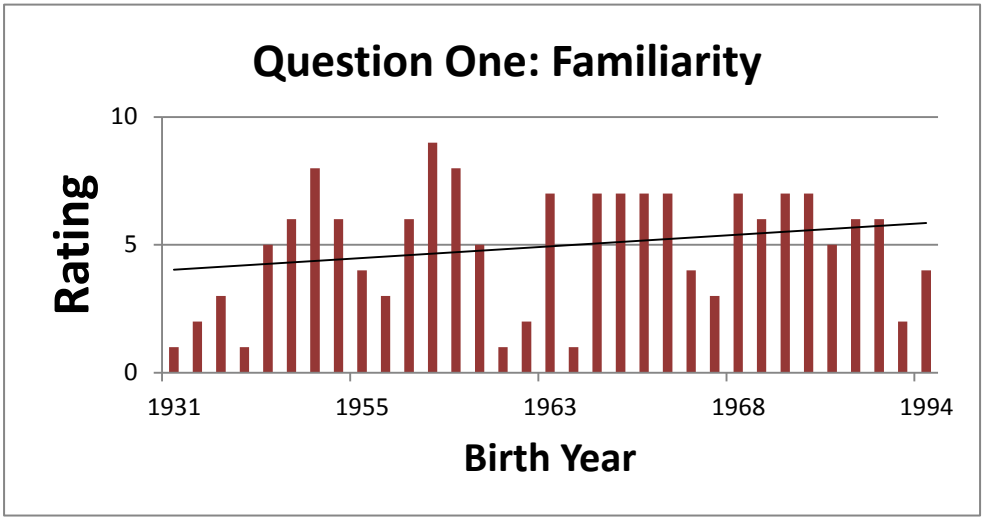

Figure 3 –

Subjects' declared familiarity with the benefits of flax, sorted by age.

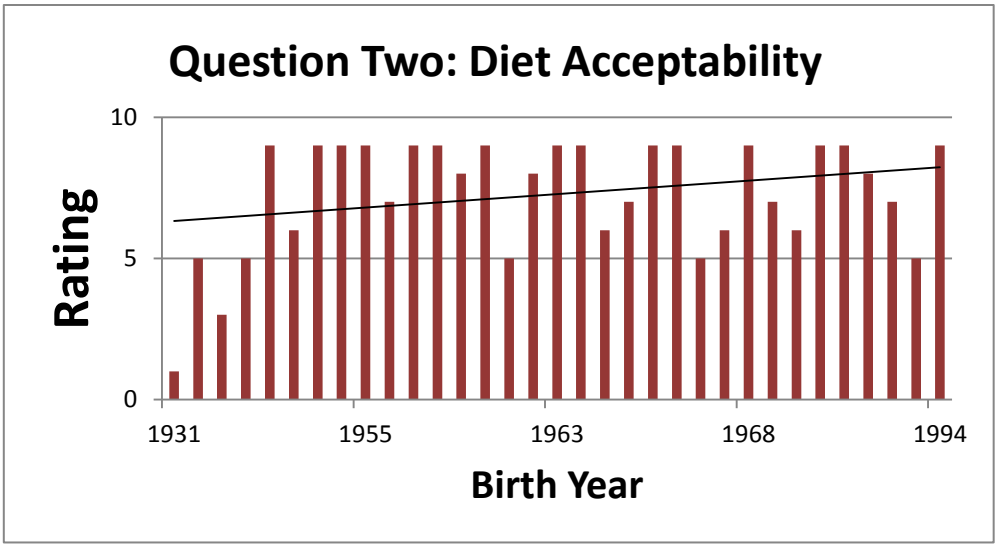

Figure 4 –

Subjects' declared willingness to consume flax as part of a regular diet, sorted by age.

When rating familiarity of the benefits of flax, males and females rated highly, primarily 6 and 7 on the 9-point scale. When rating acceptability into diets, males primarily rated 5 to 7 on scale. Females had more declared knowledge and acceptability (Figs. 5 and 6), and thirteen out of seventeen female participants gave a score of nine on the hedonic scale for acceptability in their diets (Fig. 6).

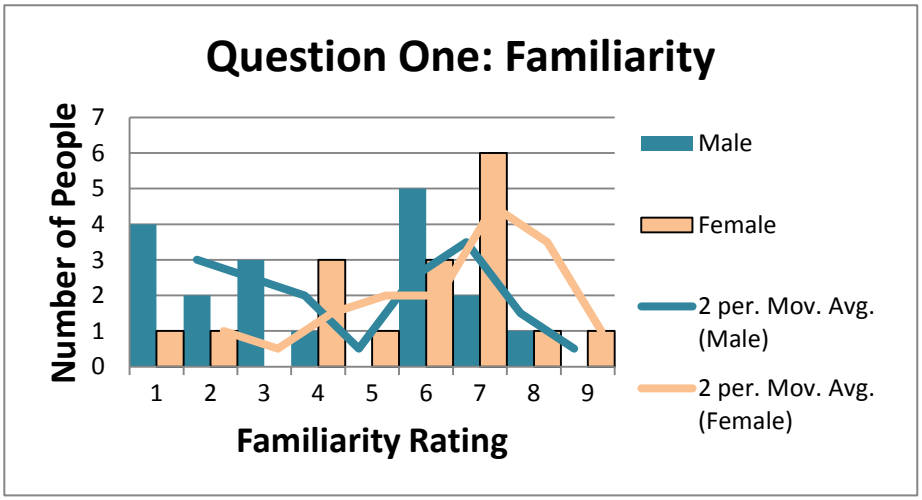

Figure 5 –

Subjects' declared familiarity with the benefits of flax, sorted by gender.

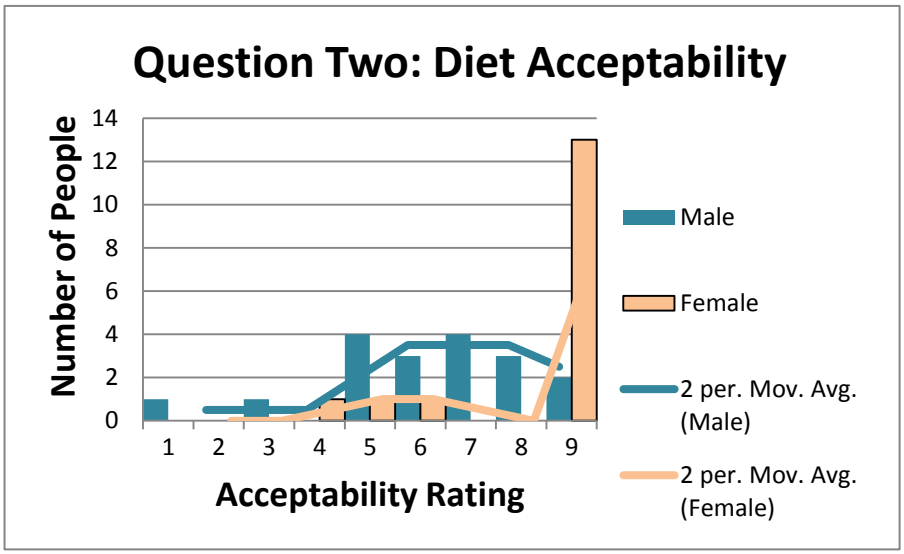

Figure 6 –

Subjects' declared willingness to consume flax as part of a regular diet, sorted by gender.

The survey also included eight questions for participants to rate their evaluations of each product's flavors and aromas. On average, ratings for flax and control products were identical, showing that flax fortification in those products had a minor effect on the flavors and aromas of the food products (Figs. 7, 8, and 9).

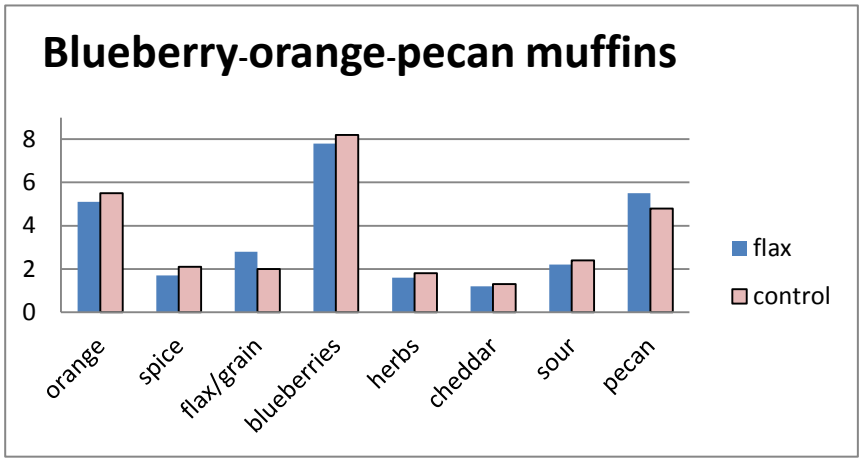

Figure 7 –

Average of subjects' ratings of the sampled muffins; ratings based on sensory perception of flavors and aromas.

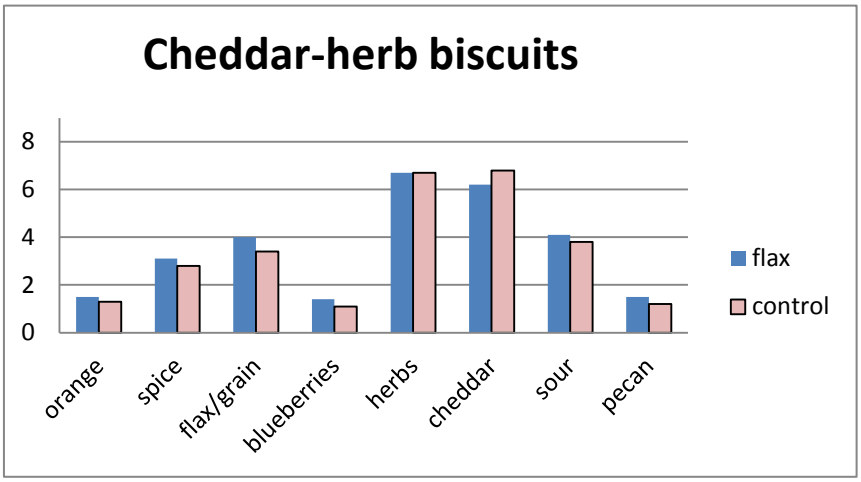

Figure 8 –

Average of subjects' ratings of the sampled rolls; ratings based on sensory perception of flavors and aromas.

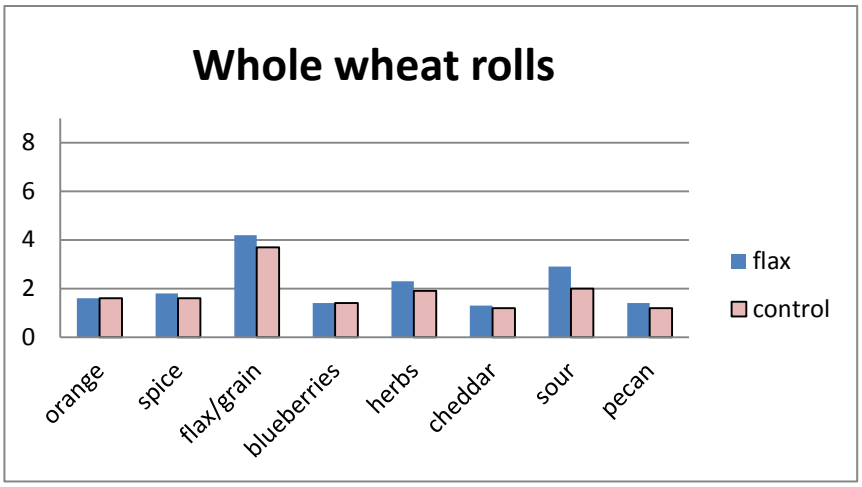

Figure 9 –

Average of subjects' ratings of the sampled biscuits; ratings based on sensory perception of flavors and aromas.

Discussion

A significant aim of this study is to promote the pursuit of the implementation of flax products in foods to as great an extent as possible. The full extent is often neglected in minor alterations to food, but it is true that any human effort of preparation even as quick and seemingly insignificant as adding milled flax or other nutrients increases the nutritional value of the food.

Conclusion

The study succeeded in development of a product with milled flax, with its benefits maintained in baking, and in products with high acceptability ratings. Most notable in the study's results is the lack of detectability of flax in the products, as well as the general preference of the flax products. Flax products were found to have greater acceptability and recommendability than controls; the flax additive was found to be insignificant or beneficial to product flavor and aroma.

Another finding of the study is that female and younger subjects were determined to have greater acceptability of flax and more declared knowledge of flax benefits. Especially to those groups, fortifiers such as milled flax and flaxseed hold potential as natural and simple additives to foods and other edible products.

This study is limited most significantly by its subjects, all of whom were adult residents of suburban New York communities. International results from subjects of all ages and economic statuses has the potential to provide more accurate data.

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Appendix

Customer Satisfaction Survey

Participation in this study is completely voluntary. If you decide not to participate, there will not be any negative consequences. Please be aware that if you decide to participate, you may stop participating at any time and you may decide not to answer any specific question.

* By selecting "Yes", I am attesting that I have read and understand the information above and I freely give my consent to participate.

Yes No

* Gender

Male Female

* What year were you born?

* What month were you born?

* How would you classify yourself? (Circle one)

Asian *Indigenous/Aboriginal*

Pacific/Islander *Latino*

Black *Multiracial*

Caucasian/White *Other*

Hispanic *Would rather not say*

General questions: (Place a circle or X-mark)

1. How familiar are you with the specific nutritional benefits of flax?

1 (Not familiar)	2	3	4	5	6	7	8	9 (Fully familiar)

2. How acceptable would you be to consuming flax in your diet on a regular basis?

1 (Not acceptable)	2	3	4	5	6	7	8	9 (Fully acceptable)

Sampling Number: (Circle one) **1 2 3 4 5 6**

Please rate the product on the following qualities: (Place a circle or X mark)

1. How convenient is the product to eat?

1 (Not convenient)	2	3	4	5	6	7	8	9 (Fully convenient)

2. How professional of a quality or commercially-made does the product appear to be?

1 (Not professional)	2	3	4	5	6	7	8	9 (Fully professional)

3. Compared to currently available similar products, is the product quality better, worse, or about the same?

1 (Poor quality)	2	3	4	5	6	7	8	9 (Excellent quality)

4. Overall, how satisfied are you with the product?

1 (Not satisfied)	2	3	4	5	6	7	8	9 (Fully satisfied)

5. How well do you like the product?

1 (Dislike)	2	3	4	5	6	7	8	9 (Like)

6. How likely are you to recommend the product to people that you know?

1 (Unlikely)	2	3	4	5	6	7	8	9 (Highly likely)

7. Would you normally consume the product?

Yes	No

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Please rate the intensity of each specific taste or flavor in the product: (Place a circle or X mark)

8. Orange - Aroma and flavor associated with the smell of freshly prepared orange peel

1 (Not evident)	2	3	4	5	6	7	8	9 (Fully evident)

9. Spice - Aroma and flavor associated with the smell of cloves

1 (Not evident)	2	3	4	5	6	7	8	9 (Fully evident)

10. Grain/flax - Aroma and flavor associated with the smell of ground flaxseed

1 (Not evident)	2	3	4	5	6	7	8	9 (Fully evident)

11. Blueberry - Aroma and flavor associated with the smell of blueberries

1 (Not evident)	2	3	4	5	6	7	8	9 (Fully evident)

12. Herbs - Aroma and flavor associated with the smell of herbs

1 (Not evident)	2	3	4	5	6	7	8	9 (Fully evident)

13. Cheddar - Aroma and flavor associated with the smell of cheddar cheese

1 (Not evident)	2	3	4	5	6	7	8	9 (Fully evident)

14. Sour - Aroma and flavor associated with the smell of buttermilk

1 (Not evident)	2	3	4	5	6	7	8	9 (Fully evident)

15. Pecan - Aroma and flavor associated with the smell of roasted pecans

1 (Not evident)	2	3	4	5	6	7	8	9 (Fully evident)