Research Article

How do consumers discuss the texture of frozen blueberries? An investigation using word association, hedonic scales and rate-all-that-apply

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Abstract

BACKGROUND: Flavour, texture, and extended shelf life are key quality traits for blueberries. Studies have used trained panelists and texture analysers to evaluate frozen blueberries. However, more studies are needed to investigate consumer perception and acceptance of frozen blueberries' texture. This study used word association, hedonic scales, and rate-all-that-apply to evaluate how consumers perceive the texture of frozen blueberries.

RESULTS: Consumers were interested in the firmness of frozen blueberries, as well as crunchiness, softness, juiciness, and smoothness. They also identified the textural descriptors mushy, tough, chewy, squishy, and mealy. The participants separated the wild blueberries from the cultivated blueberries when evaluating their liking. Textural attributes were correlated with the consumers' overall liking (juicy, firm, crunchy, smooth positively and mushy, tough, squishy negatively).

CONCLUSION: This study identified which textural attributes influence consumers' liking of frozen blueberries. Consumers preferred frozen blueberries that were firm, juicy and crunchy.
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Keywords: blueberries; texture; sensory properties; consumer perception; wild; acceptability

INTRODUCTION

Blueberry (*Vaccinium* spp.) is part of the Ericaceae family and is considered a highly valued crop around the world.[1,2] Blueberries are native to North America and have been used as a food and a health remedy for centuries.[3] Global blueberry production increased from 666 451 tons to 823 328 tons between 2018 and 2019.[1] The United States' market for blueberries has tripled since the 1970s and has increased 10–20% annually since the year 2000. This is due to consumers placing more importance on health and nutrition.[4] The Canadian blueberry industry has also seen considerable growth.[5] In 2021, Canada produced 146 551 metric tonnes of wild and cultivated blueberries, while exporting 127.7 million kg of blueberries;[6] 85.9 million kg of Canadian blueberry exports went to the United States.[6] Moreover, in 2021, 1.9 kg of blueberries were available per individual in Canada, which represented an 84% increase compared to 1.0 kg that was available in 2016.[6]

There are three main blueberry species grown in North America, including highbush (*Vaccinium corymbosum*), which is mainly referred to as cultivated and grown in cooler climates; lowbush (*Vaccinium angustifolium*), which is commonly labelled as wild blueberries; and rabbiteye (*Vaccinium asbei*).[1,7] Wild and cultivated blueberries are the two most common forms available in

the marketplace[1] and are grown in Canada.[7] Highbush blueberries are primarily grown in British Columbia, while lowbush blueberries are grown in Quebec, New Brunswick, and Nova Scotia.[6] Research in the United States has mostly focused on highbush species, while research in Canada has explored the lowbush cultivars.[8] Most consumers have a choice between fresh and frozen blueberries, although dried blueberries can also be found.[1] Blueberries are often added to food products for their nutritional benefits,[9] which include yogurts, jams, jellies, and beverages.[1]

Fruits and vegetables have been associated with reduced risk of chronic diseases like cardiovascular disease and neurodegenerative degradation, given their nutritional profile.[10-14] Most consumers in Western society are under consuming fruits and vegetables with only around 10% of consumers meeting an adequate intake of whole fruit and half the dietary fibre intake recommendation.[11] Research has shown that increased consumption of

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fruit and vegetables plays a key role in the prevention of chronic illnesses like heart disease, diabetes, stroke, cancer, Alzheimer's disease, and age-related functional decline.[15] As such, berries have become of interest to food scientists and food product developers given, their rich nutrient profile and associated health benefits.[1,15,16] Blueberries are considered a rich source of nutrients and bioactive phenolic compounds,[1,15] which include anthocyanins, tannins, and phenolic acids.[17-19] Blueberries are also abundant in water, organic acids, minerals like phosphorus, potassium, and magnesium, as well as fibre.[20,21]

Anthocyanins are the most prevalent phenolic compound in blueberries, with around 15 different anthocyanins previously reported by researchers and all are identified as health benefits of blueberry consumption.[22-24] While anthocyanins are abundant in blueberries, they are also very unstable[25,26] and generally degrade at pH values higher than 7.[27] Their stability is also affected by light, oxygen, temperature, ascorbic acid, sulphur dioxide, metal ions, proteins, specific enzymes, and other flavonoids, along with food processing and storage.[26] Fresh blueberries deteriorate rapidly once picked and have a shelf life of less than 2 weeks at 0 °C and 90–95% humidity, therefore, leading to a need for preservation and storage techniques to extend their shelf life.[28]

One of the most common techniques for preserving fruits is hot air drying. However, long drying times, exposure to higher temperatures, and changes in sample volume, colour, nutrients, and texture have been observed with this method.[29-31] Freezing is another method commonly applied to maintain the nutritional composition and flavour of blueberries.[32] The use of freeze/thawing as a pretreatment method can help with high moisture transfer during drying and also reduce blueberry skin resistance.[28,32,33] Freezing is a reduction in temperature of a food below its freezing point, leading to the formation of ice crystals, which extends preservation time through reducing water activity[26] while also decreasing enzymatic activity, microbial activity, and increasing product shelf life.[34] While freezing can be successfully used to preserve nutritional constituents and increase shelf life, challenges are present around subsequent sensory changes, primarily texture and flavour.[32,35]

In general, berries are liked and accepted when they are perceived as sweet, and disliked when sour or bitter.[36] Flavour, texture, and extended shelf life are key quality traits in industry and consumer acceptance of blueberries.[37-39] Sweet and intense blueberry flavour is positively associated with consumer purchase interest, while bad textural aspects like mealy and pasty are most detrimental.[40] While sweetness and sourness have been well studied and explained in relation to sugar content as well as titratable acidity, aroma and textural traits are more uncertain.[38,41,42] Given that texture is a primary quality trait responsible for consumer acceptance[38,42] researchers have indicated that blueberry texture is associated with physical constraints like cell turgor, cell wall structure, and peel elasticity.[40] Some research has suggested that most blueberry cultivars are firmer with tougher skins when fresh, compared to post-freezing.[43] Cultivar differences have been shown to contribute more significant impacts on sensory attributes, like flavour and texture, compared to other factors due to location and environmental changes.[4,38,43-45] Additionally, it has been suggested that faster-freezing rates and lower storage temperatures can help to improve the sensory quality of frozen blueberries.[46]

Consumer evaluation is needed to better understand the textural attributes of frozen blueberries and consumer acceptance, as most existing studies have used trained panels and texture analysers to evaluate frozen blueberries. The aim of this study was to examine how consumers discuss the textural attributes of frozen blueberries. Given that many studies have previously used trained panels and texture analysers as evaluation tools, this study wanted to evaluate what consumers think about the textural attributes of frozen blueberries using word association (WA) and rate-all-that-apply (RATA).

MATERIALS AND METHODS

The study was reviewed and approved by the Acadia University Research Ethics Board (REB #13-72).

Participants

Recruitment of participants was advertised on an email list at Acadia University (Wolfville, Nova Scotia, Canada) and with posted advertisements throughout the Annapolis Valley (Nova Scotia, Canada). Participants were recruited based on regular blueberry consumption (self-identified they had consumed blueberries in the last 2 weeks). All participants (in the word association task, $n = 88$; 58 participants identified as females and 30 as males, average age of 33.4 ± 11.7 years, in the RATA trial $n = 106$; 74 participants identified as females and 32 as males, average age of 36.5 ± 13.5 years) gave an informed consent form before participating in the study and the study was conducted in accordance with the Declaration of Helsinki.

Word association
Procedure

Participants ($n = 88$) were sent a link to a survey presented on Compusense software (Compusense Inc., Guelph, Ontario, Canada) and asked to complete the survey on their personal devices. The participants were asked to provide the first fours single words or phrases that crossed their minds when they thought about the texture of frozen blueberries.[47]

Statistical analysis

The results of the WA task were analysed following the method outlined in Ares *et al.*.[48] Terms not related to texture were removed. Briefly, common words were identified by the research team individually and then words with a similar definition were grouped into categories. The researchers then met and came to a consensus about the different categories. Frequencies for each category were tabulated.

Consumer acceptance
Samples

Blueberries were provided by local producers including Liberty, Jersey, Aurora (highbush varieties) and a wild blueberry (lowbush variety). Furthermore, blueberries were purchased from the local grocery store, one labelled as Canadian Blueberries (referred to as Commercial Highbush; Loblaws Inc., Toronto, Ontario, Canada) and another labelled as Canadian Wild Blueberries (referred to as Commercial Wild; Loblaws Inc.). In total six samples (Liberty, Jersey, Aurora, Commercial Highbush, Wild and Commercial Wild) were included in the study. All blueberries were stored at −18 °C until the day of the sensory trial. Samples were warmed to room temperature and then eight berries (served at room temperature) were placed in a 2 oz plastic cup with lids.[16] The participants also received a glass of distilled water to cleanse their

palate. Samples were served following a completely randomized design and were blinded with random three-digit codes.

Procedure

Participants completed the RATA trial within individual sensory booths at the Centre for the Sensory Research of Food at Acadia University (Wolfville, Nova Scotia, Canada). The questionnaire was presented using Compusense software (Compusense Inc.) on iPads.

Initially, the participants were asked to evaluate their overall liking of the sample as well as their liking of the flavour, texture and appearance using a nine-point hedonic scale (1 = Dislike Extremely and 9 = Like Extremely). Then, the participants completed a RATA including the top ten textural attributes (firm, crunchy, soft, juicy, smooth, mushy, tough, chewy, squishy, mealy) identified in the WA task. Participants were asked to select the attribute they considered appropriate for describing the sample and then rate the intensity using a seven-point scale (1 = Low and 7 = High).[49] The order in which the attributes were presented was randomized for each sample.[50] After evaluating the samples, participants were given an open-ended comment question asking their favourite way to consume frozen blueberries, and questions about their age and gender.

Statistical analysis

The mean and standard deviations for hedonic scales for each sample were calculated. The hedonic values were assessed using a two-way analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) test (95% confidence interval). The RATA data was treated as continuous data and interpreted as an eight-point scale considered 'not applicable' as intensity = 0.[51] The mean and standard deviation for each attribute per sample was reported. A linear mixed-effects model was performed for the sensory attribute intensities to evaluate if significant differences exist across the different samples. The participant was a random effect, and the sample was a fixed effect. If significant differences exist, a Tukey's HSD test (at 95% confidence interval) was performed.[51,52] To determine the impact of the textural properties included in the RATA question on overall liking, Pearson correlations were used to evaluate each sample separately.[53] Based on the study by Meyners et al.,[54] RATA results were converted to check-all-that-apply results and collapsed to two levels (the value of 0 if the attribute was not selected and the value of 1 if the attribute was selected). A correspondence analysis based on chi-square distances was then conducted to visualize the results. The responses to the open-ended comment were reviewed by the researchers and recurring themes were identified. Categorization of the results was completed independently by the researchers and then results were discussed among the researchers to reach a consensus.[55] Demographic questions were evaluated using descriptive statistics. All statistical analysis was performed in XLSTAT (New York, USA).

RESULTS AND DISCUSSION

Word association

The most frequently mentioned textural properties from the WA task are outlined in Table 1. The most used term was firm or firmness, which was mentioned by 44.6% of the participants (*n* = 88). Firmness has been used in many different studies[4,56] to evaluate different blueberries and is an attribute that is important to blueberry consumers. Firmness was followed by crunchy, soft, juicy,

Table 1. Frequency of mention of the different texture descriptors provided by the participants (*n* = 88) during the word association task

Texture descriptors	Percentage of mention (%)
1. Firm	44.6
2. Crunchy	24.4
3. Soft	23.2
4. Juicy	21.4
5. Smooth	20.8
6. Mushy	16.0
7. Tough	14.8
8. Chewy	13.6
9. Squishy	12.4
10. Mealy	11.3
11. Tender	10.6
12. Hard	10.2
13. Crisp	7.4
14. Watery	5.4
15. Plump	3.4
16. Gritty	4.0
17. Grainy	2.2
18. Solid	2.0
19. Rubbery	1.2‡
20. Normal	1.2

and smooth, which were all mentioned by at least 20% of the participants. After that, seven attributes (mushy, tough, chewy, squishy, mealy, tender, and hard) were mentioned by at least 10% of the participants. The consumers seem to evaluate the blueberries similarly to past studies.[56] However, positive textural attributes (e.g., firmness and juicy) were mentioned more frequently than negative attributes (e.g., mealy, tough). Past studies identified firm and juicy attributes are desired in blueberries that are firm and juicy, and dislike mealy and tough blueberries.[41,57] Furthermore, a past study using trained panelists had a scale from 'mushy/soft' to 'firm/crunchy'[16] and all of these terms were identified to describe frozen blueberry texture by the consumers in this study. Overall, the consumers were able to describe the textural properties of frozen blueberries and the WA task identified how consumers discuss the texture of the frozen blueberry. The results should help frozen blueberry producers understand how consumers discuss the texture of their product. To further examine how consumers value the textural attributes, the top ten most mentioned attributes were included in a RATA question as part of the sensory trial.

Consumer acceptance

The mean hedonic scores for the six different blueberry samples are outlined in Table 2. The appearance of the three highbush varieties (Liberty, Jersey, and Aurora) was liked significantly more than the commercial wild blueberries [referred to as Commercial Wild in Table 2; (*P* < 0.05)]. The difference in liking of the cultivated and wild blueberries may be due to the difference in berry size, as wild blueberries are usually smaller in size.[57] The flavour of the Liberty sample was liked significantly more than the Aurora and Wild blueberries (*P* < 0.05). The difference in liking of flavour for the Liberty and Aurora samples may be due to their volatile composition, as ethyl 2-methylbutanoate and ethyl 3-methylbutanoate have been found to be present in Aurora blueberries but not in Liberty.[58]

Table 2. Mean liking scores (± standard deviation) for appearance, flavour, texture, overall liking for the sample population ($n = 106$)[†‡]

Sample	Appearance	Flavour	Texture	Overall liking
Liberty	6.2b ± 1.3	7.1a ± 1.0	6.6a ± 1.3	7.0a ± 1.5
Jersey	7.5a ± 1.4	6.2ab ± 1.0	6.9a ± 1.2	6.6abc ± 1.5
Aurora	7.7a ± 1.3	6.0b ± 1.1	6.0abc ± 1.3	6.2abc ± 1.3
Commercial Highbush	5.9b ± 1.3	6.9ab ± 1.2	6.4ab ± 1.0	6.7ab ± 1.5
Wild	4.9c ± 1.8	6.1b ± 1.3	5.3c ± 1.8	5.9c ± 1.9
Commercial Wild	3.9d ± 1.5	6.6ab ± 1.8	5.6bc ± 1.8	5.9c ± 1.8

[†] All data refers to a nine-point hedonic scale, where 1 = Dislike Extremely, 5 = Neither Like or Dislike, and 9 = Like Extremely.
[‡] Means in the same column, with the same letter, are not significantly different at $\alpha = 0.05$.

Table 3. Intensity scores (mean ± standard deviation) obtained from rate-all-that-apply (RATA) evaluations ($n = 102$ participants) for the different blueberry samples[†‡]

	Liberty	Aurora	Jersey	Commercial highbush	Wild	Commercial wild
Firm	3.5ab ± 1.6	3.1ab ± 1.1	3.9a ± 1.5	3.6b ± 1.1	2.5bc ± 1.8	1.9c ± 1.5
Crunchy	2.5ab ± 1.5	2.4ab ± 1.1	3.1a ± 1.3	2.2bc ± 1.4	2.0bc ± 1.6	1.6c ± 1.4
Soft	4.1b ± 1.1	4.3b ± 1.0	3.6b ± 1.5	4.3b ± 1.0	4.2b ± 1.7	5.1a ± 1.6
Juicy	4.5a ± 1.4	4.7a ± 1.3	4.4a ± 1.6	4.4a ± 1.2	4.3a ± 1.8	4.3a ± 1.7
Smooth	3.3a ± 1.1	3.6a ± 1.2	3.1a ± 1.0	3.3a ± 1.0	3.0a ± 1.1	3.4a ± 1.3
Mushy	3.9bc ± 1.2	4.1b ± 1.1	3.0c ± 1.4	3.7bc ± 1.3	4.0b ± 1.1	5.2a ± 1.2
Tough	2.0ab ± 1.2	1.8ab ± 1.2	2.4a ± 1.1	1.9ab ± 1.2	2.1a ± 1.5	1.3b ± 1.3
Chewy	3.5ab ± 1.5	2.8bc ± 1.5	3.5ab ± 1.6	3.6a ± 1.5	3.4abc ± 1.8	2.7c ± 1.6
Squishy	2.5a ± 1.1	1.9ab ± 1.4	1.6b ± 1.2	2.3ab ± 1.1	2.5a ± 1.7	2.1ab ± 1.1
Mealy	2.7a ± 1.0	2.3a ± 0.9	2.3a ± 1.1	2.8a ± 1.0	2.3a ± 1.2	2.3a ± 1.0

[†] Means in the same column, with the same letter, are not significantly different at $\alpha = 0.05$.
[‡] Average intensities of the textural properties on the RATA (0 = Not Selected, 1 = Low and 7 = High).

The differences between the Wild blueberries and Liberty may also be attributed to the difference in volatile composition, as wild blueberries usually have a lower amount of aldehydes than cultivated blueberries.[58] The participants liking of the texture and overall liking followed similar trends with the wild blueberries being liked significantly less than the Liberty samples ($P < 0.05$), and this result may be due to the differences in berry size as described earlier.[57] Berry size is correlated to consumer preferences.[59] There were no significant differences found between the Jersey, Aurora and Commercial Highbush samples for the participants liking of texture or overall liking ($P > 0.05$). Another trend in the results is that the standard deviation for the wild blueberries is much larger than the cultivated blueberries and this may indicate some disagreement from the participants. All participants were screened for blueberry consumption, but future studies may want to ask which blueberries participants regularly consume, as familiarity impacts consumer liking.[60,61] Being regular consumers of a certain blueberry species, may impact the consumer liking scores, and future studies may want to separate consumer groups.

The results of the RATA scales showed significant differences for seven of the ten attributes identified by the participants in the WA task (Table 3). Juicy, smooth, and mealy were not found to be significantly different for the different blueberries ($P > 0.05$). Consumers were able to identify differences in the textural properties of the blueberries. Liberty, Aurora, and Jersey were found to be significantly higher in firmness than the wild blueberries and the commercial wild blueberries ($P < 0.05$). This result is reinforced by the correspondence analysis (Fig. 1), as firmness

was associated with the highbush varieties. While the commercial wild blueberries were found to be significantly softer than the other blueberries ($P < 0.05$) and were associated with soft in the correspondence analysis. However, they were not found to be significantly less squishy than the other blueberries but were associated with squishy in the graphical representation (Fig. 1).
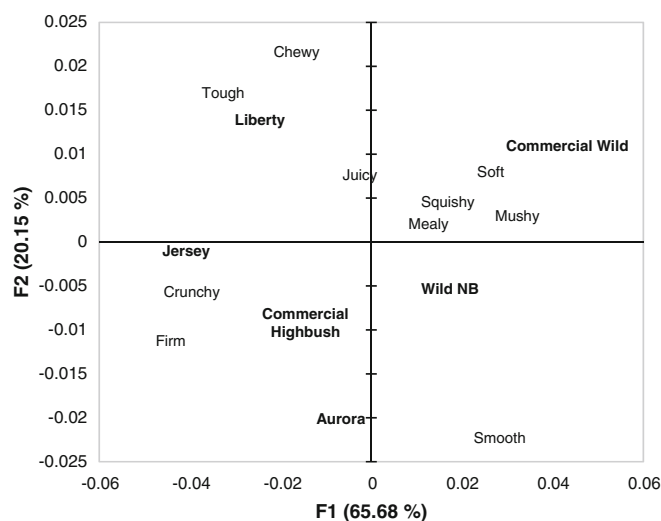

Figure 1. Correspondence analysis of the different blueberries considering rate-all-that-apply results as check-all-that-apply data.

Table 4. Pearson correlations between the textural properties [rate-all-that-apply (RATA)] and overall liking for all six samples[†]

	Liberty	Aurora	Jersey	Commercial Highbush	Wild	Commercial Wild
Firm	**0.256***	**0.277****	**0.244***	0.102	**0.375****	**0.321****
Crunchy	0.178	0.187	0.159	**0.233***	**0.235***	−0.019
Soft	0.004	−0.093	0.094	0.123	−0.115	−0.083
Juicy	**0.526****	**0.352****	**0.430****	**0.438****	**0.355****	**0.635****
Smooth	**0.218***	0.181	0.202	0.082	0.137	**0.295****
Mushy	−0.205	−0.163	**−0.249***	−0.082	**−0.314****	**−0.315****
Tough	−0.164	−0.123	−0.180	**−0.413****	−0.174	−0.122
Chewy	**0.216***	0.016	**−0.242***	−0.082	−0.010	0.016
Squishy	**−0.262***	**−0.321****	**−0.278***	**−0.293****	**−0.315****	−0.095
Mealy	0.068	−0.120	−0.146	**−0.289****	−0.076	0.035

[†] Correlation coefficients in bold are significant at *$P < 0.05$ and at **$P < 0.01$.

This may be due to the processing used to freeze the blueberries,[32,46] however, that is beyond the scope of this study, which focused on how consumers perceive frozen blueberry texture. The Jersey blueberries were found to be significantly crunchier than all other blueberries, while also being significantly less mushy ($P < 0.05$); although not significantly less squishy than the other blueberries. Jersey blueberries were also characterized as chewy, similar to the Liberty blueberries. The commercial wild blueberries were found to be the mushiest and the least tough of all the samples. Overall, the consumers generally separated the cultivated blueberries (Liberty, Aurora, Jersey) from the wild blueberries (Wild and Commercial Wild) in both the intensity scores (Table 3) and the biplot (Fig. 1).

To evaluate how the textural properties impacted the overall liking scores of the participants, Pearson correlations were calculated. When investigating the relationship of the RATA data to the overall liking for all the samples, seven textural attributes were correlated to the overall liking scores [juicy (0.448), firm (0.290), crunchy (0.188), mushy (−0.235), tough (−0.180), squishy (−0.249) and smooth (0.184), all with P-values less than < 0.0001]. The only attributes that did not influence liking were chewy, mealy, and soft. This result is reinforced when looking at the correlations between the textural properties and the overall liking in the six samples separately (Table 4). Juicy was correlated to liking for all samples. Firmness was correlated to all samples except for Commercial Highbush and squishy for all samples except for Commercial Wild. Firmness and juiciness have been found to increase consumer liking of blueberries.[4,56] Squishy has been found to decrease consumers' perception of fruit.[62] Crunchy and smooth also increased the consumers' liking of different samples. Crunchy has been found to increase consumer liking of blueberries.[37] The researchers could not find a study that identified that smoothness increased liking, but the smoothness of blueberries has been defined as a reduction in perceived fibrousness[63] and fibrousness has been found to decrease liking.[64] Mushy, tough, chewy and mealy were all found to be negatively correlated with different samples and have been found to decrease liking of blueberries.[37,39,64,65] Consumers liked frozen blueberries that are juicy, firm, crunchy and smooth and disliked blueberries that have a mushy, tough and squishy texture. Processing methods should promote frozen blueberries that have a juicy, firm, crunchy and smooth texture.

The consumers were also asked how they currently use frozen blueberries. The results of the question are shown in Table 5. The majority of participants discussed that they prefer to use them in baked goods (e.g., muffins, cakes, pie) and mixed with dairy products (e.g., in smoothies, yogurts, and ice cream). These food items could also be made with plant-based alternatives (e.g., soy milk, plant-based frozen dessert), but that was not identified by the participants. They also used frozen blueberries as a topping on cereal or granola. Only 15% of participants indicated they eat frozen blueberries on their own and that may be a limitation of this study, as the frozen blueberries were not incorporated into a baked good or dairy product. Lastly, the participants stated that they add frozen blueberries to fruit salads, mix them with other fruits to create jams, or add them to drinks.

Limitations and future studies

The study evaluated how consumers perceive the texture of frozen blueberries, however, some limitations need to be discussed.

Table 5. Results of the comment analysis relating to how consumers use frozen blueberries

Category	Percentage of mention (%)	Summary of responses identified
Baked goods	40	Muffins, cakes, baked goods, pancakes, baked, grunt, loaves, pie
Dairy	26	Smoothies, with ice cream, mixed in yogurts, with vanilla ice cream, yogurt parfaits, mixed in heavy whipping cream
Topping	20	Granola, oatmeal, cereal (hot or cold), waffles, on top of pudding, cereal topping
In isolation	15	On their own, for breakfast on their own
With other fruits	7	Fruit salads, mixed in jams with other fruit, as a snack mixed with other frozen berries
Beverages	5	Add to drinks, use them as ice cubes in summer drinks

Principally, the study included a small number of different blueberry species. Future studies should consider other blueberry species from different growing regions and harvesting times. This study focused on consumer perception and included commercially available frozen blueberries, but future studies should investigate how different processing methods impact consumer perception of texture. The participants of this study all resided in Nova Scotia, but future studies may want to include participants from other countries and regions. It may be interesting to include participants from a region like Nova Scotia, which is known for blueberry production and then compare their results to participants living in an area where blueberry production does not occur. Also, future studies may want to compare consumers' responses to trained panelists' evaluations to determine if differences exist for textural perception. As stated earlier, it may be interesting to conduct a study with different species of frozen blueberries incorporated into baked goods to determine their impact on consumer perception.

CONCLUSION

This study identified how consumers perceive the texture of frozen blueberries. Participants focused on the firmness of the blueberries, as well as crunchiness, softness, juiciness, and smoothness. The participants also identified negative textural descriptors like mushy, tough, chewy, squishy, and mealy. The participants separated the wild blueberries from the cultivated blueberries when evaluating their liking of the flavour, texture, and overall liking. The participants did not identify differences in the juiciness, smoothness and mealiness of the different blueberries, but did separate them based on the other textural attributes. The textural attributes influenced the consumers' overall liking (juicy, firm, crunchy, smooth positively and mushy, tough, squishy negatively). This study evaluated a snapshot of the commercially available frozen blueberries and identified which textural parameters are important to consumers. Future studies should continue to investigate consumer perception of frozen blueberries' textural attributes and how they can be impacted by growing region, harvest date, processing date or cultivar.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS

Conceptualization, MBM; methodology, MBM; formal analysis RM, AS, LB, MBM; investigation RM, AS, LB, MBM; resources, MBM; writing – original draft preparation, RM, MBM; writing – review and editing, RM, AS, LB, MBM; supervision, MBM; project administration, MBM; funding acquisition, MBM. All authors have read and agreed to the published version of the article.

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