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Article

Development and Validation of a Multilingual Lexicon as a Key Tool for the Sensory Analyses and Consumer Tests of Blueberry and Raspberry Fruit

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Abstract: A comprehensive lexicon is a necessary communication tool between the panel leader and panelists to describe each sensory stimulus potentially evoked by a product. In the current scientific breeding and trading scenario, a multilingual sensory lexicon is necessary to ensure the consistency of sensory evaluations when tests are conducted across countries and/or with international panelists. This study aimed to develop a reference multilingual lexicon for raspberry (*Rubus idaeus* L.) and blueberry (*Vaccinium corymbosum* L.) to perform comparative sensory tests through panels operating in different countries using their native language. Attributes were collected from state-of-the-art literature and integrated with a detailed description of the sensory stimulus associated with each term. A panel of sensory judges was trained to test lexicon efficacy. After training, panelists evaluated three cultivars of blueberry and raspberry through RATA (Rate All That Apply), which allowed missing attributes to be excluded while rating those actually present. Results showed the discerning efficacy of the lexicon developed can be a valuable tool for planning sensory evaluations held in different countries, opening up further possibilities to enrich blueberry and raspberry descriptor lists with emerging terms from local experience and evaluations of berry genotypes with peculiar traits.

Keywords: berry; sensory lexicon; sensory evaluation; RATA; multilingual lexicon

1. Introduction

Sensory analysis is aimed at capturing all product characteristics through a comprehensive evaluation of the product's perceptible attributes and their relative intensities. When applied to foods, the core of this discipline is the knowledge of human perception of taste, odor, sound, mouthfeel and visual stimuli [1]. A basic requisite of sensory analysis is to define all the possible terms useful for describing all perceived stimuli and assess similarities and differences among products. Sensory analysis guidelines accurately define the figure of the sensory scientist (panel leader) [2] possessing the appropriate expertise in this field, knowledge about sensory methodologies, and communication skills necessary for efficaciously training the sensory judges. Panelists should be trained to exploit individual perception ability, and to properly communicate, with precise terms, characteristics and intensity of their sensations.

A shared lexicon is a necessary communication tool, between a panel leader and panelists, providing the correct terms for describing each sensory stimulus. The sensory lexicon is defined as a "standardized vocabulary" [3], and it is an essential prerequisite for conducting a descriptive sensory analysis. The current distribution of sensory lexica has been reviewed by [4], and indicated the importance of increasing the availability of this essential support for a sound sensory evaluation of products. A multilingual sensory lexicon is necessary to assure the consistency of evaluation when tests are conducted across countries and/or when the participants of a sensory test speak different languages. Studies have been reported for snacks with matching translations in English, Spanish, Chinese, and Hindi [5], for kimchi cabbage in English and Korean [6], and for Sichuan pepper in English and Chinese [7].

Lawless and Civille, 2013 assigned the lexicon development procedure to highly-trained panelists, describing their individual perceptions of products and confirming them in a consensus session. However, increasing availability of literature and the development of rapid methodologies such as CATA (Check-All-That-Apply) and RATA (Rate-All-That-Apply) [8] allow sensory specialists to choose terms and propose them to trained panelists only for validation and, eventually, integration of an attribute list. RATA, highlighting a selection of comprehensive perceivable sensations, fits the attributes list validation process perfectly and reduces judges' fatigue as compared to descriptive analysis, which requires the explicit intensity assessment of all listed attributes [9,10]. This approach reduces the development time while maintaining high accuracy [10].

The novel study conducted here was implemented within the framework of the Horizon2020 project BreedingValue [11], which includes, among other activities, panel and consumer sensory evaluations of berries in different European countries in order to assess the consumer perception of a wide range of genetic resources, spanning from new pre-breeding material to established cultivars.

Since a strawberry (*Fragaria* × *ananassa* Duch.) lexicon was already developed and a specific 16-term lexicon was available [12], our research focused on raspberry (*Rubus idaeus* L.) and blueberry (*Vaccinium corymbosum* L.), both still lacking an exhaustive lexicon. Indeed, despite the growing interest in the production, trade and consumption of blueberries and raspberries, the bibliographical research evidenced the relatively low number of papers providing information on blueberry and raspberry sensory evaluation. Such a limited bibliography was not a sufficient precondition to develop a complete lexicon to be translated into different languages. Thus, the aim of this research was to develop a standard multilingual lexicon for berries, to provide panel leaders and assessors in different countries with a standard tool for performing comparative sensory tests for evaluating the same attributes but using their native language. The activity was designed to (a) develop a comprehensive sensory lexicon; (b) translate the sensory terms and definitions from English into six other languages: Finnish, French, German, Italian, Spanish, Turkish; and (c) validate the lexicons´ adequacy and effectiveness by a trained panel. The lexicons' validation was executed by a trained panel using RATA, allowing the use of a high number of descriptors, rating only those actually perceived, thus reducing so-called sensory fatigue [9,10].

2. Materials and Methods

2.1. Collection of Sensory Terms

The first step was collecting and selecting sensory attributes used in scientific literature, aiming to cover a high range of sensory stimuli provoked by blueberry and raspberry fruit. The literature research was carried out in Scopus, Web of Science and Google Scholar platforms by using the following keywords: Blueberry, Raspberry, Blueberry sensory evaluation, Raspberry sensory evaluation.

2.2. Expert Consultation and Translation of Lexicons

The first versions of the blueberry and raspberry lexicons were created in English, and further analyzed and commented by a multi-national panel of sensory experts, participating in the BreedingValue project. The sensory evaluation lists of terms were chosen through a comprehensive literature review and implemented with the contribution of sensory scientists' previous work and experience. Once consensus about sensory attributes to be included alongside a relative description had been achieved, each partner translated it into their native language. The aim was to create a 7-language sensory lexicon including English, Italian, Finnish, French, German, Turkish and Spanish.

2.3. Sensory Evaluation Tests to Validate Lexicons

The sensory evaluation tests were performed at the IBE (Institute of Bioeconomy) sensory laboratory (Bologna, Italy), under controlled environmental conditions with individual, fully-equipped sensory booths. *Fizz* software (Version 2.51 c02; Biosystémes, Couternon, France) was used for data collection. Visual aspects (color, size, shape, peculiar features) of fruit were not submitted to panelists in the validation process, since they can be measured through laboratory technology (e.g., colorimetry, image analysis).

2.4. Samples

The blueberry cultivars AtlasBlue, Rebel and Ventura, and the raspberry cultivars Adelita, Dafne and Lagorai Plus, supplied by Sant'Orsola S.C.A. (Italy), were used for the lexicon validation tests (Figure 1.). Samples, at commercial ripeness, were collected from fields in Sicily and shipped in a refrigerated truck (4 °C ± 1 °C) to Sant'Orsola SCA headquarter (Cirè di Pergine Valsugana (TN), Italy), stored at 1.5 °C ± 0.5 °C for 2 days, and delivered to IBE laboratory for sensory test evaluations conducted at room temperature (22 °C ± 2 °C).

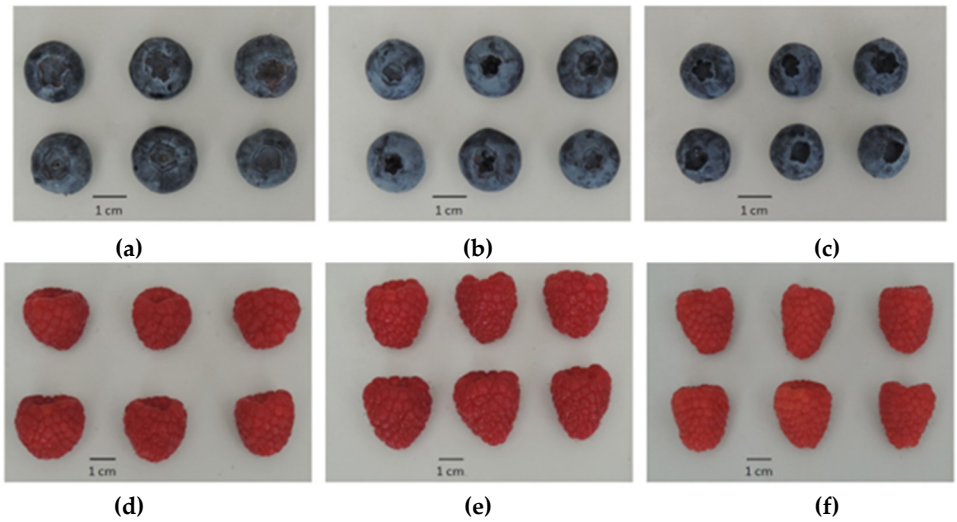

Figure 1. Cultivars used for sensory evaluation. Blueberry: (**a**) cv. AtlasBlue, (**b**) cv. Rebel, (**c**) cv. Ventura. Raspberry: (**d**) cv. Adelita, (**e**) cv. Dafne, (**f**) cv. Lagorai Plus.

2.5. Panelists

Two trained panels (16 judges for blueberry and 14 for raspberry) were involved in the sensory testing. The chosen panelists had more than 1000 h of experience in general sensory tasting for various food and sensory techniques, including attribute identification. Moreover, they had completed 100 h training on fruit-related attributes.

2.6. RATA Analysis

The panel leader explained each sensory descriptor to the panelists to upskill them on the lexicon-sorting step. Lexicon sorting was performed through the RATA sensory test [10]. The RATA evaluation sessions lasted 45 min, and two replicas were performed for each berry species. Panelists received a sample set consisting of the three cultivars, three fruits per cultivar, coded by a three-digit code, for each berry species. The presentation order of the samples was randomized among panelists using a balanced Latin square design. The order of attributes was randomized by sensory modality (texture, taste and flavor). Panelists were asked to taste each sample and check the sensory features perceivable among the list. First, the term was checked and, if applicable, the intensity perceived was indicated through a 9-point scale from "low" to "high". Instead of a 3- or 5-point scale, this was used to improve the discriminability of subtle differences [13]. After each sample, the panelists waited for 60 s to be prepared for the next evaluation and rinsed their mouths with mineral water. Judges selected and rated the attributes perceived in the tested samples, while discarding those not identified.

2.7. Statistical Analysis

Statistical analysis was performed using *SPSS* software (IBM Corp. Released 2021. IBM SPSS Statistics for Windows, Version 28.0, IBM Corp, Armonk, NY, USA). The RATA data were analyzed through two approaches: the first considered the frequency selection of terms (RATA frequencies), and the second considered the data as RATA intensities [13]. RATA frequencies were calculated by counting the number of citations for each attribute. A contingency table was built from the RATA data. According to relative frequency, the list of attributes was divided into tertiles. For each sample, only attributes belonging to the third (67–100% frequency) and second (34–66%) tertiles were used to create a Venn diagram showing the attributes shared by the three cultivars analyzed in the given berry species. The Venn diagram was computed using *R* software version 4.2.2 (R Core Team, 2022). RATA intensities were interpreted on a 10-point scale; not cited terms were scored as "0", thus, a non-selected term was considered equivalent to the "not perceivable" label (intensity = 0). A two-way ANOVA model (product and replicate) was applied to RATA intensity scores, only on attributes already selected for the Venn diagram (second and third citation tertile). A Tukey's post hoc test was calculated to test the differences between cultivars with the significance level fixed at $p < 0.05$. Mean RATA intensity values were used to generate a spider plot representing the sensory profiles of each cultivar.

3. Results

3.1. Sensory Terms Literature Research and Selection

3.1.1. Sensory Descriptors for Blueberry

In earlier reports, blueberry has been described as "fresh fruit" by Rosenfeld et al. [14], providing a list of selected sensory attributes, and as "juice" [15] with a particular focus on its flavors. Furthermore, blueberry texture has been investigated through sensory analysis, focusing on crispness [16]. For blueberry, we selected 29 terms: 17 descriptors for flavor (berry, blueberry, citrus, earthy/musty, fermented, floral, fruity, grassy, green, minty, overripe fruit, pungent, acid, spicy, strawberry, sweet, watery), three for taste (sweet, acid, bitter), eight to chemesthesis/mouthfeel (astringent, fibrous, firm, juicy, metallic, skin persistence, seedy, throat burn), and freshness as a typical fruit metadescriptor [17] (Table 1). Each attribute was described in seven languages, to allow panelists' and consumers' evaluations in their native language, while maintaining the original meaning (Table 2).

Table 1. Blueberry sensory attributes in English, Finnish, French, German, Italian, Spanish and Turkish (References: [a]: Bett-Gaber and Lea, 2013 [15]; [b]: Ferrao et al., 2020 [18]; [c]: Gilbert et al., 2015 [19]; [d]: Cheng et al., 2020 [20], [e]: Rokayya et al., 2020 [21]; [f]: Asănică, 2018 [22]; [g]: Peneau et al., 2007 [17]; [h]: Rosenfeld et al., 1999 [14]; [i]: Sater et al., 2021 [23]; [BPE]: BreedingValue Project Experts).

ENGLISH Attributes Appearance	**FINNISH Kuvaajat Ulkonäkö**	**FRENCH Attributs Apparence**	**GERMAN Attribute Aussehen**	**ITALIAN Attributi Apparenza**	**SPANISH Atributo Apariencia**	**TURKISH Özellikler Görünüm**
Skin colour [e,f,h]	Pinnan väri	Couleur de la peau	Äußere Farbe der Frucht	Colore della buccia	Color de la piel	Dış renk
Size [f]	Koko	Taille	Größe	Dimensioni	Tamaño	İrilik
Uniformity of size [BPE]	Koon tasaisuus	Homogénéité de calibre	Einheitlichkeit der Größe	Uniformita di dimensione	Uniformidad de tamaño	iriliğin bir örnek olma durumu
Pruine [BPE]	Vahapintaisuus	Pruine	Ausprägung der Wachsschicht	Pruina	Pruina	Mumsu görünüm
Glossiness [e]	Kiiltävyys	Brillance	Glanz	Lucentezza	Brillo	Parlaklık
Flavor	**Aromi/ Flavori**	**Arôme/ Saveur**	**Aroma**	**Aroma**	**Aroma/ Olor**	**Koku/ Lezzet**
Acid [a]	Hapan aromi	Acide	Sauer	Acido	Aroma ágrio	Ekşi aroma
Berry [a]	Marjainen	Petits fruits	Beere	Piccoli frutti	Baya	Karışık meyveler
Blueberry [a,b,c,f,h, i]	Pensasmustikka	Myrtille	Heidelbeere	Mirtillo	Arándano	Mavi yemiş
Citrus [a]	Sitrus	Citrus	Zitrus	Agrumi	Ágrio/Cítrico	Narenciye
Earthy/musty [a,h]	Maa	Terre/Moisi	Erdig/Muffig	Terroso	Terroso	Toprak/ Küf
Fermented [a]	Fermentoitu	Fermenté	Fermentiert/Vergoren	Fermentato	Fermentado	Fermente
Floral [a,d]	Kukkainen	Floral	Blumig	Floreale	Floral	Çiçeksi
Fruity [d]	Hedelmäinen	Arôme Fruité	Fruchtig	Fruttato	Afrutado	Meyvemsi
Grassy [d]	Ruohoinen	Herbacé	Grasig	Erba	Hierba	Otsu
Green [a,i]	Vihreä	Vert/tiges	Grün/Stengel	Verde	Verde / Tallos	Yeşil/odunsu
Minty [d]	Minttu	Menthé	Minzig	Menta	Menta	Naneli
Overripe fruit/straw-like [a]	Ylikypsä hedelmä/ olkimainen	Fruit surmature/paille	Überreifes Obst/Strohartig	Frutto sovramaturo/ paglia	Sobremaduro	Aşırı olgunlaşmış meyve/saman gibi
Pungent [a]	Pistävä	Piquant/Acre	Scharf	Pungente	Aroma ocre/pungente	Keskin aroma
Spicy [d]	Mausteinen	Piquant	Würzig	Speziato	Picante/Especiado	Baharatlı
Strawberry [a]	Mansikka	Fraise	Erdbeere	Fragola	Fresa	Çilek
Sweet [a]	Makea aromi	Sucré/Doux	Süßes Aroma	Dolce	Aroma dulce	Tatlı aroma
Watery [BPE]	Vetinen	Goût d'eau	Wässrig	Acquoso	Aroma a aguado	Sulu lezzet
Taste	**Perusmaku**	**goût**	**Geschmack**	**Gusto**	**Sabor**	**Tat**
Acid [a,b,c,h,i]	Hapan	Acide	Säuerlicher Geschmack	Acido	Agrio	Ekşi
Bitter [a,h]	Karvas	Amer	Bitterer Geschmack	Amaro	Amagor	Acı
Sweet [a,b,c,h,i]	Makea	Sucré	Süßer Geschmack	Dolce	Dulce	Tatlı
Texture/ mouthfeel	**Rakenne/ Suutuntuma**	**Texture/ Texture En Bouche**	**Textur/ Mundgefühl**	**Sensazione in bocca**	**Textura**	**Doku/Ağiz hissi**
Astringent [a]	Astringoiva	Astreingeant	Adstringierend	Astringenza	Astringencia	Buruk veya ekşilik
Fibrous [BPE]	Kuituinen	Fibreux	Faserig	Fibrosità	Fibrosidad	Lifli
Firm [e,f,h,i]	Kiinteä	Ferme	Festigkeit	Durezza	Dureza	Sert
Metallic [a]	Metallinen	Métallique	Metallisch	Metallico	Metálico	Metalik
Juicy [f,h]	Mehukas	Juteux	Saftigkeit	Succosità	Jugosidad	Sululuk
Seedy [BPE]	Siemeninen	Riche en graines	Samenreich	Presenza di semi	Presencia de semillas	Çekirdeklilik
Skin persistence [BPE]	Kuoren sitkeys	Persistance de la peau	Persistenz der Haut	Buccia persistente	Persistencia de la piel	Meyve dış kabuk dayanıklığı
Throat burn [a]	Kurkkua polttava	Brûlure de la gorge	Brennen in der Kehle	Pungenza	Sensación de ardor en la garganta	Boğaz yakan
Metadescriptor	**Yleiskuvaus**	**Metadescriptor**	**Metadeskriptor**	**Metadescrittore**	**Metadescriptor**	**Meta tanımlayıcı**
Freshness [g]	Tuoreus	Fraîcheur	Frische	Freschezza	Frescura	Tazelik

3.1.2. Sensory Descriptors for Raspberry

Relatively few studies have investigated the sensory properties of raspberry [24,25]. Studies of raspberry odor-active compounds have determined that the most important was raspberry ketone (4-(4-hydroxyphenyl)-butane-2-one) and αaL- and βbT-ionone, with linalool and geraniol peculiar to some of the tested varieties [26]. In our study, 29 terms were selected for raspberry: 19 attributes for flavor (acid, berry, caramel, chemical, citrus, cloying, fermented, floral, fruity, grassy, green, green/tomato, minty, nutty, raspberry, sweet, tropical fruit, watery, woody), three related to taste (sweet, acid, bitter), six to chemesthesis/mouthfeel (astringent, metallic, juicy, fibrous, firm, seedy), and freshness as a typical fruit metadescriptor [17] (Table 3). Each attribute was again described in seven languages to allow panelists' and consumers' evaluations in their native language, while maintaining the original meaning (Table 4).

Table 2. Descriptions of blueberry sensory attributes in English, Finnish, French, German, Italian, Spanish and Turkish.

Attributes Appearance	**ENGLISH Description Appearance**	**FINNISH Kuvaus Ulkonäkö**	**FRENCH Description Apparence**	**GERMAN Beschreibung Aussehen**	**ITALIAN Descrizione Apparenza**	**SPANISH Descripción Apariencia**	**TURKISH Özellikler Görünüm**
Skin colour	Blue colour intensity evaluation	Sinisen värin tummuus	Évaluation de l'intensité des couleurs bleues	Bewertung der Farbintensität	Valutazione dell'intensità di blu	Evaluación de la intensidad del color azul	Mavi renk yoğunluğu değerlendirmesi
Size	Berry dimension evaluation	Marjan koko arvioituna	Évaluation de la dimension des baies	Bewertung der Beerengröße	Valutazione delle dimensioni del frutto	Evaluación del tamaño del fruto	Meyve boyut değerlendirmesi
Uniformity of size	Uniformity size between the single fruit	Koon tasaisuus	Taille uniforme entre les fruits	Einheitliche Größe zwischen den einzelnen Früchten	Dimensione uniforme tra i frutti	Uniformidad de tamaño entre el fruto	Meyve iriliğinde bir örneklilik durumu
Pruine	Waxy layer detection on the fruit surface	Pinnan vahakerroksen voimakkuus	Détection d'une couche cireuse à la surface du fruit (pruine)	Bewertung der Ausprägung der Wachsschicht auf der Oberfläche	Valutazione dalla presenza di patina cerosa superficiale	Detección de una capa de ceras sobre la superficie	Meyve yüzeyinde mumlu tabaka oluşumu
Glossiness	Brightness evaluation of the fruit	Marjan pinnan kiiltävyys	Évaluation de la brillance du fruit	Bewertung des Glanzes der Frucht	Valutazione della lucentezza del frutto	Evaluación del brillo del fruto	Meyvenin parlaklık durumu
Flavor	**Flavor**	**Aromi/ Flavori**	**Arôme/ Saveur**	**Aroma**	**Aroma**	**Aroma/ Olor**	**Koku/ Lezzet**
Acid	A sharp flavor associated with products that have a sour taste	Terävä, hapantuotteeseen liittyvä aromi	Arôme âcre associé à des produits ayant un goût acide	Ein beißendes Aroma in Verbindung mit Produkten, die einen sauren Geschmack haben	Aroma forte associato a prodotti che hanno un sapore acido (acidi organici)	Aroma asociado a productos ágrios	Ekşi bir tada sahip olma hissi veren keskin bir aroma
Berry	Flavor associated with a combination of mixed berries	Marjojen, marjasekoitusten aromi	Arôme associé à une combinaison de petits fruits (fruits rouge)	Aromen, die mit einer Kombination von gemischten Beeren assoziiert werden	Sensazione aromatica associata ai piccoli frutti (fragola, lampone, mirtillo, mora)	Aroma asociado a una mezcla de bayas, pequeños frutos (frutos rojos)	Karışık meyve kombinasyonu hissi veren aroma
Blueberry	Flavor associated with fresh blueberries	Tuoreen pensasmustikan aromi	Arôme associé aux bleuets frais	Aromen, die mit frischen Heidelbeeren assoziiert werden	Sensazione aromatica associata ai mirtilli	Aroma asociado al arándano fresco	Taze Mavi yemişi hissi veren aroma
Citrus	Flavor associated with citrus fruit (ex. lemon, orange, lime)	Sitrushedelmän aromi (esim. sitruuna, appelsiini, lime)	Arôme associé aux agrumes (ex. citron, orange, citron vert)	Aromen, die mit Zitrusfrüchten assoziiert werden (z. B. Zitrone, Orange, Limette)	Sensazione aromatica associata ad agrumi (ex. Limone, Arancia, Lime)	Aroma asociado a los cítricos (ej. limón, naranja, lima)	Narenciye türlerini anımsatan aroma (portakal, limon vs.)
Earthy/musty	Flavor associated with soil (ex. red beet, boiled potato, or mushrooms)	Maaperään liittyvä aromi (esim. punajuuri, keitetty peruna, sieni)	Arôme associé à la terre (ex. betterave rouge, pomme de terre bouillie, ou champignons)	Aromen, die mit Erde assoziiert werden (z. B. rote Beete, gekochte Kartoffeln oder Pilze)	Sensazione aromatica associata con il suolo(ex. Rapa, Patata bollita o funghi)	Aroma asociado a suelo/tierra (ej. Remolacha roja, patata cocida, champiñón/setas)	Toprağı anımsatan aromalar (ör. kırmızı pancar, haşlanmış patates veya mantar)
Fermented	Flavor associated with fermented /rotting fruit or vegetable	Käyneen, pilaantuneen hedelmän tai vihanneksen aromi	Arôme associé à un fruit ou un légume fermenté ou pourri	Aromastoffe, die mit fermentiertem/faulendem Obst oder Gemüse assoziiert werden	Sensazione aromatica associata con frutta o verdura fermentata/marcia	Aroma asociado a la fermentación y la fruta podrida	Fermente/çürüyen meyve veya sebze hissi veren aroma
Floral	Sweet flavor sensation associated with flowers	Kukkiin liittyvä makea aromi	Arôme associé aux fleurs	Süßes, aromatisches Empfinden, das mit Blumen asoziiert werden kann	Sensazione aromatica associata ai fiori	Sensanción aromática dulce asociada a las flores	Çiçek kokusunu anımsatan tatlı aromatik his
Fruity	Sweet, intense flavor associated with a combination of mixed fruit	Hedelmiin liittyvä makea aromi	Arôme doux et intense associé à un mélange de fruits	Süßes, intensives Aroma, das mit einer Kombination aus gemischten Früchten asoziiert werden kann	Intensa sensazione aromatica dolce associata al mix di frutta fresca	Aroma dulzón, intenso, asociado a una mezcla de frutos	Karışık meyve kombinasyonunu anımsatan tatlı, yoğun aroma

Table 2. *Cont.*

Attributes Appearance	ENGLISH Description Appearance	FINNISH Kuvaus Ulkonäkö	FRENCH Description Apparence	GERMAN Beschreibung Aussehen	ITALIAN Descrizione Apparenza	SPANISH Descripción Apariencia	TURKISH Özellikler Görünüm
Grassy	Grassy and leafy-like flavor	Ruohoihiin, lehtiin liityvä aromi	Arôme d'herbe fraîchement coupée	Aroma das Bezieht sich auf durch geschnittenes Gras	Sensazione aromatica, erba appena tagliata o foglie	Aroma asociado a la hierba verde, hoja	Yeşil çimen ve yaprak benzeri aromaları anımsatan aroma
Green	Flavor characterizing unripe green fruit	Raakoihin hedelmiin liittyvä aromi	Arôme d'un fruit non mûr (vert)	Ein unreifes Aroma das unreife, grüne Früchte.	Sensazione aromatica associata ai frutti immaturi	Un aroma a inmaduro, característico, la fruta verde inmadura	Olgunlaşmamış meyveleri aroma
Minty	Refers to the minty flavor and cooling sensations	Minttuun, viilentävään tuntemukseen liittyvä aromi	Arôme de menthe qui donne une sensation rafraîchissante	Bezieht sich auf minzige und kühlende Aromen	Sensazione riferita ad aroma di menta, una sensazione di fresco	Aroma mentolado y de sensaciones refrescantes	Soğuk hissi veren nane benzeri aroma
Overripe fruit/straw-like	Flavor associated with overripe or bruised fruit. Reminiscent of straw aroma	Ylikypsiin hedelmiin, olkeen liittyvä aromi	Arôme de fruits trop mûrs. Rappelle l'arôme de paille	Aroma, das mit überreifen oder gequetschten Früchten assoziiert werden kann erinnert an das Aroma von Stroh	Aroma associato con frutti sovramaturi, ricorda la paglia	Aroma asociado con fruto sobremaduro/dañado. Aroma con reminiscencias a la paja	Aşırı olgunlaşmış veya çürümüş meyvelerilanımsatan aroma Samanı anımsatan aroma
Pungency	Burning sensation in nasal cavity associated with balsamic or red-wine vinegar	Nenässä pistävä, etikkainen tuntuma	Sensation de brûlure dans la cavité nasale associée au vinaigre balsamique ou au vin rouge	Ein brennendes Gefühl in der Nasenhöhle in Verbindung mit Balsamico- oder Rotweinessig	Sensazione di bruciore nella cavita nasale associata ad aceto balsamico o aceto di vino rosso	Sensación de ardor en la cavidad nasal asociada con los vinagres de vinos tintos o balsámicos	Balzamik veya kırmızı şarap sirkesini anımsatan burun boşluğunda yanma hissi yapan aroma
Spicy	Refers to the clove-like, balsamic and other spices-like flavour	Neilikkaan, balsamicoon, muihin mausteisiin viittaava aromi	Arôme faisant référence aux clous de girofle, au balsamique et à d'autres épices	Bezieht sich auf das Aroma von Gewürznelken, Balsamico und anderen gewürzartigen Aromen	Aroma riferito ai chiodi di garofano, balsamico o altre spezie	Se refiere a los aromas a clavo, balsámico y a otras especias.	Karanfil benzeri, balzamik ve diğer baharatları anımsatan aromalar
Strawberry	Fruity flavor associated with fresh strawberries	Tuoreen mansikan aromi	Arôme associé à la fraise	Fruchtige Aromen in Verbindung mit frischen Erdbeeren	Sensazione aromatica associata alle fragole	Aroma típico a fresas frescas	Taze çileği anımsatan meyvemsi aroma
Sweet	A sweet impression such as cotton candy, caramel, vanilla or sweet fruity candy (not berry) that may appear in the flavor or aromatics	Makea, vaniljainen, makeisiin, makeaan tuoksuun liittyvä aromi	Arôme donnant une impression sucrée comme de la barbe à papa, du caramel, de la vanille ou des bonbons fruités	Ein süßer Geschmack wie Zuckerwatte, Karamell, Vanille oder süße Fruchtbonbons (keine Beeren), der im Aroma oder in der Duftnote auftreten kann	Sensazione aromatica associata con il dolce come zucchero filato, caramello, vaniglia	Aroma asociado al algodón dulce, caramelo, vainilla, o caramelos afrutados (no a bayas o pequeños frutos)	Pamuk şeker, karamel, vanilya veya tatlı meyveli şeker (üzümsu meyveleri değil) anımsatan aroma.
Watery	Associated with watery flavor, tame, tasteless	Vetinen, laimea maku, mauton	Arôme associé au goût aqueux et, insipide	Assoziiert mit wässrig, mild	Flavour associato con un gusto acquoso, senza sapore	Asociado con sabor acuoso, soso, insípido	Sulanmış tatsız bir lezzet
Taste	**Taste**	**Perusmaku**	**Goût**	**Geschmack**	**Gusto**	**Sabor**	**Tat**
Acid	Related to the basic taste acid	Happoisuuden aiheuttama maku	goût associé à l'acide	Bezogen auf den Grundgeschmack sauer	Gusto associato con composti acidi	Sabor ácido	Ekşi tat
Bitter	Related to the basic taste bitter	Karvasaineiden aiheuttama maku	goût associé à la stimulation de la langue par un composé amer	Bezogen auf den Grundgeschmack bitter	Gusto associato con composti amari	Sabor amargo	Acı tat
Sweet	Related to the basic taste sweet	Sokerien tai makeutusaineiden aiheuttama maku	Goût associé à la stimulation de la langue par le sucre ou un édulcorant	Bezogen auf den Grundgeschmack süß	Gusto associato con zucchero o dolcificanti	Sabor dulce o azucarado	Tatlı tat

Table 2. *Cont.*

Attributes Appearance	ENGLISH Description Appearance	FINNISH Kuvaus Ulkonäkö	FRENCH Description Apparence	GERMAN Beschreibung Aussehen	ITALIAN Descrizione Apparenza	SPANISH Descripción Apariencia	TURKISH Özellikler Görünüm
Texture/ mouthfeel	**Texture/ mouthfeel**	**Rakenne/suutuntuma**	**Texture/ Texture En Bouche**	**Textur/ Mundgefühl**	**Texture**	**Textura**	**Doku/Ağiz hissi**
Astringent	Feeling in the mouth characterized by drying; associated with the presence of tannins	Kutistava, kurova tai kuivaava tunne suussa; tanniinien aiheuttama	Sensation complexe résultant de la contraction des muqueuses de la bouche, similaire à la sensation de sécheresse, associée aux tanins	Gefühl im Mund, das durch Austrocknung gekennzeichnet ist; verbunden mit dem Vorhandensein von Tanninen	Sensazione in bocca di secchezza, associata con la presenza di tannini	Sensación compleja que resulta de la contracción de las mucosas de la boca, parecida a la sensación de sequedad, asociada a los taninos	Tanenlerin varlığından damakta hissedilen kuruma hissi
Fibrous	The degree to which fibres are perceived throughout mastication	Kuitujen aistimisen aste pureskeltaessa	Degré de perception des fibres pendant la mastication	Grad der Wahrnehmung von Fasern während des Kauens	Grado con cui sono percepite fibre durante la masticazione	Grado de percepción de fibras durante la masticación	Çiğneme boyunca liflerin algılanma derecesi
Firm	Force required to bring teeth together during the mastication	Purentaan tarvittava voima	Force nécessaire pour rapprocher les dents pendant la mastication	Kraftaufwand, der erforderlich ist, um die Zähne während des Kauens zusammenzubekommen	Forza necessaria per la masticazione	Fuerza necesaria para unir los dientes durante la masticación	Çiğneme sırasında dişleri bir araya getirmek için gereken kuvvet
Metallic	Metallic perception in the mouth	Metallinen aistimus suussa	Sensation métallique en bouche	Metallisches Gefühl im Mund (Geschmack)	Percezione metallica in bocca	Sensación metálica en boca	Damaktaki metalik algı
Juicy	The degree of juice presence	Mehupitoisuus	Quantité de jus dans le fruit	Grad des Vorhandenseins von Saft (Saftigkeit)	Grado di presenza di succo	Cantidad de jugo en el fruto	Düşükten yükseğe meyvenin sululuk derecesi
Seedy	The degree of seed perceived during the mastication	Pureskeltaessa havaittavat siemenet	Degré de présence des graines pendant la mastication	Der Grad der während des Kauens wahrgenommenen Samen	Semi percepiti durante la masticazione	El grado de presencia de aquenios durante la masticación	Çiğneme sırasında algılanan çekirdek algılama derecesi
Skin persistence	Coriaceus skin perceived on the mouth	Kuoren sitkeyden tunne suussa	Perception d'une peau coriace dans la bouche	Wahrgenommene lederige Haut im Mund	Buccia coriacea percepita in bocca	Percepción correosa de la piel del fruto en la boca	Meyve dış kabugunun agızda hissedilmesi
Throat burn	Burning sensation perceived in the throat	Polttavan tunteen aistiminen kurkussa	Sensation de brûlure dans la gorge	Brennendes Gefühl im Rachen	Sensazione di bruciore percepita in gola	Sensación de quemazón en la garganta	Boğazda algılanan yanma hissi
Metadescriptor	**Metadescriptor**	**Yleiskuvaaja**	**Metadescriptor**	**Metadeskriptor**	**Metadescrittore**	**Meta descriptor**	**Metadescriptor**
Freshness	Meta-descriptor, satisfaction of mix features (appearance, textural, aromatic and tasting)	Yleiskuvaaja eri tekijöiden yhteisvaikutus huomioiden (ulkonäkö, rakenne, aromi, maku)	Méta-descripteur, satisfaction de la combinaison de toutes les caractéristiques (aspect, texture, arôme et goût)	Meta-Deskriptor, Zufriedenheit mit der Kombinationaller Merkmale (Aussehen, Textur, Aroma und Geschmack)	Metadescittore, soddisfazione di un un mix di caratteristiche(apparenza, texture, aroma gusto)	Metadescriptor, satisfacción por la combinación de varias características (apariencia, textura, aroma y gusto)	Meta-tanımlayıcı,karışım özelliklerinin tatmini (görünüm, dokusal, aromatik ve tat)

Table 3. Raspberry sensory attributes in English, Finnish, French, German, Italian, Spanish and Turkish. (References: [a]: Aaby et al., 2019, [24]; [b]: Zhang et al., 2021 [27]; [c]: Villamor et al., 2013 [28]; [d]: Stavang et al., 2015 [29]; [e]: Bett-Gaber and Lea, 2013 [15]; [BPE]: BreedingValue Project Experts).

ENGLISH Attributes Appearance	FINNISH Kuvaajat Ulkonäkö	FRENCH Attributs Apparence	GERMAN Attribute Aussehen	ITALIAN Attributi Apparenza	SPANISH Atributo Apariencia	TURKISH Özellikler Görünüm
Colour intensity [a,c]	Pinnan väri	Intensité de couleur	Intensität der Farbe	Intensità del colore	Intensidad del color	Renk yoğunluğu
Colour uniformity [c]	Värin yhtenäisyys	Uniformité de couleur	Gleichmäßigkeit der Farbe	Uniformità del colore	Uniformidad del color	Renk tekdüzeliği
Size [BPE]	Koko	Taille	Größe	Dimensione	Tamaño	İrilik
Shiny [BPE]	Kiiltävyys	Brillant	Glänzend	Lucentezza	Brillo	Parlaklık
Drupelet uniformity [BPE]	Drupelettien yhtäläisyys	Uniformité des drupelets	Einheitlichkeit der einzelnen Steinfrüchte	Uniformità delle drupeole	Uniformidad de las drupas	Küçük meyve birörnekliliği
Surface hairiness [BPE]	Pinnan nukkaisuus	Pilosité superficielle	Oberflächen-behaarung	Peluria superficiale	Vellosidad superficial	Yüzey tüylülüğü
Aroma/ Flavour	**Aromi/ Flavori**	**Arôme/ Flaveur**	**Aroma**	**Aroma**	**Aroma/ Olor**	**Koku/ Lezzet**
Acid [a]	Hapan aromi	Acide	Sauer	Acido	Aroma agrio	Ekşi lezzet
Berry [BPE]	Marjainen	Petits fruits	Beere	Piccoli frutti	Baya	Küçük meyve
Caramel [b]	Karamellisoitu	Caramel	Karamell	Caramello	Caramelo	Karamel
Chemical [a,b]	Kemikaali	Chimique	Chemisch	Chimico	Químico	Kimyasal
Citrus [BPE]	Sitrus	Citrus	Zitrus	Agrumi	Cítrico	Narenciye
Cloying [a]	Etova	Écoeurante	Unangenehm süßlich	Nauseante	Empalagoso	Mide bulandırıcı
Fermented [BPE]	Fermentoitu	Fermenté	Fermentiert/ Vergoren	Fermentato	Fermentado	Fermente
Floral [a,c]	Kukkainen	Floral	Blumig	Floreale	Floral	Çiçek
Fruity [b]	Hedelmäinen	Fruité	Fruchtig	Fruttato	Afrutado	Meyvemsi
Grassy [b]	Ruohoinen	Herbacé	Grasig	Erba	Herbal	Otsu
Green [a,c]	Vihreä	Vert	Grün	Verde	Verde	Yeşil lezzet
Green tomato [BPE]	Vihreä tomaatti	Tomates vertes	Grüne Tomate	Pomodoro verde	Tomate verde	yeşil domates
Minty [BPE]	Minttu	Menthe	Minzig	Menta	Menta	Nane
Nutty [BPE]	Pähkinäinen	Noisette	Nussig	Nocciola	Aroma a frutos secos	Fındık
Raspberry [c]	Vadelma	Framboise	Himbeere	Lampone	Frambuesa	Ahududu
Sweet [BPE]	Makea aromi	sucré/doux	Süßes Aroma	Aroma dolce	Aroma dulce	Tatlı aroma
Tropical fruit [BPE]	Trooppiset hedelmät	Arôme de fruit tropical	Tropische Früchte	Frutta tropicale	Frutas tropicales	tropik meyveler
Watery [a]	Vetinen	Goût d'eau	Wässrig	Acquoso	Aroma a aguado	Sulu lezzet
Woody [b]	Puu	Boisé	Holzig	Legnoso	Aroma a madera	Odunsu
Taste	**Perusmaku**	**goût**	**Geschmack**	**Gusto**	**Sabor**	**Tat**
Acid [a,c,d]	Hapan	Acide	Säuerlicher Geschmack	Acido	Acidez	Ekşi
Bitter [a,c,d]	Karvas	Amer	Bitterer Geschmack	Amaro	Amargor	Acı
Sweet [a,c,d]	Makea	Sucré	Süßer Geschmack	Dolce	Dulce	Tatlı
Texture/mouthfeel	**Rakenne/Suutuntuma**	**Texture/ Texture En Bouche**	**Textur/ Mundgefühl**	**Sensazione in bocca**	**Textura**	**Doku/Ağiz hissi**
Astringent [a,c]	Astringoiva	Astringence	Adstringierend	Astringenza	Astringencia	Burukluk veya ekşilik
Fibrous [BPE]	Kuituinen	Fibreux	Faserig	Fibrosità	Fibrosidad	Liflilik
Firm [a,c]	Kiinteä	Fermeté	Fest	Durezza	Dureza	Sertlik
Metallic [e]	Metallinen	Métallique	Metallisch	Metallico	Metálico	Metalik
Juicy [a,c]	Mehukas	Juteux	Saftig	Succosità	Jugosidad	Sululuk
Seedy [c]	Siemeninen	Riche en graines	Samenreich	Presenza di semi	Sensación de semillas en la boca	Çekirdeklilik
Metadescriptor	**Yleiskuvaaja**	**Metadescriptor**	**Metadeskriptor**	**Metadescrittore**	**Metadescriptor**	**Meta tanımlayıcı**
Freshness [d]	Tuoreus	Fraîcheur	Frische	Freschezza	Frescura	Tazelik

3.2. Sensory Evaluation

3.2.1. Blueberry Lexicon Sorting through RATA

Eight of the 29 attributes were in the third tertile (high frequency) of panel citation: blueberry flavor, acid taste, sweet taste, juicy, skin persistence, freshness, acid flavor and sweet flavor. Seven other attributes were used by a minimum of 34% of the panelists: firm, astringent, fibrous, floral, fruity, berry, and green, being thus part of the second tertile (medium frequency). Results showed that six attributes had a low frequency (peculiar traits), and five attributes were not used by the panelists to describe the berries (Table 5).

Table 4. Descriptions of raspberry sensory attributes in English, Finnish, French, German, Italian, Spanish and Turkish.

Attributes Appearance	**ENGLISH Description Appearance**	**FINNISH Kuvaus Ulkonäkö**	**FRENCH Description Apparence**	**GERMAN Beschreibung Aussehen**	**ITALIAN Descrizione Apparenza**	**SPANISH Descripción Apariencia**	**TURKISH Tanim Görünüm**
Colour intensity	Intensity of the red colour of the fruit	Punaisen värin tummuus	Intensité de la couleur rouge du fruit	Intensität der roten Fruchtfarbe	Intensità del colore rosso	Intensidad del color rojo del fruto	Meyvenin kırmızı renginin yoğunluğu
Colour uniformity	Uniformity of the red colour across the fruit surface	Punaisen värin yhtenäisyys marjan pinnalla	Uniformité de la couleur rouge sur la surface du fruit	Gleichmäßigkeit der roten Farbe auf der Fruchtoberfläche	Uniformità del colore nella superficie del frutto	Uniformidad del color rojo en la superficie	Meyve yüzeyi boyunca kırmızı rengin tekdüzeliği
Size	Berry dimension evaluation	Marjan koko arvioituna	Évaluation de la dimension des baies	Bewertung der Fruchtgröße	Valutazione delle dimensioni del frutto	Evaluación del tamaño del fruto	Meyve boyut değerlendirmesi
Shiny	Surface shining intensity	Pinnan kiillon voimakkuus	Intensité du brillant de surface	Glänzende Intensität der Oberfläche	Intensità di lucentezza superficiale	Intensidad superficial brillante	Yüzey parlama yoğunluğu
Drupelet uniformity	Drupelet shape and size uniformity	Drupelettien muodon ja koon tasaisuus	Uniformité de la forme Drupelet	Einheitlichkeit der Fruchtform	Uniformità della dimensione delle drupeole	Uniformidad de la forma drupelet	Küçük meyve şekli üniformitesi
Surface hairiness	Presence of the hair on the surface	Nukkakarvojen esiintyminen pinnalla	Présence du poil à la surface	Oberflächenbehaarung	Presenza di peluria superficiale	Presencia del cabello en la superficie	Yüzeyde kıllılık
Aroma/ Flavour	**Aroma/ Flavour**	**Aromi/ Flavori**	**Arôme/ Flaveur**	**Aroma**	**Aroma**	**Aroma/ Olor**	**Koku/ Lezzet**
Acid	A sharp flavor associated with products that have a sour taste	Terävä, hapantuotteeseen liittyvä aromi	Une saveur piquante associée à des produits qui ont un goût aigre/sûr	Ein beißendes Aroma in Verbindung mit Produkten, die einen sauren Geschmack haben	Aroma forte associato a prodotti che hanno un sapore acido (acidi organici)	Aroma asociado a productos ágrios	Ekşi bir tada sahip olma hissi veren keskin bir aroma
Berry	Flavor associated with a combination of mixed berries	Marjojen, marjasekoitusten aromi	Arôme associé à une combinaison de petits fruits (rouges)	Aroma in Verbindung mit einer Kombination von gemischten Beeren	Sensazione aromatica associata ai piccoli frutti (fragola, lampoene, mirtillo, mora)	Aroma asociado a una mezcla debayas, pequeños frutos (frutos rojos)	Karışık meyve kombinasyonunu anımsatan aroma
Caramel	Flavor associated with cooked sugars	Karamellisoidun sokerin, toffeinen aromi	Arôme associé au sucre cuit	Aromen, die mit verkochtem Zucker assoziiert werden	Sensazione aromatica associata con zuccheri cotti	Aroma asociado a azúcar caramelizada	Karamelize şekeri anımsatan aroma
Chemical	Flavor of chemicals (e.g. ethyl acetate, plastic, sulphur, spirits)	Kemikaalien aromi (esim. etyyliasetaatti, muovi, rikki, alkoholi)	Arôme de produits chimiques (e.g. acétate d'éthyle, plastique, soufre, spiritueux)	Geruch nach Chemikalien (z. B. Ethylacetat, Plastik, Schwefel, Spiritus)	Odore di chimico (es. acetato di etile, plastica, zolfo, alcol)	Aroma asociado a químicos (ej.acetato de etilo, plástico, sulfurado)	Kimyasal maddeleri anımsatan aroma (etil asetat, plastik, kükürt, alkollü içkiler vs.)
Citrus	Flavor associated with citrus fruit (e.g. lemon, orange, lime)	Sitrushedelmän aromi (esim. sitruuna, appelsiini, lime)	Arôme associé aux agrumes (ex. citron, orange, citron vert)	Aromen, die mit Zitrusfrüchten assoziiert werden (z. B. Zitrone, Orange, Limette)	Sensazione armoatica associata ad agrumi (es. limone, arancia, lime)	Aroma asociado a los cítricos (ej. limón, naranja, lima)	Narenciye türlerini anımsatan aroma (portakal, limon vs.)
Cloying	Associated with an unfresh, sickening flavor	Epätuore, ällöttävä aromi	Arôme associé à une odeur nauséabonde	Geruch, der übermäßig süßlich ist, in einem fast ekelerregenden Ausmaß	Aroma associato con qualcosa di non fresco, odore nauseante	Aroma asociado a fruto no fresco/empalagoso	Taze olmayan, mide bulandırıcı bir aroma
Fermented	Flavor associated with fermented /rotting fruit or vegetable	Käyneen, pilaantuneen hedelmän tai vihanneksen aromi	Arômes associés à un fruit ou un légume fermenté/pourri	Aromastoffe, die mit fermentiertem/faulen Obst oder Gemüse assoziiert werden	Sensazione aromatica ssociata con frutta o verdura fermentata/marcia	Aroma asociado a la fermentación y la fruta podrida	Fermente/çürüyen meyve veya sebze anımsatan aroma
Floral	Associated with flavor of flowers	Kukkiin liittyvä makea aromi	Arôme associée à l'odeur des fleurs	Erinnert an den Geruch von Blumen	Sensazione aromatica associata ai fiori	Asociado a aroma de flores	Çiçek kokusunu anımsatan aroma
Fruity	Sweet, intense flavor associated with a combination of mixed fruit	Hedelmiin liittyvä makea aromi	Arôme doux et intense associé à un mélange de fruits	Süßliches, intensives Aroma in Verbindung mit einer Kombination aus gemischten Früchten	Intensa sensazione aromatica dolce associata al mix di frutta fresca	Aroma dulzón, intenso, asociado a una mezcla de frutos	Karışık meyve kombinasyonunu anımsatan tatlı, yoğun aroma

Table 4. *Cont.*

Attributes Appearance	ENGLISH Description Appearance	FINNISH Kuvaus Ulkonäkö	FRENCH Description Apparence	GERMAN Beschreibung Aussehen	ITALIAN Descrizione Apparenza	SPANISH Descripción Apariencia	TURKISH Tanim Görünüm
Grassy	Refers to the flavor of green, grassy and leafy-like aromas	Vastaleikatun ruohon aromi	Arôme d'herbe fraîchement coupée	Aroma das Bezieht sich auf durch geschnittenes Gras	Sensazione aromatica, erba appena tagliata o foglie	Aroma asociado a la hierba verde, hoja	Yeşil, çimenli ve yaprak benzeri aromaları anımsatan aroma
Green	Associated with flavour of freshly cut green grass	Tuore tuoksu, esim. leikattu ruoho, raaka hedelmä, aromi	Arôme de fruits verts / pas mûrs	Ein unreifes Aroma das unreife, grüne Früchte.	Sensazione aromatica associata ai frutti immaturi	Un aroma a inmaduro, característico , la fruta verde inmadura	Taze kesilmiş çimeni anımsatan aroma
Green tomato	Flavor associated with unripe tomato (green tomato)	Kypsymättömään tomaattiin liittyvä aromi	Arôme associé à la tomate verte (non mure	Aromen, die an unreife Tomaten erinnern (grüne Tomaten)	Sensazione aromatic associate al pomodoro non maturo (verde)	Aromáticos asociados al tomate inmaduro (tomate verde)	Olgunlaşmamış domates (yeşil domates) ile ilişkili aroma
Minty	Refers to the minty flavor and cooling sensations	Minttuun tai viilentävään tunteeseen viittaava aromi	Arôme de menthe qui donne une sensation rafraîchissante	Bezieht sich auf die minzigen und kühlenden Aromen	Sensazione riferita ad aroma di menta, una sensazione di fresco	Aroma mentolado y de sensaciones refrescantes	Ferahlama hissi veren nane benzeri aroma
Nutty	Flavor associated with nuts	Pähkinän aromi	Arôme associé à la fruit sec	Aroma, das an Nüsse erinnert	Sensazione aromatica associata con la frutta secca	Aroma asociado a las nueces, las avellanas, las almendras y en general a los frutos secos.	kuru meyve aroma
Raspberry	Flavor of fresh raspberries	Tuoreen vadelman aromi	Arôme de framboises	Aroma frischer Himbeeren	Sensazione aromatica associata al lampone	Aroma asociado de las frambuesas frescas	Taze ahududu tadı ve aromasının
Sweet	A sweet impression such as cotton candy, honey, vanilla or sweet fruity candy (not berry) that may appear in the aroma or aromatics	Makea, vaniljainen, makeisiin, makeaan tuoksuun liittyvä aromi	Arôme donnant une impression sucrée comme de la barbe à papa, du caramel, de la vanille ou des bonbons fruités	Ein süßlicher Geruch Geschmack wie Zuckerwatte, Karamell, Vanille oder süße Fruchtbonbons (keine Beeren), der im Aroma oder in der Duftnote auftreten kann.	Sensazione aromatica associata con il dolce come zucchero filato, caramello, vaniglia	Aroma asociado al algodón dulce, caramelo, vainilla, o caramelos afrutados (no a bayas o pequeños frutos)	Pamuklu şeker, karamel, vanilya gibi tatlılıkla (üzümsü meyvelerdışında) ilişkilendirilen aroma
Tropical fruit	Flavor associated to tropical fruits such as pineapple, mango, guava, passion fruit	Trooppisten hedelmien aromi (esim. ananas, mango, guava, passionhedelmä)	Arôme associé aux fruits tropicaux tels que l'ananas, mangue, goyave, fruit de la passion	Aroma verbunden mit tropischen Früchten wie Ananas, Mango, Guave, Passionsfrucht	Aroma associate con frutti tropicali come ananas, mango, guaiava e frutto della passione	Aroma asociado a frutas tropicales como piña, mango, guayaba, maracuyá	Ananas, çarkıfelek meyvesi, mango, guava gibi tropik meyvelerle ilişkili aroma
Woody	Flavor associated with greenwood or stems	Tuoreen puun, oksien aromi	Aromatique associé au bois vert ou aux tiges	Aromen, die mit Grünholz oder Stengeln assoziiert werden	Aroma associanto con legno verde	Aroma asociado a maderas verdes o ramas	Yeşil ağaç veya saplarını anımsatan aroma
Watery	Associated with watery taste, tame, tasteless	Vetinen, laimea maku, mauton	Associé au goût aqueux, apprivoisé, insipide	Assoziiert mit wässrig , mild	Flavour associato con un gusto acquoso, senza sapore	Asociado con sabor acuoso, soso, insípido	Sulu, yavan ve tatsız bir lezzet
Taste	**Taste**	**Perusmaku**	**goût**	**Geschmack**	**Gusto**	**Sabor**	**Tat**
Acid	Related to the basic taste acid	Happamuuden aiheuttama maku	goût associé à l'acidité	Bezogen auf den Grundgeschmack Sauer	Gusto associato con composti acidi	Sabor ácido	Ekşi tat
Bitter	Related to the basic taste bitter	Karvasaineiden aiheuttama maku	goût associé à la stimulation de la langue par un composé amer	Bezogen auf den Grundgeschmack Bitter	Gusto associato con la stimolazione della lingua con composti amari	Sabor amargo	Acı tat
Sweet	Related to the basic taste sweet	Sokerien tai makeutu-saineidenaiheuttama maku	goût associé à la stimulation de la langue par le sucre ou un édulcorant	Bezogen auf den Grundgeschmack Süß	Gusto associato con la stimolazione della lingua con zucchero o dolcificanti	Sabor dulce o azucarado	Tatlı tat

Table 4. *Cont.*

Attributes Appearance	ENGLISH Description Appearance	FINNISH Kuvaus Ulkonäkö	FRENCH Description Apparence	GERMAN Beschreibung Aussehen	ITALIAN Descrizione Apparenza	SPANISH Descripción Apariencia	TURKISH Tanim Görünüm
Texture/ mouthfeel	**Texture/ Mouthfeel**	**Rakenne/Suutuntuma**	**Texture/ Texture En Bouche**	**Textur/ Mundgefühl**	**Sensazione in bocca**	**Textura**	**Doku/Ağiz hissi**
Astringent	Feeling in the mouth characterized by drying; associated with the presence of tannins	Kutistava, kurova tai kuivaava tunne suussa; tanniinien aiheuttama	Sensation complexe résultant de la contraction des muqueuses de la bouche, similaire à la sensation de sécheresse, associée aux tanins.	Gefühl im Mund, das durch Austrocknung gekennzeichnet ist; wird mit dem Vorhandensein von Tanninen in Verbindung gebracht	Sensazione in bocca di secchezza, associate con la presenza di tannini	Sensación compleja que resulta de la contracción de las mucosas de la boca, parecida a la sensación de sequedad, asociada a los taninos	Tanenlerin varlığından damakta hissedilen kuruma hissi
Fibrous	The degree to which fibers are perceived throughout mastication	Kuitujen aistimisen aste pureskeltaessa	Degré de perception des fibres pendant la mastication	Grad der Wahrnehmung von Fasern während des Kauens	Grado con cui sono percepite fibre durante la masticazione	Grado de percepción de fibras durante la masticación	Çiğneme boyunca liflerin algılanma derecesi
Firm	Force required to bring teeth together during the mastication	Purentaan tarvittava voima	Force nécessaire pour rapprocher les dents pendant la mastication.	Kraft, die erforderlich ist, um die Zähne während des Kauens zusammenzubekommen	Forza necessaria per la masticazione	Fuerza necesaria para unir los dientes durante la masticación	Çiğneme sırasında dişleri bir araya getirmek için gereken kuvvet
Metallic	Metallic perception in the mouth	Metallinen aistimus suussa	sensation métallique en bouche	Metallische Wahrnehmung im Mund	Percezione metallica in bocca	Sensación metálica en boca	Düşükten yükseğe meyvenin sululuk derecesi
Juicy	The degree of juice presence	Mehupitoisuus	Quantité de jus dans le fruit	Grad des Vorhandenseins von Saft (Saftigkeit)	Grado di presenza di succo	Cantidad de jugo en el fruto	Damaktaki metalik algı
Seedy	Seeds percived during mastication	Pureskeltaessa havaittavat siemenet	Degré de présence des graines pendant la mastication.	Während des Kauens wahrgenommene Samen	Semi percepiti durante la masticazione	Grado de percepción de las semillas durante la masticación	Çiğneme sırasında algılanan çekirdekler
Metadescriptor	**Metadescriptor**	**Yleisuvaaja**	**Metadescriptor**	**Metadeskriptor**	**Metadescrittore**	**Metadescriptor**	**Meta tanımlayıcı**
Freshness	Meta-descriptor,satisfaction of mix features (appearance, textural, aromatic and tasting)	Yleiskuvaaja eri tekijöiden yhteisvaikutus huomioiden (ulkonäkö, aromi, rakenne, maku)	Méta-descripteur, satisfaction de la combinaison de toutes les caractéristiques (aspect, texture, arôme et goût)	Meta-Deskriptor, Zufriedenheit mit der Kombination aller Merkmale (Aussehen, Textur, Aroma und Geschmack)	Metadescittore, soddisfazione di un un mix di caratteristiche (apparenza, texture, aroma gusto)	Metadescriptor, satisfacción por la combinación de varias características (apariencia, textura, aroma y gusto)	Meta-tanımlayıcı,karışım özelliklerinin tatmini (görünüm, dokusal, aromatik ve tat)

Table 5. Frequency counts of the sensory descriptors of blueberry samples. Attributes marked by *** belong to the third tertile, ** belongs to the second tertile, * belongs to the first tertile (peculiar traits).“-“indicates non-used attributes.

Attribute Modality	Attribute	Cultivar			Overall	
		AtlasBlue	Rebel	Ventura	Counts	Frequency
Flavor	Acid ***	17	17	25	59	61.5
	Berry **	15	15	18	48	50.0
	Blueberry ***	28	26	30	84	87.5
	Citrus -	7	7	10	24	25.0
	Earthy/musty *	10	15	5	30	31.3
	Fermented *	8	13	8	29	30.2
	Floral **	23	18	15	56	58.3
	Fruity **	16	18	17	51	53.1
	Grassy *	11	14	10	35	36.5
	Green **	17	16	11	44	45.8
	Minty -	8	6	8	22	22.9
	Overripe fruit *	7	18	6	31	32.3
	Pungent *	10	9	13	32	33.3
	Spicy -	6	7	4	17	17.7
	Strawberry -	5	4	7	16	16.7
	Sweet ***	25	21	19	65	67.7
	Watery -	0	0	0	0	0.0
Taste	Acid ***	15	20	30	65	67.7
	Bitter -	8	8	6	22	22.9
	Sweet ***	31	25	27	83	86.5
Mouthfeel	Astringent **	13	17	17	47	49.0
	Fibrous **	15	16	14	45	46.9
	Firm **	20	18	20	58	60.4
	Metallic -	4	5	5	14	14.6
	Juicy ***	28	25	30	83	86.5
	Seedy -	0	0	0	0	0.0
	Skin persistence ***	29	26	22	77	80.2
	Throat burn *	9	6	12	27	28.1
Metadescriptor	Freshness ***	24	23	26	73	76.0
	Overall	409	413	415	1237	50.8

Analyzing RATA data through the Venn diagram showed that several high- and medium-frequency attributes were shared by the three blueberry cultivars, while peculiar traits discriminated them (Figure 2). Fifteen attributes were shared by all the cultivars, and three attributes (overripe fruit, fermented, and earthy/musty) were absent in AtlasBlue and Ventura. Two attributes (throat burn and pungent), were present in Ventura only, and one attribute (grassy), was common to AtlasBlue and Rebel.

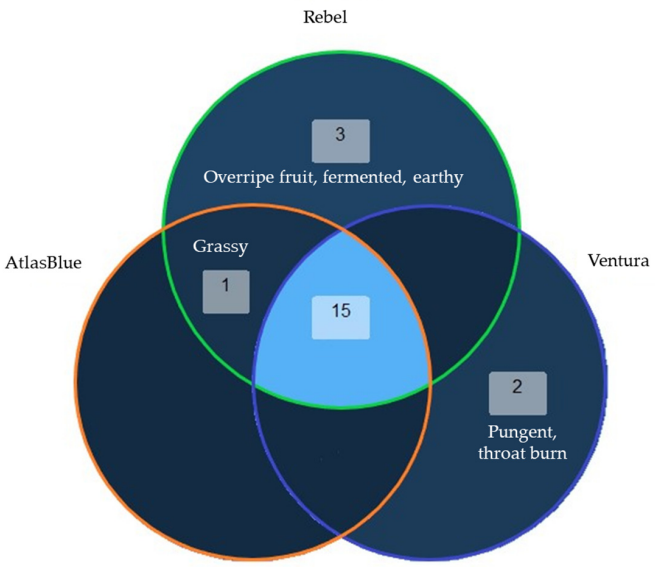

Figure 2. Venn diagram based on the attributes chosen by at least 34% of the panelists to describe blueberry cultivars. Numbers inside the diagram represent the number of terms selected by the panelists.

3.2.2. Blueberry Cultivar Profiles

The three blueberry cultivars differed in six of the "high frequency" attributes with Ventura recording the highest intensity of juiciness, acidity, freshness and blueberry flavor, while AtlasBlue prevailed for sweetness and sweet flavor (Figure 3). "Medium frequency" attributes also contributed to define the cultivar profiles; Rebel recorded the lowest firmness and the highest grassy flavor, Ventura was the least fibrous, and AtlasBlue registered the most intense floral flavor. Finally, peculiar traits, having generally a low intensity, contributed to cultivar discrimination; Ventura showed the highest throat burn and pungency, and Rebel showed the highest fermented, earthy/musty, and overripe fruit flavors.

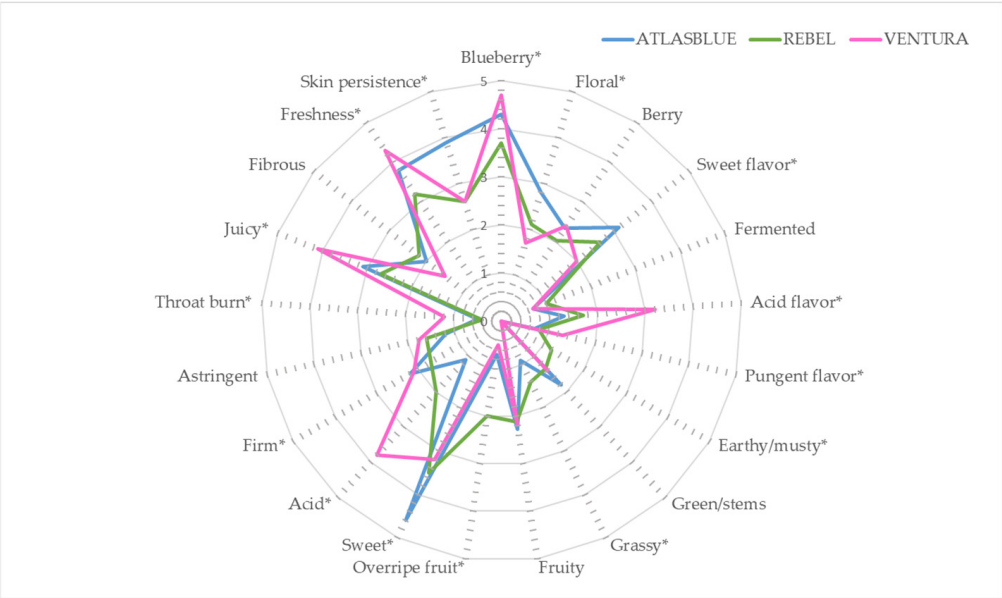

Figure 3. Spider plot of blueberry RATA intensity scores by cultivars on a 10-point scale (0–9). Significant differences ($p < 0.05$) between cultivars are marked by *.

Repeatability did not have any significant effect on replicate.

3.2.3. Raspberry Lexicon Sorting through RATA

Six of the 29 raspberry attributes were in the third tertile (high frequency) of panel citation: raspberry flavor, sweet taste, acid taste, astringent, juicy, and seedy. Eight additional attributes were used by a minimum of 34% of the panelists: freshness, firm, fruity, cloying, green, floral flavors, fibrous, and grassy, and belonged to the second tertile. Of the remaining attributes, two (bitter and chemical flavors) overcome this threshold at least in one cultivar. The attributes metallic, woody, watery and caramel flavors had a low frequency (peculiar traits), and the attributes berry, citrus, fermented, green tomato, minty, nutty, sweet and tropical fruit flavors were not used by the panelists to describe the berries (Table 6).

The Venn diagram of the raspberry RATA data showed that 14 "medium and high-frequency" attributes were common to the three cultivars. Only two cultivars were discriminated by peculiar traits (Lagorai Plus and Adelita) (Figure 4). Two attributes, chemical and bitter, were absent in Lagorai Plus and Dafne, and one attribute, cloying, was common to Lagorai Plus and Adelita. The attribute fibrous was present in Lagorai Plus only.

Table 6. Frequency counts of the sensory descriptors of raspberry samples. Attributes marked by *** belong to the third tertile, ** means belonging to the second tertile, * means belonging to the first tertile (peculiar traits).“-“indicates non-used attributes.

Attribute Modality	Attribute	Cultivar			Overall	
		Lagorai Plus	Dafne	Adelita	Counts	Frequency
Flavor	Acid ***	24	22	24	70	83.3
	Berry -	0	0	0	0	0.0
	Caramel -	3	5	5	13	15.5
	Chemical *	8	9	13	30	35.7
	Citrus -	0	0	0	0	0.0
	Cloying **	12	6	18	36	42.9
	Fermented -	0	0	0	0	0.0
	Floral **	12	15	13	40	47.6
	Fruity **	12	16	16	44	52.4
	Grassy **	11	11	10	32	38.1
	Green **	13	11	13	37	44.0
	Green tomato -	0	0	0	0	0.0
	Minty -	0	0	0	0	0.0
	Nutty -	0	0	0	0	0.0
	Raspberry ***	21	25	22	68	81.0
	Sweet	0	0	0	0	0.0
	Tropical fruit -	0	0	0	0	0.0
	Watery -	10	9	7	26	31.0
	Woody -	10	8	10	28	33.0
Taste	Acid ***	26	27	26	79	94.0
	Bitter *	5	6	12	23	27.4
	Sweet ***	19	26	22	67	79.8
Mouthfeel	Astringent ***	21	19	20	60	71.4
	Fibrous **	11	9	9	29	34.5
	Firm **	20	17	18	55	65.5
	Metallic -	8	6	8	22	26.2
	Juicy ***	24	28	25	77	91.7
	Seedy ***	25	25	26	76	90.5
Metadescriptor	Freshness **	15	14	15	44	52.4
	Overall	323	331	347	1001	1191.7

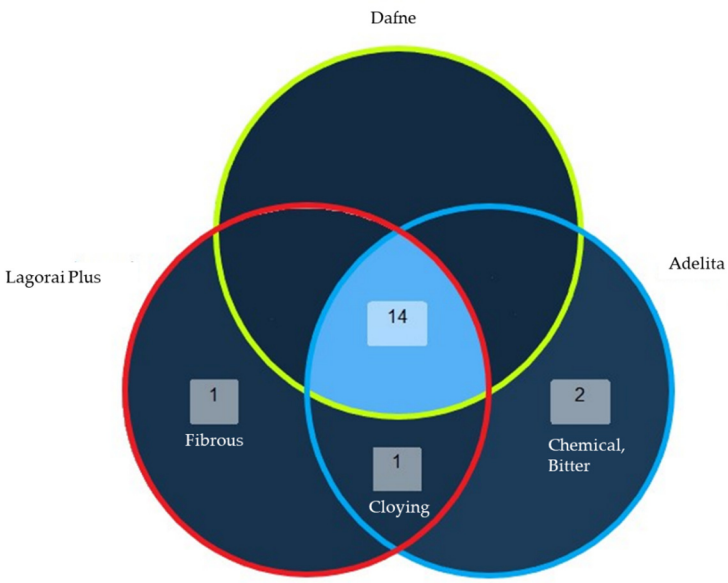

Figure 4. Venn diagram based on the attributes chosen by at least 34% of the panelists to describe raspberry cultivars. Numbers inside the diagram represent the number of terms selected by the panellists for each cultivar.

3.2.4. Raspberry Cultivar Profiles

The three raspberry cultivars tested were different for four of the “high frequency” attributes; Dafne and Adelita showed the highest intensity of raspberry flavor, Dafne also showed the highest juiciness and sweetness, while Lagorai Plus was the most acid (Figure 5). “Medium frequency” attributes also contributed to define cultivar profiles; Lagorai Plus

showed the highest firmness and fibrousness, Dafne was mainly fruity, and Adelita was mainly cloying and grassy. Among peculiar traits showing generally low intensity, Adelita expressed the highest bitter and chemical flavors.

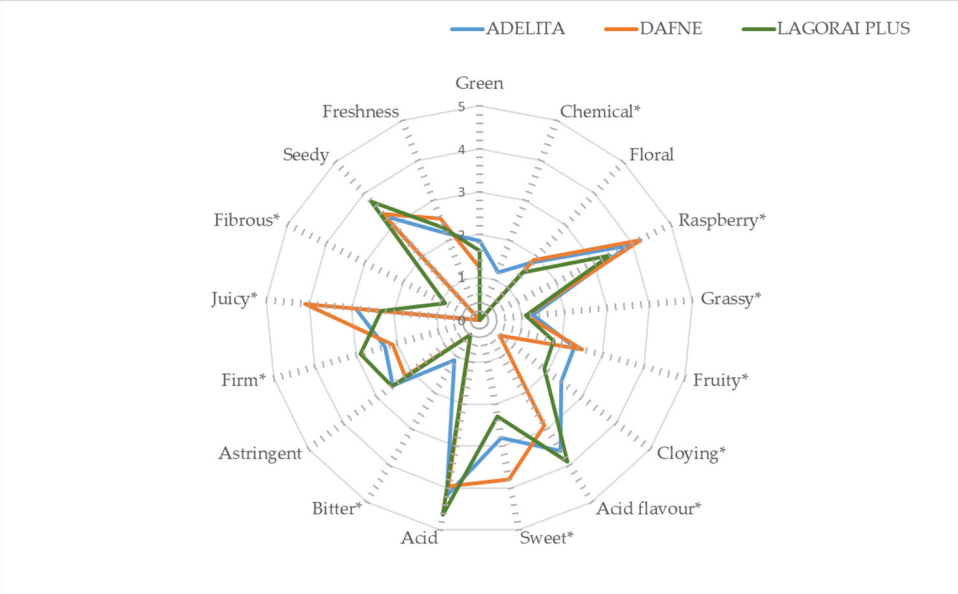

Figure 5. Spider plot of raspberry RATA intensity scores by cultivars on a 10-point scale (0–9). Significant differences ($p < 0.05$) between cultivars are marked by *.

Repeatability did not have any significant effect on replicate.

4. Discussion

4.1. Berries Lexicon Development

This study led to the identification of 29 sensory descriptors perceived during eating (basic tastes, texture, flavors) potentially present in blueberry, and the same number in raspberry, evidencing an expected high range of sensory stimuli provided by the berries. As suggested by Suwonsichon [4], lexicon creators have to clearly illustrate each chosen term to panelists, referring to previous experiences, and/or providing standard references to support panelists' term/sensation association, to validate the effectiveness and the exhaustiveness of the terms list.

4.2. Basic Tastes

In this study, the lexicon was validated by panelists through RATA, as applied on three blueberry and three raspberry cultivars selected for providing a wide range of product variability. Basic tastes such as sweet and acid are clearly perceived in most fruit including berries, due to the relevant presence of sugars (and polyalcohols) and organic acids [30]; also in this study, they were cited at high frequency both in blueberry and raspberry. Bitter recorded lower frequencies, being not typical of these fruits [15,28]. However, as it affects consumers' liking [28] it is worth assessing, even if only slightly perceived. Indeed, the bitter perception has a recognized genetic base, with about one third of consumers (supertasters), particularly sensitive to bitterness [31]. In our study, bitter taste was highlighted by more than one third of assessors only in the raspberry cultivar "Lagorai".

4.3. Flavors

Berries are particularly rich in odor active compounds, determining odor and flavors. For raspberry, the most impacting compound, responsible for the typical raspberry-like odor, is 4-(4-Hydroxyphenyl) butan-2-one, the "raspberry ketone" [26,32]. While the blueberry flavor is a mix of odor compounds not corresponding to a single odor sensation,

among them, the ones affecting the overall liking were reported to be 1-hexanol and 2-undecanone, responsible, respectively, for fruity/sweet/green, and fruity/floral sensations [18]. However, in this study, both blueberry and raspberry flavors were clearly recognized by judges who cited them highly (over 80% citation frequency). Additional cited flavors in blueberry were acid and sweet, and at low frequencies, floral, fruity, berry and green, which are also responsible for blueberry flavor. Additional cited flavor notes in raspberry were fruity, cloying, green, floral and grassy.

4.4. Mouthfeel

Among texture descriptors, juiciness was highly cited for both berries, indeed it has been considered a positive trait often related to liking [20]. Firmness was also frequently cited but at a low intensity due to the general features of these berries. Fibrousness was also cited but among the low-frequency attributes. Other texture attributes were berry type-specific: skin persistence in blueberry, seedy in raspberry. Astringency, another key attribute of fruit, related to the concentration of substances such as polyphenols [33], received medium frequency citations in blueberry and high in raspberry. Freshness, an important metadescriptor of sensations related to just-harvested fruits [17,29] was cited at high frequency in blueberry, and medium frequency in raspberry, suggesting the perishable nature of raspberry.

4.5. RATA Analysis

RATA was confirmed to be a quick and valuable alternative to the complicated traditional sensory lexicon development, as highlighted by Leone et al. [10]. Indeed, RATA has been considered a tool to produce data in line with consumer perceptions with a short time frame for data acquisition [34]. Moreover, the advantage of RATA resides in the ease of lexicon development since the terms selected are directly applied and rated [35]. Our descriptive and comparative test on blueberry and raspberry cultivars confirmed the selected lexicon efficiency through sample discrimination highlighted by attributes' intensities. Notably, not only high-/medium-frequency terms help discriminate between cultivars, but also peculiar traits, underlining their important role in describing food products. Thus, RATA was useful, especially in correctly identifying discriminative, peculiar traits of the product analyzed.

4.6. Pros and Goals

The main novelty of this research is the development of a comprehensive multilingual lexicon for raspberries and blueberries, the sensorial quality of which has been little investigated so far. Moreover, it provides a fundamental sensory tool not only for international research studies involving different partners and countries but also for breeders and the food industry to assess the potential of new varieties in the fresh fruit market, necessary in modern breeding programs aimed at improving fruit sensorial and nutritional quality [36]. Lexicon development should be seen as a necessary starting point, from which other sensory studies can evolve using well-documented terms directly or adding/adapting new terms to each individual work [37]. The lexicon developed in the present study to describe the sensory properties of fresh raspberry and blueberry will be applied in further tests in the frame of the BreedingValue project in different European countries [11], both to assess the translation relevance and to provide the opportunity for further lexicon integration.

5. Conclusions

The seven-language lexicon developed in this study can contribute to systematize blueberry and raspberry sensory evaluation at an international level. A reference sensory lexicon is useful to ease producer-consumer interaction; moreover, international markets and scientific collaborations need a multilingual lexicon to share a common meaning of each term. This research provides a comprehensive list of terms for blueberry and raspberry sensory evaluation in some of the world's most spoken languages, such as English, Spanish

and French, and in additional languages spoken in relevant berry production countries, such as Germany, Italy, Finland, and Turkey. The proposed lexicon can be used as a tool for planning panel training and consumer tests, opening up further possibilities to enrich the lexicon based on additional attributes emerging from local experience, or evaluation of new genotypes. Indeed, the lexicon, developed in English and validated by an Italian expert panel, can be applied in other languages. The developing procedure presented in this study, which starts from English, is the "hub" connecting several "spokes", i.e., the languages, and easily allows both integrating the list of sensory terms and add more languages. The international BreedingValue consortium collaboration led to the creation of this unique tool, setting the basis for a consistent sensory evaluation of blueberry and raspberry fruits.

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