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Review

Sorbitol, *Rubus* fruit, and misconception

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ABSTRACT

It is unclear how the misunderstanding that *Rubus* fruits (e.g., blackberries, raspberries) are high in sugar alcohol began, or when it started circulating in the United States. In reality, they contain little sugar alcohol. Numerous research groups have reported zero detectable amounts of sugar alcohol in fully ripe *Rubus* fruit, with the exception of three out of 82 *Rubus* fruit samples (cloudberry 0.01 g/100 g, red raspberry 0.03 g/100 g, and blackberry 4.8 g/100 g*; *highly unusual as 73 other blackberry samples contained no detectable sorbitol). Past findings on simple carbohydrate composition of *Rubus* fruit, other commonly consumed Rosaceae fruit, and additional fruits (24 genera and species) are summarised. We are hopeful that this review will clarify Rosaceae fruit sugar alcohol concentrations and individual sugar composition; examples of non-Rosaceae fruit and prepared foods containing sugar alcohol are included for comparison. A brief summary of sugar alcohol and health will also be presented.

Contents

1. Introduction

It is well established that *Rubus* fruit contain a rich array of phenolics, as summarised in Lee, Dossett, and Finn (2012), and they have long been popular due to their unique flavours (Dossett, Lee, & Finn, 2008). *Rubus* fruits are also a good source of dietary fibre, vitamins, and minerals (Kaume, Howard, & Devareddy, 2012; Lee et al., 2012; Rao & Snyder, 2010), however there is a common misconception among nutritionists, dietitians, and consumers that the sugar alcohol (also known as carbohydrate, simple polyol, and mostly acyclic polyols) content of blackberries and red raspberries (both in the genus *Rubus*) is high (personal observation). It is unclear how or when this misunderstanding began to circulate, but the confusion could stem from *Rubus* belonging to the plant family Rosaceae, which includes plums and cherries (see section on subfamily Amygdaloidae sugar alcohols section below). Considering current understanding of healthy diets, it is all the more unfortunate that misinformation can cause unnecessary consumer avoidance of fruits or vegetables (Kaume et al., 2012; Lee et al., 2012; Rao & Snyder 2010).

Fruit sugar identifications have aided plant taxonomy classification within Rosaceae (Bieleski, 1982; Moing, 2000; Wallaart, 1980), and their profiles (i.e., glucose:fructose ratio, presence or absence of specific sugar) can reveal adulteration in fruit juices and concentrates (Spanos & Wrolstad, 1987; Wrolstad, Cornwell, Culbertson, & Reyes, 1981, chap. 7; Wrolstad & Shallenberger, 1981). Despite improvements in technology, modern authenticity and assurance

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testing is still dependent on fruit sugar profiles (Nuncio-Jauregui, Calin-Sanchez, Hernandez, & Carbonell-Barrachina, 2014; Thavarajah & Low, 2006; Turkmen & Eksi, 2011). An example of Rosaceae family adulteration could be red raspberry (*Rubus idaeus* L.) products using less costly apple (*Malus domestica* L.) or pear (*Pyrus* L.) concentrates, desired sweetness would be attained while still able to assert 'no added sugar' on the label. Simple carbohydrate profiles can also be used in food standard of identity, quality assurance, and quality control for canned fruits, canned fruit juices, fruit jellies, and fruit preserves (21CFR145). Although it would be a challenge to rely on sugar profiles alone to detect ingredient adulteration, but when combined with other measurements like phenolics, free amino acids, organic acids (nonvolatile acids), or DNA testing, food agencies are able to readily identify suspect fruit products (Durst, Wrolstad, & Krueger, 1995; Lee, 2014; Nuncio-Jauregui et al., 2014; Scott & Knight, 2009; Thavarajah & Low, 2006; Van Gorsel, Li, Kerbel, Smits, & Kader, 1992).

It is unclear how nutrition professionals and consumers originally became misinformed regarding sugar alcohol levels in *Rubus* fruit. The goal of this review article is to clarify and summarise findings about the sugars found in *Rubus* fruit, and the sugars within other commonly consumed fruit from the family Rosaceae. Health benefits and risks of sugar alcohol will be briefly summarised in a later section.

2. Occurrence of sugar alcohol

Though the focus of this review is limited to the family Rosaceae (references that provided relevant values are in Tables 1–3), sugar alcohol can be found in a multitude of foods. The occurrence, distribution, metabolism, and role of sugar alcohol within plants have been well summarised (Bieleski, 1982; Loescher, 1987; Merchant & Richter, 2011; Moing, 2000; Williamson, Jennings, Guo, Pharr, & Ehrenshaft, 2002), while additional work to clarify its functions is ongoing (Williamson et al., 2002).

Sugar alcohols are present in many food crops: from apples, to seaweeds, and to mushrooms (Bieleski, 1982; Haas & Hill, 1932; Mizuno & Zhuang, 1995; Zhou et al., 2012; references listed in Tables 1–3). Known findings include apple, peach, apricot, nectarine, pear, plum (red, prune, and yellow), blackberry, red raspberry, cloudberry, red and black currant, elderberry, strawberry, bilberry, sweet cherry, sour cherry, loquat, pomegranate, whortleberry, cranberry, sea buckthorn, common hawthorn, rowan berry, narrow firethorn, mushrooms, celery, avocado, plantain, banana, grapefruit, pineapple, kiwifruit, papaya, coffee, olive, and algae. The plant kingdom is widely represented (families of Actinidiaceae, Adoxaceae, Apiaceae, Bromeliaceae, Caricaceae, Elaeagnaceae, Ericaceae, Grossulariaceae, Lauraceae, Lythraceae, Musaceae, Oleaceae, Plantaginaceae, Rhodomelaceae, Rosaceae, Rubiaceae, and Rutaceae), along with the fungi kingdom (families of Auriculariaceae, Boletaceae, Cantharellaceae, Hericiaceae, Marasmiaceae, Meripilaceae, Pleurotaceae, and Tremellaceae) (Cantin, Gogorcena, & Moreno, 2009; Colaric, Veberic, Stampar, & Hudina, 2005; Haas & Hill, 1932; Ledbetter, Peterson, & Jenner, 2006; Liu, Robinson, Madore, Witney, & Arpaia, 1999; Makinen & Soderling, 1980; Megias-Perez, Gamboa-Santos, Soria, Villamiel, & Montilla, 2014; Moing, 2000; Mizuno & Zhuang, 1995; Muir et al., 2009; Nadwodnik & Lohaus, 2008; Richmond, Brandao, Gray, Markakis, & Stine, 1981; Serrano et al., 2003; Strain, 1937; Turkmen & Eksi, 2011; Wodner, Lavee, & Epstein, 1988; Wu, Quilot, Kervella, Genard, & Li, 2003; Zhou et al., 2012; and additional references listed in Tables 1–3). Additionally, the sugar alcohol concentration within the edible parts of a plant or fungus fluctuate due to many variables, including fraction (leaf, stem, fruit, etc.), ripeness, species, genus, cultivar, genotype, environment, cultivation, processing, and storage conditions (Cantin et al., 2009; Durst et al., 1995; Fuzfai, Katona, Kovacs, & Molnar-Perl, 2004; Hecke et al., 2006; Liu et al., 1999; Makinen & Soderling, 1980; Merchant & Richter, 2011; Moing, 2000; Wallaart, 1980; Wodner et al., 1988).

3. Simple carbohydrates found in *Rubus* and other Rosaceae fruit

Red raspberry fruit, as an example of *Rubus* fruit, has been reported to contain glucose, fructose, sucrose, sorbitol, mannitol, and *myo*-inositol (Durst et al., 1995; Makinen & Soderling, 1980; Megias-Perez et al., 2014; Muir et al., 2009; Sanz, Villamiel, & Martinez-Castro, 2004; Spanos & Wrolstad, 1987; Washuttl, Riederer, & Bancher, 1973). Although, some references have not reported every individual sugar listed above and discrepancies might have arisen from variation in sample, preparation, column, detector, or method conditions (Ellefson, 2005; Fuzfai et al., 2004; Muir et al., 2009). Table 1 summarises total sugars and total sugar alcohols in fresh weight (fw) fruit from 22 genera and species, by dry weight (dw) in Table 2, and by their products in Table 3.

Data from the Rosaceae family show subfamily Amygdaloidae (tree fruits; drupes and pomes fruiting body) contained higher levels of sugar alcohols than subfamily Rosoideae (canefruit, shrubs, etc.; aggregated fruit body). Amygdaloidae fruit (apple, plum, apricot, etc.; see Tables 1–3) sugar alcohol levels ranged from none detected to 6.8 g/100 g fw (sweet cherry), while the range in Rosoideae fruit (strawberry, blackberry, raspberry, etc.; see Tables 1–3) was from undetected (most Rosoideae fruit listed in Table 1) to 0.06 g/100 g fw (strawberry; excluding the Muir et al. 2009 atypical result of 4.8 g/100 g fw). Sugar alcohol concentration and composition changed when reported in dry weight (Table 2). Dehydration (i.e., freeze drying, oven drying, or air drying) likely alters the detectable sugar proportions by naturally concentrating fruit metabolites and decreasing the fleshy part to seed ratio. For example, mannitol, xylitol, and *myo*-inositol (Megias-Perez et al., 2014; Washuttl et al., 1973) were found in dehydrated red raspberries but not fresh red raspberries (Makinen & Soderling, 1980).

Products (Table 3) of Amygdaloidae fruit (not detected to 18 g/100 mL or 100 g) had higher sugar alcohol than those of Rosoidae (not detected to 0.21 g/100 mL or 100 g), which is consistent with the trends these subfamilies had in their respective starting materials (Table 1). Dried prune plums (up to 18 g/100 g) and prune plum juices (up to 7 g/100 g) contained the highest amount of sugar alcohols (Stacewicz-Sapuntzakis, 2013; Stacewicz-Sapuntzakis, Bowen, Hussain, Damayanti-Wood, & Farnsworth, 2001). Conversely, a serving of strawberries (140 g fw), using the highest sugar alcohol level reported (0.06 g/100 g fw), would contain only 0.08 g of sugar alcohol. Even with an uncharacteristically high blackberry value (Muir et al., 2009), a serving (140 g fw) might contain 6.7 g of sugar alcohol. But, at the highest blackberry juice sorbitol reported (Fan-Chiang & Wrolstad, 2010), 0.21 g/100 mL, one serving (8 oz) would contain only 0.50 g of sugar alcohol. Again, most Rosoideae fruit products contained well below 0.21 g of sugar alcohols/100 mL or 100 g. Most of the *Rubus* fruit (see Table 2; except the Muir et al. 2009 sample) contained less sugar alcohol than gluten free Muesli (0.89 g/100 g fw), chocolate chip biscuits (0.08 g/100 g fw), sweet plain biscuits (0.21 g/100 g fw), or pretzels (0.13 g/100 g fw) (Biesiekierski et al., 2011). Additional sugar alcohol values for fruits, vegetables, grains, etc. can be found in Biesiekierski et al. (2011), Muir et al. (2009), Washuttl et al. (1973), and Yao et al. (2014).

Processing schemes can elevate sugar alcohol concentrations in finished products. Any food production using a commercial pectinase might be introducing sorbitol into their final products, as shown in Durst et al. (1995), where they reported from none detected to 55 g of sorbitol/100 g ($n = 33$) in available pectinase

Table 1
Taxonomic classification tree (left; alphabetically listed to genus), sugar alcohols, and major simple sugars (right) in Rosaceae fruit (**fresh weight, fw**) and other available fruit. Sugars within the total sugar cells are listed in no particular order.

Kingdom	Order	Family	Subfamily	Genus and species	Common names	Sugar alcohol levels; list of sugar alcohols found g/100 g fw	Total sugar; list of sugars found g/100 g fw	*n*	References
Plant	Ericales	Ericaceae	Vaccinoideae	*Vaccinium myrtillus* L.	Bilberry	0.006; sorbitol, xylitol	Total sugar not reported.	1	Makinen and Soderling (1980)
				Vaccinium oxycoccos L.	Small cranberry	0.004; sorbitol, xylitol	Total sugar not reported.	1	Makinen and Soderling (1980)
				Vaccinium uliginosum L.	Bog whortleberry	0.003; xylitol	Total sugar not reported.	1	Makinen and Soderling (1980)
				Vaccinium vitis-idaea L.	Lingonberry	0.002; xylitol	Total sugar not reported.	1	Makinen and Soderling (1980)
	Myrtales	Punicaceae	Punicoideae	*Punica granatum* L.	Pomegranate	0.3; sorbitol	11.8; glucose, fructose, sucrose, sorbitol	1	Richmond et al. (1981)
	Rhamnales	Elaeagnaceae	–	*Hippophae rhamnoides* L.	Sea buckthorn	0.03; sorbitol, xylitol	Total sugar not reported.	1	Makinen and Soderling (1980)
	Rosales	Grossulariaceae	–	*Ribes nigrum* L.	Black currant	0.03; sorbitol, xylitol	Total sugar not reported.	1	Makinen and Soderling (1980)
				Ribes rubrum L.	Red currant	0.01; xylitol	Total sugar not reported.	1	Makinen and Soderling (1980)
		Rosaceae	Amygdaloidae	*M. domestica* L.	Apple	0.005–0.6; sorbitol, xylitol	Total sugar not reported, 11–23; glucose, fructose, sucrose, sorbitol, xylitol	22	Hecke et al. (2006), Makinen and Soderling (1980), and Richmond et al. (1981)
				Prunus domestica L.	Plum (red, yellow, and prune)	0.002–2.6; sorbitol, xylitol	Total sugar not reported, 4.9–13.5; glucose, fructose, sucrose, maltose, sorbitol, xylitol	5	Makinen and Soderling (1980) and Richmond et al. (1981)
				Prunus armenica L.	Apricot	0.1–2.9; sorbitol, xylitol	7.2–13.3; Raffinose, sucrose, glucose, fructose, sorbitol	27	Ledbetter et al. (2006)
				Prunus avium L.	Sweet cherry	0.45–6.8; sorbitol	11–26; Glucose, fructose, sucrose, sorbitol	40	Ballistreri et al. (2013), Cornwell et al. (1981), Richmond et al. (1981), and Usenik et al. (2008)
				Prunus cerasus L.	Sour cherry	1.0; sorbitol	8.8; glucose, fructose, sorbitol	1	Richmond et al., 1981
				Prunus persica L.	Peach, nectarine	Not detected-4.4; sorbitol	Total sugar not reported, 3.6–10.9; sucrose, fructose, glucose, sorbitol	322	Cantin et al. (2009), Colaric et al. (2005), Richmond et al. (1981), and Wu et al. (2003)
				Pyrus L.	Pear	1.7; sorbitol	13; glucose, fructose, sucrose, sorbitol	1	Richmond et al. (1981)
				Sorbus aucuparia L.	Rowan berry	0.54; sorbitol, xylitol	Total sugar not reported.	1	Makinen and Soderling (1980)
			Rosoideae	*Fragaria* spp.	Strawberry	Not examined, 0.06; sorbitol, xylitol	Total sugar not reported, 3.9–7.4; sucrose, glucose, fructose, xylose, sorbitol, xylitol	15	Makinen and Soderling (1980), Souleyre et al. (2004), and Sturm et al. (2003)
				Rubus chamaemorus L.	Cloudberry	0.01; sorbitol, xylitol	Total sugar not reported.	1	Makinen and Soderling (1980)
				R. idaeus L.	Red raspberry	Not detected-0.03; sorbitol, xylitol	Total sugar not reported, 5.5; fructose, glucose	2	Makinen and Soderling (1980) and Muir et al. (2009)
				Rubus spp.	Blackberry	Not detected (except one sample*); *explained in text	2.6–13.9; sucrose, glucose, fructose, sorbitol*; *explained in text	74	Fan-Chiang and Wrolstad (2010), Kafkas, Kosar, Turemis, and Baser (2006), Muir et al. (2009)*, Richmond et al. (1981), and Wrolstad et al. (1980)
				Rubus (parentage unknown; see Lee et al., 2012)	Boysenberry	Not detected	6.2–8.2; glucose, fructose, sucrose	3	Fan-Chiang and Wrolstad (2010) and Wrolstad et al. (1980)
				Rubus (parentage unknown; see Lee et al., 2012)	Loganberry	Not detected	6.7–6.8; glucose, fructose, sucrose	2	Fan-Chiang and Wrolstad (2010) and Wrolstad et al. (1980)

Table 2
Taxonomic classification tree (left; alphabetically listed to genus), sugar alcohols, and major simple sugars (right) in dried Rosaceae fruit (**dry weight, dw**). Even a simple process like dehydration can effect sugar composition and ratio compared to fresh (fresh frozen) fruit. Sugars within the total sugar cells are listed in no particular order.

Kingdom	Order	Family	Subfamily	Genus and Species	Common names	Sugar alcohol levels; list of sugar alcohols found g/100 g dw	Total sugar; list of sugars found g/100 g dw	*n*	References
Plant	Rosales	Rosaceae	Amygdaloidae	*M. domestica* L.	Apple	Not detected	8.8; glucose, fructose, sucrose,	1	Megias-Perez et al. (2014)
				P. avium L.	Sweet cherry	Not detected–8.5; mannitol, *myo*-inositol	6.3–8.1; glucose, fructose, sucrose, mannitol, myo-inositol	2	Megias-Perez et al. (2014)
				P. persica L.	Peach, nectarine	0.96; sorbitol	Total sugar not reported.	1	Washuttl et al. (1973)
				Pyrus L.	Pear	4.6; sorbitol	Total sugar not reported.	1	Washuttl et al. (1973)
				P. cerasus L.	Sour cherry	0.36; xylitol	Total sugar not reported.	1	Washuttl et al. (1973)
			Rosoideae	*Fragaria* spp.	Strawberry	Not detected–5.9; mannitol, xylitol, *myo*-inositol	Total sugar not reported, 5.4–9.1; glucose, fructose, sucrose, mannitol, xylitol, myo-inositol	15	Megias-Perez et al. (2014) and Washuttl et al. (1973)
				R. idaeus L.	Red raspberry	0.18–0.29; mannitol, xylitol, *myo*-inositol	Total sugar not reported, 2.6; glucose, fructose, sucrose, mannitol, xylitol, myo-inositol	2	Megias-Perez et al. (2014) and Washuttl et al. (1973)

preparations. In some pectinase production, sorbitol is used as an osmotic agent (stabilizer) (Durst et al., 1995; Solis, Flores, & Huitron, 1996). Products made from under ripe fruit (easier to harvest and process) may contain higher than expected levels of sugar alcohols as well, since under ripe fruit normally contains more sugar alcohols than fully ripe fruit (Makinen & Soderling, 1980; Serrano et al., 2003).

4. Analysing for simple carbohydrate in fruit and fruit products

Simple carbohydrates can be distinguished by thin layer chromatography (Petrovic & Canic, 1969; Washuttl et al., 1973; Webb & Burley, 1962), gas chromatography (GC) (Makinen & Soderling, 1980; Megias-Perez et al., 2014; Sanz et al., 2004; Wrolstad, Culbertson, Nagaki, & Madero, 1980), and high performance liquid chromatography (HPLC) (Bieleski, Ripperda, Newman, & Reid, 1992; Cantin et al., 2009; Cornwell, Wrolstad, & Reyes, 1981; Fan-Chiang & Wrolstad, 2010; Durst et al., 1995; Ellefson, 2005; Muir et al., 2009; Spanos & Wrolstad, 1987; Usenik, Fabcic, & Stampar, 2008; Zhou et al., 2012). These analyses and methods have been well summarised in Brummer and Cui (2005), De Goeij (2013), Ellefson (2005), Muir et al. (2009), and Sanz and Martinez-Castro (2007) regarding the specific advantages and pitfalls of each separation technique.

Detectors typically used for GC separations (after sugars are derivatised) are Flame Ionization Detector (FID; Megias-Perez et al., 2014; Wrolstad et al., 1980) or Mass Spectrometer Detection (MSD; Fuzfai et al., 2004; Sanz et al., 2004). Several detectors are used for identification by HPLC separations, including Refractive Index Detector (RID; Lee, Keller, Rennaker, & Martin, 2009; Spanos & Wrolstad 1987), ElectroChemical Detector (ECD, also known as PAD, Pulse Amperometric Detector; Ballistreri et al., 2013; Zhou et al., 2012), UV–VIS detection (underivatised and derivatised sugars; Kumagi & Tajima 1997; Lv et al., 2009), FLD detection (after pre- or post derivatisation of sugars; Kumagi & Tajima, 1997), Evaporative Light Scattering Detector (ELSD; Biesiekierski et al., 2011; Muir et al., 2009), and Mass Spectrometer Detection (MSD, Sanz & Martinez-Castro, 2007) with different modes of separation (ion exchange, normal, size exclusion, etc.) (De Goeij, 2013).

In highly coloured small fruits, pigments (like anthocyanins) cause interference for simple carbohydrate detection when separating via HPLC and require removal prior to injection onto the HPLC. Their removal can be accomplished by several methods, including ion exchange or reversed phase sorbent mini-columns (Ballistreri et al., 2013; Cantin et al., 2009; Durst et al., 1995; Fan-Chiang & Wrolstad, 2010; Liu et al., 1999; Muir et al., 2009; Spanos & Wrolstad, 1987; van Gorsel et al., 1992), syringe filters containing nylon, PVP (polyvinylpyrrolidone), etc. (Ledbetter et al., 2006; Lee et al., 2009), or PVP and PVPP (polyvinylpolypyrrolidone) powders alone (added directly to sample; Bieleski et al., 1992; Cornwell et al., 1981). Sample preparations prior to carbohydrate analysis were well reviewed by Sanz and Martinez-Castro (2007).

5. Sugar alcohols and human health

Sugar alcohol is not a health concern for healthy individuals (Yao et al., 2014). Potential health benefits of sugar alcohols have been well summarised by Livesey (2003). Some studies show that abdominal issues attributed to sugar alcohols are not caused by sorbitol alone, but by the fructose:glucose:sorbitol ratio consumed (Biesiekierski et al., 2011; Hoekstra, van Kempen, & Kneepkens, 1993; Livesey, 2003), although additional work is

Table 3
Taxonomic classification tree (left; alphabetically listed to genus), sugar alcohols, and major sugars (right) in processed Rosaceae products. Units are in g/100 g or g/100 mL (**fresh weight, fw**), unless indicated otherwise. Sugars within the total sugar cells are listed in no particular order.

Kingdom	Order	Family	Subfamily	Genus and species	Common names	Sugar alcohol levels; list of sugar alcohols found g/100 g or g/100 mL fw	Total sugar; list of sugars found g/100 g or g/100 mL fw	Sample form	*n*	References
Plant	Dipsacales	Caprifoliaceae	–	Caprifoliaceae	Elderberry	0.03–0.13; sorbitol	Total sugar not provided.	Jam, juice	2	Washuttl et al. (1973)
	Myrtales	Punicaceae	Punicoideae	*P. granatum* L.	Pomegranate	0.3; sorbitol	No total sugar reported; 12–18 °Brix (total soluble solids)	Juice	45	Turkmen and Eksi (2011)
	Rosales	Grossulariaceae	–	*R. nigrum* L.	Black currant	0.10; arabitol, xylitol, sorbitol	Total sugar not reported.	Wine	1	Washuttl et al. (1973)
		Rosaceae	Amygdaloidae	*M. domestica* L.	Apple	0.2–0.8; arabitol, sorbitol	Total sugar not provide, 8.5; glucose, fructose, sucrose, sorbitol	Juice, wine	110	Thavarajah and Low (2006), Van Gorsel et al. (1992), and Washuttl et al., 1973
				P. domestica L.	Plum (red and prune)	0.13–18; sorbitol, galactitol	Total sugar not provided, 16–51; glucose, fructose, sucrose, sorbitol, galactitol	Jam, dried prune, prune juice	16	Stacewicz-Sapuntzakis et al. (2001), Van Gorsel et al. (1992), and Washuttl et al. (1973)
				P. armenica L.	Apricot	3.6–5.2; sorbtiol	47–51; glucose, fructose, sucrose, sorbitol	Dried	2	Stacewicz-Sapuntzakis et al. (2001)
				P. avium L.	Sweet cherry	Not detected-1.20; arabitol, xylitol, sorbitol	Total sugar not provided, 17.4; glucose, fructose, sucrose	Juice, preserve, jam	3	Van Gorsel et al. (1992) and Washuttl et al. (1973)
				P. cerasus L.	Sour cherry	0.98–1.0; arabitol, xylitol, sorbitol, galactitol	Total sugar not provided.	Jam, preserve	2	Washuttl et al. (1973)
				P. persica L.	Peach, nectarine	0.09–0.3; sorbtiol	6.9–10.1; glucose, fructose, sucrose, sorbitol	Juice	2	Van Gorsel et al. (1992)
				Pyrus L.	Pear	0.39–4.1; sorbitol	Total sugar not provided, 14.4; glucose, fructose, sucrose, sorbitol	Juice	29	Thavarajah and Low (2006), Van Gorsel et al. (1992), and Washuttl et al. (1973)
			Rosoideae	*Fragaria* spp.	Strawberry	No sorbitol detected	4.2; glucose, fructose, sucrose	Juice	1	Van Gorsel et al. (1992)
				R. idaeus L.	Red raspberry	Not detected-0.02; sorbitol	0.7–7.4; glucose, fructose, sucrose*, sorbitol* (*not detected in all samples)	Juice around single-strength	46	Durst et al. (1995)
				Rubus spp.	Blackberry	Not detected – 0.21*; *might be from pectinase	6.3–7.8; Glucose, fructose, sucrose	Juice at 10 °Brix ($n = 10$)	10	Fan-Chiang and Wrolstad (2010)

needed (Kyaw & Mayberry, 2011). Recent findings show a diet low in FODMAPs (Fermentable Oligosaccharides, Disaccharides, Monosaccharides, and Polyols) reduces abdominal issues for individuals with Irritable Bowel Syndrome (Halmos, Power, Shepherd, Gibson, & Muir, 2014), but again this is not needed for healthy individuals. The low FODMAP diet used by Halmos et al. (2014) contained no detectable to 0.44 g polyols per day (mean 0.20 g per day), while an average diet contained 2.6–5.8 g of polyols per day (mean 4.21 g per day).

Dried prune plum products (9–18 g of sorbitol/100 g) were one of the highest sorbitol containing Rosaceae fruit summarised in this review (see Table 3; Stacewicz-Sapuntzakis et al., 2001). There are positive health benefits from including dried prune plums in the human diet that were well summarised by Stacewicz-Sapuntzakis (2013) and Stacewicz-Sapuntzakis et al. (2001). The laxative effects of eating dried prune plums are due to their dietary fibre and phenolic content, in addition to their sorbitol concentration (Stacewicz-Sapuntzakis, 2013; Stacewicz-Sapuntzakis et al., 2001). The FDA (Food and Drug Administration) has asserted that sorbitol is Generally Recognized as Safe (GRAS) (21CFR184.1835), though products with sorbitol that might be consumed beyond 50 g (of sorbitol) a day are to bear the warning, "excess consumption may have a laxative effect" (e.g., sugar free candies). Mannitol (the other commonly found sugar alcohol; see Tables 1–3) is also GRAS and according to FDA its daily intake limit for food labelling (same statement as sorbitol) is 20 g (21CFR180.25).

6. Concluding remarks

Hopefully this review will aid in clarifying the misconception regarding sugar alcohol levels in *Rubus* fruit. One serving of fresh, fully ripe, *Rubus* fruit provides less sugar alcohol than one serving of processed fruit product (i.e., juice or dried product). One serving of the highest sugar alcohol level reported in fresh red raspberry contains 0.042 g (0.03 g/100 g; well below a low FODMAP diet example used in this review; Halmos et al., 2014). As most *Rubus* fruit have been found to contain no detectable levels of sugar alcohol, they are clearly not high in sugar alcohols.

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