Perspective: Identifying Ultra-Processed Plant-Based Milk Alternatives in the USDA Branded Food Products Database

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ABSTRACT

This study explored the characteristics of plant-based beverages (PBBs) that are marketed as "milks" in the United States. First, machine searches of product names and ingredients in the USDA Branded Food Products Database (BFPDB) yielded 641 nondairy PBBs that included almond, soy, coconut, cashew, other tree nut, flax/hemp, pea, and quinoa and rice "milks." The products varied in energy density and the majority of PBBs contained added salt (69%) and added sugar (53%). Scores on nutrient density metrics [Nutri-Score, Choices, and the Nutrient Rich Food index 7.3 (NRF7.3)] were higher for almond and pea products and lower for coconut PBBs, which contained saturated fat. Ingredient lists were searched further for added flavors, stabilizers, or preservatives said to be characteristic of the NOVA food classification system's ultra-processed group. Most PBBs (90.1%) and 95% of almond milks met the NOVA criteria for ultra-processed foods, because they were created from food components and contained multiple substances not used in normal cooking. Replacing milk and dairy products with plant-based alternatives will necessarily involve the use of ultra-processed foods. *Adv Nutr* 2021;00:1–8.

Statement of Significance: This work, based on the large USDA Branded Food Products Database (BFPDB), uses electronic ingredient lists to show that plant-based beverage (PBB) milk alternatives fall into the category of ultra-processed foods. The NOVA categorization scheme stands in the way of product innovation for health.

Keywords: plant-based beverages, milk alternatives, NOVA classification, ultra-processed food, sugar-sweetened beverages, Nutri-Score, Nutrient Rich Food index, nutrient profiling, USDA Branded Food Products Database, ingredient list

Introduction

Multiple studies attest to the current interest in ultra-processed foods (1–5) on the part of health professionals (6), public health agencies (7), and policy makers (8). Percentage energy from ultra-processed foods has been linked to higher risks of obesity (8), type 2 diabetes (9), metabolic syndrome (10), hypertension (11), cardiovascular disease (12), depressive symptoms (13), cancer (14), and all-cause mortality (15). Rising consumption of ultra-processed foods has become a matter of public health concern (7).

A guide to identifying ultra-processed foods was published in the journal *Public Health Nutrition* (1). Described as clear and simple by its authors (1), the NOVA food classification system assigns foods into 4 categories—unprocessed, processed, ultra-processed, and culinary ingredients—that are ostensibly based on the extent and the underlying purpose of industrial processing (1, 16). Based on published guidelines (1), industrial creation of ultra-processed food products requires wholesome foods to be fractioned into substances and then reassembled into a product that further benefits from added flavors, stabilizers, and sophisticated packaging (1, 16). The purpose of ultra-processing, as described in the NOVA literature (1, 16), is to displace wholesome unprocessed or minimally processed foods.

Plant-based beverages (PBBs) formulated and reassembled from legumes (soy), nuts, grains, and seeds are clearly intended to displace minimally processed dairy milk (17–20). Almond and soy milks are the most common, but PBB milk alternatives derived from cashews, hazelnuts, walnuts, pistachios, and macadamia nuts are also found, as are PBB products formulated from oats, rice, quinoa, amaranth, and flax or hemp seeds (21, 22). Often promoted as "healthier than milk," PBB milk alternatives are designed to allay consumer fears about allergies, lactose intolerance,

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inflammation, antibiotics, pesticides, and hormones (21–23). The use of dairy terms with reference to nondairy products is permitted in the United States (24) but is prohibited in the European Union (EU) (25).

Plant milks are typically produced by isolating oils from plant sources through soaking, grinding, and heating, sometimes under high pressure (18, 21, 26). Oil globules remain in colloidal suspension, but only in the presence of chemical stabilizers and emulsifiers. The final plant-based product is rounded off with thickening substances and hydrocolloid stabilizing agents, added salt, added caloric or noncaloric sweeteners, and a wide range of added vitamins and minerals (17, 18). The purpose of PBB processing is to prolong product shelf life, promote convenience, improve palatability, and mimic the creaminess and oral mouthfeel sensations of the original product, that is to say, milk (27).

Based on published guidelines (1, 16), ultra-processed foods can be identified by the presence on the ingredient list of added sugar and salt and/or of ≥1 substance never or rarely used in kitchens. Ingredients said to be characteristic of the NOVA ultra-processed food group include sweeteners, oils, protein isolates, and multiple additives and stabilizers that are deployed to make the final PBB product more shelf-stable, more palatable, and more appealing (1, 16).

Ingredient searches are greatly facilitated by the use of electronic ingredient lists (28). The USDA Branded Food Products Database (BFPDB) (28) lists the ingredients for 239,089 foods sold in the United States: data contributed by the manufacturers and never previously captured by the USDA. Machine searches were used to identify those PBBs that specifically used the term "milk" in their product name. Searches of ingredients were used to identify plant components (nuts, grains, legumes) and the main forms of added sugar, salt, vitamins, and minerals. Further searches were conducted for ingredients rarely used in kitchens and for additives said to identify ultra-processed foods (1). Nutrient density of PBB products was evaluated using 3 nutrient profiling models: Nutri-Score (29), Choices (30), and the Nutrient Rich Food Index 7.3 (NRF7.3) (31, 32).

Methods

The USDA BFPDB

The USDA BFPDB (28) was the result of a public–private partnership between the Agricultural Research Service of the USDA, the International Life Sciences Institute (ILSI) North America, and other organizations. The BFPDB lists 239,089 foods and provides product long name, manufacturer name, energy content, and values for those nutrients (per 100 g) that were listed on the Nutrition Facts Panel. Contributed by the manufacturers, these values were checked and verified in the course of database development (28). Associated with each item was an ingredient list. The BFPDB is publicly available and can be downloaded from the US Agricultural Data Commons (28).

Name-searches of product long names were used to identify those PBBs that specifically used the term "milk" in the product name. Searches used alternative spellings (e.g., almondmilk, cashewmilk) to identify plant milk drinks or beverages (e.g., seed milk drink; quinoamilk beverage) or milk blends (e.g., almondmilk & coconutmilk blend; almond & soymilk blend). Flavored plant milks with coffee, fruit, and other flavors were included. Cultured milks and flavored cultured milks were included. Those PBBs that did not use the term "milk" in their product name were not included. Excluded were coffee or tea *with* plant milks, and other products where plant milk was an adjunct and not the main item (e.g., tapioca pearls *with* plant milk). Adjectival names such as milked almonds or milked peanuts were not included. For PBBs with names such as "golden milk," ingredient lists were searched to ensure that a plant component (e.g., pea, cashew) was the main ingredient. PBB blends were assigned by their main component.

Excluded from analyses were PBBs with energy density that was missing or listed as 0; PBBs with energy density <10 kcal/100 g; and those whose energy density, as supplied by the manufacturer, was >250 kcal/100 g. Products with energy density >250 kcal/100 g are generally not liquids but solids or semisolids. A total of 641 PBB milk alternatives were coded by type as almond ($n = 273$), coconut ($n = 192$), soy ($n = 101$), cashew ($n = 30$), tree nut (pistachio, macadamia, walnut, or pecan) ($n = 10$), flax/hemp ($n = 16$), pea ($n = 13$), and quinoa and rice ($n = 6$).

The BFPDB Back-of-Pack ingredient list

The BFPDB ingredient list was a key resource, even though the amounts of each ingredient were not provided. The US Code of Federal Regulations Section 101.4, Title 21 (33), specifies that the ingredients must be listed in order of predominance, with those used in the greatest amount to be listed first, followed in descending order by those used in smaller amounts. Although quantitative declarations are not required in the United States, European Commission notice 2017/C393/05 does require a quantitative ingredient

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Abbreviations used: BFPDB, Branded Food Products Database; DV, Reference Daily Value; EU, European Union; FSA, Food Standards Agency; FSAm-NPS, Food Standards Agency Nutrient Profiling System (modified version); IU, International Units; LIM, nutrients to limit subscore; NRF, Nutrient Rich Food index; PBB, plant-based beverage.

declaration (QUID) when the ingredient (or a category of ingredients) is included in the food name (34).

Ingredient declarations in the USDA BFPDB were comprehensive. For example, almond milk from Ahold USA Inc. declared, "almondmilk (filtered water, almonds), cane sugar, calcium carbonate, sea salt, potassium citrate, carrageenan, sunflower lecithin, natural flavor, vitamin A palmitate, vitamin D-2, d-alpha-tocopherol (natural vitamin E)." Almond milk from White Wave Foods declared, "almond milk (water, almonds), dried cane syrup, pea protein, rice protein, calcium phosphate, magnesium phosphate, carrageenan, vanilla extract, natural flavor, locust bean gum, kosher sea salt, vitamin A palmitate, L-selenomethionine (selenium), zinc oxide, folic acid, vitamin B-12." Almond milk from Whole Foods listed, "organic almondmilk (filtered water, organic almonds), organic cane sugar, organic locust bean gum, sea salt, sunflower lecithin, tricalcium phosphate, gellan gum, potassium citrate, vitamin A palmitate, ergocalciferol (vitamin D2), DL-alpha-tocopherol acetate (vitamin E), cyanocobalamin (vitamin B-12)."

Listed in the BFPDB were the nutrients on the Nutrition Facts Panel and those for which a nutrient claim was made (28). Total sugar was listed but added sugars content was not. Given that added sugar is an important component of some nutrient density scores (31, 32), PBB ingredient lists were machine-searched for added caloric sweeteners. Those were variously described as sugar, cane sugar, pure cane sugar, dried cane syrup, evaporated cane syrup, evaporated cane juice, evaporated cane juice syrup, brown rice syrup, honey, organic maple syrup, and organic dates. The FDA defines added sugars as those that are added during the processing of foods (sugar, sucrose, fructose, dextrose), added sugars from syrups and honey, and added sugars from concentrated fruit or vegetable juices. Treated as added sugars by the FDA (35) and in the present analyses were concentrated or evaporated cane syrup or cane juice; corn, maple, date, rice, or brown rice syrup; coconut sugar; fruit juice concentrate; and date juice. Added sugars do not include naturally occurring sugars in milk, vegetables, or fruit. Based on data for beverages with no added sweeteners, naturally occurring sugars were estimated at ∼0.4 g/100 g for almond, cashew, and other nut and soy beverages, and at as much as 3.00 g/100 g for coconut milks.

Identifying ultra-processed foods

Based on the NOVA classification scheme (1–3), ultra-processed beverages are not necessarily those that have gone through industrial processes such as removal of inedible husks or shells, soaking, steam blanching, squeezing, crushing, grinding, drying, powdering, high-pressure homogenization, pulsed electric fields, ultrasound, nonalcoholic fermentation, fortification, chilling, freezing, or placing in containers (1). Rather, ultra-processed foods should be identified by the presence on the ingredient list of chemical and nonnutritive substances not used in kitchens, such as added caloric or noncaloric sweeteners, hydrogenated oils, hydrolyzed proteins, flavors, flavor enhancers, emulsifiers, emulsifying salts, thickeners, and bulking and gelling agents (1, 16). Another criterion for assigning foods to the ultra-processed category is the addition in the course of industrial processing of sugar, salt, and/or fat (1, 16).

The electronic ingredient lists were accordingly machine-searched for the presence of caloric sweeteners in their many forms (see above); added sodium listed as Himalayan salt, pink sea salt, or in other forms; and for added oils. Additional searches were conducted for ≥1 mention of protein isolates or concentrates of pea, rice, and whey; for added natural flavors and flavor enhancers; emulsifiers such as polysorbate 80; bulking agents and other thickeners such as sodium carboxymethyl cellulose, cellulose gel, guar gum, xanthan gum, locust bean gum, carrageenan, and gellan gum; and a variety of antioxidants and preservatives. Rarely used in kitchens (another NOVA criterion) were vitamin A palmitate and acetate, vitamin E acetate, vitamin D_2, vitamin B-2, zinc sulfate, zinc gluconate, calcium carbonate, sodium polyphosphate, tricalcium phosphate, potassium citrate, dipotassium phosphate, sulfur dioxide, and potassium metabisulfate, a preservative (1).

PBBs with added sugar or salt but without declared stabilizers, bulking agents, or other chemicals were assigned to the processed foods category, again following strict NOVA criteria (1, 16). Classified as "unprocessed" were those products whose ingredient lists simply read "almonds, water," "filtered water, organic almonds," or "coconut milk, 100%" with no mention of added chemicals, sugar, or salt.

Nutrient profiling models

The Nutri-Score began as the UK Food Standards Agency–Office of Communications (FSA-Ofcom) model (36, 37) that was further developed by the Santé Publique, France (38). The Nutri-Score negative "A" points are based on a food's content of calories, saturated fat, total sugars, and sodium (39). The positive "C" points are based on protein and fiber. However, protein points in Nutri-Score are considered only when the fruit, vegetable, legume, or nut content of the foods exceeds 80%, which was not the case with plant milks. The Nutri-Score was thus the composite A (negative) score minus the fiber (positive) score. Milk and PBB milk alternatives are not considered beverages for calculating the Nutri-Score (38). Nutri-Score points are converted into color-coded letter grades on consumer-facing front-of-pack labels. A final score of ≤ -1 points corresponds to letter grade A; 0–2 points correspond to letter grade B; 3–10 points correspond to C; 11–18 points correspond to D; and point scores $\geq$ 19 correspond to letter grade E.

Choices International (30) has a category of nondairy milk substitutes. Here, the scoring criteria are based on saturated fat ≤ 1.1 g/100 g; sodium ≤100 mg/100 g; total sugars ≤ 5.0 g/100 g; and beverage energy ≤40 kcal/100 g. Products need to satisfy all criteria to receive a favorable rating.

The NRF7.3 is given by NRF7.3 = NRn – LIM, where NR7 is a positive NR7 subscore of n nutrients to encourage and LIM is a negative subscore of 3 nutrients to limit (31, 32, 40, 41). The current NRF7.3 was based on protein, fiber,

TABLE 1 Nutrient density of PBBs described as "milks" by product type[1]

PBB product type	Total	PBB characteristics			Nutrient density scores		
		Added salt *n* (% total)	Added sugar *n* (% total)	Ultra-processed *n* (% total)	NRF7.3 score Mean ± SE	Nutri-Score points Mean ± SE	Choices *n* passing (%)
All	641	444 (69.3)	347 (54.1)	581 (90.1)	46.05 ± 2.75	9.63 ± 0.25	263/641
Almond	273	265 (97.1)	161 (59.0)	260 (95.2)	87.52 ± 4.08	6.06 ± 0.22	191/273
Coconut	192	19 (9.9)	51 (26.6)	173 (90.1)	− 23.70 ± 2.03	16.3 ± 0.40	0/192
Soy	101	91 (90.1)	88 (87.1)	91 (90.1)	60.52 ± 2.67	8.12 ± 0.31	31/101
Cashew	30	28 (93.3)	22 (73.3)	16 (53.3)	38.73 ± 12.18	9.47 ± 1.21	14/30
Tree nuts	10	10 (100.0)	6 (60.0)	9 (90.0)	71.09 ± 17.14	6.00 ± 0.94	8/10
Flax, hemp	16	15 (93.7)	9 (58.3)	14 (87.5)	55.37 ± 10.96	6.75 ± 1.02	11/16
Pea	13	10 (76.9)	8 (61.5)	13 (100.0)	81.11 ± 10.26	7.31 ± 1.35	6/13
Quinoa, rice	6	6 (100.0)	2 (33.3)	5 (83.3)	42.08 ± 10.25	9.17 ± 1.07	2/6
					$P = 0.000$	$P = 0.000$	

[1] Values are *n* (% total) and means ± SEs. NRF, Nutrient Rich Food index; PBB, plant-based beverage.

vitamins A and D, calcium, iron, and potassium. Nutrient standards were based on the US Reference Daily Values (DVs) as published by the FDA (33). The reference amounts were 50 g protein, 28 g fiber, 5000 IU vitamin A (original value), 800 IU vitamin D, 1300 mg Ca, 18 mg Fe, and 4700 mg K. Maximum recommended values were 20 g for saturated fat, 50 g for added sugar, and 2300 mg for sodium. Each nutrient was expressed as a percentage DV (%DV) calculated per 100 kcal and capped at 100%.

Analyses of nutrient density by product category were based on 1-factor ANOVAs followed by post hoc tests where appropriate. Analyses used the SPSS Statistical Package version 16.0 (IBM).

Results

Table 1 shows product composition and nutrient density scores by product category. Added salt was found in 444 products (69%) and added sugar was found in 347 (53%). Out of 641 PBBs, 581 (90.1%) contained flavors, gums, stabilizers, and preservatives and were therefore classified as ultra-processed foods (1).

The 3 nutrient density profiles produced comparable results. The NRF7.3 model awarded higher scores to PBBs that were higher in protein, were fortified with vitamins and minerals, had no added sugar, and were low in saturated fat. The highest NRF7.3 scores were obtained for almond, pea, and tree nut PBBs, followed by soy. The lowest scores were for coconut milk. No PBBs received a letter grade A score on Nutri-Score. Most mean Nutri-Score values by PBB category were in the 3- to 10-point range, equivalent to a C letter grade, with lower scores (good) given to almond, tree nut, and flax/hemp PBBs followed by pea. Coconut milks had higher scores (bad) and received a D letter grade. The pass rate in the Choices system was highest for almond, tree nut, flax, and hemp PBBs. Coconut milks had a 0 pass rate on the Choices system.

The 3 nutrient density profiles were clearly related. **Figure 1** shows that the Nutri-Score values for PBBs and the NRF7.3 values were closely and inversely linked ($r = -0.82$). In general, those PBBs that were rated as more nutrient dense were those that contained fewer calories per 100 g. Both Nutri-Score and the NRF7.3 model were inversely linked to energy density. The **Figure 2** scatterplot shows that the Nutri-Score point values for PBBs and their energy density (kcal/100 g) were effectively collinear: the correlation coefficient was 0.90. In this particular instance, Nutri-Score did little more than capture the energy density of the PBBs.

Figure 3 shows the relation between the NRF7.3 scores for PBBs and their energy density, indicating those that passed the Choices nutrient density criteria. The correlation between the NRF7.3 scores and energy density was −0.67, lower than for Nutri-Score but significant nonetheless.

Discussion

Machine searches of electronic ingredient lists were the ideal tools for identifying ultra-processed foods in the very large BFPDB (1). Based on published and often-restated criteria (1, 16), ultra-processed foods are products that are created mostly or entirely from substances extracted from foods, contain added sugar and salt, and also contain flavors and additives that imitate sensory qualities of the original product. PBB products, intended as milk alternatives, benefit from advanced food processing technologies that allow the processed products to mimic the sensory appeal of milk, preserve emulsion stability, maintain nutrient content, and prolong shelf life (42–45). The present searches of PBB ingredients pointed to substances extracted from legumes, nuts, grains, and seeds and to widespread use of flavors, stabilizers, and chemical additives. PBB milk alternatives were, on the whole, a perfect fit for the NOVA category of ultra-processed foods.

It would appear that the NOVA classification system, demonizing processed and ultra-processed foods (1, 16), stands counter to the ongoing innovation and reformulation of food products that are suitable for plant-forward diets. Many plant-based foods and beverages, especially those containing blended and reformulated proteins, fall into the NOVA category of ultra-processed foods (1, 16). Plant-based spreads and dips, intended to support vegetarian and

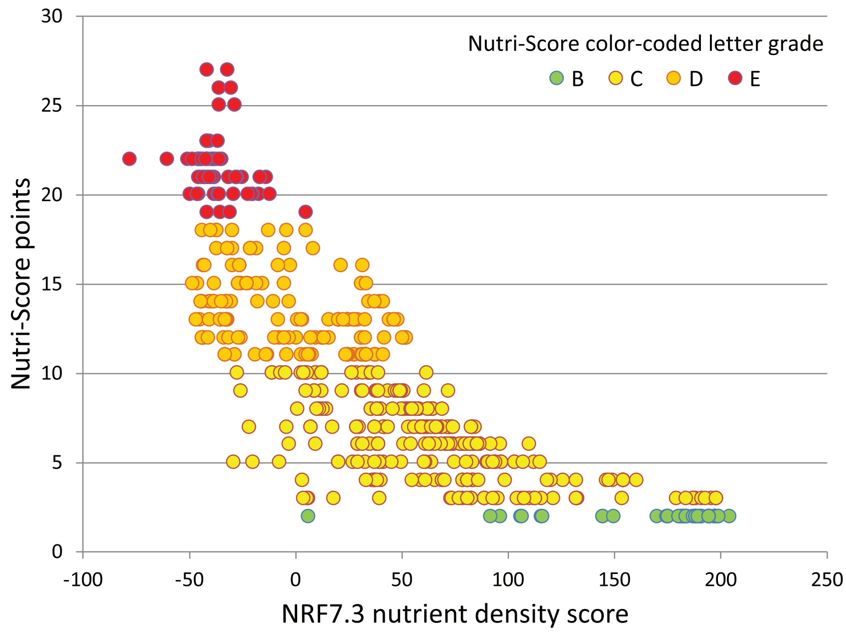

FIGURE 1 A scatterplot of Nutri-Score point values against NRF7.3 scores for plant-based beverages ($n = 641$). Nutri-Score values are color-coded to correspond to front-of-pack Nutri-Score grades. NRF, Nutrient Rich Food index.

vegan food patterns, will also fall into the ultra-processed category. In a further innovation, advanced food processing technologies are also being deployed for the production of animal-free meat analogs, from soy, peas, legumes, and wheat. Those too will qualify as ultra-processed foods (46).

The present findings pose an interesting paradox. In the current literature, ultra-processed foods have been linked to a higher risk of obesity, diabetes, cancer, and all-cause mortality (8–15). Growing evidence of a link between ultra-processed foods and higher risk of noncommunicable disease has led to calls for public health action (7).

The same literature has also identified many health benefits of plant-based diets. Plant-based dietary patterns

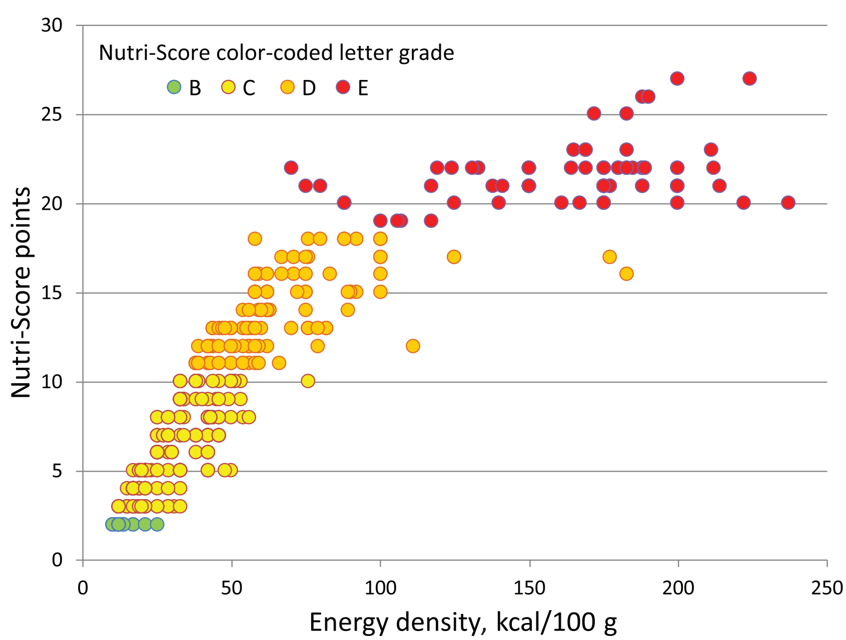

FIGURE 2 A scatterplot of Nutri-Score point values against energy density (kcal/100 g) of plant-based beverages ($n = 641$). Nutri-Score values are color-coded to correspond to front-of-pack Nutri-Score grades.

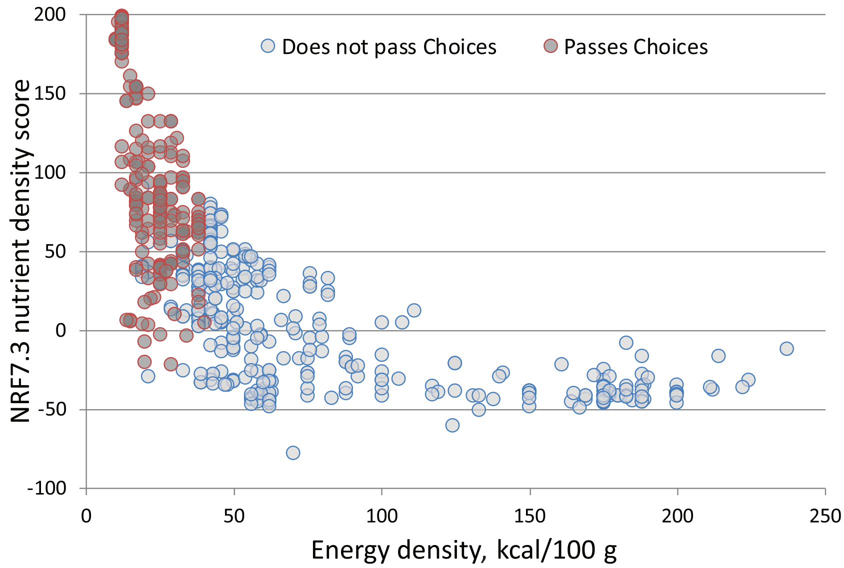

FIGURE 3 A scatterplot of NRF7.3 scores against energy density (kcal/100 g) of PBBs ($n = 641$). PBB products that pass Choices International criteria are indicated and color-coded. NRF, Nutrient Rich Food index; PBB, plant-based beverage.

have been linked to lower rates of obesity (47), diabetes (48), cancer (49), and all-cause mortality (50). Growing evidence of a link between plant-based diets and lower risk of noncommunicable disease has led to calls for public health action (51, 52).

Now it appears that most PBBs, a rapidly growing market segment, fall into the NOVA category of ultra-processed foods. As we move toward more plant-forward diets, this seeming paradox can be resolved in 1 of 2 ways. The first approach will require epidemiologists to separate "good" plant-based foods from "bad" plant-based foods, depending on health outcomes (53–55). Declarations that not all plant foods are created equal are becoming more common (56). There are further concerns that vegetarian diets that contain ultra-processed plant foods may not confer the expected health benefits (57). A Healthy Plant-Based Dietary Index (HPDI) and Unhealthy Plant-Based Dietary Index (UPDI) are already in place (53, 54). The PBB product category, in particular, would benefit from harmonization and standards of identity (58).

Despite statements to the contrary, the NOVA categorization seems to be based in part on the foods' content of added fat, sugar, and salt (59). Previous studies have reported an overlap between the NOVA ultra-processed category assignment and low NRF scores of foods (59). Because the NRF and Nutri-Score are linked, some overlap with Nutri-Score is inevitable. As shown by recent studies in France (12), large percentages of foods highly rated "A" or "B" by Nutri-Score fell into the ultra-processed NOVA category. The percentages were 23.9% for grade "A" foods and 57.8% for grade "B" with higher percentages for less favorable Nutri-Score values. The surprising conclusion was that ultra-processed foods may be deleterious to health, regardless of their favorable Nutri-Score values (12). That would seem counter to the current efforts to penalize ultra-processed foods while making Nutri-Score the nutrient density standard in the EU. Support for Nutri-Score came from a study showing that unfavorable scores on another nutrient density score [FSA Nutrient Profiling System (modified version) (FSAm-NPS)] were associated with higher mortality for all causes and for cancer and diseases of the circulatory, respiratory, and digestive systems (60). The Nutri-Score and the FSAm-NPS models are linked but so are Nutri-Score and the NRF model. More recently, the NRF11.3 model, a Sweden-adapted variant of the NRF9.3 index, was associated with lower mortality in the study population (61). It would appear that the FSAm-NPS, Nutri-Score, and the NRF scores are all related and can replace the increasingly superfluous NOVA classification of foods.

One way out of this dilemma would be for the ever-changing NOVA criteria to declare that all "good" plant-based foods are minimally processed. Coffee and tea are already classified as minimally processed in the NOVA scheme, as are freshly squeezed fruit juices, and home-made almond milk (1–3). The NOVA classification scheme could also be amended to separate "good" nonnutritive chemicals from "bad" nonnutritive chemicals. Should the NOVA guide be revised, chances are that healthy plant proteins, natural hydrocolloid stabilizers (guar gum), and nutritious vitamin and mineral mixes will no longer be indicative of ultra-processed foods. The NOVA guide might well refocus on product reformulation and the foods' content of fat, sugar, and salt.

In conclusion, dietary guidelines that promote plant-based diets but penalize industrial processing may need to acknowledge the fact that most PBB milk alternatives and, by extension, all plant-based high-quality proteins are ultra-processed foods.

Acknowledgments

The sole author was responsible for all aspects of this manuscript.

Data Availability

The USDA Branded Food Products Database (BFPDB) is publicly available online at FoodData Central.

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