RESEARCH ARTICLE

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Evaluation of energy and nutrient content of fruit juices and similar beverages in Türkiye and their investigation in terms of sustainability

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Abstract
This study aims to evaluate the contents of fruit juices and similar beverages in the Turkish market and to examine them in line with the Sustainable Development Goals. Within the scope of the study, the researchers examined the label information of 187 fruit juices and similar beverages from 26 different brands in four different product types. It was determined that all fruit nectars (100%) and almost all fruit and flavored beverages contain added sugar (92.8% for fruit beverages and 70.0% for flavored beverages). It was further detected that 17.5% of fruit nectars and 20.3% of fruit beverages contain sweeteners. Moreover, more than 100% of the daily sodium requirement is met by consuming 100 ml of fruit juice, nectar, or beverages. It was determined that orange and apple juices, apricot, peach, and cherry fruit nectars, and peach, sour cherry, and orange fruit beverages contain more sugar than freshly squeezed fruit juices ($p<0.05$). The high-fructose syrup manufacturing industry produces large volumes of waste liquid containing various waste carbohydrates, which has a significant environmental impact. Greenhouse gas emission sources are also released to the environment in sugar production processes. On the other hand, it was determined that most of the products examined were packaged in Tetra Pak® packaging. More sustainable product supply chains are those that optimize the use of materials, water, and energy throughout their lifecycle while minimizing waste from products and used packaging. In light of the data obtained from this study, it would be useful for the fruit juice industry to make regulations to ensure sustainable production and consumption patterns in order to ensure a healthy and quality life at all ages.
Keywords: Fruit Juice, Fruit Nectar, Food Labelling, Sustainable Development

INTRODUCTION

Malnutrition continues to affect millions of people globally, particularly women, children, and other vulnerable populations (Lopez de Romaña et al., 2021). Unsustainable food production is one of the leading causes of malnutrition (Grosso et al., 2020). The consumption of healthy foods produced through sustainable food systems is a fundamental approach not only for malnutrition but also for the solution to climate change, loss of biodiversity, and environmental pollution (Pekcan, 2023; UN Nutrition, 2022). United Nations member states adopted 17 Sustainable Development Goals (SDGs) to end poverty, protect the planet, and improve the lives and futures of all by 2030. Nutrition directly affects two of the Sustainable Development Goals (SDG 2: "End hunger, achieve food security and improved nutrition and promote sustainable agriculture" and SDG 3: "Ensure healthy lives and promote well-being for all at all ages"). It also indirectly affects many of the other development goals. In turn, nearly all Sustainable

Development Goals affect nutrition (Lopez de Romaña et al., 2021).

Food production and consumption significantly impact environmental objectives (SDG 6, 7, 9, 12, 13, 14, and 15). Food production is responsible for a significant portion of global greenhouse gas emissions. In addition, food production is responsible for the overuse of fresh water and agricultural land and the loss of biodiversity (Smetana et al., 2019). Considering the environmental sustainability and health consequences of food production and consumption, the necessity of a global food system transformation is discussed to achieve significant and ambitious changes in sustainability (Grosso et al., 2020). In this context, there is a growing need to evaluate the fruit juice industry, an essential economic activity in the world, regarding sustainability (Esturo et al., 2023).

When the guidelines on fruit juice consumption worldwide are examined, it is seen that the guidelines of numerous countries include the necessity of preferring whole fruits over fruit juice and place limitations on the amount of fruit juice consumption (Herforth et al., 2019). For example, the Dietary Guidelines for Americans emphasize that the majority of fruits consumed should be whole fruits rather than fruit juice and that when fruit juice is consumed, it should be 100% fruit juice (United States Department of Agriculture, 2016). Furthermore, several countries convey clearly negative messages about juice and similar beverages (Herforth et al., 2019). The Turkish Dietary Guidelines (2022) state that fruit juices contribute to daily energy intake but are insufficient in terms of dietary fiber, may cause an increase in body weight depending on the amount of consumption, and frequent consumption may cause tooth erosion because they are generally acidic. It is recommended that the daily consumption of fruit juice should be 125 mL and should not exceed 120 mL/day for 1–3-year-olds, 180 mL/day for 4–6-year-olds, 240 mL/day for 7–18-year-olds and 240 mL/day for adults (T.R. Ministry of Health, 2022). A study evaluating fruit juice consumption with 569,000 participants from 46 countries determined that adults around the world consumed an average of 0.16 servings of fruit juice per day in 2010 (Singh et al., 2015). In the sector report of the Fruit Juice Industry Association, it is stated that the consumption amount of fruit juice and similar products per capita reaches approximately 12 liters per year, and approximately 9 liters of this amount consists of 100% fruit juice and fruit nectar consumption (Akdağ, 2011).

The fruit juice sector faces various challenges to meeting the Sustainable Development Goals, such as providing healthy and safe working conditions (related to SDG 8), reducing waste from production (related to SDG 12), protecting the ecosystem (related to SDGs 14 and 15) and rational use of natural resources. Environmental sustainability and the impact of food production on the planet have come to the fore through increased consumer awareness of the nutritional benefits of fruit juices without added sugar, sweeteners, and preservatives for a healthy and quality lifestyle (Esturo et al., 2023).

This study aims to evaluate the energy and nutritional content of fruit juices and similar beverages available in the Turkish market and to examine them in line with the Sustainable Development Goals.

MATERIALS AND METHODS

This study examined the labels of fruit juices and similar beverages offered for sale in the Turkish market from supermarkets and virtual markets in Kırıkkale and Ankara provinces between August and December 2022. As a result of the market research, 187 products from 26 brands were reached. Fruit juices, fruit nectars, fruit beverages, and flavored beverages were included in the study based on the Turkish Food Codex Communiqué on Fruit Juice and Similar Products (T.R. Official Gazette, 6 August 2014). These are products produced without gas by adding water and/or other ingredients, with or without sugar. The study did not include fruit-flavored acidic beverages, fruit-flavored soda, mineral waters, and fruit-flavored beverage powders.

As a data collection tool, an evaluation form was used that provides information about the brand name, product name, fruit type, fruit ratio, ingredients, the status of added sugar, the type of added sugar, the status of sweetener content, the sweetener type of fruit juice and similar beverages, energy and nutrient content, package size, package type, and product technology. This form was created by examining the Turkish Food Codex Communiqué on Soft Drinks (Communiqué No:2007/26) (T.R. Official Gazette, 15 June 2007), the Turkish Food Codex Communiqué on Sugar (Communiqué No:2006/40) (T.R. Official Gazette, 23 August 2006), and the Turkish Food Codex Communiqué on Fruit Juice and Similar Products (Communiqué No:2014/34) (T.R. Official Gazette, 6 August 2014). The energy and nutrient contents obtained from the examination of the products were compared with the dietary reference intake levels of an average adult, and the coverage percentages were calculated (National Institutes of Health, 2023). In addition, the carbohydrate and sugar contents of the products based on the fruit type were evaluated by comparing them with freshly squeezed fruit juices (unpackaged) in the National Food Composition Database (Türkomp, 2023).

Features of fruit juices and similar drinks such as energy and nutritional content, added sugar status, added sugar type, sweetener content, sweetener type, fruit type, production technologies and packaging were examined in terms of sustainability based on the articles "to ensure a healthy and quality life at all ages" (SDGs 3) and "to provide sustainable production and consumption patterns" (SDGs12).

Statistical analysis

The data obtained from the study were evaluated with the SPSS 22.0 statistical package program. The conformity of the variables to the normal distribution was examined by visual (histogram and probability graphs) and analytical methods (Kolmogorov-Smirnov and Shapiro-Wilk tests). Qualitative variables are expressed as numbers (n) and percentages (%), and quantitative variables as lower and upper values, mean, and standard deviation ($\bar{X} \pm SD$). Pearson's Chi-square test was used to compare categorical variables, and Fisher's Exact Chi-square test was used when the number of samples in the crosstab was insufficient, and the assumption could not be met. The comparison of two groups independent of a numerical variable in parametrically distributed data was performed with the help of a one-sample t-test. For data showing a non-parametric distribution, the Wilcoxon one-sample signed-rank test was used, and the deviation values from the reference were given. In all statistical tests, the confidence interval was accepted as 95.0%, and statistical significance was accepted as $p<0.05$.

RESULTS AND DISCUSSION

Within the scope of the study, the label information was examined for 187 fruit juices and similar beverages from 26 different brands in four different product types. These products consist of six kinds of fruit juices from 12 brands, 10 kinds of fruit nectars from 16 brands, 15 kinds of fruit beverages from 17 brands, and six kinds of flavored beverages from five brands (Table 1).

Table 1. Number of brands, types, and products of fruit juice and similar beverages included in the study

Product Type	Number of Brands (n)	Number of Fruit Types (n)	Number of Products (n)
Fruit Juices	12	6	51
Fruit Nectars	16	10	57
Fruit Beverages	17	15	69
Flavored Beverages	5	6	10

Table 2 presents information on the type of fruit, fruit ratios, the status of added sugar content and type, the status of sweetener content and type, product technology, and packaging type of 187 fruit juices and similar beverages examined within the scope of the study. The majority of the products consisted of mixed fruit types. It was determined that the products with the highest fruit rate were fruit juices and fruit nectars. All fruit nectars (100%) and almost all fruit and flavored beverages contain added sugar (92.8% for fruit beverages and 70.0% for flavored beverages). The most common type of added sugar is sucrose. Fruit juices and flavored beverages do not contain sweeteners, while 17.5% of fruit nectars and 20.3% of fruit beverages contain sweeteners. Furthermore, 70.0% of fruit nectars containing sweeteners, and 50.0% of fruit beverages containing sweeteners contain sucralose. It was determined that most of the products examined were packaged in Tetra Pak® packaging.

Table 3 presents the comparison of the energy and some nutrient contents of 100 ml of fruit juice and similar beverages with the dietary reference intake levels of an average adult and the percentages of coverage. It was determined that fruit juice has the highest coverage percentage in general in terms of meeting the needs of an adult individual. The consumption of 100 ml of fruit juice fulfills 2.53% of the daily energy requirement, 9.21% of the carbohydrate need, and 0.66–0.80% of the protein need. Fruit juice consumption meets 21.62% of free sugar intake, fruit nectar consumption meets 21.84%; fruit beverage consumption meets 19.64%, and flavored beverage consumption 19.46%. It has been found that more than 100% of the daily sodium requirement is met with the consumption of 100 ml of fruit juice, fruit nectar, or fruit beverages.

When the carbohydrate and sugar content of fruit juices and similar beverages were compared with freshly squeezed fruit juices according to the National Food Composition Database (Türkomp), it was determined that orange-type fruit juices contained fewer carbohydrates and more sugar compared to freshly-squeezed orange juice, and apple-type fruit juices contained more carbohydrates and sugar compared to freshly-squeezed apple juice ($p<0.05$). Apricot- and peach-type fruit nectars contained fewer carbohydrates and more sugar than freshly-squeezed apricot and peach juices, respectively ($p<0.05$). Sour cherry fruit nectars contained more sugar than freshly-squeezed cherry juice ($p<0.05$). Peach- and cherry-type fruit drinks contained fewer carbohydrates and more sugar compared to freshly-squeezed peach and cherry juices, respectively. Finally, orange-type fruit drinks contained more sugar than freshly-squeezed orange juice ($p<0.05$) (Table 4).

Sustainable development aims to provide economic and social development and environmental protection. These aspects of sustainable development are crucial to securing the future of the juice industry. For this reason, fruit juice and similar beverages should be produced within the limits of sustainability (Esturo et al., 2023). From this point of view, it has become essential to focus on the sugar contents, sugar amounts, fructose-glucose syrup contents, and production and packaging techniques of fruit juice and similar beverages that all age groups can reach. This study hence evaluated the energy and nutritional content of fruit juices and similar beverages in Türkiye regarding the sustainability from different aspects.

The Sustainable Development Goals and Indicators booklet published by the Presidency of the Republic of Türkiye Strategy and Budget Department in 2019 includes the articles "to ensure a healthy and quality

Table 2. Evaluation of fruit juice and similar beverages in terms of sustainability

	Fruit Juices (n=51)		Fruit Nectars (n=57)		Fruit Beverages (n=69)		Flavored Beverages (n=10)		
	N	%	n	%	n	%	n	%	p
Fruit Type									
Mixed	31	60.8	18	31.5	23	33.3	2	20.0	
Apricot	-	-	14	24.5	3	4.3	1	10.0	
Peach	-	-	13	22.8	5	7.2	-	-	
Cherry	-	-	5	8.8	10	14.5	-	-	
Orange	6	11.8	2	3.5	5	7.2	-	-	
Apple	8	15.7	-	-	-	-	2	20.0	0.00[a*]
Lemon	-	-	-	-	8	11.7	1	10.0	
Pineapple	-	-	1	1.8	6	8.7	1	10.0	
Pomegranate	4	7.8	1	1.8	-	-	-	-	
Mango	-	-	1	1.8	1	1.4	3	30.0	
Others (**)	2	3.9	2	3.5	8	11.7	-	-	
Fruit Ratio									
%100	51	100.0	-	-	-	-	-	-	
%25-99	-	-	57	100.0	9	13.0	-	-	0.00[a*]
%10-24	-	-	-	-	58	84.1	-	-	
<%10	-	-	-	-	2	2.9	7	70.0	
Not specified	-	-	-	-	-	-	3	30.0	
Condition of Containing Added Sugar									
Yes	-	-	57	100.0	64	92.8	7	70.0	0.00[b*]
No	51	100.0	-	-	5	7.2	3	30.0	
Type of Added Sugar									
Sucrose	-	-	34	59.6	34	53.1	6	85.7	
Fructose-glucose syrup	-	-	11	19.4	5	7.8	-	-	0.133[a]
Sucrose+Fructose-glucose syrup	-	-	6	10.5	8	12.5	-	-	
Not specified	-	-	6	10.5	17	26.6	1	14.3	
Sweetener Content Status									0.001[a*]
Yes	-	-	10	17.5	14	20.3	-	-	
No	51	100.0	47	82.5	55	79.7	10	100.0	
Sweetener Type									
Sucralose	-	-	7	70.0	7	50.0	-	-	
Acesulfame K+Sucralose	-	-	2	20.0	3	21.5	-	-	
Aspartame+Acesulfame K	-	-	-	-	2	14.3	-	-	0.717[a]
Aspartame+Acesulfame K+Sucralose	-	-	-	-	1	7.1	-	-	
Acesulfame K+Sodium Cyclamate+Sucralose	-	-	-	-	1	7.1	-	-	
Not specified	-	-	1	10.0	-	-	-	-	
Product Technology									
Pasteurization	36	70.6	36	63.2	45	65.2	3	30.0	
Flash Pasteurization	4	7.8	-	-	-	-	-	-	0.017[a*]
Heating+Cooling	-	-	1	1.7	1	1.5	-	-	
Not specified	11	21.6	20	35.1	23	33.3	7	70.0	
Packaging Type									
Tetra Pak	34	66.7	48	84.2	41	59.4	6	60.0	
PET	4	7.8	-	-	18	26.1	-	-	
Glass	12	23.5	1	1.8	-	-	3	30.0	
Tetra Rex	-	-	3	5.3	6	8.7	-	-	0.00[a*]
Sunpack	1	2.0	4	6.9	-	-	-	-	
Tin box	-	-	1	1.8	2	2.9	-	-	
Pouch partners	-	-	-	-	2	2.9	-	-	
Polypropylene	-	-	-	-	-	-	1	10.0	

* p<0.05, ** Mandarin, Guava, Grape, Crane, Passion Fruit, Blackcurrant, Pear, Strawberry, Grapefruit, Black Mulberry, [a] Fisher test, [b] Chi-square test, PET: Polyethylene terephthalate

Table 3. Evaluation of energy and some nutritional content of fruit juices and similar beverages according to references (100 ml)

Energy and Nutrients	Fruit Juices (n=51)		Fruit Nectars (n=57)		Fruit Beverages (n=69)		Flavored Beverages (n=10)	
	$\bar{X}$±SD Min-Max	Coverage Percentage	$\bar{X}$±SD Min-Max	Coverage Percentage	$\bar{X}$±SD Min-Max	Coverage Percentage	$\bar{X}$±SD Min-Max	Coverage Percentage
Energy (kcal)	50.67 ± 8.44 20.00-72.00	%2.53[a]	47.01 ± 8.58 28.00-65.00	%2.35[a]	41.81 ± 11.36 4.00-59.00	%2.09[a]	39.95 ± 15.33 17.50-64.00	%1.99[a]
Carbohydrate (g)	11.98 ± 2.12 4.00-16.30	%9.21*	11.29 ± 2.14 5.00-15.50	%8.68*	10.13 ± 2.82 0.20-14.00	%7.79*	10.06 ± 3.88 4.30-16.00	%7.73*
Sugar (g)	10.81 ± 2.40 2.10-16.30	%21.62[b]	10.92 ± 2.27 4.80-15.50	%21.84[b]	9.82 ± 2.93 0.00-14.00	%19.64[b]	9.73 ± 3.65 4.10-14.00	%19.46[b]
Fat (g)	0.02 ± 0.06 0.00-0.30	-	0.02 ± 0.09 0.00-0.50	-	0.03 ± 0.12 0.00-0.50	-	0.00 ± 0.00 0.00-0.00	-
Saturated fat (g)	0.00 ± 0.00 0.00-0.00	-	0.0036 ± 0.018 0.00-0.10	-	0.0079 ± 0.032 0.00-0.20	-	0.00 ± 0.00 0.00-0.00	-
Protein (g)	0.37 ± 0.72 0.00-5.00	%0.66-0.80*	0.08 ± 0.19 0.00-1.00	%0.14-0.17*	0.046 ± 0.12 0.00-5.00	%0.08-0.1*	0.00 ± 0.00 0.00-0.00	%0*
Sodium (g)	2.20 ± 3.47 0.00-8.00	%146.66**	1.64 ± 3.15 0.00-7.50	%109.33**	1.60 ± 3.13 0.00-7.50	%106.66**	0.00 ± 0.00 0.00-0.00	%0**
Salt (g)	0.0032 ± 0.014 0.00-0.10	%0.064[c]	0.0045 ± 0.019 0.00-0.10	%0.09[c]	0.0063 ± 0.016 0.00-0.10	%0.126[c]	0.032 ± 0.056 0.00-0.13	%0.64[c]
Fiber (g)	0.22 ± 0.37 0.00-1.60	%0.57-0.88**	0.38 ± 0.73 0.00-3.30	%1.0-1.52**	0.08 ± 0.24 0.00-1.00	%0.21-0.32**	0.00 ± 0.00 0.00-0.00	%0**

SD: Standard deviation [a] The percentage of coverage was calculated from the energy intake of 2000 kcal for an average adult. [b] According to the World Health Organization (WHO) recommendation to reduce total energy intake for free sugar intake to less than 10%, free sugar intake is equivalent to a maximum of 50 grams of sugar per day. [c] The percentage of coverage was calculated from WHO recommendations (<5 g/day salt). * The percentage of coverage is calculated from Recommended Dietary Allowances (RDAs). ** The coverage percentage is calculated with Adequate Intakes (AIs).-: Not determined.

Table 4. Comparison of carbohydrate and sugar content of fruit juices and similar beverages according to fruit type with freshly squeezed fruit juices in the National Food Composition Database (Türkomp)

Fruit Type		Türkomp	Fruit Juices (n=51)		Fruit Nectars (n=57)		Fruit Beverages (n=69)		Flavored Beverages (n=10)	
		Reference Values (g)	Deviation from Reference	p	Deviation from Reference	p	Deviation from Reference	p	Deviation from Reference	p
Apricot	Carbohydrate	14.28	-	-	-2.93 (n=14)	0.002*	-3.6467 (n=3)	0.109	-9.98 (n=1)	-
	Sugar	6.82	-	-	+4.1338 (n=14)	0.004*	+3.78 (n=3)	0.109	-2.62 (n=1)	-
Cherry	Carbohydrate	12.69	-	-	-0.07 (n=5)	0.893	-2.34 (n=10)	0.016*	-	-
	Sugar	5.91	-	-	+6.59 (n=5)	0.043*	+4.22 (n=10)	0.007*	-	-
Peach	Carbohydrate	14.23	-	-	-2.8685 (n=13)	0.003*	-4.284 (n=5)	0.042*	-	-
	Sugar	5.61	-	-	+5.165 (n=13)	0.002*	+4.336 (n=5)	0.042*	-	-
Orange	Carbohydrate	14.64	-4.0733 (n=6)	0.028*	-4.34 (n=2)	0.180	-3.56 (n=5)	0.500	-	-
	Sugar	4.6	+4.66 (n=6)	0.028*	+5.66 (n=2)	0.180	+6.42 (n=5)	0.043*	-	-
Pomegranate	Carbohydrate	13.03	+1.195 (n=4)	0.144	+0.07 (n=1)	-	-	-	-	-
	Sugar	4.84	+6.435 (n=4)	0.068	+7.26 (n=1)	-	-	-	-	-
Apple	Carbohydrate	9.95	+1.8875 (n=8)	0.011*	-	-	-	-	-0.95 (n=2)	0.157
	Sugar	3.25	+8.1625 (n=8)	0.012*	-	-	-	-	+5.75 (n=2)	0.157
Grape	Carbohydrate	13.45	+2.85 (n=1)	-	-	-	-	-	-	-
	Sugar	6.68	+9.62 (n=1)	-	-	-	-	-	-	-
Strawberry	Carbohydrate	11.90	-	-	-	-	-0.5 (n=1)	-	-	-
	Sugar	-	-	-	-	-	-	-	-	-

* p<0.05, Wilcoxon one-sample sign rank test

life at all ages (SDGs 3)" and "to provide sustainable production and consumption patterns (SDGs 12)" (T.R. Strategy and Budget Department, June 2020). When fruit juice and similar beverages are evaluated in terms of ensuring a healthy and quality life at all ages, it is seen that these products in the Turkish market generally have a high sugar and sodium content, beverages other than fruit juice contain added sugar, and fruit nectar and

fruit beverages contain sweeteners. It was determined that all of the fruit nectars, the contents of which were examined, and almost all of the fruit beverages and flavored beverages contained added sugar. The use of sucrose and fructose-glucose syrup is common in fruit juices and similar beverages with added sugar in the Turkish market.

Nutrition labels are of great importance when making the right food choice in order to protect and improve health and reduce the risk of disease (Erem et al., 2018). However, according to the observations, the product labels did not specify the type of added sugar in 10.5% of fruit nectars, 26.6% of fruit beverages, and 14.3% of flavored beverages. In the study where the compliance of 16 fruit juice samples of apple, pomegranate, orange and grape varieties offered for sale in the Turkish market was investigated with the Turkish Food Codex and fruit juice standards, it was determined that some samples did not comply with the standards in terms of formol number, sorbic acid and benzoic acid amounts and Hydroxymethylfurfural (HMF) content. It was determined that fruit juice samples, which should not contain preservatives, contained preservatives, contrary to the relevant standards. In addition, the lead content in two of the apple juice samples, all of the pomegranate and grape juice samples, and three of the orange juice samples was found to be higher than the lead levels allowed in the communiqué (Tüfekci and Fenercioğlu, 2010). On the other hand, it is stated in the Turkish Dietary Guidelines (2022) that fruit juices should always be made of 100% fruit, with pasteurization, and without added sugar, and may be diluted with water (T.R. Ministry of Health, Ankara 2022). The study findings show that the fruit juices evaluated in the study are generally suitable, but the sodium content of even 100 ml of beverage is above the daily requirement of an adult individual (146.66%). A similar situation was observed in fruit nectars and fruit beverages. In addition to this finding, it was seen that free sugar intake was quite high, with the consumption of 100 ml of fruit juice and similar beverages. As a matter of fact, orange and apple juices, apricot, peach, and cherry fruit nectars, and peach, sour cherry, and orange fruit beverages contain more sugar than freshly-squeezed fruit juices ($p<0.05$). Health care costs are high for chronic diseases (such as type 2 diabetes, obesity, hypertension, metabolic syndrome, and kidney disease) that have an increased risk of occurring as a result of frequent and excessive consumption of sugar, fructose or glucose syrup (Bray, 2013; Hayran, 2019; T.R. Strategy and Budget Department, 2020). When evaluated from another aspect, it was determined that 17.5% of fruit nectars and 20.3% of fruit drinks contained sweeteners. Moreover, 70.0% of fruit nectars contained sweeteners, and 50.0% of fruit drinks contained sucralose. Sweeteners are risky compounds when consumed in excessive amounts and frequently, and it should not be ignored that many health hazards are associated with excessive consumption of artificial sweeteners (Singh et al., 2020). It is possible to reduce the global burden of chronic diseases by reducing the consumption of sweetened beverages. When all these findings are evaluated together, it becomes clear that the content of fruit juices and similar beverages in the Turkish market has deficiencies in terms of their suitability for sustainable development goals (SDGs 2 and 3). In this context, it is thought that it is necessary to focus on initiatives that will reduce health expenditures and eliminate the emergence of diseases in order to improve the health of society and improve the quality of life in parallel with the goals of sustainable development (Hayran, 2019; T.R. Strategy and Budget Department, 2020).

When the fruit juice industry is assessed in terms of providing sustainable production and consumption patterns (SDGs 12), it is seen that there is a negative result similar to the third objective of the Sustainable Development Goals. Fruit juices and fruit juice concentrates may contain naturally occurring free sugars and added (additional) sugars (such as sucrose and fructose-glucose syrup) (World Health Organization, 2023). Although sucrose is a natural product extracted from sugar cane and sugar beet pulp, it is not natural because the fructose in the fructose syrup contains a modified structure (Yılmaz and Nurcan, 2015). Fructose syrup, which is found in many packaged foods, especially fruit juices and carbonated drinks, is a food additive preferred by manufacturers instead of sucrose because of its advantages, including being a stronger sweetener than sucrose, being cheaper and having osmotic stability, providing a long shelf life as it does not crystallize quickly, and having organoleptic effects (Arslan and Şanlıer, 2016; Aşıcı et al., 2020). Within the scope of the efforts to limit the use of starch-based sugars in foods and to promote healthy nutrition, the press release of the T.R. Ministry of Health on the report of the Science Board (Effects of Starch-Based Sugars on Health) recommends supporting the industry in minimizing the use of high fructose corn syrup by reformulation (T.R. Ministry of Health, 2018). When purchasing fruit juices and similar beverages, the sugar content and type on the label should be read, and the nutritional choice should be made carefully. Products with the phrase "does not contain added sugar" on the label should be preferred (T.R. Ministry of Health, 2022).

On the other hand, the high-fructose syrup manufacturing industry produces large volumes of waste liquid containing various waste carbohydrates, which has a significant environmental impact (Gao et al., 2021). Greenhouse gas emission sources are also released to the environment in sugar production processes, and this situation is a matter of national concern (de Figueiredo et al., 2010). According to Türkiye's Water Footprint report prepared in cooperation with the World Wide Fund for Nature (WWF- Türkiye) and the T.R. Ministry of Forestry and Water Management, beet sugar production, since

Türkiye has the highest blue water footprint among the leading sugar beet producer countries, beet sugar production, which requires intensive water use, cannot be considered as an example of sustainable production. As the demand for water resources increases, the amount of blue water used for sugar beet will pose a greater risk (WWF-Turkey, 2014). It is predicted that using plant-based packaging made of polyethylene, a renewable polyethylene obtained from sugar cane, and, more importantly, reducing sugar consumption will contribute to the global goals for protecting human health, climate, and biodiversity. In this context, it is essential to evaluate the effectiveness of policies on reducing national sugar consumption and to expand their scope, to renew, strengthen and effectively implement environmental policies (de Andrade et al., 2020).

When the production technologies are examined, it is seen that the pasteurization method is frequently used. The food industry is responsible for approximately 30% of the world's total energy consumption and 22% of the total greenhouse gas emissions. Energy consumption depends on processing time and temperature, and the primary energy consumption in juice bottling plants emerges from juice pasteurization, bottle cleaning, and cooling. Water footprints between 0.6 and 1.48 L per liter of juice are reported in the juice industry (Esturo et al., 2023). Some processing methods can reduce water consumption by recycling or reusing water at different stages of production. It is thought that using these methods can reduce the blue water footprint.

In a study investigating greenhouse gas emissions from fruit production, the carbon footprint of fruit production in China was found to be 0.24, 0.27, 0.14, 0.37, and 0.18 kg CO2 -eq/kg for apples, bananas, oranges, peaches, and pears, respectively (Yan et al., 2016). In different studies conducted in Türkiye, the greenhouse gas rate for orange production was determined as 0.08 kg CO2 -eq/kg (Saltuk et al., 2022), and for apple, grape, pomegranate, and strawberry as 0.09, 0.10, 0.15, and 0.78 kg CO2 -eq/kg, respectively (Eren et al., 2019). On the other hand, the waste generated during fruit juice production from citrus fruits corresponds to approximately half of the whole fruit weight and 10–30% of the fruit weight for apple juice production (Esturo et al., 2023). Sour cherries, pomegranates, and strawberries are other industrial fruits that generate high amounts of waste. In light of this information, it is thought that peach, which constitutes 9.6% of the products in the Turkish market examined in this study, and strawberry, which constitutes 0.5%, may pose a disadvantage in terms of carbon footprint. Citrus fruits, which constitute 13.4% of the products in the Turkish market, sour cherries, which constitute 8%, and pomegranate, which constitutes 2.7%, may pose a disadvantage in terms of food waste.

More sustainable product supply chains are those that optimize the use of materials, water, and energy throughout their lifecycle while minimizing waste from products and used packaging (Russell, 2014). However, in a study involving participants with different roles in juice production from 20 countries, it was reported that only 44.11% of companies implemented measurable targets for reducing, reusing, and recycling packaging materials, in addition to systems to reduce the use of energy and materials (Esturo et al., 2023). Most fruit juices and similar beverages examined in this study had Tetra Pak, glass, and PET-type packaging. The amount of waste originating from packaging used to store beverages, such as Tetra Pak, is constantly increasing, and most of this waste is treated as garbage by landfilling and incineration. This causes a massive waste of resources and environmental pollution problems. For this reason, converting Tetra Pak wastes into valuable chemicals or fuels is thought to benefit the economy and the environment. In addition, solutions continue to be developed for the difficulties of recycling Tetra Pak wastes (Ma, 2018). Most food packaging, such as plastic, glass, and tin, can be recycled. Bottle-to-bottle recycling provides a significant reduction in environmental burdens. PET, a polyester plastic, is one of the most widely used packaging materials for beverages. A PET bottle is more easily recycled due to its single-layer and single-material composition. Thus, glass bottles have performance advantages not found in alternative packaging options such as aluminum cans, cardboard boxes, and other plastics. Compared to glass, PET bottle is lighter and has a lower carbon footprint in production and transportation (Benyathiar et al., 2022). Another thing to consider when choosing packaging is the acidic content of soft drinks, which makes the metals in the cans more soluble. In a study investigating exposure to potentially toxic elements through the consumption of non-alcoholic beverages such as flavored beverages and energy drinks offered for sale in Türkiye, it was found that in some samples, at least one of the cadmium, nickel, iron and manganese contents were measured above the threshold values determined by official authorities. Before a particular material is used as packaging, the possibility of contamination of contaminants from the packaging to the food must be evaluated through tests (Yüksel et al., 2023). On the other hand, essential and non-essential element concentrations of fruit juices produced by some commercial brands in Türkiye were determined and a health risk assessment was made. When risk analysis was performed by calculating the hazard indexes of non-essential, trace and ultra trace elements and the target carcinogenic risks, it was determined that the HI and TR values of the samples were less than 1 and 1x10−4, respectively. As a result, all samples were evaluated in the low risk group. (Demir et al., 2020). The packaging of a product is linked to SDGs 12 as well as SDGs 3. In this sense, active packaging, eco-design packaging, transportation options, and systems based on returnable glass bottles or easily recyclable materials are foreseen as improvements that can be planned by the fruit juice

industry in the future (Esturo et al., 2023).

The limitations of the study are that fruit-flavored acidic beverages, fruit-flavored sodas and mineral waters, fruit-flavored beverage powders were not included in the study.

CONCLUSION

It has been determined that fruit juices and similar beverages in the Turkish market are inadequate in terms of sustainability in terms of ensuring a healthy and quality life at all ages as they have a high sugar and sodium content, beverages other than fruit juice have added sugar content, and fruit nectars and fruit beverages contain sweeteners. One possible way to balance the health benefits and harms of these products is to consume them in moderation and to choose beverages with a lower energy density and higher nutritional value that do not contain added sugar or artificial sweeteners.

In this study, considering the environmental effects of the sugar beet and fructose syrup production industry, it was observed that the addition of sucrose obtained from sugar cane and sugar beet and the addition of fructose syrup to fruit juices and similar beverages contradict some of the sustainable development goals. It is also clear that the fruit juice industry has deficiencies in terms of sustainability, as sustainable product supply chains that optimize the use of materials, water and energy, and technologies that will minimize waste from products and used packaging have not yet been provided. In light of the data obtained from this study, it is thought that it would be beneficial for the fruit juice industry to make regulations to ensure sustainable production and consumption patterns. For the sustainability of the fruit juice industry, it is of great importance for fruit juice producers to adopt innovative technologies that will reduce water use, sustainable agricultural practices, waste management strategies such as the reuse and recycling of packaging materials, and post-production food waste. It is also foreseen that reducing the chemicals used in the production process of fruit juices and similar beverages and using alternative, natural and biological solutions will also be effective in terms of sustainability. Fruit juice producers should take a sensitive approach to human health by producing fruit juice with clean content and reduced sugar content. At the same time, producers should support the sustainability of food systems in terms of nutrition with 100% sustainable fruit juices by producing solutions against environmental problems such as decreasing water resources, consumed energy, climate change and reducing food residues, and meeting consumer demands. For the sustainability of the fruit juice industry, not only the producers but also the consumers must take responsibility. Consumers should prefer organic, local, and sustainable fruit juices, primarily seasonal fruits, in order to support sustainable fruit juice production.

COMPLIANCE WITH ETHICAL STANDARDS

This research article complies with research and publishing ethics.

Peer-review

Externally peer-reviewed.

Conflict of interest

The authors have no conflict of interest to disclose.

Author contribution

Berk G. and Kayhan B. collected the study data and contributed significantly to the content. Kaçar M. contributed significantly to the content and revised it critically for important intellectual content, and approved the final content of the manuscript. Özenir Ç. designed and drafted the work and revised it critically for important intellectual content and final approval of the version to be published. All authors have read and agreed to the published version of the manuscript.

Ethics committee approval

Ethics committee approval is not required.

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Data availability

Not applicable.

Consent to participate

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