A Comparison of the Energy, Fat, and Salt Content of Chips Consumed in Ten Different Countries Based on Nutrition Label Information

Fatmanur Hümeyra ZENGİN
Kastamonu University, Faculty of Health Science,
Nutrition and Dietetics Department
humeyrazengin@hotmail.com
ORCID: 0000-0003-1586-5878

Tuğba TATAR
Kastamonu University, Faculty of Health Science,
Nutrition and Dietetics Department
dyt.tugba@hotmail.com
ORCID: 0000-0002-6030-3033

Emine AHMETOĞLU
Independent Dietitian
amine.aoglu@gmail.com
ORCID: 0009-0001-3606-0908

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Abstract

Chips are among mostly consumed snacks worldwide. Their nutritional composition may vary significantly between countries. This study aimed to compare the energy, total fat, saturated fat, and salt contents of chips consumed in ten countries. The nutrition labels of 554 chips available in online markets were examined. The highest energy content was in the United States of America (USA), and the lowest was in Germany. Regarding total fat, the highest value was also observed in the USA, whereas Türkiye had the lowest. Potato chips contained the highest energy and total fat levels. Reduced-salt chips had the highest energy and total fat content. Regarding salt content, the highest salt value was in reduced fat chips. These findings indicate that the nutrient content of chips varies significantly depending on the country, raw materials, and processing methods. Reformulating commonly consumed chips can enhance compliance with daily macronutrient intake, reduce nutritional problems, and support global health goals by promoting equitable access to healthier food options.

Keywords: *Snack foods, nutrition labeling, dietary fats, dietary sodium*

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Introduction

Today, extended working hours and the increasing diversity of food products have contributed to changes in consumers' dietary habits. Furthermore, persuasive advertising strategies have played a significant role in shaping these changes. This situation has increased the tendency toward ready-to-eat foods (Ugur & Şimşek, 2021). It is known that ready-to-eat foods generally contain high levels of salt, fat, and sugar. Excessive consumption of these foods is thought to be the leading cause of increased risk of developing many chronic diseases, such as obesity, diabetes, cancer, and cardiovascular diseases (Albuquerque et al., 2018). With the increase in consumption of ready-to-eat snacks, production has also increased. Chips are at the top of the ready-to-eat snack groups. While the consumption of chips in Türkiye was 400 g per capita/ year in 2004, it increased to 1 kg in 2012 (Özdemir & Malayoğlu, 2017). According to TurkStat data, 21.4% of children reported consuming snacks such as chips and crackers daily. This rate increases in direct proportion with increasing age (Türkiye İstatistik Kurumu, 2023). When it comes to chips, fried potato chips are the first type that comes to mind (Ugur & Şimşek, 2021). In developed countries, fresh potato consumption has decreased and processed potato consumption has increased (Özdemir & Malayoğlu, 2017). In a study conducted in Australia, annual potato chips sales per capita increased by 5% in 5 years and reached 2.1 kg per person (Gearon et al., 2021). In the United Kingdom (UK), the longest aisle in supermarkets is the one dedicated to chips, chocolate, and confectionery (Thornton, 2013). Potato chips produced by the traditional method contain approximately 35-38% fat (Joshi et al., 2016). The main techniques used to produce chips are frying and extrusion. In the frying method, high-temperature cooking in oil is applied. In the extrusion process, lubrication is applied while seasoning the chips. In this way, chips contain oil by 1/3 of their weight (Ertop et al., 2016). Research shows a highly significant relationship (dose-response) between per capita sugar, salt, and fat consumption and the prevalence of obesity, hypertension, and diabetes (Dasgupta et al., 2015). In Western-style diets, starchy foods such as breads and snacks, especially chips, are among the foods that provide the most salt to the diet (Tian & Fisk, 2012). Salt reduction practices and programs are observed in countries such as Türkiye, the UK, the United States of America (USA), and European Union member countries (Ilgaz ve Yarangümeli, 2019; Webster et al., 2011). In a study initiated in Finland in 1979, salt content in packaged products was reduced by 20-25% and an average reduction of 30% in salt consumption was realized. The result was a decrease in blood pressure and a reduction in related diseases (Tuomilehto et al., 1981). Many factors affect the energy, fat, and salt content of chips, including the type of raw material, cooking method, and oil used. To combat rising obesity rates and their consequences, food and nutrition policy is being implemented that aims to reduce the calorie, fat, sugar, and/ or salt content of packaged products (Thomas et al., 2022). Packaged foods such as chips are typically high in fat, salt, and sugar; however, their composition may vary across countries. A study conducted in seventeen countries reported that the fat, sugar, and sodium contents of hyper-palatable processed foods were higher in the United States compared to other countries, while lower levels were observed in Italy and Germany (Jun et al., 2025). Determining and comparing the nutritional composition of chips based on food labels across different countries may contribute to reducing inequalities in dietary opportunities. Furthermore, examining variations in cooking methods, raw materials, and processing technologies of products marketed in different countries may provide a novel perspective for developing nutritionally improved products. This study aims to compare the energy, total fat, saturated fat, and salt contents of chips consumed in ten different countries. It is important to identify the factors that lead to healthier chip production and to encourage the adoption of improved manufacturing practices. These practices may serve the purpose of reducing fat and salt consumption in terms of public health.

Methods

This study is a descriptive observational study, based on a cross-sectional analysis of nutrition label information. Data collection was carried out between July and October 2023. In this study, the nutritional composition of chips available in online markets across different countries was examined based on product labels, using 100 grams as the reference unit for energy (kcal), fat (g), saturated fat (g), and salt (g) contents. A total of 554 chip products from ten countries—Türkiye, Australia, Germany, the United States, Saudi Arabia, Switzerland, South Korea, Greece, Poland, and India—were included in the analysis.

Product pages of widely used national/international e-commerce platforms and online stores of chain supermarkets in each country were scanned. The search was conducted using terms such as "chips," "potato chips," and "corn chips," and category filters on the relevant platforms.

The researcher used a predefined data collection form. The following fields were recorded for each product: country, brand, cooking method, raw material (potato, corn, etc.), energy (kcal), total fat (g), saturated fat (g), salt, and sodium (mg) content per 100 grams of each product.

Inclusion and exclusion criteria

Inclusion: Chip products sold individually or in packages with a nutrition label on the product page, providing energy (kcal), total fat (g), saturated fat (g), and salt/sodium (mg) information. Exclusion: Insufficient/missing nutritional information; "variety packs/promotional packs"; multiple listings of the same product with the same formulation (duplicate records); and non-chip snacks (crackers, popcorn, etc.).

Since sodium content is given instead of salt content in some countries, salt content was calculated based on the sodium value using the conversion factor Salt (NaCl) (mg) = Sodium (Na) (mg)*2.5 (WHO, 2023).

Classification of data: Chips were classified according to the type of raw material, type of oil used in the preparation, and sales category.

1. Chips were grouped as "potato, corn, chickpea, lentil, tarhana, and rice chips" according to raw material type. For chips containing potato and corn, whichever is higher in percentage is counted in the chips group.
2. Chips were grouped by the sales category as "traditional, oven-baked, reduced fat, kettle cooked, popped, sun dried and reduced salt".
3. Chips were grouped according to the type of oil used in the preparation as "palm, canola, sunflower, corn, peanut, coconut, avocado, rapeseed, safflower, cotton, butter, lard, olive, soybean, rice bran oil, and unknown type of oil". Since most chips do not contain a single type of fat, a single product could belong to multiple categories.

Statistical analysis

SPSS 25.0 statistical program was used to evaluate the data obtained in this study. For qualitative data, numbers and percentages (%) were presented. Descriptive statistics, including mean, standard deviation (SD), median, minimum, maximum values, were calculated for quantitative data. The distribution of continuous variables was assessed using the Kolmogorov-Smirnov test. Kruskal-Wallis Test was applied to evaluate differences between non-normally distributed variables. When a significant difference between groups was identified, pairwise comparisons were conducted with post hoc tests to identify the subgroups that caused the difference. *P*-value less than 0.05 was considered statistically significant (Fisher, 1934).

Results

A total of 554 potato chips were evaluated in this study, including 64 from the United States (11.6%), 42 from Switzerland (7.6%), 66 from Germany (11.9%), 83 from Poland (15.0%), 41 from Greece (7.4%), 59 from Türkiye (10.6%), 36 from Saudi Arabia (6.5%), 65 from India (11.7%), 27 from South Korea (4.9%), and 71 from Australia (12.8%).

Energy, fat, saturated fat, and salt content of chips

The energy, fat, saturated fat, and salt contents per 100 grams of chips by country are given in the Table 1. The highest energy content value was in the USA (median 536.0 kcal), and the lowest value was in Germany (median 503.5 kcal). In terms of total fat per 100 g of chips. The highest fat content was in the USA (median 32.1 g) and the lowest in Türkiye (median 25.2 g). In terms of saturated fat content in chips. The highest country was Saudi Arabia (median 14.0 g), and the lowest country was Australia (median 2.5 g). In terms of salt content, the highest salt value of median 1.6 g was equal in 4 countries (Switzerland, Germany, Poland, and India). The lowest salt values were 0.5 g in the USA and Saudi Arabia. There was a significant difference between energy, total fat, saturated fat, and salt contents in chips by country ($P < 0.05$).

Energy, fat, saturated fat, and salt amounts in chips by type of raw material

The distribution of chips according to raw material is given in the Figure 1. Potato (61.9% n = 343) and corn (30.1% n = 167) were the most commonly used raw materials in the production of chips. Lentil (1.3% n = 7), rice (1.4% n = 8), and Tarhana (fermented flour and yogurt mixture) (1.6% n = 9) were used the least.

Table 1

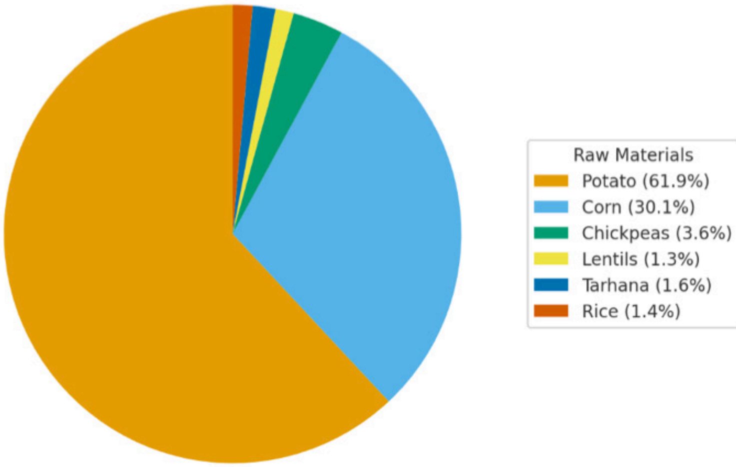
Energy, fat, saturated fat and salt contents of 100 grams of chips by country

Country	Energy (kcal)		Fat (g)		Saturated Fat (g)		Salt (g)	
	Mean±SD	Median(min-max)	Mean±SD	Median(min-max)	Mean±SD	Median(min-max)	Mean±SD	Median(min-max)
USA (n = 64)	515.0 ± 44.9	536.0 (393.0– 607.0)	27.7 ± 7.2	32.1 (7.1 - 35.7)	5.3 ± 3.5	5.4 (0 - 8.9)	0.5 ± 0.2	0.5 (0.2 - 1.7)
Switzerland (n = 42)	523.7 ± 30.0	522.0 (469.0 – 645.0)	29.7 ± 4.4	31.9 (20.0– 36.0)	5.1 ± 3.1	4.6 (1 - 11.8)	1.8 ± 0.6	1.6 (0.9 - 3.2)
Germany (n = 66)	501.0 ± 33.5	503.5 (394.0 – 561.0)	26.4 ± 6.7	28.0 (9.9 - 37)	2.8 ± 1.4	2.7 (1.3 - 8.9)	1.7 ± 0.5	1.6 (0.6 – 3.0)
Poland (n = 83)	510.0 ± 23.8	516.0 (441.0 – 559.0)	28.2 ± 5.9	31.0 (4.3 – 35.0)	4.1 ± 3.7	2.6 (0.4 - 16)	1.6 ± 0.4	1.6 (0.4 - 2.8)
Greece (n = 41)	515.9 ± 41.6	526.0 (418.0 – 583.0)	28.6 ± 7.5	32.0 (14.0– 42.0)	6.7 ± 5.5	4.2 (1.5 - 20)	1.5 ± 0.8	1.3 (0.0 - 5.2)
Türkiye (n = 59)	479.1 ± 62.3	500.0 (346.0 – 572.0)	22.6 ± 11	25.2 (0.1 - 36.1)	6.8 ± 5.4	3.7 (0.1 - 16.2)	1.8 ± 0.9	1.5 (1.0 - 5.2)
Saudi Arabia (n = 36)	506.7 ± 39.8	518.5 (346.0 – 550.0)	29.3 ± 6.2	31.0 (12.4 - 35.6)	12.2 ± 4.2	14 (2.7 – 16.0)	0.9 ± 0.7	0.5 (0.2 - 2.7)
India (n = 65)	520.7 ± 33.2	532.0 (446.0 – 571.0)	28.5 ± 5.9	30.0 (17.0– 36.0)	10.3 ± 4.9	12.1(2.0– 17.0)	1.5 ± 0.8	1.6 (0.4 - 6.5)
South Korea (n = 27)	540.1 ± 39.1	532.0 (446.0 – 607.0)	30.1 ± 7.0	30.7 (12.4– 40.0)	9.4 ± 4.8	11.6(0.0– 16.0)	1.2 ± 0.9	1.0 (0.2 - 3.6)
Australia (n = 71)	498.9 ± 38.2	504.0 (247.0 – 550.0)	27.0 ± 4.6	26.6 (12.3– 35.0)	5.2 ± 4.7	2.5 (1.2 - 15.1)	1.4 ± 0.5	1.2 (0.4 - 3.1)
Total (n = 554)	508.8 ± 41.7	518.0 (247.0 – 645.0)	27.5 ± 7.1	29.5 (0.1 – 42.0)	6.3 ± 5.0	3.6 (0.0 – 20.0)	1.4 ± 0.7	1.4 (0.0 - 6.5)
Test statistic	60.946		31.009		151.817		191.121	
P	$P < 0.001$ *		$P < 0.001$*		$P < 0.001$*		$P < 0.001$*	

Kruskal-Wallis H test * $P < 0.05$

Figure 1

Chips distribution by raw material



The energy, fat, saturated fat, and salt contents of chips by raw material type are given in the Table 2. A significant difference was found between the energy, total fat, saturated fat, and salt contents of the chips according to the raw material type (P <0.05). The energy and total fat values of the chips by raw material type were evaluated. The chips with the highest energy and total fat content were potato chips (median 524.0 kcal; median 32.0 g, respectively), while the chips with the lowest were tarhana chips (median 386.0 kcal; median 3.7 g, respectively). Regarding saturated fat content in chips, the highest chips were corn chips (median 4.5 g) and the lowest chips were chickpea chips (median 1.2 g). However, there was no significant difference between lentil, rice, tarhana, and chickpeas in terms of energy, total fat, and saturated fat. When salt content were evaluated, the highest salt value in the chips belongs to tarhana chips (median 3.1 g). Tarhana chips were significantly higher than other types (P <0.05).

Table 2

Energy, fat, saturated fat and salt contents per 100 g of chips by raw material type

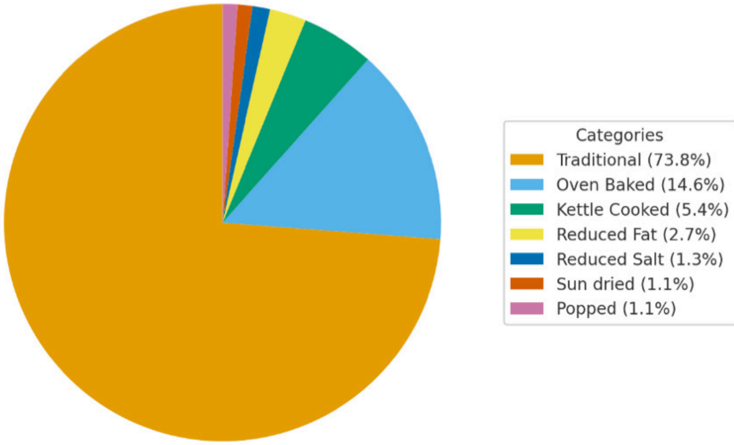
Raw Material	Energy (kcal)		Fat (g)		Saturated Fat (g)		Salt (g)	
	Mean±SD	Median (min-max)	Mean±SD	Median (min-max)	Mean±SD	Median (min-max)	Mean±SD	Median (min-max)
Potato (n = 343)	516.8 ± 30.4	524.0 (387.0 – 583.0)^{c}	29.7 ± 5.7	32.0 (4.3 – 40.0)^{c}	6.6 ± 5	3.9 (0.0- 17.0)^{c}	1.4 ± 0.7	1.3 (0.0 - 6.5)^{a}
Corn (n = 167)	510.7 ± 42.2	503.0 (247.0 – 645.0)^{b}	26.6 ± 5.5	25.6 (12.3 – 42.0)^{b}	6.8 ± 4.9	4.5 (1.2 – 20.0)^{bc}	1.5 ± 0.7	1.5 (0.2 - 5.2)^{a}
Chickpea (n = 20)	455.1 ± 52.6	464.0 (361.0 – 607.0)^{a}	16.4 ± 5.6	16.1 (6.2 - 23.6)^{ab}	1.2 ± 1.2	1.2 (0.0 - 3.6)^{abc}	1.3 ± 0.8	1.4 (0.4 - 2.8)^{a}
Lentil (n = 7)	436.9 ± 41.8	453.0 (393.0 – 476.0)^{a}	17.2 ± 4.0	18.0 (12.5 - 21.1)^{ab}	1.9 ± 0.4	1.8 (1.7 - 2.7)^{abc}	1.5 ± 1.1	1.5 (0.4 – 3.0)^{a}
Tarhana (n = 9)	381.9 ± 22.0	386.0 (346.0 – 416.0)^{a}	3.7 ± 2.2	3.7 (0.1 - 7.2)^{ab}	1.8 ± 1.2	1.7 (0.1 - 3.9)	3.1 ± 0.2	3.1 (2.8 - 3.5)^{b}
Rice (n = 8)	464.9 ± 25.3	464.0 (418.0 – 500.0)^{a}	19.6 ± 3.7	19.0 (16.0 – 27.0)^{ab}	3.1 ± 2.7	1.8 (1.5 - 9.5)^{abc}	1.1 ± 0.5	1.0 (0.4 - 1.8)^{a}
Total (n = 554)	508.8 ± 41.7	518.0 (247.0 – 645.0)	27.5 ± 7.1	29.5 (0.1 – 42.0)^{ab}	6.3 ± 5.0	3.6 (0.0 – 20.0)^{abc}	1.4 ± 0.7	1.4 (0 - 6.5)^{a}
Kruskal-Wallis H	97.862		135.613		74.000		31.163	
P	P <0.001*		P <0.001*		P <0.001*		P <0.001*	

Kruskal-Wallis H test * P <0.05 $^{a-c}$ No difference between groups with the same letter for each score (Dunn's test)

Energy, fat, saturated fat and salt amounts of chips by sales category

The distribution percentages of chips by sales category are given in the Figure 2. The traditional chips category had the highest number of products (73.8% n = 409), while the reduced salt and popped chips category had the lowest (1.1%, n = 6).

Figure 2
Distribution of chips by sales category



The energy, fat, saturated fat and salt content per 100 g of chips by the sales category are given in the Table 3. A significant difference was found between the energy, total fat, saturated fat and salt contents of the chips according to the sales category (P <0.05). Reduced-salt chips had the highest energy and total fat contents (median 550.5 kcal; median 34.0 g, respectively), while sun-dried chips had the lowest energy and total fat contents (median 386.0 kcal; median 3.7 g, respectively). There was no significant difference between reduced salt chips and traditional chips. Although both categories had higher values than other chip types. Regarding saturated fat content, traditional chips had the highest median value (median 5.4 g). There was no significant difference between the others. In terms of salt content, the highest salt value in chips was in chips with sun dried (median 3.1 g) and the lowest salt value was in chips with reduced salt (median 0.3 g). There was no significant difference between reduced salt chips, kettle cooked chips and popped chips.

Table 3
Energy, fat, saturated fat and salt amounts in 100 grams of chips according to sales categories

	Energy (kcal)		Fat (g)		Saturated Fat (g)		Salt (g)	
	Mean±SD	Median (min-max)	Mean±SD	Median (min-max)	Mean±SD	Median (min-max)	Mean±SD	Median (min-max)
Traditional (n = 409)	522.7 ± 29.8	525.0 (247.0 – 645.0)[b]	30.2 ± 4.4	31.7 (12.3 – 42.0)[b]	7.5 ± 5.1	5.4 (0.0 – 20.0)[b]	1.4 ± 0.7	1.4 (0.2 - 6.5)[d]
Oven baked (n = 81)	464.3 ± 46.3	464.0 (348.0 – 607.0)[a]	18.2 ± 6.8	17.9 (0.9 – 33.0)[c]	2.8 ± 2.4	2.1 (0.0 – 12.0)[ab]	1.5 ± 0.8	1.5 (0.4 - 5.2)[d]
Reduced fat (n = 15)	464.6 ± 22.6	472.0 (420.0 – 500.0)[a]	19.8 ± 3.8	21.0 (13.0 – 26.0)[ac]	1.6 ± 0.3	1.7 (1.0 - 1.9)[ab]	1.9 ± 0.7	1.8 (0.5 - 3)[cd]
Kettle cooked (n = 30)	492.8 ± 13.9	497.0 (468.0 – 536.0)[a]	26.7 ± 2.1	25.8 (24.8 – 32.0)[ac]	3.1 ± 2.4	2.3 (1.8 - 11.6)[ab]	1.0 ± 0.5	1.1 (0.3 - 2)[acd]
Reduced salt (n = 6)	545.7 ± 20.4	550.5 (511.0 – 571.0)[b]	33.1 ± 2.8	34.0 (28.0 - 35.7)[b]	4.6 ± 2.4	4.2 (2.3 - 8.9)[ab]	0.3 ± 0.3	0.3 (0.0 - 0.7)[acd]
Sun dried (n = 7)	386.1 ± 20.7	386.0 (346.0 – 416.0)[a]	4.1 ± 2.3	3.7 (0.1 - 7.2)[ac]	2.0 ± 1.3	1.7 (0.1 - 3.9)[ab]	3.1 ± 0.2	3.1 (2.8 - 3.5)[bc]
Popped (n = 6)	459.2 ± 24.6	462.0 (418.0 – 487.0)[a]	19.0 ± 4.2	17.5 (16 – 27.0)[ac]	3.5 ± 3.1	2.3 (1.5 - 9.5)[ab]	1.2 ± 0.5	1.1 (0.4 - 1.8)[acd]
Total (n = 554)	508.8 ± 41.7	518.0 (247.0 – 645.0)	27.5 ± 7.1	29.5 (0.1 – 42.0)	6.3 ± 5.0	3.6 (0.0- 20.0)	1.4 ± 0.7	1.4 (0.0 - 6.5)
Kruskal-Wallis H	209.946		223.911		153.668		55.319	
P	$P < 0.001$*		$P < 0.001$*		$P < 0.001$*		$P < 0.001$*	

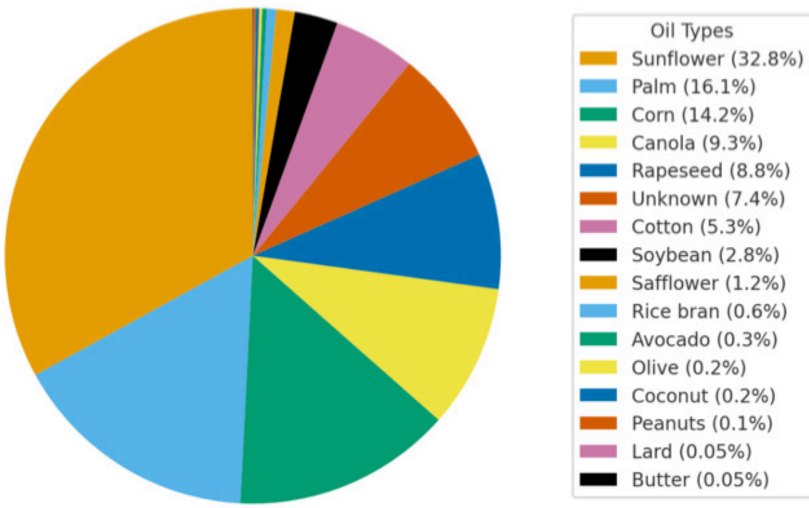
Kruskal-Wallis H test * P <0.05 [a-c] No difference between groups with the same letter for each score (Dunn's test)

Distribution of chips according to the types of oil used in the preparation of chips

In the study, there were 52 chips for which oil type information was not given. The distribution of chips according to the type of oil used in their preparation are given in the Table 3. Sunflower oil was the most commonly used oil in chips (33.3%, n = 279). The least commonly used oils were lard, peanut oil, and butter, each used in only one product (0.1%, n = 1).

Figure 3

Distribution of chips according to the types of oil and fat used in the preparation of chips



Discussion

Many factors affect the energy, fat, and salt content of chips, including the type of raw material, cooking method, cooking oil, and national production policies. This study compared the energy, total fat, saturated fat, and salt contents of chips consumed in 10 countries. In a study conducted in the United States involving 30 foods, chips had the highest fat and sodium levels. In another study, chips were categorized into 16 categories and were found to be the food with the highest fat content among thousands of foods (Uzun et al., 2007). Potato chips are also among the most commonly consumed snacks worldwide, particularly by children (Ouhtit et al., 2014). From a public health perspective, raising awareness about the energy, fat, and salt content of chips are very important.

Energy, fat and saturated fat content of chips by country

In this study, the country with the highest energy content value of chips per 100 g was the USA (median 536.0 kcal), while the lowest value was in Germany (median 503.5 kcal). When the total fat values per 100 g of chips are examined, the highest fat content is in the USA (median 32.1 g), while the lowest value is in Türkiye (median 25.2 g). In terms of saturated fat content in chips, the highest value is in Saudi Arabia (median 14.0 g), and the lowest value is in Australia (median 2.5 g). Significant differences were observed between the energy, total fat and saturated fat contents of chips by country ($P < 0.05$). In a study conducted in Lithuania in which 22 chips were examined, the salt content of 100 g of chips was found to be between 2.0 - 5.0 g, the fat content between 30.0 - 40.0 g, and the energy content between 1726.0 - 2255.0 kJ (Kalnina et al., 2017). In a study conducted in Portugal on 18 different potato chips, total fat ranged between 20.0 ± 0.51 and 42.8 ± 1.57 g and saturated fat ranged between 1.85 ± 0.01 and 19.2 ± 0.51 g (Albuquerque et al., 2012). In a study conducted in Australia on 103 different chips, Wijesundera et al.found that saturated fat in potato chips ranged from 7.9 to 46.7 g/100 g (Wijesundera et al., 2007). In a study examining 57 chips sold in Türkiye, the energy median per 100 g was 519.0 kcal (247-645 kcal), the total fat median value was 30.0 g (0.1-42.0 g), and the saturated fat median value was 3.6 g (0.0-20 g). In the same study, there was 42.29 ± 6.26 g of saturated fat in 100 g of fat in potato chips and 42.66 ± 3.33 g of saturated fat in 100 g of oil in corn chips (Çakmak et al., 2011). In a study conducted in Canada by Elias and Innis, they detected an average of 27.8 g/100 g of fat in potato chips and an average of 31.3 g/100 g of saturated fat in corn chips (Elias & Innis, 2002). When the data of 52 chips in Türkiye are examined in our study, the median energy is 504.5 kcal (346-572 kcal), the median of total fat is 26.1 g (0.1-36.1 g), and the median of saturated fat is 4.9 g (0.1-16.2) per 100 g. In all studies, including our study, it is seen that the energy, total fat, and saturated fat contents of chips are quite high. Replacing high-fat, high-saturated fat, and high trans-fat snacks with those rich in polyunsaturated fatty acids (PUFA) and low in saturated fatty acids and trans fatty acids reduces low density lipoprotein (LDL) and total cholesterol levels in individuals (St-Onge et al., 2007). The findings from different countries highlight common patterns (e.g., consistently high fat and energy content) and notable variations in nutrient profiles. These differences may reflect variations in production methods, regulations, and consumer preferences. The evidence suggests that international efforts should focus on reducing fat and saturated fat contents in chips and establishing harmonized standards and policies to guide manufacturers toward healthier formulations. Considering the widespread consumption of chips and the negative effects of saturated fat intake on health, reducing the total fat and saturated fat content of chips may help to reduce the incidence of many health problems, especially cardiovascular diseases.

Salt content of chips by country

In our study, when the salt amounts of chips were analysed according to the countries, the highest salt value in chips was equal to 1.6 g in 4 countries (Switzerland, Germany, Poland and India). The lowest salt values are in the USA and Saudi Arabia with 0.5 g. There is a significant difference between the salt contents of chips from different countries ($P < 0.05$). When the data of 59 chips sold in Türkiye are examined in our study, the median salt value is 1.5 g (1.0-5.2). In another study examining 57 chips sold in Türkiye, the median salt value of chips was 1.4 g (0.0-6.5) (Çakmak et al. 2011). In a study conducted on 18 different potato chips sold in Portugal, the salt content of the chips was between 0.127 ± 0.01 g and 2.77 ± 0.24 g per 100 g (Albuquerque et al., 2012). These findings demonstrate that while salt levels in chips vary across countries, they consistently contribute to excess dietary sodium intake. The higher salt content observed in chips in Germany and Switzerland may be due to the fact that, although these countries have mandatory sodium declaration on pre-packaged foods, there are no other mandatory measures aimed at reducing salt (Kwong et al., 2023). Cardiovascular diseases due to hypertension are one of the leading causes of mortality and morbidity worldwide. A diet high in salt is one of the leading risk factors for hypertension. Latest estimates from global burden of disease data show that the average daily salt intake in adults is 14 g (Afshin et al., 2019), almost 3 times more than the WHO recommended salt intake of 5 g (World Health Organization, 2012). From a public health perspective, reducing salt consumption is among the health policies of many countries (Kwong et al., 2023). Studies show that one of the foods with high salt content is chips (De Assis et al. 2022). From a public health standpoint, aligning industry reformulation strategies with international salt reduction targets could play a crucial role in reducing population-level hypertension and cardiovascular disease risk.

Energy, fat, saturated fat and salt amounts of chips by sales category

When chips are examined according to sales categories in our study, only 1.1 % of the chips are in the reduced-salt chips category. Chips with the highest energy and total fat content were chips with reduced salt (median 550.5 kcal; median 34.0 g, respectively). In reduced-salt chips, more flavorings or spices are used to enhance flavor (Buechler & Lee, 2020). Our findings suggest that reducing salt in chips may also increase the fat content. Therefore, attention should be paid to fat levels during the production of reduced-salt chips, and the use of alternative flavorings or new technologies should be encouraged. Due to the well-established adverse health effects of excess fat consumption, there has been increased interest in the development of technologies to reduce fat in chips. It has been proven that modification of the product surface reduces fat, reducing moisture by 10% after pre-drying reduces fat by 54%, and hydrocolloid coating on potato chips reduces fat by 57% after deep frying (Lumanlan et al.,2020). Chips with reduced fat are sold on the market using various methods. When chips are examined according to sales categories in our study, only 2.7% of the chips are in the reduced-fat chips category.

One of the new cooking methods for chips is the "kettle-cooked" method. The primary difference between kettle-cooked and traditional frying is the cooking technique. In the traditional method, potatoes are fried continuously on a moving belt. In kettle-cooked chips, cold potatoes are placed in a deep pot filled with oil and fried in batches, similar to homemade preparation. As each new batch of cold potatoes is added, the oil cools slightly, producing chips that are dark and unevenly cooked. Potatoes prepared this way retain more nutrients and contain lower fat (Kalita & Jayanty, 2017). In our study, the kettle-cooked method was used in 5.4% of chips. Although reduced-fat chips have a lower fat content than traditional chips, they contain similar amounts of fat to oven-baked and kettle-cooked chips, but they also contain more salt than all of these types of chips. No extra oil is added during the production of chips in the sun drying method. Therefore, energy and fat content is lower than other production methods. In our study, all chips used in the sun drying method were tarhana chips. One of the reasons why tarhana chips have lower energy, total fat and saturated fat content is that they are produced by the sun drying method. In our study, the sun dried method is used in 1.3% of the total chips. Despite the development of many new methods for producing healthier chips, traditional frying remains the most commonly used method (73.8%). Our study shows that most of the chips sold are produced using traditional frying methods and therefore have higher energy and fat contents. Despite technological advancements, traditional frying methods still dominate the market due to production costs, consumer habits, and taste preferences. While innovative methods have clear potential, market adoption is low, suggesting a gap between research findings and commercial application. New technologies may reduce risk factors like fat content while increasing another known health risk factor, such as salt. Such situations pose a public health paradox. Therefore, caution should be exercised when developing new technologies.

Energy, fat, saturated fat and salt content in chips by type of raw material

In a study, a significant positive relationship was found between salt and fat content in the ready meals and potato products. Accordingly, as the amount of salt increases in the ready meals and potato products, the content of fat also increases (Albuquerque et al., 2018). In our study, potato chips are the most common type of chips in the market and their energy and total fat contents are higher than chips made from other foods. Limiting the use of potatoes in chip production and developing products with lower energy and fat contents may contribute to public health improvement. Tarhana, which is traditionally consumed in Anatolia, the Middle East and the Balkans, was first produced as a food that could last for a long time for soldiers. It is produced by boiling peeled cracked wheat in water and drying it after adding yogurt (Yıldırım & Güzeler, 2017). Previous studies have shown that tarhana improves the lipid profile and has a high antioxidant content (Eraslan, 2024; Yavuz et al., 2024). Tarhana chips are considered to be more nutrients than potato chips, one of the most popular chips (Özdemir & Zencir, 2017). In our study, when the energy, total fat and saturated fat values of the chips according to the type of raw material are examined, it is seen that tarhana chips had the lowest energy, total fat, and saturated fat contents (median 386.0 kcal, 3.7 g, 1.8 gper 100 g respectively). However, when the salt amounts were analysed, the highest salt value in the chips belonged to tarhana chips (median 3.1 g). Therefore, developing suitable formulation and processing methods to reduce the amount of salt when preparing tarhana chips. In addition, tarhana chips are among the chips sold only in Türkiye. Expanding their production and promotion—after reformulation to lower salt levels—in other countries could provide a healthier alternative.

Distribution of chips according to the types of oil used in the preparation of chips

The quality and type of frying oils are closely related to the quality of the fried food. Oils undergo thermal and oxidative degradation, and the polymers formed under these conditions harm health. Volatile degradation products affect the flavor of the food, while non-volatile compounds affect how long the oil can be used for frying. Antioxidants, naturally occurring or added in oils and foods, affect the quality of the oil during deep frying (Warner, 2004). The position and composition of fatty acids in glycerol determine the susceptibility of fats to oxidation. Oils rich in unsaturated fatty acids are more sensitive and oxidised more rapidly than fats containing less unsaturated fatty acids. In addition, the formation and accumulation rates of primary oxidative compounds increase with increasing degree of unsaturation. Therefore, soya bean, sunflower, corn and grapeseed oil are not suitable for frying due to their high PUFA content. In general, oils rich in monounsaturated fatty acids, such as olive oil, are more stable than PUFA-rich oils (Machado et al., 2023). Extra virgin olive oil was previously considered unsuitable for frying because of its relatively low smoke point (≈205 °C) compared to other oils, such as peanut (≈225 °C), sunflower (≈255 °C), soybean (≈242 °C), and palm oil (≈227 °C). A low smoke point was thought to facilitate oxidation. However, recent research has demonstrated that the smoke point is not a reliable indicator of oil performance or stability (de Alzaa et al., 2018). Extra virgin olive oil is now recognized as the best oil for frying because it is rich in monounsaturated fatty acids, low in polyunsaturated fatty acids, and contains antioxidant compounds that protect against oxidation during cooking (Lozano-Castellon et al., 2022). In a study, potato chips were deep-fried at 180°C for 4 minutes using extra virgin olive oil, canola and grapeseed oils. The antioxidant and monounsaturated fatty acid content of potato chips was found to be higher when cooked in extra virgin olive oil compared to canola oil and grapeseed oil. The highest polar compounds in foods were found when canola oil and grapeseed oil were used. Extra virgin olive oil reduces polar compounds and trans fatty acids in chips. The results show that extra virgin olive oil improves the nutritional profile of food when deep-fried without negatively affecting flavor or appearance compared to canola and grapeseed oils (de Alzaa et al., 2021). Additionally, in a study where potato slices were fried with sunflower oil and olive oil, it was observed that frying with olive oil caused less fat intake than frying in sunflower oil (Alkaltham et al., 2020). Globally, chips are generally prepared using several different oils. In our study, there are 55 chips for which oil type information is not given. According to the types of oil used in the preparation of chips, the most used oil in chips are sunflower oil (33.3%, n = 279). The least used fats are lard, coconut oil and butter with 0.1% (n = 1). Olive oil, which is recommended for its antioxidant properties, is among the least used oil types with a usage rate of 0.2%. The use of olive oil as frying oil should be encouraged to produce healthier chips. In cases where olive oil cannot be used, popularizing practices that will increase the antioxidant properties of the oil used (adding turmeric, etc.) may also be an alternative solution.

Strengths and limitations: In the present study, nutritional data were obtained directly from product labels of chips available in online markets, rather than through laboratory-based analyses. This label analysis approach allows for assessing a large number of products across countries in a cost- and time-efficient manner. However, it should be noted that food label information may vary in accuracy depending on national regulations and manufacturer reporting practices. Highlighting these methodological considerations is essential to contextualize the findings and acknowledge label-based data's inherent limitations.

Conclusion

The results of this study indicate that the nutritional value of potato chips, a snack widely consumed across all age groups, particularly among children and adolescents, needs to be improved. Reformulation strategies that reduce salt, saturated fat, and total energy while maintaining sensory acceptability are crucial, as excessive consumption of these nutrients is closely linked to major public health problems such as cardiovascular disease, hypertension, and childhood obesity. However, while reducing fats using new technologies can increase risk factors, such as salt, to maintain consumer acceptance. This situation indicates that alternative methods that can minimize such paradoxes must be developed. Food manufacturers should be encouraged to adopt oils with more favorable fatty acid profiles, such as olive oil, while exploring more nutrient-dense raw materials. Consumer education campaigns can raise awareness of the health risks of excessive salt and saturated fat consumption and encourage conscious purchasing behaviors. These campaigns should emphasize the importance of reducing the consumption of chips, which are considered ultra-processed foods, for a healthy diet. Together, these measures can contribute to reducing diet-related chronic diseases and promoting healthier eating habits worldwide. The reformulation of chips also supports the United Nations Sustainable Development Goals (SDG 3: Good Health and Well-being, SDG 12: Responsible Consumption and Production) by reducing the risk of diet-related diseases beyond individual health and at a population level.

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