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Sodium content of Packaged foods in Uruguay by country of origin: regulatory challenges and trade considerations

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Abstract

Background Excessive sodium intake is a major public health concern. Many countries have implemented sodium reduction programs, including voluntary and mandatory reformulation strategies. However, these measures may have significant trade implications, particularly for countries reliant on food imports. This study examines the potential trade impact of sodium reduction policies in Uruguay, a small open economy in South America. For this purpose, the following objectives were pursued: i) assess the sodium content of national and imported food products available in the Uruguayan market, and ii) to compare sodium content with regional sodium reduction benchmarks for both national and imported products.

Results 53.6% of the 4719 analysed products were imported from 40 countries, with Argentina and Brazil accounting for the largest shares. While no consistent differences in sodium content were found between national and imported products, adopting the targets defined by the Pan American Health Organization (PAHO) as mandatory limits would render 56.6% of imported products non-compliant. In 32 of the 62 subcategories, more than half of the imported products exceeded the PAHO targets, and in four subcategories, none of the imported products met the target.

Conclusions Results suggest that mandatory sodium reduction policies would affect national and imported products similarly and are unlikely to constitute discriminatory trade measures. Establishing sodium thresholds tailored to Uruguay's market, such as category-specific medians, could achieve gradual, feasible reductions while mitigating trade impacts.

Keywords Food reformulation, International trade, Salt, Public policy, Food environments

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Background

High systolic blood pressure has been identified as the foremost global risk factor for mortality, contributing to 10.8 million (19.5% of) deaths globally [1]. Considering that extensive evidence has demonstrated a direct relationship between high sodium intake and elevated blood pressure [2], reducing sodium intake has been identified as one of the most cost-effective strategies for alleviating the burden of NCDs through the prevention of cardiovascular events and associated mortality [3, 4]. In response, the 2013 World Health Organization's Global Plan of Action for the Prevention and Control of Noncommunicable Diseases set a target to reduce global sodium intake by 30% by 2025, encouraging member states to adopt evidence-based interventions such as food reformulation and other regulatory measures [5].

Considering that packaged or out-of-home foods are a relevant source of dietary sodium in most regions of the world [6], food reformulation has been widely regarded as a cost-effective policy for reducing sodium intake at the population level [7–9]. This approach does not require changes in consumer behaviour and can support population-wide reductions in sodium intake while allowing individuals to continue consuming their usual foods [10–12]. Sodium reduction programs can be implemented as voluntary or mandatory reformulation measures [13, 14].

Voluntary reformulation programs rely on collaboration between governments and food manufacturers to reduce sodium levels in processed foods [15, 16]. These programs often take the form of public-private partnerships or government-facilitated agreements where companies commit to reformulation goals [16, 17]. Meanwhile, mandatory sodium reformulation involves government-imposed regulations that set upper sodium limits for specific food categories [16]. These measures compel manufacturers to reformulate products to comply with legal requirements, as seen in Argentina, Colombia, and South Africa which have successfully implemented mandatory sodium limits across a range of food products [15, 16, 18, 19].

Voluntary sodium reformulation programs have been the most widely implemented worldwide [14]. The UKs salt reduction initiative (2003–2011) is a frequently cited example of a successful voluntary approach, achieving notable reductions in salt consumption through industry pledges supported by consumer education campaigns [20]. Although voluntary reformulation policies are less invasive for industries, they have been reported to lead to inconsistent implementation, as companies may prioritise profit over public health goals and have limited incentives to reformulate in the absence of accountability mechanisms or enforcement provisions [21, 22]. Overall, the available evidence shows that mandatory sodium reduction policies are more effective than voluntary ones, leading to larger reductions in population sodium intake [13, 21].

A further distinction between voluntary and mandatory reformulation programs pertains to their potential trade implications. Voluntary approaches are not expected to generate major trade effects, as compliance is optional. In contrast, mandatory approaches may introduce trade-related challenges as importers must ensure their products comply with local sodium regulations, potentially facing restricted market access [17, 19]. Such policies may be interpreted as Technical Barriers to Trade under World Trade Organization (WTO) rules [16, 17]. Some scholars have further characterized mandatory reformulation policies, such as trans-fat bans, as overly intrusive [23, 24]. Nevertheless, international experience with mandatory limits for sodium, trans fat, and saturated fat demonstrates that these policies are both feasible and justified, given their public health objectives [16, 17].

Even when mandatory sodium targets do not constitute Technical Barriers to Trade, trade-related arguments, especially from industry actors, may deter governments from progressing with regulatory measures, contributing to policy inertia [25, 26]. For example, a previous qualitative study identified the high proportion of imported food products in the Mongolian market as a barrier for the implementation of sodium reduction programs [19]. In this context, analysing the potential trade implications of adopting mandatory sodium limits becomes essential for informing policymaking and anticipating regulatory impacts, particularly when a large number of categories are included.

Context and study aims

The present study uses Uruguay, a small high-income South American country with a population of 3,444,263 inhabitants [27], as case study. The country has minimal border restrictions and limited non-tariff measures [28]. Its economic growth and development are strongly tied to its export sector, particularly agricultural commodities and food products such as meat and soybeans [29]. Uruguay also maintains a diversified import profile, with food imports (particularly processed and ultra-processed products) playing a significant role [28, 30].

Uruguay is a founding member of the Southern Common Market (Mercosur), a regional trade bloc established in 1991 that includes Argentina, Brazil, Paraguay, and Venezuela (currently suspended) as member countries. Bolivia is in the process of becoming a full member. Mercosur countries, particularly Argentina and Brazil, are Uruguay's main trading partners, comprising one-third of its foreign trade [27]. Other key partners include the European Union, the United States, and Russia for exports, and China for imports [28].

While data on population-level sodium intake in the country is lacking, hypertension and cardiovascular diseases pose significant public health challenges. The most recent statistics indicate that 36.6% of adults aged 25 to 64 years are affected by hypertension [31]. Cardiovascular diseases remain the leading cause of mortality, accounting for 23.5% of all deaths in 2022 [32]. To address these issues, Uruguay implemented a front-of-package (FOP) nutrition labelling regulation in 2021, requiring warning labels on products high in sodium, total fat, saturated fat, and/or sugars [33]. Although this policy may have encouraged the food industry to reduce the sodium content of their products [34], formal reformulation programs targeting sodium and sugar have not yet been established, despite their inclusion in the Ministry of Health's 2030 health objectives [35]. At the regional level, Argentina and Brazil have also adopted FOP nutrition labelling systems that highlight products high in nutrients associated with non-communicable diseases, following broader trends across Latin America [36]. With respect to sodium reduction policies, Argentina has implemented mandatory sodium targets, whereas Brazil has adopted a voluntary approach [14].

In this context, the present work aimed to examine the potential trade implications of implementing sodium reduction programs in Uruguay. For this purpose, the following objectives were pursued: i) assess the sodium content of national and imported food products available in the Uruguayan market, and ii) to compare sodium content with regional sodium reduction benchmarks for both national and imported products.

Methods

This cross-sectional study used a database of labelling information of packaged food products commercialized in Uruguay. A concise overview of the data collection process is presented below, with additional methodological details outlined in a prior study on food additives [37].

Data collection procedures

Data were obtained from food labels of products available in 9 supermarkets in two cities: Montevideo, the national capital, and Maldonado, a regional capital in the south-east region. Supermarkets were selected to reflect a range of characteristics, including representation from both large and medium-sized retail chains.

Data collectors used a smartphone app to systematically survey all available processed and ultra-processed products. They scanned the barcodes, manually recorded product names, and photographed three key label components: the front of the package, nutrient declaration, and ingredient list. In compliance with Uruguayan food labelling regulations, these elements are mandatory. Data collection occurred between August and October 2021.

Following data collection, researchers manually extracted information from the photographs and entered it into an online spreadsheet. For each product, details such as product name, brand, packaging material, net weight, country of origin, ingredient list, and complete nutritional information were recorded. According to Uruguayan legislation, all labels must indicate the country of origin, defined as the country where the product was produced or, when production occurs in more than one country, the country where the last substantial transformation took place. Products differing in attributes such as name, company, packaging, weight, origin, nutritional content, or ingredients were treated as distinct items. To ensure accuracy, quality assurance protocols were implemented to identify and correct discrepancies between the extracted data and the original photographs. The resulting database included 7343 unique products.

Product classification

Products were categorized based on the framework provided by the Pan American Health Organization (PAHO) Regional Sodium Reduction Targets [38]. These targets were selected because they serve as a policy instrument that provides direction and political vision for the development of mandatory sodium reduction targets across the region of the Americas. They are designed to function as a regional reference for the monitoring of sodium content in food products [38]. All 16 categories and 75 subcategories defined in the PAHO targets were considered. To better capture local dietary patterns, two additional subcategories—fresh pasta without filling and fresh pasta with filling—were incorporated, given their frequent consumption in Uruguay. Fresh pasta without filling was assigned the PAHO target for Category 13a - Plain pasta and noodles, as consumed or dry, uncooked (0 mg/100 g), while fresh pasta with filling was assigned the target for Category 12 - Pasta, noodles, rice, or grains with sauce or seasonings (330 mg/100 g).

The product name displayed on the label, required to correspond to one of the product categories defined in Uruguayan legislation, was used for classification. The classification process was independently conducted by two researchers, and disagreements were resolved through discussion. Products that did not correspond to any category within the PAHO Regional Sodium Reduction Targets were excluded from the analysis ($n = 2{,}624$). These categories are expected to make only a minor contribution to total population sodium intake and/or generally contain low sodium levels. Examples of the excluded categories are sweetened beverages, yogurt, ice-cream, candies, and chocolate.

Data analyses

Data analyses were conducted using R software version 4.2.0 [39]. The distribution of products according to their origin and their median sodium content were calculated at the aggregate level and separately for each subcategory. The Mann-Whitney-Wilcoxon test was used to statistically compare the median sodium content of nationally produced and imported products, considering a significance level of 0.05.

The sodium content of each product was compared with 2022 PAHOs regional sodium reduction targets [38]. The decision to use the 2022 targets was based on the date of data collection (2021). For each subcategory, the proportion of products exceeding the PAHO target was calculated, both at the aggregate level and separately for products from different regions of origin.

Results

A total of 4719 products spanning 14 categories and 62 subcategories were analysed. Nationally produced items comprised less than half of the sample (46.4%, $n = 2{,}188$), while the remaining 53.6% ($n = 2{,}531$) were imported from 40 countries across the Americas, Europe, Asia, and Oceania (Fig. 1). Argentina and Brazil were the most common origin of the imported products, collectively accounting for 26.7% of all analyzed products (14.1% and 12.6%, respectively).

The proportion of imported products varied across subcategories, ranging from 0.0 to 97.0% (Table 1). The subcategories with the largest proportion of imported products were *Spicy sauce*; *Canned beans, chickpeas and lentils*; *Canned fish; Frozen potatoes and similar products*; *Canned vegetables* and *Salad dressing & vinaigrette*. All of these subcategories had than 90% of imported products. In contrast, no imported products were identified within the subcategories *Sandwiches*, *Uncooked sausages*, and *Uncooked bacon*.

Median sodium content

The median sodium content of the analysed products was 389.3 mg per 100 g. All subcategories exhibited substantial variability in sodium content, as reflected by their interquartile ranges (Table 1).

At the aggregate level, nationally produced products had a statistically significant higher median sodium content than imported products, although the difference was relatively small. Variations in sodium content between nationally produced and imported products were observed across subcategories (Table 1).

In seven subcategories, nationally produced products had a statistically significantly higher sodium content compared to imported counterparts: *Bouillon cubes and powders*; *Canned fish*; *Hard cheese, grated and ungrated; Patés and meat spreads*; *Pickled vegetables*; *Processed cheese*; *Refrigerated or frozen appetizers, sides and entrees*. Conversely, imported products had a statistically significantly higher sodium content in 18 subcategories: *Burgers, meatballs, meatloaf and breaded meat and poultry: Chips, popcorn, and/or extruded snacks; Cookies and sweet biscuits; Fresh pasta (no filling); Gravy, cooking sauces, dips, and salsa; Ketchup and similar tomato-type condiments; Meat analogues and other meat alternatives*; *Mustard; Packaged deli meats – fully cooked; Packaged dry-cured deli meats – dry cured, fermented, no thermal process; Pantry and hearth bread, rolls and buns; Pasta sauce; Pastries, squares, and quick/sweet breads; Pretzels and snack mixes; Salad dressing & vinaigrette; Butter, margarine, and butter blends; Savoury biscuits and crackers; Tomato sauce*. For the remaining subcategories, there were no statistically significant differences in sodium content based on product origin.

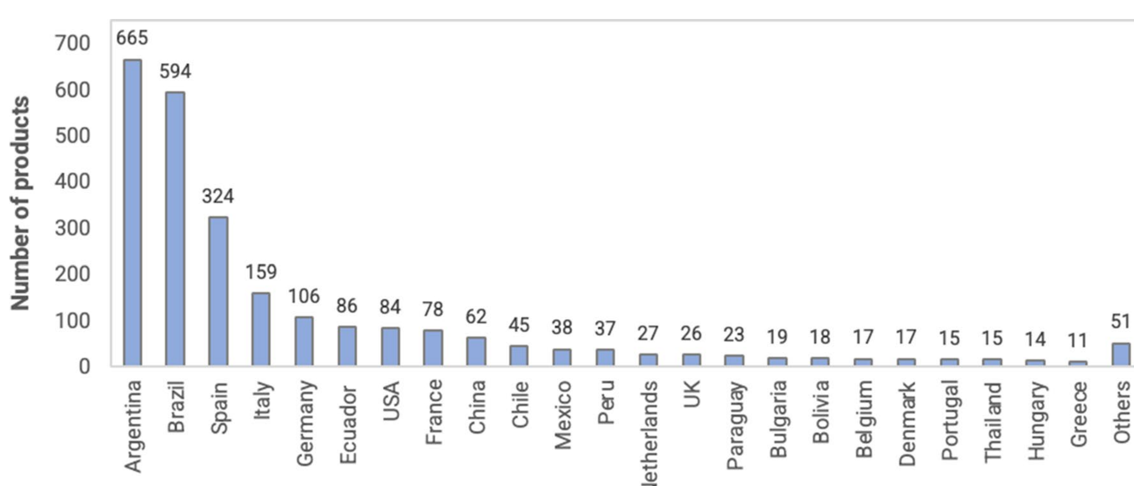

Fig. 1 Countries of origin of the imported products included in the database. Note: countries with less than 10 products are included in the category 'others': India, Serbia, Australia, Morrocco, Israel, Switzerland, El Salvador, Indonesia, Norway, Polonia, Colombia, Korea, Latvia, Russia, Sweden, Turkey

Table 1 Median sodium content and interquartile range (IQR) of products commercialized in the Uruguayan market per subcategory, according to their origin (nationally produced vs. Imported). For each sub-category, the p-value of the mann-whitney-wilcoxon test comparing the median sodium content of nationally produced and imported products is presented

Category/sub-category	Number of products	Median sodium content (mg/100 g)	IQR (mg/100 g)	Nationally produced		Imported		p-value
				Percentage of products (%)	Median sodium content (mg/100 g)	Percentage of products (%)	Median sodium content (mg/100 g)	
1. Bread, bread products and crisp breads								
1a-Pantry and hearth bread, rolls and buns	138	391.0	367.5–442.5	86.2	384.0	13.8	480.0	**0.016**
1b-Tortillas (wheat), wraps, naan, roti	10	487.0	422–922.0	50.0	410.0	50.0	1063.33	0.093
1c-Bread with additions	10	601.3	510.0–943.8	50.0	496.0	50.0	993.8	0.095
1d-Other bread products	97	500.0	303.3–600.0	91.8	500.0	8.2	258.8	0.274
2. Cakes, biscuits, pastries and sweet breads								
2a-Savoury biscuits and crackers	327	550.0	393.6–711.7	44.6	495.0	55.4	630.0	**< 0.001**
2b-Cookies and sweet biscuits	607	170.0	97.8–260.0	40.2	117.0	59.8	216.0	**< 0.001**
2c-Pastries, squares, and quick/sweet breads	186	205.5	82.0–298	53.8	133.0	46.2	248.3	**< 0.001**
2d-Cakes	103	100.0	35.0–328.8	82.5	86.7	17.5	291.7	0.294
4. Breakfast cereal								
4a-Ready to eat and hot instant breakfast cereals	98	280.0	197.5–509.8	21.4	325.3	78.6	278.3	0.638
5. Savoury snacks								
5a-Nuts, seeds, and kernels, seasoned and candied	100	510.0	335.0–900.0	52.0	426.7	48.0	664.0	0.185
5b-Chips, popcorn, and/or extruded snacks	142	592.0	400.0–788.0	30.3	408.0	69.7	607.1	**< 0.001**
5c-Pretzels and snack mixes	81	880.0	700.0–1200.0	27.2	700.0	72.8	1056.0	**< 0.001**
5d-Other savory snacks	29	226.0	40.0–400.0	41.4	400.0	58.6	220.0	0.434
6. Cheese								
6a-Fresh cheese (e.g., fresh mozzarella and others)	68	450.0	335.8–600.0	86.8	450.0	13.2	450.0	0.530
6b-Soft cheese (e.g., unripened goat cheese, cream cheese)	14	37.3	28.0–46.7	92.9	28.0	7.1	52.0	0.116
6c-Semi-hard cheese (e.g., mozzarella, cheddar and others)	66	600.0	500.0–766.7	57.6	573.3	42.4	600.0	0.076
6d-Hard cheese, grated and ungrated	78	1700.0	1267.5–1800.0	93.6	1700.0	6.4	640.0	**0.011**
6e-Processed cheese	100	460.0	399.2–820	71.0	490.0	29.0	383.3	**0.001**
7. Processed vegetables, beans, and legumes								
7a-Tomato paste with additions	69	125.0	30.0–211.7	46.4	185.0	53.6	59.2	0.265
7b-Canned vegetables	161	276.2	230.0–350.0	8.7	242.0	91.3	278.5	0.267
7c-Canned beans, chickpeas and lentils	97	226.9	159.0–269.2	3.1	236.9	96.9	221.2	0.446
7d-Baked and refried beans (mashed)	11	374.0	163.8–464.0	27.3	486.0	72.7	351.0	0.609
7e-Frozen potatoes and similar products	58	127.6	26.9–345.7	5.2	172.9	94.8	82.4	0.874
7f-Dry mashed or scalloped potatoes (as consumed)	46	20.8	5.5–122.6	67.4	21.3	32.6	15.0	0.503
7 g-Pickled vegetables	112	404.0	296.2–1021.5	28.6	491.0	71.4	403.0	**0.006**
7i-Olives	109	1500.0	1309.0–1755.0	38.5	1500.0	61.5	1415.0	0.193
8. Processed meat and poultry								
8a-Packaged deli meats – fully cooked	22	976.3	770.6–1075.6	90.9	908.8	9.1	1755.0	**0.026**
8b-Packaged dry-cured deli meats – dry cured, fermented, no thermal process	14	1227.5	983.1–1792.5	64.3	992.5	35.7	1827.5	**0.043**
8c-Uncooked sausages	37	813.0	659.6–895.0	100.0	813.0	0.0	-	-
8d-Cooked sausages	48	867.5	729.0–1068.6	93.8	867.5	6.3	778.7	0.913
8e-Uncooked bacon – belly	4	1422.5	1152.8–1485.3	100.0	1422.5	0.0	-	-

Table 1 (continued)

Category/sub-category	Number of products	Median sodium content (mg/100 g)	IQR (mg/100 g)	Nationally produced		Imported		p-value
				Percentage of products (%)	Median sodium content (mg/100 g)	Percentage of products (%)	Median sodium content (mg/100 g)	
8f-Burgers, meatballs, meatloaf and breaded meat and poultry	74	480.0	421.9–580.0	67.6	465.0	32.4	569.2	**0.027**
8 g-Ham, canned meat and poultry, and uncooked, pickled, cured and smoked meats that are not deli meats	12	840.0	435.0–994-0.2	41.7	860.0	58.3	555.0	0.254
8 h-Patés and meat spreads	44	669.5	450.0–830.0	18.2	825.0	81.8	585.0	**0.047**
9. Processed fish and seafood								
9a-Canned fish	252	420.0	349.0–527.0	5.2	500.0	94.8	418.3	**0.035**
9c-Fish and seafood cakes, fingers or burgers, seasoned, and breaded or battered or with sauces	18	316.5	175.7–370.0	11.1	266.2	88.9	316.5	0.833
9d-Smoked, salted, pickled and kippered fish	6	1323.0	693.5–1780.0	33.3	751.0	66.7	1780.0	0.481
10. Soy products and meat alternatives								
10b-Meat analogues and other meat alternatives	48	326.9	133.8–402.3	62.5	306.4	37.5	386.0	**0.005**
11. Soups								
11a-Wet and dry soups (as consumed)	67	265.2	236.9–301.0	55.2	269.6	44.8	265.2	0.558
12. Ready-made foods, convenience foods, and mixed dishes								
12c-Pasta, noodles, rice or grains with sauce or seasonings (as consumed)	11	289.2	272.0–320.0	81.8	275.3	18.2	330.2	0.218
12d-Pasta, noodles, rice or grains with sauce or seasonings (dry mix, as sold)	67	975.0	377.6–1366.4	41.8	975.0	58.2	959.2	0.253
12f-Pizza and pizza snacks	49	515.4	332.9–636.0	85.7	500.0	14.3	556.0	0.231
12 h-Refrigerated or frozen appetizers, sides and entrees	75	449.5	332.9–660.0	93.3	460.0	6.7	294.0	**0.042**
12 g-Sandwiches	5	224.0	188.0–517.1	100.0	224.0	0.0	-	-
13. Pasta and noodles fresh or dry without seasoning								
13-Fresh pasta (no filling)	59	285.0	14.0–553.0	62.7	16.0	37.3	555.0	**< 0.001**
13-Fresh pasta with filling	130	325.0	178.9–454.3	96.2	325.0	3.8	397.1	0.475
14. Granola and energy bars, and nut butters/spreads								
14a-Granola, cereal and energy bars	186	101.7	47.6–154.3	26.3	116.0	73.7	96.0	0.126
14b-Nut butters and nut spreads	14	140.6	42.0–270.0	14.3	0.0	85.7	170.3	0.140
15. Fats and oils								
15a-Butter, margarine, and butter blends	24	535.0	0.0–980.0	58.3	0.0	41.7	990.0	**< 0.001**
15b-Mayonnaise	61	758.3	733.3–833.3	19.7	745.8	80.3	758.3	0.064
15c-Salad dressing & vinaigrette	33	674.0	561.5–1166.7	9.1	400.0	90.9	753.9	**0.033**
16. Sauces, dips, gravy and condiments								
16a-Bouillon cubes and powders (as sold)	42	20333.3	18905.2–22105.3	28.6	22022.2	71.4	19126.3	**0.008**
16b-Pasta sauce	58	394.2	278.1–576.8	60.3	311.0	39.7	543.3	**< 0.001**
16c-Pesto	33	900.0	625.0–1547.5	60.6	830.0	39.4	1040.0	0.770
16d-Tomato sauce	74	333.2	236.7–399.3	52.7	265.0	47.3	381.0	**< 0.001**
16e-Ketchup and similar tomato-type condiments (as consumed)	44	812.5	500.0–1013.0	38.6	500.0	61.4	941.7	**0.001**
16f-Mustard	69	1083.3	500.0–1762.5	31.9	500.0	68.1	1633.3	**< 0.001**
16 g-Spicy sauce	33	1188.0	740.0–2700.0	3.0	740.0	97.0	1519.0	0.431
16 h-Gravy, cooking sauces, dips, and salsa (as consumed)	20	528.1	294.8–720.3	45.0	99.0	55.0	700.0	**0.040**
16j-Soy and other salty oriental sauces	46	4645.3	3533.3–5986.7	30.4	3638.9	69.6	5010.0	0.101

Table 1 (continued)

Category/sub-category	Number of products	Median sodium content (mg/100 g)	IQR (mg/100 g)	Nationally produced		Imported		p-value
				Percentage of products (%)	Median sodium content (mg/100 g)	Percentage of products (%)	Median sodium content (mg/100 g)	
16 l-Dry seasoning mixes for rice and side dishes	5	7600.0	0.0–7600.0	20.0	15404.8	80.0	3800.0	0.264
16 m-Dry seasoning mixes for meat and fish	18	13389.2	12694.7–15376.0	16.7	12589.2	83.3	13389.2	0.870
Total	4719	389.3	186.7–670.4	46.4	392.0	53.6	388.6	**< 0.001**

Note: p-values lower than the significance level (0.05) are highlighted in bold

Comparison with PAHO sodium reduction targets

At the aggregate level, 50.0% of the analysed products exceeded PAHO sodium reduction targets. However, the extent of deviation from these targets varied significantly across subcategories. As shown in Table 2, the percentage of products surpassing the PAHO target ranged from 0.0% for *Soft cheese* to 97.2% for *Uncooked sausages*. Subcategories with the largest share of products exceeding the PAHO targets included *Sausages - uncooked; Fresh pasta (no filling), Bread with additions; Bouillon cubes and powders; Canned vegetables; Soy and other salty oriental sauces; Dry seasoning mixes for meat and fish; Pantry and hearth bread, rolls and buns; Smoked, salted, pickled and kippered fish*. Conversely, six categories had fewer than 20% of products exceeding the PAHO sodium reduction target: *Granola, cereal and energy bars; Tomato paste with additions; Other savoury snacks; Dry mashed or scalloped potatoes; Processed cheese; Soft cheese.*

Deviations from PAHO targets also differed depending on product origin (Table 2). The percentage of nationally produced products exceeding PAHO sodium reduction targets was 42.3%, whereas for imported products the percentage accounted for 56.6%. None of the imported products within four subcategories met the PAHO sodium reduction targets: *Bread with additions; Gravy, cooking sauces, dips, and salsa; Packaged deli meats – fully cooked; Fresh pasta (no filling)*. For another 28 subcategories, more than 50% of the products did not meet the targets.

Deviations from PAHO sodium reduction targets within subcategories largely varied according to the region of origin of products (Table 2). However, there was no clear trend regarding differences among regions. In the specific case of the Mercosur region, all products exceeded the PAHO regional sodium reduction targets for products within seven subcategories: *Bread with additions; Fresh pasta (no filling); Butter, margarine, and butter blends; Olives; Salad dressing & vinaigrette; Cooked sausages; Fresh pasta (no filling).* None of the products imported from other American countries met the PAHO targets in five subcategories, and none of the products imported from other world regions met the targets in nine subcategories (Table 2).

Discussion

This study provides a comprehensive assessment of the sodium content in packaged food products available in the Uruguayan market from a trade perspective, analysing differences between nationally produced and imported products. The findings highlight the notable presence of imported processed and ultra-processed foods in the Uruguayan market, which accounted for over half of the analysed products. At the aggregate level, nationally produced and imported products exhibited a similar sodium content, although variations in sodium content across different subcategories were identified. This suggests that sodium reduction programs would impact both national and imported products in a comparable manner, reinforcing the non-discriminatory nature of such policies.

Although voluntary reformulation strategies offer a more flexible framework that enables industry stakeholders to gradually align with sodium reduction targets, they have been shown to be less effective than mandatory policies [13, 21, 22]. Given the substantial share of imported products in the Uruguayan market, voluntary approaches may not be effective across a broad range of categories, as imported products are unlikely to be reformulated under this scheme, particularly due to Uruguay's relatively small market size.

Implementing mandatory regulations could be a more effective strategy for ensuring sodium reduction across all products in Uruguay. This approach would provide a level playing field for domestic manufacturers and could contribute to achieve meaningful reductions in sodium content across a range of categories. It would be necessary for Uruguay to notify the WTO about the introduction of mandatory sodium reduction policies to ensure compliance with international trade regulations [40]. This step is crucial to justify such measures as necessary for public health, supported by technical, scientific, statistical, and nutritional evidence. Given Uruguay's strong reliance on food imports, it is likely that industry actors

Table 2 Percentage of products of each subcategory exceeding PAHO target for sodium content at the aggregate level and disaggregated by region of origin

Category/sub-category	PAHO sodium target (mg/100 g)	All products (n = 4719)	Nationally produced (n = 2188)	Imported products: All imported products (n = 2531)	Imported products: Mercosur countries (n = 1282)	Imported products: Other American countries (n = 309)	Imported products: Other regions of the world (n = 940)
1. Bread, bread products and crisp breads							
1a-Pantry and hearth bread, rolls and buns	340	84.8	84.9	84.2	80.0	-	88.9
1b-Tortillas (wheat), wraps, naan, roti	550	30.0	0.0	60.0	0.0	-	100.0
1c-Bread with additions	420	90.0	80.0	100.0	100.0	-	-
1d-Other bread products	400	67.0	68.5	50.0	50.0	50.0	50.0
2. Cakes, biscuits, pastries and sweet breads							
2d-Cakes	300	33.3	31.0	44.4	53.3	-	0.0
2b-Cookies and sweet biscuits	225	35.3	16.3	47.9	48.8	87.5	37.5
2c-Pastries, squares, and quick/sweet breads	260	37.6	28.3	47.7	56.9	0.0	36.4
2a-Savoury biscuits and crackers	640	34.9	19.2	47.5	49.6	0.0	43.5
4-Breakfast cereal							
4a-Ready to eat and hot instant breakfast cereals	260	56.1	61.9	54.5	60.7	54.5	20.0
5-Savoury snacks							
5b-Chips, popcorn, and/or extruded snacks	530	54.9	34.9	63.6	72.1	34.6	76.7
5a-Nuts, seeds, and kernels, seasoned and candied	265	77.0	69.2	85.4	81.6	100.0	100.0
5d-Other savory snacks	525	6.9	0.0	11.8	0.0	10.0	100.0
5c-Pretzels and snack mixes	800	61.7	22.7	76.3	80.0	-	74.4
6-Cheese							
6a-Fresh cheese (e.g., fresh mozzarella and others)	480	43.9	45.6	33.3	25.0	-	40.0
6b-Soft cheese (e.g., unripened goat cheese, cream cheese)	420	0.0	0.0	0.0	-	-	0.0
6c-Semi-hard cheese (e.g., mozzarella, cheddar and others)	650	44.6	45.9	42.9	0.0	-	44.4
6d-Hard cheese, grated and ungrated	1300	64.1	67.1	20.0	0.0	-	25.0
6e-Processed cheese	1000	6.0	7.0	3.4	5.6	-	0.0
7. Processed vegetables, beans, and legumes							
7a-Tomato paste with additions	400	13.0	12.5	13.5	0.0	-	21.7
7b-Canned beans, chickpeas and lentils	220	50.5	66.7	50.0	55.6	0.0	48.5
7c-Canned vegetables	150	87.6	85.7	87.8	79.2	93.8	91.0
7d-Baked and refried beans (mashed)	280	63.6	66.7	62.5	0.0	83.3	-
7e-Frozen potatoes and similar products	170	50.0	66.7	49.1	36.8	-	55.6
7f-Dry mashed or scalloped potatoes (as consumed)	290	6.5	9.7	0.0	0.0	-	0.0
7 g-Pickled vegetables	680	33.9	46.9	28.8	20.0	11.1	35.1
7i-Olives	1300	75.9	82.9	71.6	100.0	-	63.5
8. Processed meat and poultry							
8a-Packaged deli meats – fully cooked	900	54.5	50.0	100.0	-	-	100.0
8b-Packaged dry-cured deli meats – dry cured, fermented, no thermal process	1350	42.9	22.2	80.0	-	-	80.0
8c-Uncooked sausages	600	97.2	97.2	-	-	-	-
8d-Cooked sausages	840	59.6	61.4	33.3	100.0	-	0.0
8e-Uncooked bacon – belly	700	75.0	75.0	-	-	-	-
8f-Burgers, meatballs, meatloaf and breaded meat and poultry	540	32.4	22.0	54.2	56.5	-	0.0
8 g-Ham, canned meat and poultry, and uncooked, pickled, cured and smoked meats that are not deli meats	915	33.3	40.0	28.6	20.0	-	50.0
8 h-Patés and meat spreads	720	36.4	87.5	25.0	0.0	-	33.3
9. Processed fish and seafood							
9a-Canned fish	320	78.9	92.3	77.8	61.1	85.2	78.1
9c-Fish and seafood cakes, fingers or burgers, seasoned, and breaded or battered or with sauces	310	50.0	50.0	50.0	46.7	-	100.0
9d-Smoked, salted, pickled and kippered fish	540	83.3	100.0	75.0	-	-	75.0

Table 2 (continued)

Category/sub-category	PAHO sodium target (mg/100 g)	All products (n = 4719)	Nationally produced (n = 2188)	Imported products			
				All imported products (n = 2531)	Mercosur countries (n = 1282)	Other American countries (n = 309)	Other regions of the world (n = 940)
10. Soy products and meat alternatives							
10b-Meat analogues and other meat alternatives	410	25.0	13.3	44.4	75.0	16.7	50.0
11. Soups							
11a-Wet and dry soups (as consumed)	260	61.2	56.8	66.7	64.0	100.0	0.0
12. Ready-made foods, convenience foods, and mixed dishes							
12c-Pasta, noodles, rice or grains with sauce or seasonings (as consumed)	330	27.3	22.2	50.0	50.0	-	-
12d-Pasta, noodles, rice or grains with sauce or seasonings (dry mix, as sold)	870	58.2	57.1	59.0	87.5	25.0	42.1
12f-Pizza and pizza snacks	500	54.2	48.8	85.7	85.7	-	-
12 h-Refrigerated or frozen appetizers, sides and entrees	575	34.7	35.7	20.0	-	-	20.0
12 g-Sandwiches	500	40.0	40.0	-	-	-	-
13. Pasta and noodles fresh or dry without seasoning							
13-Fresh pasta (no filling)	0	93.2	89.2	100.0	100.0	-	100.0
13-Fresh pasta with filling	330	43.4	42.7	60.0	60.0	-	-
14. Granola and energy bars, and nut butters/spreads							
14a-Granola, cereal and energy bars	170	19.9	22.4	19.0	16.0	45.5	100.0
14b-Nut butters and nut spreads	330	23.1	0.0	25.0	0.0	-	33.3
15. Fats and oils							
15a-Butter, margarine, and butter blends	510	50.0	21.4	90.0	100.0	-	66.7
15b-Mayonnaise	670	78.7	58.3	83.7	92.9	0.0	33.3
15c-Salad dressing & vinaigrette	800	39.4	0.0	43.3	100.0	66.7	27.3
16. Sauces, dips, gravy and condiments							
16a-Bouillon cubes and powders (as sold)	18000	88.1	100.0	83.3	83.3	-	-
16b-Pasta sauce	330	58.6	45.7	78.3	64.3	100.0	100.0
16c-Pesto	800	53.1	50.0	53.8	33.3	0.0	75.0
16d-Tomato sauce	300	59.5	43.6	77.1	45.5	100.0	90.9
16e-Ketchup and similar tomato-type condiments (as consumed)	800	50.0	29.4	63.0	36.4	85.7	50.0
16f-Mustard	1000	52.9	19.0	68.1	50.0	77.8	75.0
16 g-Spicy sauce	1100	51.5	0.0	53.1	66.7	57.1	37.5
16 h-Gravy, cooking sauces, dips, and salsa (as consumed)	350	75.0	44.4	100.0	-	100.0	100.0
16j-Soy and other salty oriental sauces	2900	87.0	85.7	87.5	88.9	88.9	85.7
16 m-Dry seasoning mixes for meat and fish	10000	86.7	-	86.7	90.0	80.0	-
16 l-Dry seasoning mixes for rice and side dishes	10000	20.0	100.0	0.0	0.0	-	0.0
Total	-	50.0	42.3	56.6	53.6	66.8	57.2

who produce foods imported into Uruguay would raise concerns to their home/national government regarding the impact on trade. These concerns may be raised in international trade forums; for example, in the WTO Technical Barriers to Trade Committee as a Specific Trade Concerns. However, it is important for public health policy makers to be aware that mandatory sodium reformulation is consistent with key trade principles, and as a non-discriminatory measure, based on evidence and designed to protect public health, this would not be a Technical Barrier to Trade [16, 17]. A similar conclusion was drawn by a Canadian task force when analysing mandatory trans-fat limits [41]. In addition, although several WTO members have raised trade concerns about regulations mandating nutrient limits (including mandatory sodium targets) these measures have not resulted in formal disputes [17, 42]; [43]). This pattern suggests that, while mandatory sodium limits may trigger discussions or concerns within the WTO Technical Barriers to Trade Committee, they are unlikely to escalate into litigation. Similar dynamics have been observed for other nutrition-related measures, such as front-of-pack nutrition labelling, which generated debate but did not culminate in dispute settlement [44].

Beyond formal WTO processes, it is important to recognise that the trade impacts of mandatory targets could introduce policy inertia or regulatory chill through industry pressure and government-to-government lobbying [25, 26]. Such dynamics have been documented globally, and particularly across Latin America, in the implementation of various food and nutrition policies [19, 26, 45, 46]. Industry actors are expected to frame public health measures as trade-restrictive or economically harmful to influence decision-makers, even when these claims lack legal basis [47–50]. Therefore, acknowledging the potential trade impacts of mandatory sodium targets is essential, as it helps anticipate the broader political economy dynamics in which such regulations are embedded.

A potential initial strategy for implementing mandatory sodium reformulation programs could involve targeting product categories with a high proportion of nationally produced items, such as cheeses, processed meats and bread. These products are widely consumed in Uruguay and are known to contribute substantially to overall sodium intake [51], making them strategic starting points for sodium reduction initiatives with meaningful public health benefits. However, the health impact of this approach would likely be smaller than that of policies covering a broader range of food categories. In this regard, modelling studies assessing the potential effects of different mandatory sodium target scenarios on population sodium intake could provide valuable evidence to guide policymaking.

Guidance by Codex could potentially facilitate the implementation of mandatory sodium limits in Uruguay. Because Codex is referenced in the agreements of the WTO as an international standards setting body, its guidance is influential in a trade context [52]. At the global level, the Codex Alimentarius provides an agreed framework regarding nutrient limits, with nutrient reference values (NCD specific) established for saturated fat and sodium, which have helped to support global efforts towards reformulation [53]. In the Uruguayan context, given the substantial contribution of neighbouring countries to the national food supply, a regional regulatory approach could facilitate the implementation of sodium reduction policies and increase their effectiveness. Establishing mandatory sodium limits as a technical regulation at the MERCOSUR level, encompassing Argentina, Brazil, Paraguay, and Uruguay, could facilitate intra-regional trade by creating harmonized standards across member states. Once adopted at the MERCOSUR level, the regulation would then be internalised by each country and incorporated into national legislation [54].

Another possible avenue to facilitate the cross-border implementation of mandatory sodium limits is the development of an internationally agreed framework, akin to a simplified version of the Framework Convention for Tobacco Control (FCTC). Such a framework could establish binding commitments alongside non-binding guidelines to support the adoption of evidence-based sodium reduction targets [55]. This approach has been proposed in the context of the reduction of trans fat consumption [56] and could be extended to the regulation of sodium content. Although negotiating a complex international agreement poses significant challenges, a harmonised regulatory framework could ease compliance for regional producers and strengthen public health efforts across multiple countries.

The substantial variability in sodium content across all product categories, as reflected in the wide interquartile ranges, suggests considerable scope for reformulation and indicates the technical feasibility of introducing mandatory sodium targets. This heterogeneity implies that many products are already manufactured with substantially lower sodium levels, demonstrating that further reductions are achievable within existing technological and sensory constraints.

However, the findings of the current work also show the further suggest that if PAHOs sodium reduction targets were adopted as mandatory limits, a significant proportion of imported products would no longer comply with regulatory requirements, potentially restricting market access for various food categories. This would be particularly problematic for categories such as bread with additions, packaged deli meats, and cooking sauces, where all imported products exceeded PAHOs limits. Given the high proportion of imported foods in the Uruguayan market, such strict restrictions could affect product availability and consumer choice while also raising concerns about price increases due to reduced market competition. In addition, in some categories a large proportion of national products already contain lower sodium levels than the limits proposed by the PAHO. Instead of relying on PAHO targets, which are based on products commercialised in other Latin American countries, Uruguay could establish sodium thresholds that more accurately reflect the national market. For instance, maximum sodium targets could be set at the median sodium content of products available in Uruguay, enabling a more gradual reduction and mitigating potential trade impacts. A one-size-fits-all approach may not be appropriate, and adapting international recommendations to local realities is essential for effective implementation. This strategy has been adopted by other Latin American countries, such as Argentina and Colombia, when developing their mandatory sodium limits [57, 58].

Another significant drawback of PAHOs proposed maximum sodium targets is that, in several product categories, the median sodium content of items sold in the Uruguayan market exceeds the recommended limits by more than 15%. This suggests that achieving compliance could require noticeable reductions in sodium levels, potentially altering taste profiles in a way that consumers would immediately detect [59–65]). A sudden and drastic reduction may lead to lower consumer acceptance, negatively impacting sales and discouraging industry participation in reformulation efforts [60, 66]. To mitigate this risk, sodium reduction programs could adopt a gradual, reduction approach, allowing consumers to adjust over time without experiencing a sudden change in taste [20, 67, 68]. Percentage reductions aligned with the maximum sodium decrease that does not noticeably affect salty taste (approximately 10–15%) could be implemented [60, 62]. Although international food companies have been reported to market products with varying nutritional compositions across countries [69, 70], it is less likely that they would produce a specific formulation solely for the Uruguayan market given its relatively small size. For this reason, implementing gradual and percentual sodium reductions, unlikely to be noticeable to consumers, could be more acceptable to multinational companies, as such changes would not be perceived by consumers in other markets. However, empirical research is needed to confirm this hypothesis.

Limitations and future research directions

This study provides novel insights on the trade implications of sodium reduction policies, however, several limitations must be acknowledged. First, the sodium content analysis was based on food labelling information, which may not fully reflect actual sodium levels due to potential discrepancies in reporting or variations in batch production. Second, data were collected in a limited number of outlets that do not represent all products available in the Uruguayan market. Despite the large overall dataset, some subcategories included few products. While these limitations may affect the generalizability of findings for certain subcategories, they are not expected to compromise the overall validity of the conclusions regarding the trade implications of mandatory maximum sodium targets. Finally, this study does not account for consumer purchasing and consumption patterns, which are critical for understanding the real impact of sodium reduction initiatives.

Future studies should examine the technical feasibility of different sodium reduction policy options. Gaining an in-depth understanding of the perspectives and acceptability of these policies among key stakeholders, including policymakers, industry representatives, and consumers, would provide valuable insights into the barriers and facilitators that could shape policy adoption and implementation. Understanding the economic implications of reformulation, such as cost impacts on manufacturers and potential price shifts for consumers, could also contribute to designing effective and sustainable sodium reduction programs.

Conclusion

This study provides one of the first trade-oriented assessments of sodium content in packaged foods, using Uruguay, a small Latin American country with a high reliance on food imports, as a case study. These results suggest that mandatory sodium reduction policies would affect both groups similarly and are unlikely to constitute discriminatory trade measures.

The substantial variability in sodium content across all subcategories indicates clear technical potential for reformulation. However, applying PAHOs sodium targets as mandatory limits could unintentionally restrict the entry of many imported products. Establishing sodium thresholds tailored to Uruguay's market, such as category-specific medians, could achieve gradual, feasible reductions while mitigating trade impacts. Similar approaches have been used by other Latin American countries. Successful implementation of sodium reduction policies in Uruguay will require strong government commitment and active involvement to overcome the domestic and international challenges related to potential trade impacts that are identified in the present work

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Data availability
The data generated and analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no conflicting interests that could have influenced the results reported in the present work.

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