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A label survey to identify ingredients potentially containing GM organisms to estimate intake exposure in Brazil

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Abstract

Objective: To identify ingredients from products and by-products derived from GM crops in packaged food products and to analyse the presence of these ingredients in the foods most commonly consumed by the Brazilian population.
Design: Cross-sectional study.
Setting: A search of the scientific literature to identify the use of products and by-products derived from GM crops in foods in Brazil and a study of food labels in a supermarket belonging to one of the ten largest supermarket chains in Brazil.
Subjects: To identify the ingredients present in packaged food products and their nomenclatures, the labels of all packaged food products available for sale in a supermarket were analysed. Subsequently, the presence of potential GM ingredients in the foods most commonly consumed by the Brazilian population was analysed.
Results: A total of twenty-eight GM crops' by-products with applications in the food industry (from soyabeans, corn, cotton and a yeast) were identified. Such by-products are presented as food ingredients or additives on food labels with 101 distinct nomenclatures. Most of the variety (63·8 %) and the quantity (64·5 %) of the foods most commonly consumed by Brazilians may contain a least one GM ingredient.
Conclusions: The presence of at least one potential GM ingredient was observed in more than half of the variety of foods most commonly consumed by the Brazilian population. Such ingredients were identified with distinct nomenclatures and incomplete descriptions, which may make it difficult to identify potential GM foods and confuse consumers when making food choices.

Keywords
GM organisms
GM foods
Food labelling
Food labels

The production of GM foods is increasing worldwide, regardless of a country's development level. GM foods are derived from organisms in which the genetic material (DNA) has been altered in a way that does not occur naturally[1,2]. They are also referred to as 'transgenic foods'. In Brazil, they have various agronomic characteristics, particularly tolerance to herbicides and resistance to insects[3].

Brazil has the second largest GM cultivation in the world, or the equivalent of 27 % of the world's production of GM organisms (GMO)[4], which occupies an area of 49·1 million hectares and takes up approximately 70 % of Brazil's arable land[5]. In addition, of all soyabeans, corn and cotton grown in Brazil, 96·5, 88·4 and 78·3 %, respectively, are GM[4], without considering the potential for biological contamination from planting to processing[6]. The following crops were approved for cultivation and consumption in Brazil between 1998 and 2018: sixteen varieties of soyabean, forty-four of corn, fifteen of cotton and one of yeast (*Saccharomyces cerevisiae*), as well as a variety of beans that has not yet been made available for consumption[7].

From these data, it can be inferred that most of the foods sold in Brazil that contain soya, corn or cotton in their composition come from GM plants. Ingredients derived from soyabean, corn and cotton products and by-products are widely used by the food industry due to their large agricultural production, low cost and technical applications[8,9], and are increasingly present in the population's diet[10].

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This fact has been evidenced by studies on the laboratory detection of GMO in Brazilian foods, which found that GM ingredients were present in processed meats, hot dog sausages, sausages, ham, bakery products and snack foods, as well as in corn- and soya-based products such as powdered soya milk, soya drinks, biscuits, instant soups, desserts and other foods[11–14].

Studies have shown that the consumption of GM foods can be harmful to health, especially when considering the pesticides associated with them[15]. The following conditions have been observed: hepatic and renal toxicity in animals that were fed GM corn; the appearance of tumours in rats that were fed GM corn[16–18]; inflammation in the stomachs of pigs that were fed GM corn and soyabeans[19]; and damage to the mucous membranes of the jejune surface in rats that were fed GM corn[20]. In man, such harm has been associated with neurological problems, hormonal changes, infertility, cancer, diabetes, obesity, gastrointestinal disorders, depression, heart disease, autism, Alzheimer's disease and coeliac disease[21–26].

In recent years, an increase in products containing GMO and an increase of diseases in the realm of global public health have been observed as well as the increased use of pesticides associated with GM crops[25,27,28]. Swanson *et al.*[25] showed that the significant increase in the incidence of twenty-two chronic diseases in the USA correlated strongly with the increased cultivation of GM crops and the application of glyphosate-based herbicides, evidencing their effects on human health. Thus, consuming these foods has serious implications for public health, exposure to pesticides and the consequent risks of acute and chronic poisoning, in addition to the diseases mentioned above.

Considering the potential impacts caused by GM food consumption, the precautionary principle should be adopted. According to this principle, in cases where there are threats of serious or irreversible damage, a lack of full scientific certainty should not be used as a reason for postponing cost-effective measures to prevent environmental degradation. In other words, this principle calls for the adoption of measures against potential risks that cannot yet be identified according to current knowledge[29].

To comply with the precautionary principle, it is essential that the population has access to information on the presence of GM ingredients on food labels. In Brazil, the reporting of information on labels aims to guarantee the right to information, which is set forth in the Federal Constitution of 1988 and recommended by the Brazilian Consumer Protection Code, which states that clear and adequate information on the composition of food is a basic consumer right[30,31].

According to Biosafety Law No. 11 105/2005 (Article 40)[2], foods and food ingredients intended for human or animal consumption that contain or are produced from GMO or their derivatives must provide this information on their labels, in accordance with Decree No. 4680/2003. This decree states that all foods and food ingredients with more than 1% of their composition containing or produced from GMO must be labelled. Ordinance No. 2658/2003 of the Ministry of Justice requires the identification of GMO on food labels with the symbol of the letter T in the centre of a yellow triangle[32,33]. However, Brazilian studies have revealed cases in which GM ingredients have made up more than 1% of packaged food products without these components being reported on the label, as required by GMO labelling legislation[13,14,34]. Thus, it is evident that the right of consumers to information about the presence of GM ingredients on food labels is not always being guaranteed.

The present study's hypothesis is that most of the foods consumed by the Brazilian population may contain GM soya, corn and/or cotton derivatives. This is due to the increasing cultivation of GM soyabeans, corn and cotton in Brazil (which represents 96·5% of soyabeans, 88·4% of corn and 78·3% of cotton grown in the country) and the fact that these plants give rise to many by-products used by the food industry. However, presenting these products or by-products in the ingredients list can be confusing to consumers because the terms are complex and difficult to understand or may not make their origin clear (as in the cases of maltodextrin, starch and guar gum). However, we have not identified this type of study in the literature.

Therefore, the objective of the present study was to identify ingredients from products and by-products potentially derived from GM crops on labels of packaged food products sold in a supermarket and to analyse whether these ingredients are present in the foods most commonly consumed by the Brazilian population.

Methods

The present study was a cross-sectional, descriptive and exploratory study, which was conducted in three stages (Fig. 1).

Stage 1

In the first stage, a literature review was conducted in the Scopus and SciELO article databases, Google Scholar, books, websites and documents to identify products and by-products potentially derived from GM crops approved for consumption in Brazil that are used as ingredients by the food industry. The keywords used in the searches were: 'soybean', 'corn', 'cottonseed' and '*Saccharomyces cerevisiae*', in combination with 'food industry' and 'technological application'. In addition, the snowball technique was used, searching for articles in the references of the studies found. This stage aimed to create an initial list of products and by-products derived from soyabeans, corn and cotton as well as their uses, since many of these may

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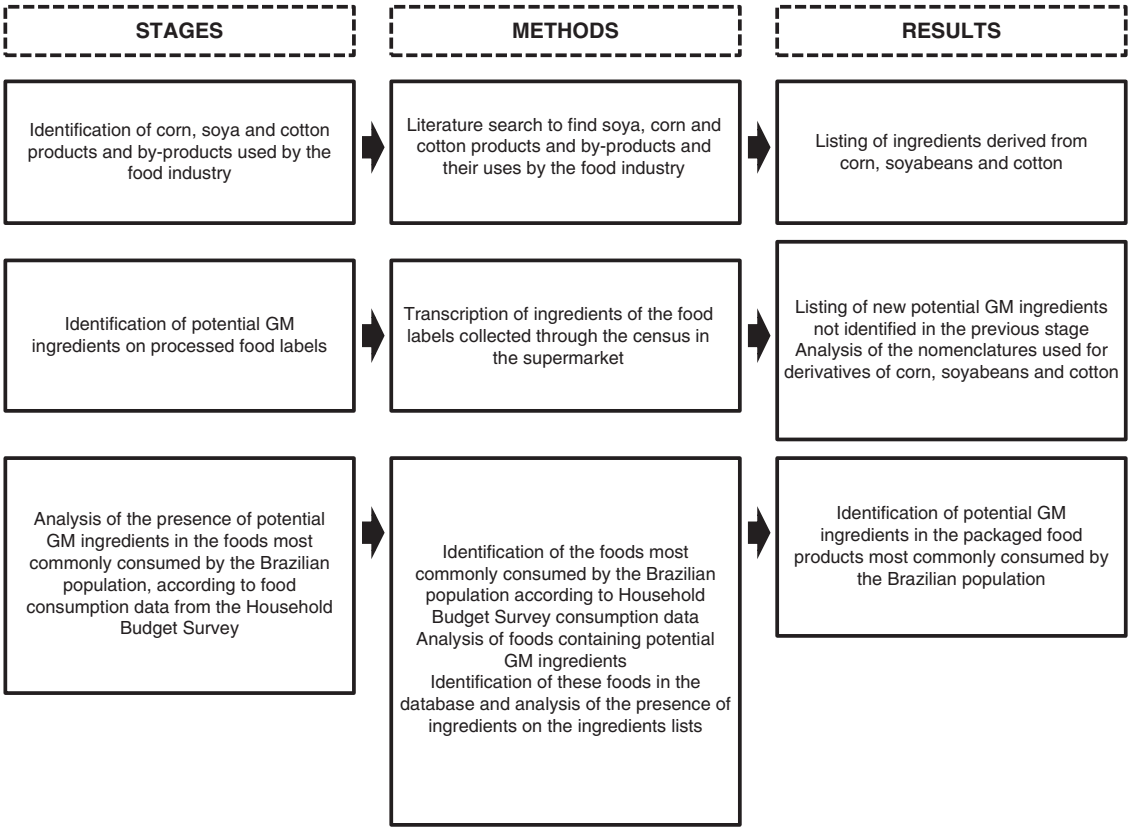

Fig. 1 Study stages of the label survey to identify ingredients potentially containing GM organisms to estimate intake exposure in Brazil

not be recognized as ingredients derived from soyabeans, corn or cotton solely from the nomenclatures used in the ingredients lists. The data were analysed and the results are expressed qualitatively with the technological purposes of the food industry ingredients.

Stage 2

In the second stage, these products and by-products were identified on the labels of packaged foods available for sale in a large supermarket in Brazil. The selected supermarket belongs to one of the ten largest Brazilian chain stores, according to the Brazilian Supermarket Association, with twenty-seven stores throughout the country. We also sought to identify other possible nomenclatures for products and by-products derived from GM crops that were present on the labels but not previously identified in the literature.

All packaged food products that met the criteria established by Brazilian and Mercosur packaged food labelling regulations (No. 259/2002)[35] were included in the study. The analysis performed on all the packaged foods sold raises the possibility that the same foods may be sold in other countries. In addition, few countries have performed labelling analyses that consider all the foods available in a supermarket[36–41]. Foods exempted from mandatory labelling (those packaged in the presence of the consumer) as well as those intended for animal consumption were not included.

The following food product identification information was recorded: name, trade name, brand, manufacturer and country of origin. All labels were photographed for later identification, transcription and ingredients list analysis. The data collectors were trained and the data were collected with the aid of computer tablets, using electronic forms developed in the EpiCollect Plus software program. In total, the information from 5048 food products was collected during a period of five months in 2013–2014.

An analysis was made of the information provided on the ingredients list of all collected food labels. Three researchers exactly transcribed the ingredients and food additives in the order they appeared in the ingredients list on each food label using Microsoft Excel® 2010. For quality control purposes, the data were cross-checked with the data transcribed by three other researchers.

Based on the results obtained in the literature review in Stage 1, the ingredients lists were analysed using the text mining in R technique[42–44]. In this way, all terms present on the foods' ingredients lists were listed. From this listing, all information on the ingredients of all foods was analysed manually to identify the presence of other ingredients and the *S. cerevisiae* yeast, as well as the nomenclatures used for corn, soyabean and cotton derivatives. Thus, we identified the presence of ingredients

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derived from products and by-products of these crops that were not initially listed. In the case of ingredients that did not contain the words 'corn', 'soy' and 'cotton', such as guar gum and citric acid, the literature was consulted again to confirm the origin of such ingredients.

It should be noted that a label's ingredients list is the only way for consumers to identify the presence of potentially GM ingredients in packaged foods sold in Brazil. This is because GMO labelling legislation is often not followed.

Regarding ingredients whose origin was unclear, they were considered potential corn, soyabean or cotton by-products when the scientific literature considered this possibility. For example, one specific ingredient is starch, which can come from corn, manioc or other cereals. When an ingredient's origin is not specified, it may be a corn by-product and therefore can be considered to potentially contain GMO. An example of a doubtful ingredient is margarine, since complete information on the ingredients used in its production is not made available to consumers. Thus, margarine can originate from sunflower or canola oil, but can also be made from corn, soyabean or cottonseed oil. Thus, when in doubt, margarine that had no designation of origin was considered to potentially contain GMO.

Moreover, as the current study analyses the situation from the point of view of consumer information, it is assumed that if a manufacturer does not provide the complete name of an ingredient, it is leaving its origin in doubt and the analysis should therefore provide for this. That is, if a manufacturer does not use ingredients derived from corn, soyabeans or cotton or that contain the *S. cerevisiae* yeast, it should make this information clear on the label. Otherwise, it may be considered to be using one or more of these ingredients.

Stage 3

The last stage consisted of identifying the potential presence of ingredients potentially derived from GM crops in the foods most commonly consumed by the Brazilian population. To this end, secondary per capita consumption data from the 2008–2009 Household Budget Survey (HBS)[45] were used. The HBS is a national household survey that is conducted during a period of an entire year every 5 years by the Brazilian Institute of Geography and Statistics in a representative sample of Brazilian households. To obtain information on personal food consumption, data from a randomly selected sub-sample of households (n 13 569) were used. Data on food and beverage consumption over a 24 h period were collected through dietary records that were completed by individuals over 10 years of age (n 34 003) on two non-consecutive days. Details on the sampling plan and study design of the HBS can be found in the Brazilian Institute of Geography and Statistics' report[45].

The informants cited a total of 1121 foods. These foods were divided into twenty-four groups and 105 subgroups[45]. For the present study, all food subgroups defined by the HBS were considered.

From this list of foods most commonly consumed by the Brazilian population, we sought to identify the foods that contain ingredients derived from soyabean, corn and cotton products and by-products and the *S. cerevisiae* yeast (results of Steps 1 and 2, Table 1), which are potentially GM. To this end, we searched the database of packaged food products collected in the supermarket to find the same or similar foods for each food item in the groups and subgroups of foods most commonly consumed by the Brazilian population. All potential GM ingredients in these foods were analysed and listed, and the results were expressed as 'may contain' when any analysed food contained such an ingredient.

Results

In the scientific literature, information was found on one cotton product, thirteen soyabean products and by-products and fourteen corn products and by-products which provide the raw materials for different ingredients used by the food industry for various purposes. From the ingredients lists of the 5048 foods analysed in the supermarket, 101 distinct nomenclatures were identified corresponding to ingredients derived from corn, soyabeans and cotton and referring to the presence of the *S. cerevisiae* yeast, which may contain GMO. Of these, thirty were terms referring to derivatives of corn, twenty-six to soyabeans, three to cotton and one referred to a yeast. Thirty-two terms did not indicate the ingredient's origin, possibly being common to the three. For example, vegetable fat and vegetable oil can be produced from corn, soyabean, cottonseed or some other plant source.

Table 1 shows the soyabean, corn and cotton products and by-products or potential by-products, their main technological purposes in the food industry and the nomenclatures found in the ingredients lists of the 5048 food products analysed.

Of the 101 nomenclatures used to designate the ingredients, thirty-two did not specify origin. However, they were considered likely to be soyabean, corn and cotton by-products according to the scientific literature and the criteria explained earlier in the 'Methods' section. These ingredients include citric acid, vegetable oil, vegetable fat (fractionated, hydrogenated, processed and partially hydrogenated), guar and xanthan gums, mono- and diglycerides of fatty acids, lecithin, protein, vegetable protein, starch, modified starch, dextrin, polydextrose, maltose, maltodextrin, semolina, glucose syrup, glucose, high-fructose syrup, glucose syrup, glucose–fructose syrup, polyols, xylitol, mannitol and sorbitol, as well as non-malted cereals.

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Table 1 Soyabean, corn and cotton by-products used by the food industry, their main technological applications and the nomenclatures found in the ingredients lists of the 5048 packaged food products analysed, Brazil, 2013–2014

Potential GM products	Potential GM by-products	Technological applications in the food industry	Nomenclatures observed on labels
Cotton	Cottonseed oil	Used for frying and in the composition of processed foods	Cotton Vegetable fat* Cottonseed oil Cottonseed vegetable oil
Soyabeans	Water-soluble soya extract (soya milk)	Used as a protein source and can be used as a food or food ingredient[65]	Soyabean extract
	Soya flour Degreased soya flour Soya grits	Used as a protein source to add to foods[66]	Soyabean meal Soya flour Soya flakes Soya grits
	Soyabean fibre	Added to foods to increase fibre content[67]	Soyabean fibre
	Guar gum	Used as a thickening, gelling, emulsifying and stabilizing agent in foods and beverages[68]. It can be combined with proteins by altering their rheological, solubility and gelling properties and thus may contain traces of soya protein[69]	Guar gum*
	Xanthan gum	Used as a suspending agent, gelling agent, stabilizer, emulsifier, thickener and to control the rheological properties of dough and flour, extending their shelf-life[70]. Combined with soya protein, it contributes to gelling and improves food texture. Thus, it is a product that may contain soya protein[71]	Xanthan gum*
	Soyabeans	Ingredient of culinary preparations such as soups, sauces and salads	Soyabeans Granulated soyabeans Toasted soyabeans Soyabean derivatives Soyabean traces
	Soya lecithin	Contributes to improving volume, fat dispersion and anti-staling in bakery products, reduction of viscosity and prevention of crystallization in chocolates, and is used as a stabilizer and emulsifier in foods[72]	Lecithin* Soya lecithin Powdered milk†
	Soya sauce	Fermented sauce obtained from soyabeans, used as a seasoning or culinary ingredient	Soya sauce Shoyu
	Soyabean oil	Used as a seasoning, in fried foods and for the production of fats, such as margarines. It can undergo a hydrogenation, interesterification or fractionation process to obtain adequate plasticity characteristics in the final product[73]. Fatty acid mono- and diglycerides can come from soyabeans and are components of many processed foods, being used as stabilizers[49]	Soyabean oil Soyabean vegetable oil Vegetable oil* Hydrogenated soyabean fat Vegetable fat* Soyabean vegetable fat Fractionated vegetable fat* Hydrogenated vegetable fat* Processed vegetable fat* Partially hydrogenated vegetable fat* Fatty acid monoglycerides and diglycerides* Margarine†
	Fermented soyabean paste	Can be used in the preparation of soups and vegetables and to season meats	Miso
	Isolated soyabean protein	Used as a consistency agent for meat products and as a protein source[9,65,74]	Protein* Soyabean protein Hydrolysed soyabean protein Isolated soyabean protein Vegetable protein*
	Concentrated soyabean protein	Protein source used as an ingredient in the manufacturing of foodstuffs[65] and in meat-based emulsions, bakery products, powdered drinks and soups, baby food and cereals[9]	Protein* Soyabean protein Concentrated soyabean protein Vegetable protein*
	Textured soyabean protein	Used as a food ingredient, as a protein source and as an extender in meat products[65] due to its water binding, fat emulsion and stabilizing properties and its organoleptic characteristics such as texture, appearance and firmness of the final product[75]	Protein* Soyabean protein Textured soyabean protein Vegetable protein*
Corn	Citric acid	Produced from the fermentation of inexpensive starch- and sucrose-based feedstocks, with corn being the most commonly used raw material[76]. It is used in the food and beverage industry as an acidulant or antioxidant to preserve or enhance flavours and aromas[77]	Citric acid*

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Table 1 *Continued*

Potential GM products	Potential GM by-products	Technological applications in the food industry	Nomenclatures observed on labels
	Corn starch	Used industrially to obtain dextrose and glucose[74] and as a cooking preparation ingredient	Starch* Corn starch Yeast† Chemical yeast†
	Modified corn starch	Used as a thickener, to control water loss in foods, as well as to promote fermentation and crunchiness in biscuits[74]	Modified starch* Modified corn starch Pre-gelatinized starch*
	Dextrinized starch	Used as a thickener in sauces and baby food, as it is easier to digest[74]	Corn starch
	Corn dextrose	Used as toppings for cakes	Dextrin Corn dextrose Polydextrose*
	Corn flour and corn grits	Used as an ingredient in culinary preparations	Corn meal Biju flour Corn flour Polenta (corn porridge) flour Corn flakes Non-malted cereals* Food colouring† Corn grits Corn flakes
	Corn	Used as an ingredient in culinary preparations	Corn porridge Creamed corn Corn Wholegrain corn powder Ground corn Corn-on-the-cob
	Corn maltose	Possesses properties of sweetness, high thermostability, low hygroscopy and viscosity, preventing sucrose crystallization[78]. Maltose is also important in brewing, as its content influences the quality of the final product, particularly for beer[79]	Maltose*
	Corn maltodextrin	Provides improved texture, reduced flour taste, modifies sweetness and controls non-enzymatic browning. Maltodextrin is used as an ingredient in confectionery products, meat products, alcohol-free beers, sauces, baby food, soup mixes and sports drinks[80]	Maltodextrin* Corn starch maltodextrin Corn maltodextrin
	Corn oil	An edible oil derived from corn and used in culinary preparations	Corn oil Vegetable oil* Corn vegetable oil
	Corn protein	Can be used to enrich foods	Protein* Corn protein
	Corn semolina	One of the sources of cereal starch resulting from the incomplete grinding of corn. It is used in the food industry to produce low-moisture, crunchy products[81]	Corn semolina Semolina*
	Corn syrup	Provides flavour, colour, aroma, texture and sweetness to foods[48]. It is used as a humectant, preventing the loss of water from food, and as a way to introduce reducing sugars into preparations, providing greater colouring on the surface and a crunchier texture. It has a higher sweetening power than sucrose and controls crystallization in sweets and jams/jellies[49,82]	Glucose* Corn glucose High-fructose syrup* Glucose syrup* Corn glucose syrup Glucose–fructose syrup* Corn syrup High-fructose corn syrup
	Polyols	Produced by the partial hydrolysis of corn, wheat or potato starch and subsequent hydrogenation of the hydrolysate under high temperature/pressure. They are viscosity and consistency agents, humectants and crystallization modifiers and act as sweeteners[49]	Xylitol* Mannitol* Sorbitol*
Yeast	*Saccharomyces cerevisiae*	In its active form, *S. cerevisiae* is used in the baking industry to form carbon dioxide, in the alcoholic fermentation of beers and wines, and in other fermentative processes. In its inactive form, it is used as a nutritional supplement and an aroma and flavour enhancer. It produces the enzyme invertase, which is used as food additive to produce inverted sugar, used by the food industry to manufacture sweets and ice cream[51]	Yeast Biological yeast

*Ingredients that are potentially corn, soya or cotton by-products.
†Composite ingredients listed in the ingredients lists that may contain some ingredients derived from corn, soya or cotton.

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Other examples of doubtful ingredients are food colouring, chemical yeast, powdered milk and margarine, as full information on their production components are not available when these ingredients appear on the packaged food ingredients lists. Nevertheless, such compound ingredients are known to contain soyabean or corn derivatives such as corn starch (which is present in food colouring and chemical yeast), soya lecithin (present in powdered milk) and soyabean, corn and other vegetable oils (which are components of margarine). Biological yeast, in turn, is composed of *S. cerevisiae* yeast, yet this information is not available to consumers either.

Of the 105 subgroups of foods consumed by the Brazilian population, thirty-eight did not contain any potential GM ingredients. These included foods such as rice, beans, fruits, vegetables, roots, tubers and oilseeds. Table 2 shows the potential GM ingredients present on the ingredients lists of packaged food products collected in the supermarket. It is worth noting that such packaged foods contained at least one of the ingredients listed, but not necessarily all of the ingredients due to variation in the products' composition.

It was observed that 63·8 % (sixty-seven food subgroups) of the variety of foods most commonly consumed by the population contain potential GM ingredients. The mean per capita amount of daily food consumption of the Brazilian population was 1587·8 g. Of this, 1023·8 g (64·5 %) came from foods containing ingredients derived from soyabean, corn and cotton by-products.

It is noteworthy that most of the food items analysed contained three or more ingredients derived from corn and/or soyabeans, which are potential GMO. No cotton-derived ingredients were identified in the packaged food products analysed.

Discussion

From the literature, the present study identified several soyabean, corn and cotton by-products, as well as a yeast, that were identified with 101 distinct nomenclatures on the labels of the packaged food products analysed from one of the largest supermarket chains in Brazil. Therefore, the study's relevance and scientific contribution is highlighted, since there is not yet any information available or systematized in the literature regarding the food industry's widespread use of these potentially GM ingredients. In this respect, we must also highlight the study's methodological rigour, which included the complementary stages necessary to find 101 nomenclatures for potentially GM ingredients. The first stage consisted of a literature search to initially identify products and by-products derived from soyabeans, corn and cotton and their uses by the food industry. We then identified these products and by-products and the new nomenclatures on the labels of more than 5000 packaged foods sold in Brazil and possibly abroad. Without such methodological rigour, the number of potentially GM ingredients could have been underestimated, thus failing to reveal the magnitude of their use and presence in the foods most consumed by the Brazilian population. Our study used current national data and can make a significant contribution to public health actions.

Soyabean-derived products are used as ingredients in various foods. Several by-products are extracted from soyabeans and are mainly used due to their low cost and functional characteristics, since they act as emulsifiers, stabilizers, thickeners and consistency agents and improve the texture and viscosity of foods. They also constitute a source of protein[9]. This explains their presence in many of the packaged food products that were investigated in the present study, such as meats, meat-based preparations, processed meats, pâtés, soya-based drinks, breads, pastas, cakes, ready-to-eat *farofa* (manioc flour), cereals, biscuits, chocolates, frozen pizzas, sandwiches, breaded snacks and ice cream.

Among the by-products derived from corn, starch is the one most used in the food industry as a raw material or food additive[46,47]. Corn syrup is also widely used by the food industry for the purpose of sweetening and prolonging the shelf-life of food[48].

The present study's literature review stage was necessary to identify by-products with nomenclatures that are difficult to recognize as originating from GM ingredients merely by analysing the ingredients lists on the food labels. For example, citric acid is a food additive that is widely used in packaged food products. It is not always derived from fruits and can be obtained from the aerobic fermentation of corn sugar, a fact that the nomenclature does not make clear. Other examples are xanthan gum and guar gum, which are not necessarily derived from soyabeans. However, soya protein can be incorporated during their production process. These gums make it possible to increase viscosity[48,49] and are present in many of the foods we studied, such as beverages, meats, yoghurts, instant noodles, ice cream, chocolate drinks, sauces and condiments.

The stage in which the ingredients lists of 5048 packaged foods were analysed identified 101 distinct nomenclatures to designate twenty-eight by-products derived from soyabeans, corn and cotton as well as *S. cerevisiae* yeast. One such example is soyabean oil, which was identified with twelve different nomenclatures in the ingredients lists, among them vegetable fat. Glucose syrup, which is derived from corn, appeared with thirteen different nomenclatures in the evaluated ingredients lists, many of which did not use the term 'corn'. These issues can make identification difficult for consumers who try to avoid consuming these foods for various reasons.

The absence of by-product source specification can make it difficult to identify GMO in the ingredients lists of packaged food products. Of the 101 nomenclatures

Table 2 Groups and subgroups of the processed foods most consumed by the Brazilian population according to the 2008–2009 Household Budget Survey, mean per capita amount consumed and potentially GM ingredients present in the packaged food ingredients lists collected in the supermarket survey, Brazil, 2013–2014

Group	Subgroup	Mean daily food consumption per capita (g)	Potentially GM ingredients present in the packaged food ingredients lists collected in the census
Non-alcoholic beverages	Coffee	215·1	Coffee with milk: may contain vegetable fat, glucose syrup, maltodextrin and/or soya lecithin, as it contains powdered milk Cappuccino coffee: may contain maltodextrin, vegetable fat, glucose syrup and/or soya lecithin, as it contains powdered milk
	Reconstituted powdered juices/drinks	145·0	Processed juices, drinks and reconstituted powdered juices of various flavours: may contain maltodextrin, citric acid, aspartame and/or xanthan gum
	Soft drinks	100·2	May contain corn starch and/or citric acid
	Other non-alcoholic beverages (energy drinks, coconut water)	2·7	Hydro-electrolytic supplement: may contain glucose and/or citric acid, which may come from GM corn
	Soya-based beverages	1·6	Powdered soya milk and flavoured/powdered soya milk: were among the most consumed foods but were not collected in the search Plain or flavoured soya-based beverages may contain soyabeans, soyabean extract, soya protein, maltodextrin, xanthan gum, soya lecithin and/or citric acid
	Total	464·6	
Meats	Beef, poultry, pork, fish	134·9	Animals may have received GM soya and GM corn feed Tender chicken: may contain soya protein, maltodextrin, glucose syrup Chester chicken: may contain soya protein, glucose Chicken steak: may contain corn flour, vegetable shortening, soya protein, xanthan gum, starch, maltodextrin Turkey breast: may contain maltodextrin, soya protein, starch Beef burger: may contain soya protein, maltodextrin, glucose Chicken burger: may contain soya protein, hydrogenated vegetable fat, maltodextrin
	Beef-based preparations	128·7	Meatballs: may contain soya protein, maltodextrin, starch, citric acid Beef stroganoff: may contain soya protein, corn starch, maltodextrin, margarine, soyabean oil
	Processed meats	21·6	Pork sausage: may contain dextrin, soya protein, maltodextrin Chicken sausage: may contain soya protein, maltodextrin, vegetable protein Mixed sausage: may contain soya protein, glucose Hot dog sausage: may contain soya protein, starch, vegetable oil Bologna: may contain glucose syrup, maltodextrin, corn starch, soya protein, yeast extract Cooked ham: contains soya protein, maltodextrin, dextrose Processed ham: may contain maltodextrin, soya protein, vegetable protein, corn starch, citric acid Processed turkey: may contain starch, maltodextrin, soya protein Pâté (chicken, ham, etc.): may contain soya protein, starch, corn glucose, maltodextrin, margarine, vegetable protein, citric acid, xanthan gum
	Total	154·8	
Dairy products	Whole and skimmed milk	39·4	Animal may have received GM soya or corn feed
	Flavoured and sweetened dairy beverages	29·7	Chocolate-flavoured food compound: may contain hydrogenated vegetable fat, guar gum, fatty acids, soya lecithin Chocolate milk/drink: may contain corn starch, guar gum, xanthan gum Flavoured milk: may contain corn starch, maltodextrin, hydrogenated vegetable fat, xanthan gum Flavoured powdered milk: may contain maltodextrin, whole milk powder (soya lecithin), xanthan gum, citric acid Dairy beverages may also contain GM yeast that is used in the fermentation process
	Yoghurts	224·5	Yoghurts of various flavours: may contain corn starch, citric acid, xanthan gum
	Cheese	6·8	Creamy cheese: may contain starch, maltodextrin Cheese may contain GM yeast for fermentation
	Milk-based preparations	8·2	Cornmeal porridge/corn porridge/*cremogema*: may contain maltodextrin, corn starch Cereal-based liquid food: may contain corn oil, maltodextrin, soya lecithin, starch, corn flour Corn cream/corn starch: can be obtained from GM corn
	Whole or skimmed powdered milk	0·3	The 'instant' versions may contain soya lecithin and/or isolated soya protein
	Total	84·5	

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Table 2 *Continued*

Group	Subgroup	Mean daily food consumption per capita (g)	Potentially GM ingredients present in the packaged food ingredients lists collected in the census
Bakery products	Salt bread, wholegrain bread, diet/light bread	54·3	Tube-shaped bread: may contain vegetable fat, soya flour, soya lecithin, glucose, fatty acids, fructose, soyabean oil Buttered bread: may contain vegetable fat, soya flour, soya lecithin, fatty acids Processed sliced bread: may contain vegetable fat, soya flour, soya lecithin Hamburger buns: may contain soyabean oil, fructose Corn bread: may contain cornmeal, margarine, soyabean oil, fatty acids, corn flakes Toast: may contain corn starch, vegetable fat, soya lecithin Wholegrain bread: may contain soyabean oil, corn starch, vegetable fat Most of these contain soya and corn derivatives (soyabean oil, dextrose, corn starch) Any type of bread may also have been produced using *Saccharomyces cerevisiae* yeast (biological yeast) during the alcoholic fermentation process
	Total	54·3	
Soups and broths	Soups and broths	50·3	Beef broth, onion or vegetable soup (powdered soup): may contain maltodextrin, yeast extract, corn starch, vegetable fat, glucose syrup, soya lecithin, corn, powdered milk, fatty acids
	Total	50·3	
Flour and pasta	Noodles and noodle-based preparations	36·3	Noodles, noodles with meat, yakissoba noodles: may contain vegetable fat, soya sauce, yeast extract, guar gum, citric acid
	Instant noodles	5·3	Ramen/instant noodles/ready-to-eat noodles: may contain vegetable fat, maltodextrin, yeast extract, xanthan gum, guar gum, corn flakes
	Pasta	4·9	Lasagne: may contain soya protein, corn starch, soyabean oil, margarine, maltodextrin Cappelletti/cannelloni/ravioli: may contain hydrogenated vegetable fat, maltodextrin, soya protein, vegetable protein, margarine, soyabean oil
	Farofa (Brazilian dish made of manioc flour fried in fat (oil or butter) that can be enriched with other ingredients (sausage, egg, vegetables))	1·9	Ready-to-eat *farofa*: may contain corn flour, vegetable oil, soya protein, maltodextrin, yeast extract, corn, cornmeal
	Breakfast cereals	0·8	Cereal bars: may contain maltodextrin, soya lecithin, glucose, sorbitol, corn cream, glucose syrup, corn oil, corn flour, polydextrose Breakfast cereal: may contain corn flour, glucose syrup, corn, maltodextrin, guar gum, vegetable fat, starch Milk flour: may contain milk powder, which contains soya lecithin Granola/cereal mix: may contain corn flakes, corn oil, maltodextrin, corn kernels, soya flour, maltodextrin, soya, soya protein, chemical yeast, soya lecithin Corn flakes: may contain corn, corn flour, glucose syrup
	Total	49·3	
Alcoholic beverages	Beer	31·1	May contain non-malted cereals, which are usually derived from corn
	Wine	1·6	GM yeast may have been used in the wine production process during the alcoholic fermentation stage
	Total	34·1	
Pizza, salty snacks and sandwiches	Sandwiches	11·8	Cheeseburger, hamburger: may contain hydrogenated vegetable fat, soya flour, soya protein, vegetable fat, maltodextrin, dextrin, corn starch, milk powder, soya lecithin, corn syrup, soya sauce, corn protein, soyabean oil
	Fried and baked salty snacks	10·1	Cassava cakes, cod cakes, *coxinha*, croquet, *empada*/*empadão* of various flavours, *enroladinho*, *esfirra* of various flavours (these are common Brazilian salty snacks): may contain margarine, corn starch, soyabean oil Breaded chicken pieces: may contain vegetable fat, soya protein, xanthan gum, starch, yeast extract, citric acid *Pastel* (a common Brazilian salty snack): may contain margarine, hydrogenated vegetable fat Chicken nuggets: may contain vegetable fat, starch, soya protein, dextrose, guar gum, dextrin Mixes for cheese bread: may contain corn starch, vegetable fat, margarine *Kibbeh*: may contain soya protein Quiche: may contain margarine, corn starch Salty pies of any flavour: may contain soyabean oil, corn, corn starch, margarine, chemical yeast, citric acid, corn flour, hydrogenated vegetable fat, vegetable fat, soya flour, soya protein

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Table 2 *Continued*

Group	Subgroup	Mean daily food consumption per capita (g)	Potentially GM ingredients present in the packaged food ingredients lists collected in the census
	Pizza	4·8	Frozen pizzas of various flavours: may contain vegetable soyabean oil, corn starch, dextrose, soya protein
	Processed salty snacks	0·7	Crisps: may contain vegetable oil, corn starch, maltodextrin, dextrin, corn syrup, glucose, chemical yeast, corn kernel, corn fibre, soya lecithin, fatty acids, citric acid, dextrose, milk powder (containing soya lecithin)
	Total	27·4	
Cereals	Corn and preparations	20·4	Foods cited: corn grits, meal, grains, ground, preserved, cooked, chilli, *pamonha*, flour, polenta, couscous, popcorn (foods consisting of or containing corn)
	Total	20·4	
Sweets	Chocolate powders	0·8	Chocolate powders, ovomaltine, food supplement: may contain glucose, powdered milk (containing soya lecithin), soya lecithin, maltodextrin, corn starch, guar gum, xanthan gum
	Milk-based sweets	5·5	Powder for puddings of various flavours: may contain corn starch, maltodextrin Creamy dairy desserts/mousse/delicacies: may contain corn starch, guar gum, vegetable fat, glucose syrup, dextrin Milk sweet: may contain glucose, corn starch, milk powder (contains soya lecithin), citric acid
	Ice cream/popsicles	4·6	Ice cream or popsicles of any processed flavour: may contain corn starch, maltodextrin, corn glucose, glucose syrup, soya protein, soya lecithin, chemical yeast, vegetable fat, corn cream, vegetable fat, vegetable oil, acids fatty acids, guar gum, citric acid
	Chocolate	3·5	Chocolate bars/bonbons: may contain soya flour, glucose syrup, vegetable fat, milk powder (contains soya lecithin), sorbitol, chemical yeast, polydextrose, starch, corn flour, soya lecithin, hydrogenated vegetable fat Chocolate truffles: may contain maltodextrin, corn glucose, corn starch, hydrogenated vegetable fat, glucose syrup, soya lecithin, vegetable fat
	Fruit-based sweets	2·3	Fruit jam in syrup, fruit jelly: may contain high-fructose corn syrup, citric acid
	Honey/brown sugar/table sugar and other sweeteners	0·9	Powdered honey may contain maltodextrin (from corn starch). This was not collected in the search
	Other sweets (regional preparations, diet/light, among others)	8·1	Candies, gum: may contain glucose syrup, citric acid, soya lecithin, hydrogenated vegetable fat Manioc flat bread, peanut candy: may contain glucose, corn starch, hydrogenated vegetable fat, citric acid, soya lecithin Dessert of any type: may contain maltodextrin, corn starch, glucose, vegetable fat, dairy compound, starch Nougat: may contain glucose, soya lecithin, hydrogenated vegetable fat, glucose syrup, soyabean oil Honey bread: may contain hydrogenated vegetable fat, corn starch, chemical yeast, soya lecithin, vegetable fat, maltodextrin, soya flour Panettone: may contain vegetable fat, soya lecithin, starch, fatty acids, citric acid, glucose syrup, margarine
	Total	25·5	
Biscuits and crackers	Biscuits, crackers and stuffed biscuits/crackers	15·4	Biscuits, doughnuts, wafer biscuits, stuffed biscuits, stuffed doughnuts: may contain corn starch, chemical yeast, vegetable fat, glucose syrup, soya lecithin, chemical yeast, corn flour Crackers, wholegrain crackers, stuffed crackers, salty doughnuts: may contain hydrogenated vegetable fat, yeast, chemical yeast, soya lecithin, vegetable oil, corn starch, yeast extract
	Total	15·4	
Cakes	Cakes	13·9	Cakes of various flavours, cornmeal cake, corn bread, cornmeal flour: may contain vegetable fat, corn glucose, fatty acids, chemical yeast, soya lecithin, glucose syrup, corn starch, corn oil, glucose Ready-mix cakes: may contain maltodextrin, corn flour, hydrogenated vegetable fat, glucose syrup, corn starch, soya flour, soya protein, fatty acids, chemical yeast
	Total	13·9	
Eggs	Eggs	11·7	Eggs: hens may have received GM soya- and corn-based feed
	Total	11·7	
Oils and fat	Oils and fats	6·8	Soyabean oil: may be derived from GM soyabeans Margarine: may contain vegetable oils, which may made from GM soyabeans or corn Mayonnaise: may contain soyabean oil, corn starch, citric acid, guar gum. Some flavoured mayonnaises may also contain soya sauce
	Total	6·8	

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Table 2 *Continued*

Group	Subgroup	Mean daily food consumption per capita (g)	Potentially GM ingredients present in the packaged food ingredients lists collected in the census
Legumes	Other legumes	1·3	Cited foods containing soya, i.e. tofu, soya paste, soya protein, vegetable protein, vegetable meat, soya meat, soya protein, vegetable protein, whole soyabeans, soya fibre: contain soyabeans
	Total	1·3	
Sauces and condiments	Sauces and condiments	0·5	Cited foods that may contain soya, corn: Soya/shoyo sauce: may contain soyabeans Ketchup: may contain modified starch Tomato pasta and tomato sauce: may contain corn starch, vegetable oil, xanthan gum Mustard: may contain soyabean oil, corn starch, xanthan gum, citric acid
	Total	0·5	
Fried roots and tubers	Chips	0·5	Chips and potato sticks: may contain vegetable oil, vegetable fat
	Total	0·5	
Total		1023·8	

evaluated, thirty did not specify origin but were considered likely to be soyabean, corn and cotton by-products according to the scientific literature. These by-products included vegetable fat, starch, guar gum, xanthan gum, citric acid, dextrose, glucose syrup, glucose, maltose, maltodextrin, sorbitol, mannitol, xylitol and non-malted cereal.

In the case of starch, corn starch represents more than 80 % of all types used[50]. However, we highlight the difficulty of identifying the origin of an ingredient on the labels of some of the foods analysed in the present study, possibly because Brazilian food labelling law[35] does not require this information to be provided. For example, an ingredient can be indicated merely as starch instead of corn starch. Therefore, the use of complete ingredient names by the food industry should be mandatory in order to specify ingredient origin.

Likewise, the absence of information on the composition of compound ingredients can make it difficult to identify GMO in the ingredients lists of packaged food products. For example, the present study identified foods that may contain soya or corn derivatives, but do not have their ingredients broken down, such as when they contain food colouring, chemical yeast, powdered milk and margarine. These foods are reported in the ingredients list of a food without indicating their components. This is due to the fact that Brazilian and Mercosur food labelling regulations do not require certain compound ingredients to be reported on food labels if they represent less than 25 % of a food's composition[35]. These limitations of the law may hinder consumers' access to accurate information, which is vitally important in cases of allergies to soyabeans, corn or cotton or when one wants to avoid consuming GMO derivatives.

Many soyabean and corn by-products are used as additives by the food industry. One example is soya lecithin, which was present in several of the food groups analysed in the present study and acts as an emulsifier in powdered milk, chocolate drinks, biscuits, cakes, breads and soups and as a stabilizer in cereal bars, dairy drinks and candies. As the law does not require additives to be described in descending order of quantity in ingredients lists, lecithin may be listed as one of the last ingredients of a food even though it is present in a greater quantity than ingredients listed before it[35]. Thus, the effect of the sum of the quantities of potential GM additives present in the same food is not accounted for, which makes it difficult for consumers to assess and decide which packaged food products to select at the time of purchase.

Besides soyabeans and corn, another GMO that may be present in the Brazilian population's diet is *S. cerevisiae* yeast, popularly known as baking yeast, which is widely used in the food and beverage industry in various ways[51]. It is used during the alcoholic fermentation stage of producing beer, which is the most commonly consumed alcoholic beverage in Brazil. In addition to GM yeast, Brazilian researchers[52] have also discovered the presence of GM corn as a substitute for barley malt in major Brazilian beer brands. Brazilian law[53] allows up to 45 % of the malt in beer to be substituted with another source of less expensive cereal, and corn is the one most commonly used to manufacture beer.

The analysis of secondary data on the Brazilian population's food consumption showed that most of the variety (63·8 % of the food subgroups) and quantity (64·5 % of the total daily amount) of the foods consumed daily by Brazilians is liable to contain ingredients derived from GM foods.

In this regard, it seems that the consumption of processed packaged food products may increase the chances of the Brazilian population consuming GM foods. This information is in line with data from the Council for Biotechnology Information[54], which estimates that most processed foods in Brazil contain at least one ingredient derived from soya or corn. In Canada, it is estimated that about 75 % of processed foods contain or are produced from ingredients such as GM corn, soyabeans or

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canola[55]. In addition, according to the present study's analysis, most of the foods most consumed by the Brazilian population had three or more ingredients derived from potential GM corn and soyabeans.

This fact raises concerns about effects on public health due to a lack of scientific evidence on the safety of consuming these foods. This is because foods derived from soyabeans and corn may also contain residues of herbicides associated with their cultivation, which also pose risks to human health due to the known effects of these substances[18,22–25,56–59].

For example, a main meal such as lunch in Brazil may include rice, beans, ready-to-eat *farofa*, instant noodles, chicken steak and chips, all of which may contain GM ingredients, either from the ingredients they contain or from the ingredients added during their preparation, such as soyabean, corn or cotton oil used to prepare rice, beans and chips. In addition, ingredients added as seasonings to meals (such as processed sauces) may also contain GM ingredients. Thus, a meal containing foods typically consumed by Brazilians can easily contain several GM ingredients and GM ingredients can be present in all the meals consumed in a single day.

Furthermore, the results of the HBS show that changes in Brazilian food consumption patterns have occurred in the last three decades, with increases of up to 400 % in the consumption of processed food products such as biscuits and soft drinks as well as a decline in the consumption of basic and traditional foods of the Brazilian diet such as rice and beans[60]. Despite this decline, beans were found to be the food with the second highest per capita consumption. In September 2011, the National Technical Commission on Biosafety[7] approved GM beans developed by the Brazilian Agricultural Research Corporation (Embrapa) for sale in Brazil. Although it is not yet available for consumption, this GM crop raises concerns due to a lack of further studies on its impacts and because beans are an integral part of the Brazilian diet, being consumed daily by nearly all Brazilians of all age groups.

Returning to the example of lunch mentioned above, the recommendations of the Dietary Guidelines for the Brazilian Population stand out, as they note that even if a person does not consume ultra-processed foods for lunch (avoiding ready-made *farofa*, instant noodles, chicken steak and chips), the lunch could still contain GM foods in all of its culinary preparations if, for example, soyabean, corn and/or cottonseed oil were used to cook the food. Thus, even if a person follows the Brazilian dietary guidelines' recommendations exactly and only eats what he/she prepares at home, he/she may still be exposed to GM foods depending, for example, on the type of fat used to prepare the food (corn, soyabean or cotton oil) or the type of yeast used to bake bread at home. It should also be pointed out that the Dietary Guidelines for the Brazilian Population has not taken a position on GM foods in its recommendations[61].

The present study's data showed that about 24·5 % of the Brazilian population's per capita daily food consumption comes from products of animal origin (meat, milk, dairy products and eggs). These results are a cause for concern, since animals fed with feed produced with GM corn and/or soyabeans may also constitute a source of GMO in human food[62]. Thus, the population can increase its consumption of GM foods by eating beef, pork and poultry from these animals or by consuming foods derived from them, such as dairy products, eggs and pork fat.

In summary, considering the data analysed, the Brazilian population consumes a wide variety of packaged food products that may contain GM ingredients on a daily basis. However, many of these foods do not have their composition clearly identified on their labels. This may be due to Brazilian law, which requires foods to be labelled only if more than 1 % of their composition is comprised of GMO. Thus, foods composed of less than 1 % of GMO are exempted from mandatory labelling, even though this does not mean that they do not contain GMO. In addition, no information has been found on compliance with this regulation. Thus, it can be assumed that the food industry may omit this information and fail to label a product, even if it contains more than 1 % of GMO. In either case, the right of consumers to clear and accurate information about the products they consume is not being guaranteed, as advocated by the Brazilian Consumer Defence Code[31].

Furthermore, food additives are not required to be labelled in decreasing order of quantity and several products do not need to identify the origin of their raw materials, making it even more difficult to identify GMO by reading the labels of packaged food products. For this reason, we highlight the scientific relevance of the present study, which contains a list of potential GM ingredient nomenclatures that was prepared from the identification of these ingredients on the labels of packaged food products available for sale in a Brazilian supermarket. In addition, it should be emphasized that no studies exist that establish a safety percentage for the consumption of these foods. Therefore, even if a product contains less than 1 % of GMO in its composition and is not labelled, it does not mean that it does not pose health risks, since a safe consumption amount has not been established.

In most of the studies available in the scientific literature, the presence of GMO in food is identified through laboratory analysis. Thus, one possible limitation of the present study is the fact that it cannot be determined with certainty whether the food ingredients listed as potential GMO are actually so. However, unlike laboratory studies that analyse samples from a small group of foods, the present study analysed the labels of all foods available in a supermarket. In light of the increasing production of GM foods in Brazil, which corresponds to 96·5 % of the soyabeans, 88·4 % of the corn and 78·3 % of the cotton grown in the country[4], in addition to the high risk of contamination throughout the production chain, it is assumed

to be very likely that the ingredients derived from such foods are GM. Thus, it can be inferred that it is very likely that packaged food ingredients derived from soyabeans, corn and cotton are GM, even if they have not undergone laboratory testing.

This affirmation is supported even when considering the import/export data for these crops in Brazil. In 2017, grain production in Brazil totalled approximately 114 million tons of soyabeans, 98 million tons of corn and 3·8 million tons of cotton[63]. Of this total, 68·1 million tons of soyabeans (59·7 %), 19 900 tons of corn (0·02 %) and 450 tons of cotton (0·01 %) were exported. On the other hand, 253 000 tons of soyabeans, 1600 tons of corn and 401 tons of cotton were imported into Brazil in 2017, which corresponds to less than 0·23 % of the total grain remaining in the country (production + imports – exports)[64]. Furthermore, Brazil imports soyabeans, corn and cotton mainly from Paraguay, Argentina and the USA[64], which are among the countries that plant the most GM seeds in the world[4]. These data indicate that, even though most of the Brazilian production of these grains is exported, the country is practically self-sufficient in its internal supply.

Therefore, the production that remains in the country together with the amount that is imported contribute to maintaining a large quantity of GM grain in the country, thus maintaining the potential trend of the occurrence of GMO in packaged foods sold in Brazil. We emphasize that the import/export data refer to the grains of products and not their sub-products (e.g. soyabean oil, soya flour, corn starch, corn flour, etc.). However, we point out that only 528 (10·5 %) of the 5048 foods analysed in the present study were imported.

It is also worth noting that the public sector has a responsibility to monitor labelling and perform laboratory tests to identify the presence of GM ingredients in foods to verify compliance with labelling legislation. Furthermore, the present study may contribute to showing the magnitude of the presence of such ingredients in the packaged food products most commonly consumed by the Brazilian population.

In this respect, we emphasize the importance of the method used, which can serve to guide more specific research in the future on the food groups in which the presence of potentially GM ingredients has been identified. In addition, the present study analysed the labels of all foods available for sale in a Brazilian supermarket, which would make it unfeasible to perform laboratory analyses on such a large number of foods. It is also worth noting that the study was conducted from the point of view of the consumer, who only has access to a food's ingredients list, which is currently the sole source of information available to identify potentially GM ingredients in packaged foods sold in Brazil.

Another limitation refers to the analysis of secondary data obtained from the HBS, whose accuracy cannot be evaluated. However, the use of secondary data was shown to be effective to test the hypothesis about the Brazilian population's high consumption of potentially GM ingredients. The HBS data in Brazil resemble the national dietary data from several countries and constitute the main source of national information on the Brazilian population's food acquisition and consumption. Our study was based on the most recent available data on the Brazilian population's food consumption: the 2008–2009 HBS. Data based on food consumption tend to approximate the population's actual dietary patterns and have been used to establish food consumption patterns. Household budget surveys reflect the beginning of the consumption chain and enable the formulation of public policies that can modify the population's food supply and health standards.

In addition, numerous population studies are currently seeking to relate diet to the incidence of various diseases. However, GM ingredients are generally not being analysed. Thus, the current study considers and recommends the attention of researchers to the population's exposure to foods containing GM ingredients and potentially related diseases.

Conclusion

The present study has shown the high exposure the Brazilian population has to potential GM ingredients through the consumption of packaged food products, which were available in a supermarket. More than half of the foods most commonly consumed by the Brazilian population may contain at least one ingredient derived from potential GM soyabeans, corn or cotton. From the results of the present study, it was possible to demonstrate the difficulty consumers face in identifying the presence of these potential GM ingredients in food, since 101 different nomenclatures were observed on the packaged food labels analysed.

Soya, corn and cotton by-products have been widely used by the food industry for different technological purposes and such use may be underestimated due to the use of ingredients whose origin (derived from soyabeans, corn or cotton) may be unknown, both to health professionals and to consumers. Therefore, we emphasize the importance identifying these nomenclatures that designate potentially GM ingredients, as similar listings have not been found in the scientific literature. This information can be used to support the actions of health professionals with the public, as well as to support discussions about food legislation. In addition, it may help in future studies to investigate the relationship between GM food consumption and health.

Considering the precautionary principle, the present study suggests that regulations be made more restrictive in relation to the approval and production of GM crops in the country, as these crops have not been subjected to an in-depth analysis of their environmental, social and health impacts. In addition, foods derived from soyabeans, corn and cotton may also contain residues of the pesticides associated with their cultivation, adding to the risks to human health caused by the already known effects of

these substances and the consequent public health expenditures to treat these diseases.

Competent government agencies should monitor packaged food products to require that information on the presence of GM ingredients be reported on their labels. In addition, it is considered increasingly necessary to act in the legislative sphere to reduce the food industry's use of by-products derived from GM soya, corn and cotton. This is due to concerns about the effects of consuming these foods on human health, both due to a lack of scientific evidence on the safety of consuming GMO and the use of pesticides associated with the cultivation of these foods.

Furthermore, we cite the adoption of public health actions to guide the population in identifying the presence of GM ingredients in packaged products. Also highlighted is the need for policies that encourage the production and consumption of organic foods and incentives for small agricultural producers that do not use the wide range of by-products that are commonly used by large food corporations for technological purposes.

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