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Consumption of ultra-processed products is associated with vitamin D deficiency in Brazilian adults and elderly

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Abstract

Although studies show that the intake of ultra-processed products (UPP) has a negative impact on health, diet quality and dietary vitamin D, its influence on serum concentrations of this vitamin remains unknown; therefore, it is essential to verify the association between the UPP consumption and vitamin D deficiency. This is a cross-sectional, household, population-based study, carried out with 229 individuals aged 20 years or older, residents of the city of Teresina, Piauí, Brazil. Socio-demographic, lifestyle, food consumption and anthropometric data were collected. Food consumption was obtained using a 24-h food recall, and foods were grouped according to the NOVA classification. Plasma concentrations of calcidiol–25 (OH) D3 were determined by HPLC. Crude and adjusted binary logistic regression was applied to estimate the association between UPP consumption and vitamin D deficiency. Most individuals aged 20–39 years were vitamin D deficient (52·1 %). UPP contributed 19·9 % to the energetic intake of the participant's diet. This contribution was higher for individuals with vitamin D deficiency (22·5 %, $P = 0·04$). In addition, a high intake of UPP was associated with twice the risk of vitamin D deficiency in comparison with low consumption of UPP (OR: 2·05; CI 1·06, 4·50; P: 0·04). Our results suggest that the consumption of UPP may have a negative impact on serum concentrations of vitamin D; more studies are needed.

Key words: Ultra-processed foods: Food consumption: Vitamin D: Deficiency

Micronutrient deficiencies are important contributors to the global burden of disease and rising morbidity and mortality rates. It is estimated that one-third of the world's population suffers from at least one form of micronutrient deficiency[1]. Although the main cause of these deficiencies is the insufficient presence of micronutrients in the diet, vitamin D, for example, has its concentration also influenced by factors not related to the diet, such as low exposure to solar radiation[2].

More recently, some studies have shown that the greater presence of ultra-processed products (UPP) in the diet was inversely associated with dietary intake of vitamin D[3,4]. These findings reinforce the need to investigate the impact of consumption of UPP on serum concentrations of vitamin D, since the importance and versatility of this vitamin in the body are increasingly evident. Vitamin D plays an active role in immune function, protein synthesis, muscle function, cardiovascular function, inflammatory response, cell growth and musculoskeletal regulation[5].

Studies carried out in representative samples of the Brazilian population showed that the UPP group has a higher content of free sugars, total fats, saturated fats and trans fats, and a lower content of proteins, fibres and micronutrients[2,4]. These foods are characterised by the NOVA food classification system that was first proposed by Monteiro *et al.*[6] and is now endorsed by the United Nations and the WHO. NOVA categorises foods according to the nature, extent and reasons for food processing. UPP are defined by this system as industrial formulations generated by compounds extracted, derived or synthesised from foods or food substrates[7].

Furthermore, despite of some foods which naturally contain vitamin D, such as oily fish (sardines, herring, tuna, mackerel, salmon), cod liver oil, egg yolks, shiitake mushrooms, liver, milk and derivatives thereof, the dermal synthesis after ultraviolet radiation (UVB) remains to be the main source of vitamin D, responsible for 90 % of the replacement of this vitamin[8]. However, despite vitamin D being produced by exposing the

Abbreviations: 24hR, 24-h food recall; UPP, ultra-processed product.

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skin to sunlight, its dietary intake becomes essential when sun exposure is insufficient to meet daily requirements. This has become common, particularly among people residing in urban centres who are exposed to suboptimal levels of sunlight[9].

Therefore, considering that the micronutrient content in UPP tends to be lower than the existing content in other food groups such as unprocessed or minimally processed foods, and emphasising the importance of the contribution of a healthy diet in vitamin D deficiency to population, it is essential to verify the association between the consumption of UPP and vitamin D deficiency, since there are still no studies showing this association.

Methodology

Study design and population

This is a cross-sectional study, part of the base project entitled 'Population-Based Health Survey (ISAD-PI)', carried out from August 2018 to December 2019, in the cities of Teresina and Picos, in the state of Piauí.

This research included adults from 20 to 59 years of age and elderly people aged 60 years and over from the city of Teresina, Piauí. Individuals residing in private households were eligible for the study, except individuals residing in collective households, pregnant women and those with a disability that would make it impossible to carry out the research.

Sample size

The study sample was selected through a cluster sampling process in two stages: primary sampling units (UPA), composed of census sectors, and in the second stage, households, based on IBGE census data for the year of 2010[10].

To calculate the sample size, we considered the size of the population and the number of private households in Teresina (767 557 inhabitants; 210 093 households)[10]. From these data, the mean number of individuals for both sexes, per household, in each of the following age groups was calculated: children under 2 years of age; children aged 3–4 years; children aged 5–9 years; adolescents aged 10–14 years; adolescents aged 15–19 years; adults aged 20–59 and elderly people over 60. A necessary total number of 578 households were then estimated. The final sample size for this study was adjusted using $n = n_0/0{\cdot}90$, assuming a response rate of 90 %, resulting in $n \cong 642$ households.

Following the same sampling plan, 50 % of the households were selected, forming a subsample for the collection of food consumption data, through the application of 24-h recalls, as well as for blood analysis. More details about the sample size and sampling plan of the ISAD-PI were published in the study by Rodrigues *et al.*[11]

After completing the survey, the final sample included 497 households in Teresina, and the subsample consisted of 248 households. In the end, data were obtained from 229 individuals, 90 participants aged 20–39 years and 139 aged 40 years or older, who had food consumption and biochemical data (Fig. 1). The present study was approved by the Ethics and Research Committee of the Federal University of Piauí, under Opinion 2,552,426.

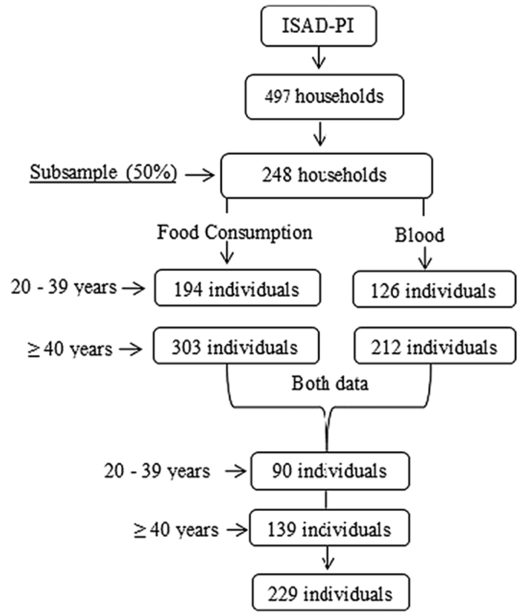

Fig. 1. Study sample flow chart.

Data collection and anthropometric measurements

Demographic, socio-economic, anthropometric, lifestyle, skin colour, sun exposure, vitamin D supplementation, physical activity, chronic kidney disease and food consumption data were collected using structured questionnaires applied by trained interviewers using the Epicollect 5® application on mobile devices.

Anthropometry was performed according to the recommendations by Cameron[12] and Jelliffe & Jelliffe[13]. To weigh the participants, a portable electronic scale (SECA®, model 803) with a precision of 100 g was used, and a stadiometer (SECA®, model messband 206) was used to measure height, with an accuracy of 0·1 cm. The BMI for adults was classified according to the WHO[14] and for the elderly, the values established by Lipschitz *et al.*[15]

Dietary assessment

The food consumption of the studied population was obtained through the application of the 24-h food recall (24hR), based on the multiple-pass method[16]. A second 24hR was applied to 40 % of the population, in a 2-month interval, in which the same procedures that were used during the first interview were performed, with the aim of correcting intrapersonal variability. The replication rate was chosen based on the research by Verly-Júnior *et al.*[17], in which it can be observed that the application of a second 24hR in 40 % of the sample did not mean loss of accuracy for estimating food consumption, regardless of sample size.

Home measurements reported by interviewers were transformed into g or ml using the Table for the Evaluation of Food Consumption in Home Measurements, based on the study by Pinheiro *et al.*[18] Energy intake was calculated based on the

Brazilian Food Composition Table[19], the Nutritional Composition Table of Food Consumed in Brazil[20] and the Food Composition Table: Support for Nutritional Decisions[21].

The reported food items were categorised according to the NOVA food classification[22] based on the extent and purpose of the applied food processing, including unprocessed or minimally processed foods and UPP for the analyses. Unprocessed (or natural) foods are edible parts of plants (seeds, fruits, leaves, stems, roots) or of animals (muscle, offal, eggs, milk), and also fungi, algae and water, after separation from nature.

Minimally processed foods are unprocessed foods submitted to processes such as removal of inedible or unwanted parts of the food, drying, dehydration, crushing or grinding, fractioning, roasting, cooking with water only, pasteurisation, refrigeration or freezing, packaging, vacuum packaging, non-alcoholic fermentation and other processes that do not involve the addition of substances such as salt, sugar, oils or fats to unprocessed food, for example, wheat grains are transformed into flour, couscous and pasta, maize grains into flour and polenta, coffee beans are roasted and ground, milk is pasteurised and meat is chilled or frozen[22,23].

The NOVA classification system defined UPP as industrial formulations typically made with five or more ingredients. These ingredients often include substances and additives used in the manufacture of processed foods such as sugar, oils, fats and salt, as well as antioxidants, stabilisers and preservatives, including soft drinks, milk drinks, fruit nectar, powder mixes for making drinks with fruit flavour, packaged snacks, sweets and chocolates, 'cereal' bars and ice cream[22,23]. Consumption of food groups was evaluated as a percentage of the total energy value of the participants' diets, and all food consumption analyses were performed using the Stata software (version 13.0).

Nutrients were adjusted for intrapersonal variability, using the statistical modelling technique of the Multiple Source Method software version 1.0.1, from the Department of Epidemiology of the German Institute of Human Nutrition Potsdam-Rehbrücke (DIfE), Nuthetal, Brandenburg, Germany, 2011[24].

Usual food consumption is estimated by the Multiple Source Method through short-term measurement data, such as the 24hR, through statistical modelling that consists of three steps[25], simplified as follows: In the first step, it is estimated the individual's probability of consuming a food or nutrient (p_i^*) and the intrapersonal and interpersonal variance by logistic regression, where $m_{i/z}$ is the individual's consumption probability prediction model, g_{back} is the corresponding residue after inverse transformation and $\hat{t}_i$ is the variance correction of the individual's consumption probability[25]: $p_i^* = m_{i/z} + g_{back} + \left(\hat{t}_i\right)$.

The second step is to estimate the individual's observed consumption (Y_i^*) and the intra-individual and inter-individual variance by means of linear regression, where $M_{i/z}$ is the prediction model of the day of observed consumption, F_{back} is the residual corresponding after inverse transformation and $\widehat{T}_i$ *is* the variance correction of the individual's observed consumption (Haubrock *et al.*[25]): $Y_i^* = M_{i/z} + F_{back} + \left(\widehat{T}_i\right)$. Finally, in the last step, the usual food consumption for the individual is estimated by multiplying the data obtained in the previous steps, that is, p_i^* and Y_i^{*}[25]: $p_i^* \times Y_i^*$.

Vitamin D analysis

Blood samples (15 ml) were collected by a trained professional and subsequently the plasma was separated and transported to the Micronutrient Laboratory of the São Paulo School of Public Health (FSP/USP), where the plasma concentrations of calcidiol–25 were determined. (OH) D3 by HPLC, according to the Vitamin D Standardisation Program, and as adapted from the method described by Neyestani *et al.*[26]. Calcidiol values ≤ 20 ng/ml were classified as vitamin D deficient, according to the Endocrinology Society of the United States[27].

Statistical analysis

The STATA program version 13.0 (Stata Corporation) was used for statistical analysis. Pearson's χ^2 test was used to determine socio-demographic and anthropometric characteristics according to the serum concentrations of vitamin D. The Shapiro Wilk test was used to assess data distribution, and Student's *t* test was used to compare means. To verify the association between the consumption of UPP and the vitamin D biomarker, the population was distributed according to tertiles of the contribution of UPP to the diet (percentage of energy intake). Crude and adjusted binary logistic regression was applied to estimate the association between the consumption of UPP and vitamin D deficiency. To control for confounding, the independent variables included in the adjusted model were identified through the construction of the directed acyclic graph in DaGitty software version 3.0. Based on the backdoor criterion[28], the need for a minimum adjustment for age, sex, skin colour, sun exposure, vitamin D supplementation, physical activity, BMI and chronic kidney disease was identified. The significance level adopted was 5 %.

Results

The characteristics of the population studied according to serum concentrations of vitamin D are presented in Table 1, in which the socio-demographic variables are indicated, in which it is noted that most individuals aged 20–39 years were with vitamin D deficiency (52·1 %). Regarding marital status, 53·3 % were single and showed to be deficient in this vitamin.

Table 2 shows the energy contribution of the food groups, according to the degree of processing in the diet. The group of unprocessed or minimally processed foods made the greatest contribution to the energetic intake of the participants' diet (67·7 %); however, the group of UPP showed a significant contribution (19·9 %). In addition, it is noted that unprocessed or minimally processed foods contribute a greater amount of vitamin D compared with UPP (3·42 mcg *v.* 0·34 mcg), which demonstrates that unprocessed or minimally processed foods contribute a greater amount 10 times more vitamin D than UPP (Table 2).

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Table 1. Socio-demographic and anthropometric characteristics according to serum levels of Vitamin D
(Numbers and percentages)

	Total		Vitamin D normal		Vitamin D deficient		
	n	%	*n*	%	*n*	%	*P*
Sex							0·26
Female	159	69·4	99	72·3	60	65·2	
Male	70	30·6	38	27·7	32	34·8	
Age (years)							
20–39	90	39·3	42	30·7	48	52·1	0·00*
≥ 40	139	60·7	95	69·3	44	47·8	
Marital status							0·02*
Single	101	44·1	52	38·0	49	53·3	
Married	128	55·9	85	62·0	43	46·7	
Level of education							0·22
Not literate	9	3·9	7	5·1	2	2·2	
Primary education	73	31·9	43	31·4	30	32·6	
High school	91	39·7	59	43·1	32	34·8	
University education	56	24·4	28	20·4	28	30·4	
Skin colour							0·27
White	29	12·7	22	16·1	7	7·6	
Black	42	18·3	25	18·2	17	18·5	
Brown	132	57·6	74	54·0	58	63·0	
Others	26	11·3	16	11·7	10	10·9	
Sun exposure							0·91
Do not expose	35	15·3	22	16·1	13	14·1	
1–2 times a week	38	16·6	23	16·8	15	16·3	
3 times or more	156	68·1	92	67·1	64	69·6	
Physical activity							0·24
Yes	179	78·5	104	75·9	75	82·4	
No	49	21·5	33	24·1	16	17·6	
Nutritional status							0·59
Thinness	20	8·8	11	8·0	9	9·9	
Eutrophy	73	32·0	45	32·8	28	30·8	
Overweight	69	30·3	45	32·8	24	26·4	
Obesity	66	28·9	36	26·3	30	33·0	
Chronic Kidney disease							0·35
Yes	3	1·3	1	0·7	2	2·2	
No	226	98·7	136	99·3	90	97·8	

Vitamin D normal: > 20 ng/ml; vitamin D deficient: ≤ 20 ng/ml; *n*: sample number. Pearson's χ^2 test. *p < 0.05.

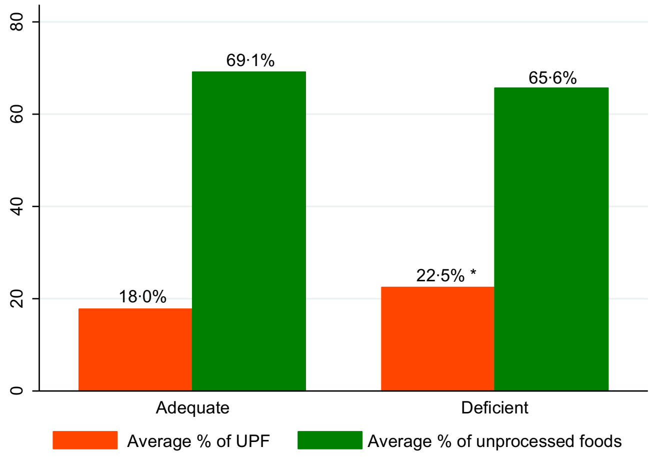

Fig. 2. Energy contribution (%) of unprocessed or minimally processed and ultra-processed foods according to serum levels of vitamin D.

The energetic contribution of UPP in the diet was significantly higher in the group of individuals who had vitamin D deficiency, as well as between the sexes, in which it was possible to observe a greater energy contribution of UPP for males who had deficient concentrations of this vitamin (Fig. 2 and Fig. 3).

The regression analyses of the association between vitamin D deficiency and tertiles of the percentage of contribution in the total energy value of the diet of the food groups regarding the degree of processing and according to the age group are described in Table 3. The significant association between the high consumption of UPP and vitamin D deficiency was observed that this association was also maintained after adjusting the model (OR: 2·05; CI 1·06, 4·50; $P = 0·04$).

Discussion

The evidence from this study shows the negative impact of consumption of UPP on serum concentrations of vitamin D, highlighting healthy eating as one of the components that can help prevent this vitamin deficiency, thus emphasising the importance of analysing the relationship between intake of these food groups and micronutrient deficiency. These results are a reflection of the nutritional transition that is characterised by the increased consumption of UPP, which contain high energy density, high levels of sugars, fats and poor in micronutrients such as vitamin D. Therefore, the increase in UPP consumption in Brazil and in most countries[29] is a reflection of changes in eating habits that are characterised by reduction in the

Table 2. Energy contribution of in natura or minimally processed and ultra-processed foods in the total diet and UPP contribution to vitamin D intake

Food groups*	Energy kcal	Min-Max kcal	% Energy	Min-Max	Mean vitamin D (mcg)
Unprocessed or minimally processed foods	1176·5	14·8–4002·8	67·7	3–100	3·42
Processed culinary ingredients	144·2	0–784·2	9·0	0–43·3	0·03
Processed foods	62·4	0–1554·8	3·4	0–41·9	0·04
Ultra-processed foods	364·7	0–1989·0	19·9	0–84·2	0·34
Total	1747·8	14·8–8330·8	100	3–269·4	3·83

Contribution of UPP to vitamin D intake

	Vitamin D normal (mcg)	Vitamin D deficient (mcg)	*P*
Ultra-processed foods	0·30	0·21	0·47

* NOVA classification; UPP, ultra-processed product; Min, minimum; Max, maximum; Student's *t* test.

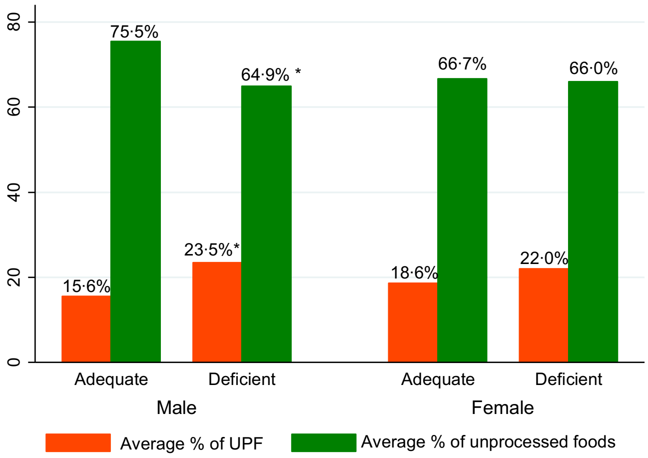

Fig. 3. Energy contribution (%) of unprocessed or minimally processed and ultra-processed foods according to serum levels of vitamin D and sex.

consumption of fresh foods that can contribute to decrease in the risk of micronutrient deficiencies such as vitamin D[30].

The high prevalence of vitamin D deficiency found in this study was 40·2 %; similar results were observed in a survey carried out with adolescents in a region of northeastern Brazil, which highlighted a prevalence of 45·6 % of deficiency, indicating that despite the individuals residing in a sunny region, a significant deficiency was identified[31].

Vitamin D deficiency is a global health problem, regardless of region, age, sex and ethnicity[27,32]. The population studied in this research showed a higher prevalence of vitamin D deficiency for younger and single adults, such results do not corroborate those found by Teama *et al.*[33], in which they showed that vitamin D had a negative correlation with age, that is, the older the age, the higher the risk of deficiency. The cutaneous synthesis of vitamin D depends on the exposed skin surface and the duration of sun exposure, in addition the extent of clothing due to cultural or religious factors and the use of topical sunscreen can block effective dermal synthesis, which may justify the result of this research, as it is a study carried out in a region with a high incidence of UVB irradiation, which favours the practice of protection from sun exposure by individuals[34].

The results of this study show that the energy contribution of UPP (19·9 %) was similar to that found for the Brazilian population in the Household Budget Survey (19·7 %) (POF 2017–2018)[35] and lower than the values found in the USA (55·5 %)[36], Canada (42 %)[37], Australia (39 %)[38], Colombia (41 %)[39] and Mexico where consumption ranged from 4·5 % kcal in the lowest quintile of consumption to 64·2 % kcal in the highest quintile[40], suggesting that the consumption of unprocessed or minimally processed foods, culinary ingredients and processed foods is higher among Brazilians. In addition, the significant energetic contribution of UPP presented in males with vitamin D deficiency highlights that maybe women are more careful with their health in relation to healthy eating and also

Table 3. Crude and adjusted analysis between vitamin D deficiency and tertiles of the percentage of contribution in the TEV of the diet of the food groups according to the degree of processing and according to the age group
(Odds ratios and confidence intervals)

	Vitamin D					
Food groups	OR	CI	*P*	OR	CI	*P**
Unprocessed or minimally processed foods						
1º tertile	1·67	0·78, 3·54	0·17	1·81	0·86, 3·83	0·11
2º tertile	1·10	0·58, 2·08	0·75	1·19	0·56, 2·55	0·63
3º tertile	1			1		
Ultra-processed foods						
1º tertile	1·00			1·00		
2º tertile	1·11	0·45, 2·72	0·81	1·11	0·37, 3·28	0·84
3º tertile	1·84	0·95, 3·56	0·07	2·05	1·06, 4·50	0·04
Sex						
Female						
Unprocessed or minimally processed foods						
1º tertile	0·84	0·39, 1·77	0·63	1·24	0·64, 2·38	0·54
2º tertile	0·85	0·41, 1·77	0·67	0·99	0·45, 2·21	0·99
3º tertile	1·00			1·00		
Ultra-processed foods						
1º tertile	1			1·00		
2º tertile	1·11	0·40, 3·10	0·82	1·35	0·39, 4·70	0·62
3º tertile	1·44	0·70, 2·93	0·30	1·70	0·81, 3·55	0·14
Male						
Unprocessed or minimally processed foods						
1º tertile	0·33	0·05, 2·09	0·22	1·50	0·59, 3·82	0·38
2º tertile	0·23	0·04, 1·11	0·06	0·72	0·28, 1·84	0·48
3º tertile	1·00			1·00		
Ultra-processed foods						
1º tertile	1·00			1·00		
2º tertile	1·11	0·26, 4·76	0·88	0·83	0·11, 6·24	0·85
3º tertile	3·6	1·11, 11·67	0·03	3·21	0·70, 14·74	0·12

TEV, total energy value. Binary logistic regression.
* Adjusted for age, sex, skin colour, sun exposure, physical activity, BMI, vitamin D supplementation and chronic kidney disease.

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emphasises the low concentrations of vitamin D in this food group, since that there was a higher consumption of these foods in the deficient group of this vitamin.

UPP, when compared with unprocessed or minimally processed foods, had a lower amount of dietary fibre and micronutrients and a higher amount of salt, sugar and saturated fats[41]. This food group still has unfavourable ingredients in its composition that can negatively reflect on the quality of the diet[4]. Observational studies in different populations show inverse dose–response associations between the contribution of UPP and the consumption of proteins, fibres, essential vitamins and minerals[2,40–42].

This is the first study to investigate the influence between the consumption of UPP on vitamin D deficiency. In this context, the level of food processing according to the NOVA classification[22] and the significant energy supply of UPP in individuals with vitamin D deficiency were considered. A possible explanation is due to the high consumption of UPP, since they are rich in carbohydrates, lipids and have a lower concentration of proteins and micronutrients, such as vitamin D. According to Hribar[43], in the absence of cutaneous biosynthesis induced by UVB light, food intake becomes the most important source of vitamin D, whose main contributors to dietary intake of this vitamin are the few foods that naturally contain vitamin D, fortified foods and supplements.

The present study was carried out in a region of high UVB irradiation, and because it is a place with high sun exposure, vitamin D deficiency can be neglected, perhaps on the assumption that such a deficiency is unlikely to occur in these regions. Variation in vitamin D status among people living in the same city or country is partially related to religious, lifestyle and nutritional differences[44]. Low latitude regions, such as Brazil, allow the synthesis of vitamin D in adequate concentrations during most seasons of the year due to the availability of UVB rays[45] and the possibility of individuals being exposed to sunlight. However, paradoxically, studies carried out in populations of tropical countries, such as Brazil, showed high prevalence of vitamin D deficiency and insufficiency[46,47].

The results of a representative survey of the Brazilian diet showed that the micronutrient content in UPP is up to two times lower compared with the existing levels in unprocessed or minimally processed foods; furthermore, in another analysis carried out in the USA, an inverse relationship was highlighted between the dietary contribution of UPP and the content of proteins, fibres, vitamins A, C, D, E and Zn; therefore, it is possible to consider that the high consumption of UPP is one of the factors that can negatively impact the concentrations of vitamin D and consequently lead to a deficiency of this vitamin, since they are unhealthy foods and poor in micronutrients[2,4].

The significant association between UPP consumption and vitamin D deficiency found in this study further underscores the negative influence of these foods on serum concentrations of this vitamin. Despite the lack of records from other studies that have evaluated the association between the consumption of UPP and vitamin D deficiency, some evidence that this consumption could influence the concentration of micronutrients was highlighted by studies that show that the intake of these foods of lower cost and low nutritional quality may be associated with a higher prevalence of inadequate intake of vitamin D[3,4].

In the USA, using data from the National Health and Nutrition Examination Survey from 2009 to 2010, an association was found between the consumption of UPP and the dietary content of added sugars[48]. In addition, the mean content of proteins, fibres, vitamins A, C, D and E, Zn, K, P, Mg and Ca in the diet decreased significantly with the increase in the energy contribution of UPP[49]. The intake of these foods of low nutritional quality may be associated with a higher prevalence of inadequate intake of vitamin D, Ca and P, with implications for bone health[3,50,51].

Previous studies have addressed the controversy over the association between consumption of UPP and the proportion of individuals whose intake is below micronutrient requirements, as well as the difficulty in establishing adequate and safe levels of micronutrients in foods without increasing the risk of consuming amounts above the tolerable upper intake limit[52]. The bioavailability of micronutrients depends on the composition of the food and possibly on its encapsulation method in some specific formulations. Furthermore, UPP do not offer the same health benefits as natural foods[3,53].

Thus, considering the high energy contribuition of UPP and its low concentrations of Vitamin D in Brazilian diet, as well as the association observed between high consumption of UPP with a higher risk of vitamin D deficiency, the present findings reinforce the importance of futher studies to investigate the association of UPP and micronutrients, especially vitamin D. UPP represents the food group secondly most consumed by the Brazilian people, as well as they are considered unhealthy[35]. Therefore, it is evident that reducing the consumption of UPP is a natural way to promote healthy eating[4].

Some limitations of this research need to be highlighted, such as its cross-sectional design that limits cause-and-effect relationships. Some errors can also be identified in the use of the 24hR, due, in part, to reported errors on consumption (excess or underreporting). However, with the aim of minimising these errors, two recalls were used, the first applied to the entire population and the second to 40 % of the same, to correct intrapersonal variability[17]. Among the strengths of this study, it is one of the few to demonstrate an association between the consumption of UPP and vitamin D deficiency in adults.

Conclusion

The results of this research show that the contribution of UPP to the diet is negatively associated with the serum concentrations of vitamin D, increasing significantly the risk of this micronutrient deficiency; therefore, it is essential to carry out more studies investigating the relationship between the consumption of this food group and micronutrients, especially vitamin D, as it is an important vitamin for bone development and in the regulation of other micronutrients such as Ca and P.

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There are no conflicts of interest.

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