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Ultra-processed foods have the worst nutrient profile, yet they are the most available packaged products in a sample of New Zealand supermarkets

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Abstract

Objective: To examine the availability of packaged food products in New Zealand supermarkets by level of industrial processing, nutrient profiling score (NPSC), price (energy, unit and serving costs) and brand variety.

Design: Secondary analysis of cross-sectional survey data on packaged supermarket food and non-alcoholic beverages. Products were classified according to level of industrial processing (minimally, culinary and ultra-processed) and their NPSC.

Setting: Packaged foods available in four major supermarkets in Auckland, New Zealand.

Subjects: Packaged supermarket food products for the years 2011 and 2013.

Results: The majority (84 % in 2011 and 83 % in 2013) of packaged foods were classified as ultra-processed. A significant positive association was found between the level of industrial processing and NPSC, i.e. ultra-processed foods had a worse nutrient profile (NPSC = 11·63) than culinary processed foods (NPSC = 7·95), which in turn had a worse nutrient profile than minimally processed foods (NPSC = 3·27), $P < 0·001$. No clear associations were observed between the three price measures and level of processing. The study observed many variations of virtually the same product. The ten largest food manufacturers produced 35 % of all packaged foods available.

Conclusions: In New Zealand supermarkets, ultra-processed foods comprise the largest proportion of packaged foods and are less healthy than less processed foods. The lack of significant price difference between ultra- and less processed foods suggests ultra-processed foods might provide time-poor consumers with more value for money. These findings highlight the need to improve the supermarket food supply by reducing numbers of ultra-processed foods and by reformulating products to improve their nutritional profile.

Keywords
Processed food
Nutrient profiling
Price
Food brands
Supermarket interventions

Unhealthy diets play a central role in the onset of non-communicable disease. Approximately 11 % of disability-adjusted life years in New Zealand (NZ) are attributable to the effects of poor diets[1,2]. Even modest improvements in diet could have a major impact on health if they are adopted by much of the population[3,4]. One particular food group of concern is processed foods. Evidence indicates that higher levels of processing are related to decreasing healthiness of foods[5]. Nevertheless, sales of processed foods have increased rapidly; these foods currently account for approximately three-quarters of total world food sales (total $US 3·2 trillion in sales)[6] and contribute between 40 % and 75 % of the energy and nutrients consumed in developed countries[7,8].

Improving diets is a priority for public health, and effective and sustainable interventions are urgently needed. There is clear evidence showing that promotional campaigns are minimally effective[9] and that research should be looking into the design of the food environment to achieve healthier population diets[10]. One of the most important food environments is the supermarket as this is the place where people in Western countries purchase most of their food[11] (in NZ, 87 % of people shop at a supermarket at least once per week[12]).

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Different aspects within supermarkets could influence consumer food choices, including the affordability of various foods[13]. Different studies have indicated that unhealthier food is relatively cheaper compared with more nutrient-dense food; in particular, foods high in fat and sugar have been found to be cheaper than less energy-dense foods[14–16]. While there is some debate in the literature about this topic[17], there is consensus that price may form a barrier to buying healthier food, particularly for people with a low socio-economic status[18].

Accessibility and availability of less healthy food also influence consumer food purchasing decisions. Due to technological innovations and agricultural subsidies, food has become more available, varied and affordable[19]. However, our food system is strongly commercial and economically driven[20]. This commercial focus produces an over-supply of dietary energy including from low-nutrient crops such as sugar and corn[21]. Moreover, many of the products available are in processed form and contain excessive salt, sweeteners, refined grains and oils[22]. Evidence indicates that supermarkets in different developed countries display a large variety of processed foods high in sugars and fats and have more shelf space allocated to snack foods than to fresh fruit and vegetables[23]. In addition, global food manufacturers have a vested interest in the production and sale of ultra-processed foods because production costs are low and highly processed foods have a long shelf-life and a high retail value[24].

Monteiro *et al.* describe a three-level classification system to categorize processed foods based on the applied industrial processes: (i) unprocessed or minimally processed; (ii) culinary processed; and (iii) ultra-processed food products[5]. This classification system is used in the present study and is elaborated upon in the 'Methods' section.

The present study aims to use this classification to measure the packaged food environment in NZ supermarkets by examining the nutrient profiling score, price and product variety in relation to level of industrial processing. The study hypothesizes that foods with a higher level of industrial processes applied will be (i) less healthy, (ii) cheaper and (iii) more highly available compared with minimally processed foods.

Methods

Data sources

The NutriTrack database was used to examine the packaged food environment in NZ supermarkets. NutriTrack is an existing database developed by the University of Auckland to monitor the packaged food supply and identify opportunities for healthier reformulation of processed foods. Information is collected directly from all packaged supermarket products annually in four large NZ supermarkets in the Auckland region. In NZ, there is a duopoly in the retail market where the cooperatives Foodstuffs and Progressive Enterprises Ltd control over 90 % of the retail market[25]. NutriTrack collects data from the four largest franchises within these two cooperatives, and then the largest store for each chain, providing the widest product range. The NutriTrack database includes brand and package information and all nutrients present on the mandatory Nutrition Information Panel[26]: energy (kJ), protein (g), carbohydrate (g), sugar (g) total fat (g), saturated fat (g) and sodium (mg). Products are categorized into a food categorization system used by the Global Food Monitoring Group[27]. Categories include, for example, beverages, dairy, eggs, fish and fish products.

For the present study, NutriTrack 2011 and 2013 databases were used. NutriTrack 2013 (the most recent available) was used to gain insight into brand variety. However, price information was not included in NutriTrack 2013 and thus NutriTrack 2011, which contains price information, was used to gain insight into the healthiness and price. NutriTrack 2011 contains data collected from two major supermarket stores on 6020 packaged foods categorized into thirteen food categories and NutriTrack 2013 contains data collected from four major supermarket stores on 13 406 products categorized into fifteen food categories.

Measures

Level of processing

A taxonomy developed by Monteiro *et al.* was used to categorize packaged foods into three levels of industrial processing: (i) unprocessed or minimally processed foods (group 1); (ii) processed culinary (group 2); and (iii) ultra-processed foods (group 3)[5]. The industrial processes applied to the products in group 1 do not substantially alter the foods, whereas the processes applied to group 3 result in products with no resemblance to the original foods. For example, portioning, drying and freezing are industrial processes included in group 1. Group 2 includes for example pressured and milled products; and salting, baking and (deep) frying are examples of industrial processes applied to products placed in group 3[5]. For some of the food sub-categories the classification was ambiguous, these were: cream, plain dairy milk, other milk, nuts and fruit, and some processed meat products. For example, the sub-category 'other milk' contained coconut milk (group 2) and flavoured milks (group 3), but had to be classified as an entire category into only one of these groups. As a rule, when classifying a food sub-category that was ambiguous a conservative approach was taken where the sub-category was placed into a more industrial processed food group (Table 1).

Price

Three price measures were calculated for each individual product to enable a comprehensive review of price: energy cost ($NZ/100 kJ), unit cost ($NZ/100 g or ml) and serving cost ($NZ/serving). We consider $NZ/serving to be the

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Table 1 Packaged food products subdivided into three levels of processing

	Level of processing		
	Group 1: Minimally processed	Group 2: Culinary processed	Group 3: Ultra-processed
Included food sub-categories	Fruit and vegetable drinks, water, eggs, bran, grains, plain rice, chilled fish, frozen fish, dried fruit, frozen fruit, unsalted nuts, dried legumes and vegetables, unprocessed frozen vegetables	Flour, plain noodles, plain pasta, fresh pasta, sugar, plain dairy milk, soya milk, edible oils and oil emulsions	Cordial bases, electrolyte drinks, energy drinks, hot drink mixes, ice tea drinks, soft and flavoured drinks, bread and bakery products, breakfast cereals, cereal bars, flavoured noodles, packet pasta, canned pasta, rice-based dishes, rice crumbs, convenience foods, cheese, cream, desserts, ice cream, condensed milk, flavoured dairy, other milk, powdered milk, yoghurt, canned fish, fish with pastry, fruit bars, dried fruit and nut mixes, fruit in juice/syrup, other fruit, jam and spreads, nut and fruit bars, nut bars, nuts and fruit, salted nuts, canned vegetables, frozen potato products, processed frozen vegetables, pickled vegetables, meat alternatives, processed meat, other deserts, sauces spreads and seasonings, snack foods

most relevant, since the serving size is a standardized measure that makes it easier to compare similar foods[28].

Nutrient profiling score

The Food Standards Australia New Zealand Nutrient Profiling Scoring Criterion (NPSC)[29] was calculated for all products in order to determine their healthiness. The NPSC system allocates products an overall score based on both 'positive' and 'negative' nutrients including: energy (kJ), saturated fat, sugars, sodium, fibre, protein, and % fruit, vegetable and nut content. The system is used to determine eligibility of foods to carry health claims in Australia and NZ. All foods and beverages are divided into three categories: category 1 includes beverages; category 2 includes any food not included in 1 or 3; and category 3 includes fats and oils. The scoring criteria differ for the three categories. Scores range between −10 and 28, with higher scores indicating a worse nutrient profile.

The NutriTrack 2011 data set did not contain all the required information to allocate the NPSC; fruit and vegetable percentage and (in the absence of a health claim) fibre content are not mandatory to list on NZ food products. Consequently, only 1518 of the 6020 products listed fibre on the Nutrition Information Panel. Indeed, two adaptions had to be made to the NPSC model[26]. First, since data on the fruit and vegetable percentage were missing, this component could not be used when calculating the NPSC. Second, since it can be expected that fibre is mostly listed in specific food categories (e.g. cereals), it was decided to exclude this from the NPSC to make the comparison between food categories more equitable. Sub-analysis revealed that this exclusion led to a slight increase in the mean NPSC from 3·6 to 5·9, meaning that the values used in our analysis will be slightly worse than the true NPSC.

Product and brand variety

All individual food products were categorized into three groups: (i) food manufacturer; (ii) brand; and (iii) sub-brand. The NutriTrack 2013 database contained data on sub-brand (brand or logo which is listed on the front of package of the product[30]) but an Internet search was required to determine whether these sub-brands were stand-alone brands or part of an overarching brand. For example, Woolworths Select and Woolworths Homebrand are different brands on the package, but both belong to the overarching brand Woolworths. Next, the site of the Ministry of Economic Development[31] was used to identify the food manufacturers behind these brands. This website lists all manufacturers active in the NZ food and beverage market. All brands that were not stand-alone were allocated to the higher-level food manufacturer. These food manufacturers were a combination of national and global acting companies. To assess the size of the food manufacturers, the number of products available in our supermarket sample was counted (i.e. in the present paper, product availability refers to the number of unique products, not the shelf inventory).

Statistical analysis

Statistical analyses were conducted using the statistical software package IBM SPSS Statistics version 22. Descriptive analyses were used to determine the number of unique products, energy costs, unit costs, serving costs and NPSC for the three levels of processing (groups 1, 2 and 3). An ANOVA *F* test was used to compare the NPSC, energy costs, unit costs and serving costs across processed food groups. Prior to this test, the homogeneity of variance was tested and when there was variance between the groups, the Brown–Forsythe test was used instead. Bonferroni and Games–Howell *post hoc* tests were used relatively when variance was equal and with non-equal variance to determine which groups differed significantly from each other. For this test, food categories were required to have products in at least two of the three processed food groups. Five categories met this condition: beverages, cereals, dairy, fish and fish products, and fruit and vegetables.

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Next, the overall association between the NPSC and three price measures was explored using a linear regression model. Price was the dependent variable and the NPSC was the independent variable, adjusting for food category. These analyses were stratified by food category. Food categories containing <150 of the total 6020 products were considered too small to produce reliable estimates and were excluded. These categories were oils, eggs and other miscellaneous.

Sensitivity analysis was conducted to establish whether the classification of ambiguous food categories had any effect on results observed. In addition, analysis was repeated excluding beverages because their low energy density could impact observed associations between price and nutrient profiling scores[32].

Finally, the overall brand variety, brand variety within the different processed food groups and brand variety within different food categories was explored using descriptive analysis. Distinctions were made between food manufacturers, brands and sub-brands. For these analyses, the focus was on the food categories most likely to be adversely associated with non-communicable diseases, including ready meals, crisps and snacks, biscuits, chocolates and sweets, breakfast cereals and soft drinks[33].

Results

Descriptive data

The 2011 NutriTrack data set contained 6020 packaged food and beverage products with a mean NPSC score of 10·58 (SD 9·2). The mean energy cost was $NZ 1·17 (SD 7·2) per 100 kJ. The mean unit and serving costs were $NZ 1·77 (SD 1·6) per 100 g and $NZ 1·06 (SD 1·4) per serving, respectively).

NutriTrack 2013 contained data on 13 406 packaged food products. The overall mean NPSC score of these products was 9·87 (SD 9·2).

Nutrient profiling score and price for different levels of processed food

Six hundred and twenty-two (10·3 %) packaged products were classified as minimally processed (group 1), 332 (5·5 %) as culinary processed (group 2) and 5066 (84·2 %) as ultra-processed foods (group 3). Table 2 shows the NPSC scores and costs for these three food groups.

The present study observed a difference in variance in NPSC scores between the three groups and therefore the Welch and Brown–Forsythe test was used, which supported the findings of the ANOVA in all cases. Results showed that the three processed food groups had statistically significantly different mean NPSC scores ($P < 0·001$) and the *post hoc* Games–Howell test showed that the mean for each group differed significantly from the mean for both other groups ($3\times$ $P < 0·001$). The mean NPSC score was the lowest (best nutrient profile) in the minimally processed group (3·27) and highest in the ultra-processed group (11·63).

No statistically significant differences were found in energy cost by level of processing ($P = 0·144$). However, significant differences were observed in unit cost between all groups ($3\times$ $P < 0·050$); the ultra-processed group had the highest unit cost ($NZ 1·87/100 g) and the culinary processed group had the lowest ($NZ 1·02/100 g). In addition, serving cost differed significantly between the minimally and culinary processed groups ($P < 0·001$), and between the culinary and ultra-processed groups ($P < 0·001$). The minimally processed group had the highest cost per serving with a mean of $NZ 1·16 (SD 1·02) and the culinary processed group had the lowest cost with a mean of $NZ 0·64 (SD 1·08) per serving (Table 2).

Differences in NPSC score and costs between the three levels of processing within five food categories are shown in Table 3. With the exception of fish and fish products and the culinary processed food category for cereals, the NPSC score was consistently higher (worse nutrient profile) for higher levels of processing. However, this difference was statistically significant only for beverages, cereals and dairy ($3\times$ $P < 0·001$). In addition, within the fish and fish products and fruit and vegetables categories, the energy cost ($P < 0·001$, $P = 0·517$), unit cost ($P < 0·007$, $P < 0·001$) and serving cost ($P < 0·001$, $P < 0·001$) were consistently higher in the minimally processed food group (Table 3).

Association between nutrient profiling score and price

For all products combined, a significant linear relationship was found between NPSC score and all three price

Table 2 Nutrient profiling score and costs of 6020 packaged foods available for sale in New Zealand supermarkets in 2011

	Level of processing									
	Group 1: Minimally processed (*n* 622)			Group 2: Culinary processed (*n* 332)			Group 3: Ultra-processed (*n* 5066)			Overall ANOVA
	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*	*P* value
NPSC score	3·27	5·68	609	7·95	10·67	327	11·63	8·95	5028	<0·001
Energy cost ($NZ/100 kJ)	1·56	1·55	609	0·59	0·70	322	1·16	7·86	5061	0·144
Unit cost ($NZ/100 g)	1·38	1·53	622	1·02	1·03	332	1·87	1·67	5065	<0·001
Serving cost ($NZ/serving)	1·16	1·02	621	0·64	1·08	329	1·07	1·44	5028	<0·001

NPSC, Nutrient Profiling Scoring Criterion, is used to determine the healthiness of products and ranges between −5 and 40; higher scores indicate less healthy products.

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measures. However, all associations were weak: energy cost: $B = -0{\cdot}089$, $P < 0{\cdot}001$, $R^2 = 0{\cdot}013$; unit cost: $B = 0{\cdot}071$, $P < 0{\cdot}001$, $R^2 = 0{\cdot}163$; serving cost: $B = -0{\cdot}027$, $P < 0{\cdot}001$, $R^2 = 0{\cdot}031$. For all three price measures, food category was found to be an effect modifier and thus analyses were also conducted separately for each food category. These results are shown in Table 4. Again, most associations (twenty-six out of thirty) were weak, although a moderate association was found for dairy, beverages and fish. For dairy, a negative association was observed between NPSC score and energy cost and a positive association with unit cost.

Sensitivity analysis

Sensitivity analyses to explore the impact of ambiguous classifications of food categories revealed similar results to the differences in NPSC score and energy cost between the

Table 3 Differences in energy, unit and serving costs according to level of processing across five food categories for 6020 packaged foods available for sale in New Zealand supermarkets in 2011

	Level of processing			
	Group 1: Minimally processed	Group 2: Culinary processed	Group 3: Ultra-processed	ANOVA
Food category	Mean	Mean	Mean	*P* value
Beverages				
NPSC score	1·40	–	4·46	<0·001
Energy cost ($NZ/100 kJ)	2·69	–	11·65	0·002
Unit costs ($/NZ100 g)	0·37	–	0·87	<0·001
Serving costs ($NZ/serving)	1·08	–	1·22	0·172
Cereals				
NPSC score	2·38	2·31	9·49	<0·001*
Energy cost ($NZ/100 kJ)	0·31	0·32	0·33	0·800
Unit costs ($/NZ100 g)	1·29	0·89	1·59	<0·001†
Serving costs ($NZ/serving)	0·59	0·96	0·91	0·082
Dairy				
NPSC score	–	−0·97	15·21	<0·001
Energy cost ($NZ/100 kJ)	–	1·79	0·73	<0·001
Unit costs ($/NZ100 g)	–	0·30	2·51	<0·001
Serving costs ($NZ/serving)	–	0·67	1·02	0·001
Fish and fish products				
NPSC score	2·14	–	1·56	0·377
Energy cost ($NZ/100 kJ)	1·35	–	0·45	<0·001
Unit costs ($/NZ100 g)	2·61	–	1·99	0·007
Serving costs ($NZ/serving)	2·27	–	1·60	<0·001
Fruit and vegetables				
NPSC score	5·73	–	6·57	0·087
Energy cost ($NZ/100 kJ)	1·18	–	1·08	0·517
Unit costs ($/NZ100 g)	1·67	–	1·11	<0·001
Serving costs ($NZ/serving)	0·93	–	0·60	<0·001

NPSC, Nutrient Profiling Scoring Criterion, is used to determine the healthiness of products and ranges between −5 and 40; higher scores indicate less healthy products.
**Post hoc* Games–Howell showed that NPSC score differed significantly ($P < 0{\cdot}050$) between group 1 & 3 and group 2 & 3.
†*Post hoc* Games–Howell showed that unit cost differed significantly ($P < 0{\cdot}050$) between group 1 & 2 and group 2 & 3.

Table 4 Associations between nutrient profiling score (NPSC) and price by food category for 6020 packaged foods available for sale in New Zealand supermarkets in 2011

	Energy cost ($NZ/100 kJ)			Unit cost ($NZ/100 g)			Serving cost ($NZ/serving)		
Food category	R^2	*B*	*P* value	R^2	*B*	*P* value	R^2	*B*	*P* value
Beverages	0·018	−0·723	0·012	0·362*	0·147	<0·001	0·058	−0·046	<0·001
Bread	0·006	−0·013	0·025	0·029	0·023	<0·001	0	0	0·991
Cereal	0·101	−0·010	<0·001	0·122	0·046	<0·001	0·005	−0·010	0·085
Convenience	0·156	−0·071	<0·001	0·026	0·032	0·003	0·077	−0·192	<0·001
Dairy	0·413*	−0·032	<0·001	0·411*	0·134	<0·001	0·001	0·002	0·384
Fish	0·028	−0·029	0·011	0·338*	0·206	<0·001	0·087	0·067	<0·001
Fruit and vegetables	0·069	−0·080	<0·001	0·234	0·088	<0·001	0	−0·002	0·537
Meat	0·048	−0·023	<0·001	0·055	0·065	<0·001	0	0	0·980
Sauces and spreads	0·046	−0·154	<0·001	0·012	0·024	0·002	0·075	−0·043	<0·001
Snack foods	0·021	−0·036	0·001	0·013	0·030	0·011	0	−0·001	0·803

NPSC, Nutrient Profiling Scoring Criterion, is used to determine the healthiness of products.
*Moderate association between the nutrient profiling score and price.

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three groups. Further, analyses excluding beverages revealed similar results for the trend in NPSC score for the three different processed food groups. The analyses showed slightly different outcomes for the cost measures, but the directions of the associations stayed the same.

Product and brand variety

The NutriTrack 2013 database (13 406 products) was used to assess product variety. A total of thirty different food manufacturers were indicated as active in NZ, together producing 47·4 % (*n* 6351) of all packaged food available in supermarkets. The two biggest food manufacturers were Foodstuffs (1079 products) and Woolworths Limited (729 products). Together these food manufacturers produced 1808 products, accounting for 13·5 % of all packaged products available in supermarkets in NZ. The ten biggest food manufacturers produced 4707 products, accounting for 35·1 % of the products. When the study focused specifically only on ultra-processed foods, Foodstuffs (*n* 887) and Heinz (*n* 634) were the two single biggest food manufacturers producing 13·7 % of all ultra-processed foods available in NZ supermarkets. The ten biggest food manufacturers within ultra-processed foods together produced 36·9 % (*n* 4089) of ultra-processed foods.

The largest product variety was observed for ultra-processed foods (11 085 products, 82·7 % of total). Our analysis revealed that these products were produced by a relatively small number of manufacturers (Table 5). More detail on the product range for a set of key product categories that are linked to non-communicable diseases, i.e. breakfast cereals, biscuits, chocolates and sweets, ready meals, soft drinks, and crisps and snacks[32], is provided in Table 5. For example, 311 breakfast cereal products were available, of which ninety-two (29·6 %) were produced by two food manufacturers, Ozone Organics and Kellogg's. Likewise, we observed 703 varieties of chocolates and sweets (6·3 % of all ultra-processed foods); 255 of these (36·3 %) were produced by two food manufacturers, Mondelèz/Kraft and Nestlé. Mondelèz/Kraft produced these chocolates and sweets under nine different brands. Two hundred and seventy-four products were categorized as soft drinks and divided into two subcategories: sugar-free (*n* 44) and sugar-sweetened (*n* 230). Ninety-five (34·7 %) soft drinks were products by two food manufacturers, Coco Cola and PepsiCo.

Discussion

The present study aimed to map the packaged food environment in NZ supermarkets by examining the different levels of industrial food processing in relation to NPSC score, price and product variety. Our analyses showed a significant positive association between the level of industrial processing and NPSC score, indicating that ultra-processed foods had a worse nutrient profile than culinary processed foods, which in turn had a worse nutrient profile than minimally processed foods. These findings confirm our hypothesis that highly processed foods have a worse nutrient profile. A large majority (83 %) of packaged products were classified as ultra-processed and our study found that relatively few food manufacturers produced a large number of products and brands. These results show there is clear potential to improve product availability in supermarkets, in particular by reducing the large variety of very similar ultra-processed foods.

Our findings support those of Monteiro and colleagues, who suggest that diet quality decreases when purchases of ultra-processed food increase[5]. In the present study we found that the NPSC score was significantly worse for ultra-processed foods compared with their less processed counterparts. This finding was consistent across and within food categories.

The original UK model[34] upon which the NPSC was based states that if beverages score 1 or more and if foods score 4 or more, then these are classified as 'high in saturated fat, sodium or sugar'. The present study showed that, except for fish, for all food categories the mean NPSC score of ultra-processed foods clearly exceeded this value

Table 5 Number of product varieties and manufacturers per food sub-category for 13 406 packaged foods available for sale in New Zealand supermarkets in 2013

Food sub-category	No. of products	Top two manufacturers	No. of brands owned by manufacturer	Produced no. of products	% of total products
Breakfast cereals	311	Ozone Organics	2	51	16·4
		Kellogg's	1	41	13·2
Biscuits	696	Campbell's	1	121	17·4
		Griffins	3	104	14·9
Chocolates & sweets	703	Mondelèz/Kraft	9	189	26·9
		Nestlé	3	66	9·4
Ready meals	294	Heinz	1	28	9·5
		Hansells	2	21	7·1
Soft drinks	274	Coca Cola	3	67	24·5
		PepsiCo	4	28	10·2
Crisps & snacks	433	PepsiCo	6	99	22·9
		Griffins	2	65	15·0

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(beverages 4·46; cereals 9·49; dairy 15·21; fruit and vegetables 6·59). Since supermarkets are the most important point of food purchase[12], the high availability of ultra-processed foods is a major concern.

A review by Glanz *et al.* showed that increased availability of unhealthier foods in supermarkets increases sales[35] and already ultra-processed foods contribute at least 60 % of dietary intake in Western countries[36,37]. There are different interventions in the supermarket environment that could potentially reduce the consumption of these less healthy foods, including strategies focusing on the '4 P's' of the marketing mix: price, products, placement and promotion[35]. Promising strategies could be the reduction or relocation of unhealthier foods to less prominent shelf-space, the placement of healthier foods in more visible and accessible locations, reduction in promotion of high-fat, high-salt and high-sugar foods, and creating checkout aisles with healthier products[35].

One aspect that could increase the attractiveness of ultra-processed foods is affordability. However, in contrast to our hypothesis, in the present study we found no clear patterns in the association between price (energy cost, unit cost or serving cost) and level of processing. Our study did find some patterns within specific food categories, where the energy, unit and serving costs were higher for minimally *v.* ultra-processed fish and fruit and vegetables. Likewise, our study did not find a strong association between the healthiness (NPSC) of products and their price. We did find some statistically significant associations for energy cost and serving cost, which were both negatively correlated with NPSC score, but these were very weak. This supports the findings by Ni Mhurchu and Ogra, who stated it is possible in NZ to improve diet quality with comparable but healthier products without also increasing the cost of the diet (e.g. moving from ultra-processed to minimally processed)[38].

Many other studies in the literature, however, report that healthier foods tend to cost more[16,28,39]. A possible explanation for the difference in findings of our study compared with this previous work could be that they mostly used energy density to classify the healthiness of products[16,28,39], while we used nutrient profiling. It can be argued that nutrient profiling is a better method, since it takes a more complete approach to the healthiness of food by looking not only at energy levels, but also at saturated fat, added sugars, salt levels and protein. However, not only the absolute price is important to consider, but also 'the price of convenience'[40]. Ultra-processed foods are more convenient and require less preparation, cooking skills and time compared with less processed foods and people are prepared to pay for this[40]. Since our study did not observe significant absolute cost differences between minimally and ultra-processed foods, it can be argued that they still could be perceived cheaper in terms of value for money[40].

The present study found that 35 % of all packaged foods available in NZ supermarkets were produced by the ten biggest food manufacturers. This is comparable to numbers from the USA showing that 32 % of the packaged food is produced by the ten biggest food manufacturers[24]. Similar trends were observed within food categories. For example, our study observed that one manufacturer produced 189 (27 % of total) chocolates and sweets displayed through nine different brands. Furthermore, we found that a large number (*n* 1079, *n* 729) of food products were manufactured by the two largest supermarkets themselves (Foodstuffs and Progressive Enterprises Ltd). Together these supermarkets represent the largest food-producing manufacturers (14 % of all products), meaning that these two supermarkets do not only own 90 % of the market share, but also predominantly produce and sell their own products. These numbers suggest that there are strong incentives for manufacturers to produce many varieties of basically the same processed foods. Stuckler and colleagues gave three explanations for this phenomenon: low production costs, long shelf-life and high retail value[24].

To our knowledge the present study is the first that gives detailed insight into the availability, variety and healthiness of different processing levels of packaged foods available in supermarkets. However, there are some limitations that are important to consider. First, it is important to acknowledge the limitations of the three-tier taxonomy used to classify processed food products[5]. The processes making products eligible for inclusion in the ultra-processed food group were much broader than the processes for the minimally and culinary processed food groups. This could be a reason why the ultra-processed food group included substantially more products (*n* 5066) than the two other levels (*n* 662 and 332, respectively). However, the method of classification had been validated and used in other studies[33,36,41]. To the best of our knowledge no other taxonomies exist to classify food by level of processing. Further, our sensitivity analyses, where fewer products were classified as ultra-processed, revealed similar results as the main analyses. Another limitation is that our study focused exclusively on packaged foods. Therefore it does not provide insight into the complete supermarket environment which also includes fresh produce (e.g. fresh fruits and vegetables, raw nuts, etc.) and thus is healthier than the supermarket environment presented here. However, our study does highlight how unhealthy most packaged foods available in supermarkets are. While the availability of more healthy foods is important, recent evidence shows that when both healthy and less healthy foods are highly available (as in supermarkets) this still has negative consequences for obesity[35].

A strength of the current research was the use of the NutriTrack database. This database is unique in that it contains nutrient information on all packaged foods for sale in major NZ supermarkets, including brand details. Data are collected annually based on a published protocol[27] and data collection is undertaken in the four biggest supermarket stores in the largest city in NZ. The use of the

NPSC nutrient profiling model is another strength of our study. This is a rigorous method of assessing the healthiness of foods as it looks at both positive and negative nutrients. Unfortunately, we were not able to include all aspects of the NPSC score, such as fibre and % fruit, vegetable and nut, meaning that the true values might be healthier than the ones presented here. However, since this information was left out consistently, all products were affected equally, meaning that it likely did not affect reported differences between groups.

Finally, it is possible we might have misclassified some products in relation to their producing food manufacturers. However, the study used a quality database from the Ministry of Economic Development of NZ and most products were easy to track. In addition, the results are aligned with American data which gives us confidence that the results are valid.

Our study reveals there are clear opportunities to improve the packaged food environment in supermarkets, in particular with regard to the availability of ultra-processed foods. One strategy to achieve this is via voluntary industry codes[42]. A study by Stuben *et al.* showed that if food manufacturers were interested in improving the nutritional quality of their products, this could have lasting positive impacts on population BMI. However, that same study also revealed that these efforts would decrease their market share in low nutritional quality products in the long term, which explains the low interest of food manufacturers in reformulating their products[42]. Food manufacturer initiatives supported by governmental regulation are therefore expected to be more effective in creating a healthier food environment. To achieve this, governments should take a leading role[43].

Conclusion

The majority of packaged foods in NZ supermarkets are ultra-processed and these foods are also the least healthy. The present study found no significant price difference between ultra- and less processed foods, indicating ultra-processed foods might provide time-poor consumers with more value for money. There is a vast range of product and brand varieties of essentially the same product and these are produced by a relatively small number of manufacturers, including supermarket-owned brands. These findings highlight a clear need for improvement of the supermarket packaged food environment, where we should focus on displaying a smaller number of less healthy ultra-processed foods and more healthy products, and increase efforts to reformulate products to make them healthier.

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