A survey of high-protein snack foods

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Executive summary

Introduction

High-protein diets have gained popularity on the island of Ireland. Consumers report that they are following these diets for nutrition and health reasons. This report aims to:

- Investigate the protein intakes of adults on the island of Ireland
- Survey the nutritional content of a sample of snack products labelled “high protein”
- Identify from recently published scientific studies the potential health outcomes of high-protein diets.

Methods

- The most recent protein intake data was identified from the national dietary datasets for adults in Northern Ireland and in the Republic of Ireland. This data was compared to the recommendations in both jurisdictions.
- High-protein cereal bars or “snack” bars, yoghurts and quark, dairy drinks and smoothies were surveyed in the top five supermarkets in each jurisdiction. Price and nutrition label data were collected. “Traffic-light” labelling criteria were used to categorise products as “low” (green label), “medium” (amber label) or “high” (red label) for total fat, saturated fat, sugar and salt.
- A systematic survey of studies and articles on this topic was conducted to establish the health outcomes of high-protein diets.

Findings

- Adults over 18 years of age were found to be consuming enough protein.
- Seventy-seven percent of the high-protein bars surveyed were high in saturated fat and a source of added salt and sugar.
- High-protein yoghurts and quark, dairy drinks and smoothies surveyed had lower saturated fat content but are a source of added salt and sugar.
- The only benefit identified in literature to support consuming more protein than the Reference Nutrient Intake recommended amount was in older adults, to prevent sarcopenia (loss of skeletal muscle mass and strength as a result of ageing).

Conclusion

- It is evident that commercial high-protein snack products, particularly high-protein bars, are not as healthy as perceived by consumers.
- Adults' protein needs can be met by consuming a varied diet containing a range of protein sources, without the inclusion of commercial high-protein food products.

Contents

List of Tables

List of Figures

1 Introduction

High-protein diets have become increasingly popular on the island of Ireland (IOI); between 2015 and 2017, there was a 2% increase in consumers in the Republic of Ireland (ROI) and Northern Ireland (NI) who reported following high-protein diets (1, 2). Consumers report high-protein diets as being beneficial for sustaining a healthy lifestyle, ensuring adequate protein intakes, enhancing muscle function, supporting bone health, managing weight, increasing energy and contributing to satiety (satisfaction of hunger) (3) which may explain the increasing popularity of high-protein diets.

Mintel's Global New Products Database, cited by Board Bia, stated that between 2012 and 2016 there was a 498% increase in the number of foods making 'high-protein' claims in the United Kingdom (UK) and Ireland[1]. Given that people are consuming these products for health and nutrition reasons it is important to investigate the benefits of consuming extra dietary protein.

[1] Board Bia, *Understanding protein into the future*, 2019 https://www.bordbia.ie/industry/insights/food-alert/understanding-protein-into-the-future/ [accessed 24 November 2019]

2 Objectives

The specific objectives of this research were to:

- Investigate the protein intakes of adults on the IOI.
- Understand consumers' views of high-protein bars.
- Sample a selection of snack food products labelled "high protein" that are sold on the IOI and review their nutritional content.
- Undertake a literature review to identify the health outcomes associated with high-protein diets.

3 Methods

Secondary analysis of dietary protein intake

The ROI National Adult Nutrition Survey (NANS) and the NI National Diet and Nutrition Survey (NDNS) were analysed to investigate the most recent dietary intake data for adults on the IOI (4, 5). This was then used to establish current levels of protein consumption. Intakes were expressed as "percentage energy from food" (%) and "grams per day" (g/day). This information was compared to the dietary guidelines in ROI and NI (6, 7).

Consumer survey

A survey of consumers (n=2018) on the island of Ireland was conducted in 2019 by Ipsos MRBI to gather their views on protein bars. This was carried out in the Republic of Ireland through Ipsos MRBI's telephone omnibus service and through Ipsos MRBI's face-to-face omnibus service in Northern Ireland. Respondents were asked:

- Do you think of protein bars as being healthy or unhealthy?
- Do you ever purchase protein bars?
- How often do you buy them?
- Why do you purchase protein bars?

High-protein snack products survey

High-protein products selection

Products with "high-protein" claims were surveyed. To make a "high protein" claim at least 20% of the energy value of the food must be provided by protein (8). Three product categories were surveyed:

- Cereal bars and "snack" bars,
- Yoghurts and quark (a dairy product similar to a curd or cottage cheese with a concentrated protein content due to processing) (9), and
- Dairy drinks and smoothies.

These categories were selected based on the most commonly purchased "high-protein" products as reported by consumers on the IOI (3).

Products were purchased over a 2-week period in 2018 (between 27 March and 9 April 2018).

- All high-protein bars, yoghurts and quark, dairy drinks and smoothies that could be identified were purchased.
- Where multiple flavours of a product existed these were all purchased, because the nutritional profile (the fat, sugar and salt contents) of each may vary.
- If the same product was available in multiple stores, it was purchased in the first store only.
- Yoghurts and quark, dairy drinks and smoothies were selected from the chill cabinets.
- Cereal bars or snack bars were selected from the area of the store near the checkout tills and in the "health food" and "snack food" sections.
- Receipts were kept for price information.

Supermarket selection

Five retail outlets were surveyed in the ROI and in NI (Appendix 1):

- The 2 supermarkets with the greatest market share
- The 2 convenience stores with the greatest market share
- The discount store with the greatest market share.

Market share data was used to identify the top stores (10-13). Limited data on NI market share was available as it is incorporated into UK data. Also, some major retailers in the UK do not trade in NI, so the store with the next greatest market share was selected.

Stores in Cork and Belfast were selected to provide a snapshot (a set of data taken at one point in time) in the ROI and NI, respectively. Google maps identified stores located closest to the *safe*food offices, in Cork and Belfast.

Data analysis

Photos of the labelling on the front and back of each pack were taken and saved electronically. Information was recorded on: date of purchase, store, product, brand, jurisdiction (NI or the ROI), price in pounds sterling (£) or euro (€), serving size (g or ml), and the energy in kilocalories (kcal), total fat (g), saturated fat (g), sugar (g), salt (g) and protein (g) per 100 g and per serving (Appendix 2, Appendix 3). Ingredients were also recorded (Appendix 4Error! Reference source not found.).

Mean, maximum and minimum values for each variable for the three different product category were calculated. Traffic-light labelling criteria for foods and drinks (Appendix 5) was used to identify products as "low", "medium" or "high" in fat, saturated fat, sugar and salt (Appendix 6) (14). The label on the products surveyed was reviewed to ensure that all products had more than 20% energy value from protein.

Literature review to establish health outcomes of high-protein diets

A search of electronic databases (PubMed, Web of Science, Google Scholar and ScienceDirect) was conducted between 19 February 2018 and 9 March 2018. A list of the search terms used is in Error! Reference source not found.. Reference lists of articles meeting the inclusion criteria were examined to identify other potential sources of information.

Inclusion criteria for literature review

A number of different study or paper types were considered for inclusion in the literature review:

- **Reviews:** A review paper evaluates and discusses the research methods and results of existing studies, and also looks at other, non-scientific, publications on a given topic. The author (the researcher) combines their findings to create an overview of the current knowledge on that topic, including any weaknesses or gaps in the knowledge.
- **Meta-analyses:** Meta-analysis is a way of combining and comparing data collected from multiple existing studies on a given topic.
- **Systematic reviews:** A systematic review also evaluates the methods and results of existing studies (secondary data), but focuses on finding measurable scientific evidence that will answer a specific, predefined question.
- **Prospective cohort studies:** A prospective cohort is a population study group that is relevant to the topic being investigated. The cohort is monitored and their data is measured over time to identify changes associated with a given factor (for example, the effects of high levels of protein in the diet of adults on the IOI).

Other inclusion criteria were:

- Papers published in the last 20 years
- Full text of the study available
- Only human studies with subjects 18 years of age and older were included
- Studies could comprise of male and/or female subjects
- Only studies published in English language were included

4 Results

Secondary analysis of dietary protein intake

The recommended protein intake for adults 18 years of age or older is 0.75 grams per kilogram of body weight per day (6, 7). Protein should provide 12 to 15 percent of adults' daily energy intake (15).

Dietary intake data shows that consumption of protein is adequate across all age groups, and that consumers are getting more protein than the recommended amount (Table 1) (4, 5, 7, 16).

Table 1: Mean daily intake of protein for adults in the Republic of Ireland and in Northern Ireland, by age and gender and in comparison with recommended protein intakes

	Age group (years)	Reference nutrient intake of protein (g/day)*	Age group (years)	Protein intake data (g/day)	Protein intake data (% energy from food)**
Republic of Ireland					
Males	18–64	56.0	18–64	100.2	18.5
	65+	56.0	65+	85.2	18.8
Females	18–64	47.0	18–64	70.4	17.6
	65+	47.0	65+	69.4	18.3
Northern Ireland					
Males	19–50	55.5	19–64	87.4	18.0
	50+	53.3	65+	75.8	17.0
Females	19–50	45.0	19–64	66.6	17.3
	50+	46.5	65+	60.5	17.9

* Guidance on the reference nutrient intake of protein sourced from (16, 17)

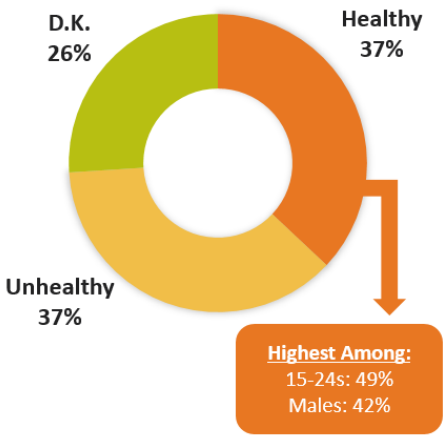
** Guidance on protein intake as a percentage of energy from food sourced from (15) which recommends that protein should provide 12 to 15 percent of adults' daily energy intake.

Dietary protein intake data sourced from (4, 5).

Consumer survey

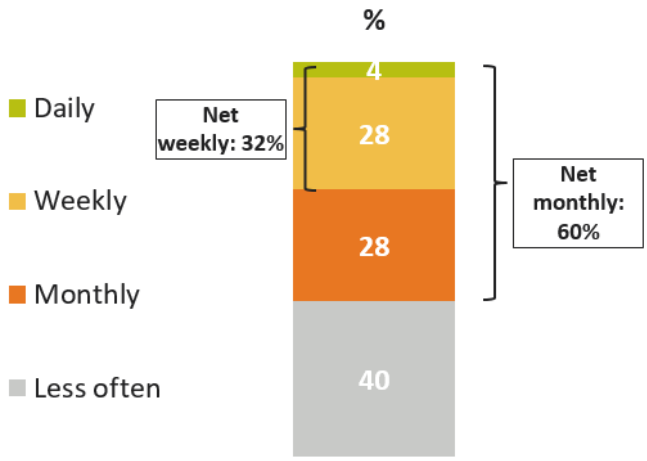
Results from the consumer survey showed that 37% of adults on the Island of Ireland (IOI) consider protein bars to be healthy (Figure 1). The perception of protein bars as being healthy was highest among 15-24 year olds and males. Just over a quarter (28%) of adults have purchased a protein bar, with 25-34 year olds most likely to have purchased at 42%. Just under one third (32%) of adults who purchase protein bars do so weekly or more often (Figure 2).

Figure 1: Perception of protein bars by consumers on the island of Ireland



Question: Do you think of protein bars as being healthy, or unhealthy? Base:All Respondents: IOI: 2,018. DK- don't know

Figure 2: Consumers frequency of purchase of protein bars

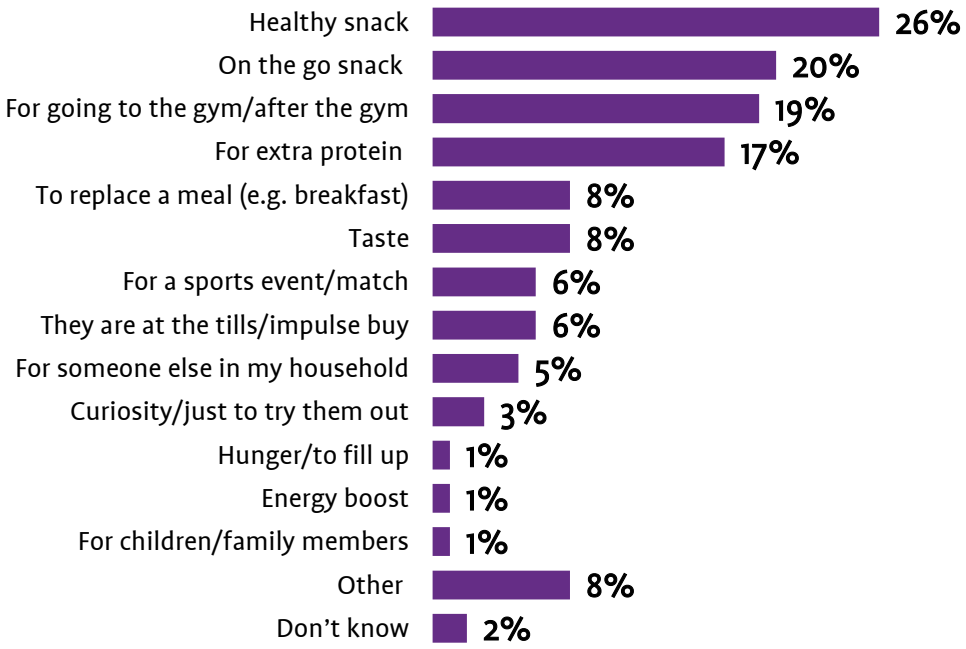


Question: How often do you buy them? Base: All respondents who purchase protein bars: IOI: 564.

The main reasons given by respondents for the purchase of protein bars (Figure 3) included:

- They are considered a healthy snack (26%)
- As an on the go snack (20%)
- For a snack before/after the gym (19%)
- For extra protein (17%)

Figure 3: Consumers reasons for purchase of protein bars



Question: Why do you purchase protein bars? Base: All respondents who purchase protein bars: 564 IOI. Respondents provided more than one answer therefore total exceeds 100%.

High-protein snack products survey

Eighty-three "high protein" products were sampled:

- 39 bars
- 26 yoghurts and quark
- 18 dairy drinks and smoothies

The mean, minimum and maximum nutritional content of each group of high-protein snack products surveyed is presented per serving and per 100 grams or millilitres of product (Table 2).

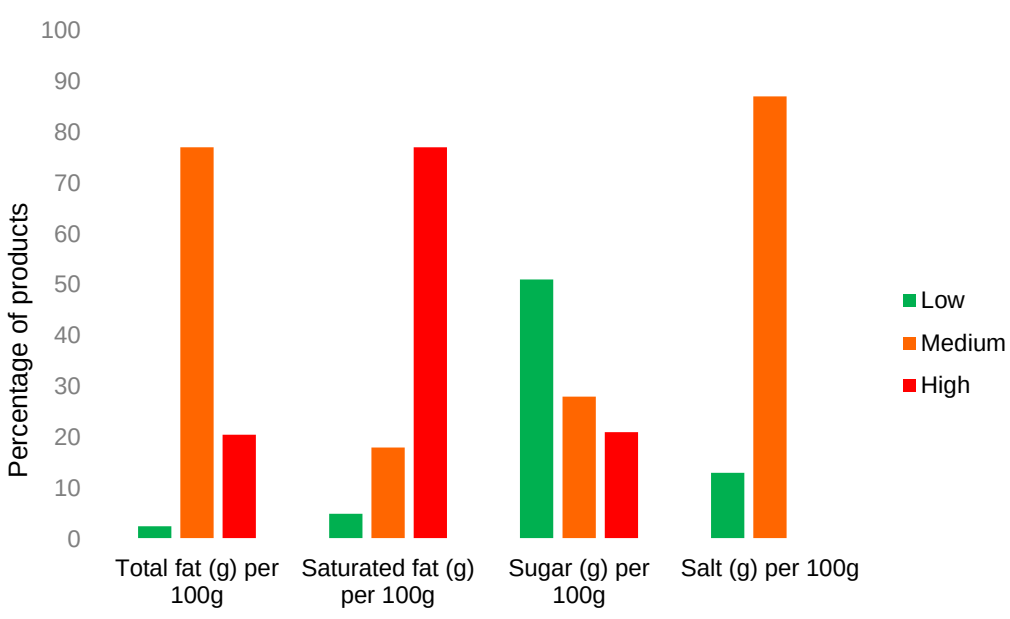
The nutritional content of the individual products from each group is presented per serving and per 100 g or 100 ml (Tables 3-5).

High-protein bars

The serving size ranged from 40-61 g with a mean of 55 g (Appendix 3). The protein content per 100 g ranged from 18.2-40.2g per 100 g (Table 3). When characterised using the traffic-light labelling criteria (Figure 4):

- 79% had an amber label for total fat
- 77% had a red label for saturated fat
- 51% had a green label for sugar; 28 % amber and 21 % red
- 87% had an amber label for salt.

Figure 4: Nutritional profile of high-protein bars surveyed using traffic-light labelling criteria



- Chocolate was listed as the primary ingredient in 38% (n=15) of bars surveyed.
- Protein was identified as the first ingredient in 35% (n=14) of cereal bars or snack bars, respectively. Protein content was mainly derived from milk proteins (whey and casein) and the vegetable protein soy.
- Oils (palm, coconut, soy, sunflower, safflower, shea, rapeseed and mint) were also ingredients listed in 62% of bars.

- Sucrose was an ingredient in 41% of bars. Other sources of sugar such as fruit, fruit purees, fruit juices and syrups, were also prominent. Sweeteners were identified as an ingredient in 69% of the high-protein bars.
- Added salt was listed on 90 % of ingredients lists.

Figure 5 provides an example of a list of ingredients in a protein bar. A full list of ingredients for all the products surveyed is provided in Appendix 4.

Figure 5: Ingredients list of "Fulfil® Peanut & Caramel Vitamin & Protein Bar"

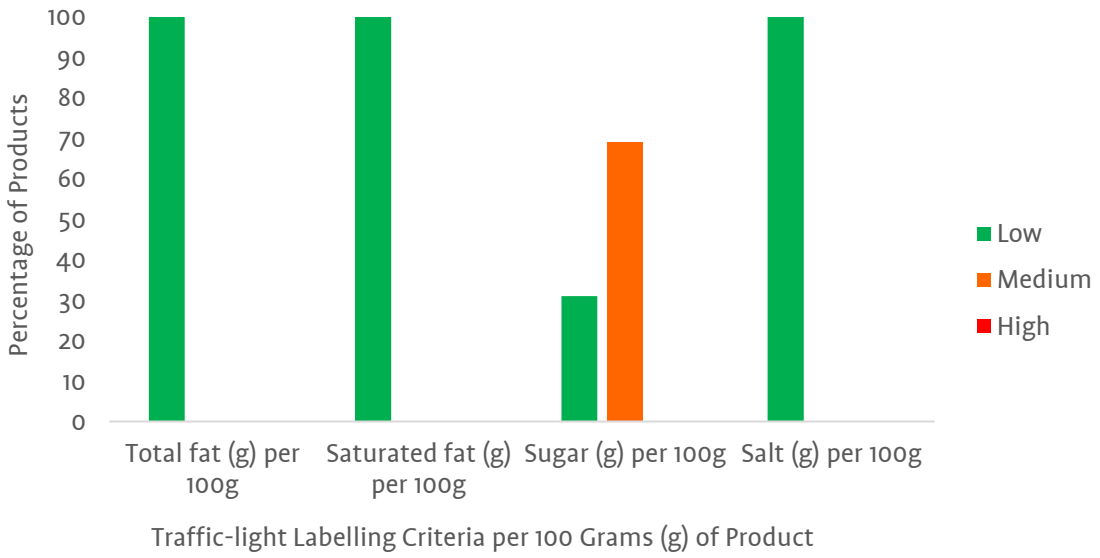
Milk chocolate with fibres and sweeteners (20%) (cocoa butter, inulin, oligofructose, cocoa mass, whole milk powder, skimmed milk powder, sweetener [erythritol, steviol glycosides], emulsifier [soy lecithin], flavours), milk protein, caramel-flavoured layer (16.4%) (bulking agent [polydextrose], palm fat, xylitol, skimmed milk powder, emulsifier [soy lecithin], salt), gelatine hydrolysate, humectant (glycerol), peanuts (5.6%), soy crisps (5.5%) (soy protein, tapioca starch, salt), cocoa butter, flavours (contains peanut), low-fat cocoa, soy oil, vitamins (vitamin C [ascorbic acid], vitamin B3 [nicotinamide], vitamin E [tocopheryl acetate], calcium pantothenate, vitamin B2 [riboflavin], vitamin B6 [pyridoxine hydrochloride], vitamin B1 [thiamin hydrochloride], folic acid, vitamin B12 [canocobalamine]), salt, sweetener (sucralose), emulsifier (soy lecithin)

High-protein yoghurts and quarks

The serving sizes of the products from this category surveyed ranged from 125 g to 200 g; the most common serving size was 150 g (Appendix 3). The protein content per 100g ranged from 8.0-11.2 g per 100g (Table 4). When characterised using traffic-light labelling criteria:

- All of these types of products had low values for total fat, saturated fat and salt content (4).
- Seven out of ten had medium values for sugar.

Figure 6: Nutritional profile of high-protein yoghurts and quarks surveyed using traffic-light labelling criteria



Milk was the primary ingredient in all 26 yoghurts and quarks sampled. This was the main source of protein in these products.

Sucrose was an ingredient in 35% of products. Other sources of sugar such as syrups, whole fruit, fruit purees and fruit juices were observed in 81% of ingredients lists. Sweeteners were identified as an ingredient in 27% of yoghurts and quarks.

Figure 7 provides an example of a list of ingredients in a sample yoghurt. A full list of ingredients for all the products surveyed is in Appendix 4.

Figure 7: Ingredients list of "Glenisk® Strained Greek Style Yogurt, Mango & Passionfruit"

> Skimmed milk, water, mango (4%), sugar, passionfruit (2%), maize starch, natural flavouring, cultures (*Streptococcus thermophilus*, *Lactobacillus bulgaricus*).

High-protein dairy drinks and smoothies

A two-fold difference in serving size (between 250 ml and 500 ml) was observed between dairy drinks. The most common serving size was 330 ml (Appendix 3). The protein content per 100 g ranged from 4.4-8.2 g per 100ml (Table 5).

When characterised using the traffic-light labelling criteria:

- The majority (83%) of dairy drinks and smoothies surveyed were low in total and saturated fat (Figure 8).
- All products had a low salt content and a medium sugar content.

Figure 8: Nutritional profile of high-protein dairy and smoothies surveyed using traffic-light labelling criteria

Milk was identified as the primary ingredient in 16 of the 18 drinks surveyed.

Whey and casein were identified as protein sources in 67% of dairy drinks and smoothies. Soy protein was only identified in 1 product.

Fruit was the primary ingredient in 2 of the drink products. Sucrose and fructose were ingredients in 44% and 50% of drinks, respectively, and sweeteners were present in 39%.

Figure 9 is provided as an example of a list of ingredients in a protein smoothie. A full list of ingredients for all the products surveyed is in Appendix 4.

Figure 9: Ingredients list of "Upbeat® Dairy Protein Smoothie, Strawberry"

Whey protein concentrate (milk) (79%), strawberry juice from concentrate (12%), strawberry puree (8%), natural strawberry flavouring with other natural flavourings, beetroot concentrate, stabiliser (pectin), acidity regulator (lactic acid), sweetener (sucralose).

Comparison of the 3 different types of high-protein snack products

- Dairy drinks and smoothies had the highest mean protein content per serving (19.8 g).
- Protein bars had the highest mean protein content per 100 g (31.7 g per 100 g).
- Protein bars contained the most energy both per serving and per 100 g. They also had the highest mean total fat and saturated fat per serving.
- Dairy drinks and smoothies had the highest mean sugar content per serving (21.3 g).
- Protein bars had the highest sugar content per 100 g (12.4 g per 100 g).
- Dairy drinks and smoothies had the highest mean salt content per serving (0.4 g).
- Protein bars had the highest mean salt content per 100 g (0.6 g per 100 g).

Table 2: Nutrition content (mean, minimum and maximum) of high-protein snack products surveyed, per serving and per 100 grams or millilitres of product

			Per Serving (g or ml)			Per 100 g or 100 ml		
Product Category	Serving size range (g or ml)	Nutrition profile	Mean	Mini-mum	Maxi-mum	Mean	Mini-mum	Maxi-mum
Protein bars (n=39)	40–61	Energy (kcal)	198.2	155.0	246.0	377.4	309.0	500.0
		Total fat (g)	7.6	1.6	12.3	14.8	2.9	30.8
		Saturated fat (g)	3.6	0.2	7.4	7.0	0.3	15.0
		Sugar (g)	6.4	1.1	24.5	12.4	1.8	44.6
		Salt (g)	0.3	0.1	0.6	0.6	0.1	1.1
		Protein (g)	16.9	8.5	24.1	31.7	18.2	40.2
Yoghurts and quark (n=26)	125–200	Energy (kcal)	111.2	84.0	149.0	69.0	53.0	92.0
		Total fat (g)	0.3	0.0	1.6	0.2	0.0	1.3
		Saturated fat (g)	0.2	0.0	1.5	0.1	0.0	1.2
		Sugar (g)	10.1	5.8	15.0	6.3	3.3	10.0
		Salt (g)	0.18	0.0	0.3	0.1	0.0	0.2
		Protein (g)	15.2	12.0	20.0	9.5	8.0	11.2
Dairy drinks and smoothies (n=18)	250–500	Energy (kcal)	195.0	152.0	280.0	62.0	46.0	77.0
		Total fat (g)	2.9	0.3	6.0	0.9	0.1	2.2
		Saturated fat (g)	1.7	0.3	5.0	0.6	0.1	2.0
		Sugar (g)	19.8	10.4	28.5	6.4	3.3	10.7
		Salt (g)	0.4	0.0	0.6	0.1	0.0	0.2
		Protein (g)	19.1	10.8	27.0	5.8	4.3	8.2

Table 3: Nutrition content of high-protein bars surveyed per 100g

Brand	Product Name	Energy (Kcal) per 100g	Sugar (g) per 100g	Total fat (g) per 100g	Saturated fat (g) per 100g	Salt (g) per 100g	Protein (g) per 100g
SportyFeel	High protein bar caramel	396	1.8	10.6	6.1	0.45	40.2
Grenade	Carb killa cookies & cream high protein bar	362	2.5	13.7	7.3	0.72	38.9
Grenade	Carb killa fudge brownie high protein bar	359	2.4	13.3	7.1	0.75	38.9
Grenade	Carb Killa caramel chaos high protein bar	357	2.4	13.2	6.9	0.75	38.7
Fulfil	White chocolate & cookie dough vitamin & protein bar	355	4.9	13.2	7.5	0.72	38.6
Grenade	Carb killa white chocolate cookie high protein bar	358	3.3	13.5	6.9	0.61	37.4
Weider	Yippie! Chocolate lava	401	2.7	18	10.1	1	37
Weider	Yippie! Cookies - double choc	396	2.5	17	9.8	0.44	37
Fulfil	Triple chocolate deluxe vitamin & protein bar	395	2.7	17	9.9	0.2	36.4
Fulfil	Cookies & cream vitamin & protein bar	379	3.4	16.9	8.8	1.04	36.4
Fulfil	Chocolate orange vitamin & protein bar	369	4.9	13	7.4	0.22	36.4
Fulfil	Lemon Zinger vitamin & protein bar	386	4.2	13	7.3	0.13	36.4
Fulfil	Chocolate caramel & cookie dough vitamin & protein bar	342	4.1	12	6.4	0.61	36.4
Fulfil	Peanut & caramel vitamin & protein bar	373	3.3	15.9	7.9	0.73	36.3
Weider	Yippie! Peanut-caramel	404	3.1	18	10.2	0.45	36
Weider	Yippie! Brownie vanilla	398	2.7	17	10	0.52	36
Fulfil	Milk chocolate & mint vitamin & protein bar	344	4.5	12.5	7.1	0.86	35.9
SportyFeel	High protein bar mint chocolate	369	7.7	14.5	6.5	0.88	35.9
Fulfil	Dark chocolate & mint vitamin & protein bar	338	2.5	12.3	7.2	0.82	35.5
Nutramino	Protein bar peanut & caramel	410	4.7	20	9.1	0.47	35
SportyFeel	High protein bar double chocolate & almond	370	8	15	6.5	0.83	34.9
Fulfil	Coconut & chocolate vitamin & protein bar	344	3.5	14.1	10.2	0.19	34.4
Fulfil	Strawberry & vanilla vitamin & protein bar	309	5.4	8.2	2.7	0.56	33.4
Nutramino	Protein bar creamy caramel	394	29	12	6.7	0.45	33
Nutramino	Protein bar crispy vanilla & caramel	413	24	16	11	0.57	32
Nutramino	Protein bar sweet coconut	439	22	21	15	0.23	31
Nutramino	Protein bar dark chocolate & orange	414	19	17	10	0.44	30
Vitality	High protein nutri-bar chocolate mousse	322	11	12	5	0.6	26
Vitality	High protein nutri-bar cookies & cream	322	11	12	5	0.6	26
Vitality	High protein nutri-bar peanut butter crunch	322	11	12	5	0.6	26

Nature Valley	Protein salted caramel nut	500	13.5	30.8	7.7	1.08	25.8
Nature Valley	Protein peanut & chocolate	495	15.5	30	8.8	0.97	25.5
Bounce	Cacao mint protein energy ball	433	26	21	6.1	0.82	22
Bounce	Coconut & macadamia protein bliss energy ball	388	18	18	6.7	0.64	21
Trek	Toffee triumph protein energy chunks	355	36	10.7	2.1	1	21
Trek	Cocoa peanut peak protein energy chunks	386	35	13.2	2.1	0.9	20.9
Trek	Peanut power wholefood energy bar	369	38.4	10.9	1.8	0.8	18.5
Trek	Cocoa chaos wholefood energy bar	330	41.4	6.3	1.3	0.5	18.2
Trek	Berry Burst wholefood energy bar	322	44.6	2.9	0.3	0.5	18.2

Table 4: Nutrition content of high-protein yoghurts surveyed in IOI per 100 g

Brand	Product Name	Energy (Kcal) per 100g	Sugar (g) per 100g	Total fat (g) per 100g	Saturated fat (g) per 100g	Salt (g) per 100g	Protein (g) per 100g
The Collective	Pro-yo High Protein Yoghurt Coconut with Honey and Vanilla	92	7.4	1.3	1.2	0.23	11.2
The Collective	Pro-Yo High Protein Yoghurt Berries Boysenberry, blueberry & acai	84	7.8	0.4	0.3	0.23	11.1
Arla	Skyr Icelandic Style Yoghurt Natural	65	4	0.2	0.1	0.14	11
Milbona	Skyr Natural	62	4	0.2	0.1	0.13	11
Fage	Fage Total 0%	57	4	0	0	0.1	10.3
Tesco	Tesco High Protein Natural Yoghurt	68	5.6	0.4	0.3	0.2	10.2
Arla	Arla Protein Greens Mango-Kale-Lime	75	6.6	<0.5	<0.1	0.14	10
Arla	Arla Protein Blueberry	72	6.3	<0.5	<0.1	0.15	10
Arla	Arla Protein Passion Fruit and Papaya	72	6.3	<0.5	<0.1	0.15	10
Arla	Skyr Icelandic Style Yoghurt Pear, Apple & Cinammon	76	6	0.2	0.2	0.07	10
Arla	Arla Protein Strawberry	71	6	<0.5	<0.1	0.15	10
Glenisk	Glenisk Strained Greek Style Yoghurt Natural	56	4	0	0	0.1	10
Arla	Skyr Icelandic Style Yoghurt Sour Cherry	79	8.3	0.2	0.1	0.02	9.4
Arla	Skyr Icelandic Style Yoghurt Mixed Berries	76	7.8	0.2	0.1	0.08	9.4
Arla	Skyr Icelandic Style Yoghurt Strawberry	75	7.4	0.2	0.1	0.13	9.4
Milbona	Skyr Blueberry	56	4	0.2	0.1	0.1	8.9
Milbona	Skyr Raspberry	56	3.9	0.2	0.1	0.1	8.9
Milbona	Skyr Strawberry	55	3.8	0.2	0.1	0.1	8.9
Milbona	Skyr Vanilla	53	3.3	0.2	0.1	0.1	8.8
Tesco	Tesco High Protein Natural Yoghurt with Pineapple, Mango & Lime	73	6.8	0.3	0.2	0.2	8.7
Glenisk	Glenisk Strained Greek Style Yoghurt Vanilla	78	10	0	0	0.09	8.5
Glenisk	Glenisk Strained Greek Style Yoghurt Coconut	77	9.4	0	0	0.09	8.5
Glenisk	Glenisk Starined Greek Style Yoghurt Raspberry	68	7.5	0	0	0.08	8.3
Glenisk	Glenisk Strained Greek Style Yoghurt Mango & Passionfruit	66	7.4	0	0	0.08	8.3
Glenisk	Glenlisk Strained Greek Style Yoghurt Blueberry	66	7.7	0	0	0.08	8.2
Glenisk	Glenisk Strained Greek Style Yoghurt Strawberry	67	7.6	0	0	0.08	8

Table 5: Nutrition content of high-protein drinks surveyed in IOI per 100 ml

Brand	Product Name	Energy (Kcal) per 100ml	Sugar (g) per 100ml	Total fat (g) per 100ml	Saturated fat (g) per 100ml	Salt (g) per 100ml	Protein (g) per 100ml
Acti-shake	Acti-shake chocolate	58	4.4	0.5	0.1	0.13	8.2
Acti-shake	Acti-Shake strawberry	52	4.6	0.1	0.1	0.14	7.6
Weetabix	Strawberry & raspberry breakfast drink	77	4.5	1.2	0.7	0.23	7.6
Weetabix	Vanilla breakfast drink	76	4.5	1.1	0.7	0.23	7.6
Ufit	Strawberry flavour high protein milkshake	54	3.3	1	0.5	0.08	7.2
Fuel	High protein liquid breakfast chocolate	67	7.8	0.2	0.1	0.2	6.1
Fuel	High protein liquid breakfast strawberry	58	6.1	0.1	<0.1	0.2	6.1
Upbeat	Dairy protein smoothie berry	46	3.8	0.5	0.3	0.1	6
Upbeat	Dairy protein smoothie strawberry	47	3.7	0.5	0.3	0.12	6
Avonmore	Protein milk chocolate	56	5.7	1.2	0.7	0.11	5.4
Avonmore	Protein milk vanilla	50	4.8	1	0.6	0.11	5.4
Avonmore	Protein milk	49	4.8	1	0.6	0.11	5.1
Mooju	Fresh chocolate milk	76	10.3	1.7	0.8	0.14	4.7
Mooju	Hazelnut flavoured chocolate milk	76	10.3	1.7	0.8	0.14	4.7
Naked	Protein tropical punch	65	10.7	0.2	0.2	0.01	4.4
Mooju	Fresh strawberry milk	70	10.4	1.1	0.6	0.14	4.4
Mooju	Fresh banana milk	70	10.2	1	0.6	0.14	4.4
Savse	Protein punch	70	6.1	2.2	2	0.09	4.3

Price of high-protein snack products

Price information was recorded for 67 products in the ROI and 51 products in NI. (The full list of product prices is in Appendix 2

Appendix 2). Mean, maximum and minimum costs per unit of product in each jurisdiction are summarised in Table 6: .

- High-protein bars were the most expensive snack product and high-protein yoghurts and quark were the least expensive.

High-protein products were sold in a wide range of unit sizes, leading to variation in cost. Products available in larger unit sizes retained higher prices (Appendix 2

- Appendix 2).

Table 6: Cost (mean, minimum and maximum) for high-protein snack products surveyed, per unit in the Republic of Ireland and in Northern Ireland

		Republic of Ireland cost (€)			Northern Ireland cost (£)		
High-protein snack product category	Serving size range (g or ml)	Mean	Minimum	Maximum	Mean	Minimum	Maximum
Protein bars	40–61	2.27	1.00	3.00	1.78	0.90	2.49
Yoghurts and quark	125–500	1.30	0.85	3.49	1.16	0.75	2.99
Dairy drinks and smoothies	250–50	2.08	0.79	4.99	1.62	1.00	2.95

Health outcomes of high-protein diets

Evidence suggests high-protein diets may influence bone and muscle health, weight management, blood lipids (for example, cholesterol, a fatty deposit that can line and eventually block blood vessels), blood pressure, glycaemic control (blood sugar regulation) and kidney and liver function. However, in existing literature no consistent definition of “high-protein” was evident.

Studies also reported intakes in several ways (g/day, % of daily total energy and/or g/kg body weight/day) and from a range of sources (total protein intake, animal protein and/or plant protein consumption), making comparisons difficult. A detailed literature review can be found in Appendix 8.

Bone health

Protein is a major constituent of bone, contributing to its mass and volume (18). The effects of protein intakes above the Reference Nutrient Intake (RNI) on bone density and fracture risk are not consistent or conclusive (19-22).

- The only benefit of high protein intakes was found to be on bone health in the elderly population – people above 50 years of age (18, 23, 24).

Muscle function

Protein is an important component of muscle, contributing to 30% of its mass (25). Muscle mass declines progressively in older adults – those over 60 years of age (26-30). This loss of muscle function can lead to sarcopenia (26, 28-30).

- Research suggests that increasing protein intakes to levels above the RNI among those aged over 60 may help preserve their muscle mass (28-30).

Weight management and satiety

High-protein diets have been used for weight management since the 1960s. The Atkins, Zone, Protein Power, Sugar Busters and Stillman diets all advocate high protein intakes (31).
It has been suggested that high-protein diets promote weight loss by suppressing the release of hormones that promote appetite, whilst encouraging the release of hormones that reduce appetite (30, 32). However, studies exploring this relationship are conflicting (21, 33, 34).

- Short-term studies illustrate positive outcomes of high-protein diets for body composition (for example, gaining muscle and losing fat) (21).
- Longer-term studies have found no evidence of improvements in anthropometric measurements (body mass index or "BMI", waist-to-hip ratio and so on) (33, 34).

Blood lipids, blood pressure and glycaemic control

Two studies have investigated the effects of high-protein diets on lipids, glycaemic control and blood pressure (21, 34).

- Both studies found no significant differences in measures of total cholesterol, low-density lipoprotein (LDL, often called "bad cholesterol"), fasting glucose or glycated haemoglobin (HbA1c) (measures of blood sugar levels taken after fasting for a certain period and after eating).
- Both studies noted a decrease in fasting insulin (a hormone that regulates blood sugar).
- There were conflicting findings for high-density lipoprotein (HDL, often called "good cholesterol"), triglycerides (stored body fat), fasting insulin and blood pressure (21, 34).

Liver and kidney function

The liver and kidneys play an important role in the metabolism of proteins (35). ("Metabolism" means all the chemical reactions that happen in the body to keep it functioning and alive.) The liver and kidneys have to work harder to metabolise or break down proteins and high-protein diets may have negative consequences for some individuals (30).

- It has been suggested that high-protein diets increase the risk of fatty liver disease, particularly among those who are elderly or overweight. For healthy subjects the outcomes are unknown. (36, 37).
- It is also suggested that high protein intakes may have negative outcomes for those with existing kidney dysfunction or disease. The consequences for healthy individuals remain inconclusive (30, 32, 38-40).

Summary of review of existing literature on outcomes of high-protein diets

- Overall, there is no conclusive evidence to suggest that consuming more protein than the RNI will provide healthy individuals with additional health benefits.
- The increased risk of sarcopenia amongst older adults provides the best evidence that some benefit that could be gained from higher protein intakes among this population group. There is also promising evidence of small positive effects on bone health for those over 50 years of age.

5 Discussion

The product survey found that commercial high-protein snack foods, particularly high-protein bars, are sources of saturated fat, added sugar and salt. Overconsumption of foods with a high saturated fat, sugar and salt content have been linked to overweight and obesity (41). This increases the risk of developing additional adverse health outcomes such as cardiovascular disease, some cancers, diabetes and raised blood pressure (41).

There is no evidence that population protein intakes are low (Table 1). Consumers may be uncertain as to whether they are getting sufficient amounts, creating a potential desire to enrich their diet with additional protein from commercial sources.

The saturated fat, salt and sugar content of commercial high-protein bars is likely to have a negative impact on healthy eating. High-protein bars were found to be highly processed products, with chocolate listed as the first ingredient in 38% of bars.

On average, high-protein bars are comparable to a small standard chocolate bar in their calorie, fat, saturated fat and salt content (Table 7). Chocolate is on the "top shelf" of the food pyramid. These foods are not needed for good health and should not be consumed every day but at most once or twice a week (42, 43).

Table 7: Mean nutrition content of 55-gram high-protein bars surveyed compared with the nutrition content of 3 popular chocolate bars

Product	Serving size* (g)	Energy (kcal) per serving*	Total fat (g) per serving*	Saturated fat (g) per serving*	Sugar (g) per serving*	Salt (g) per serving*	Protein (g) per serving*
High-protein bar	55.0	197.5	6.7	3.3	7.3	0.30	17.6
Cadbury's Flake®	32.0	167.0	8.8	5.2	19.0	0.08	2.4
Mars Malteser®	40.0	203.0	9.2	5.7	22.4	0.45	2.6
Mars Milky Way®	43.0	194.0	7.2	3.4	26.6	0.16	1.5

Sources: Nutrition content and serving size of chocolate bars accessed from (44), (45), (46).

The addition of whey, casein or soy protein as an ingredient in these products is most common in the cereal bar and “snack” bar category. Soy and whey protein are unpalatable ingredients – they are unappealing to look at and unpleasant to eat – which provides a challenge for food product manufacturers.

Fat, sugar and salt are key components to food palatability (47). Foods with higher quantities of these ingredients have greater sensory appeal (47). Introducing sweetness (sugar) and increasing fat overcomes poor palatability (48). This may account for the high or medium fat, sugar and salt content identified in high-protein bars.

High-protein yoghurts and quark, dairy drinks and smoothies surveyed had a high sugar content. The base ingredient identified in this group of products was milk, which is a source of natural sugar. Consumers need to be made aware of the amount of sugar in these products; quantities ranged from 3.3 g to 10.7 g of sugar per 100 ml of product in comparison with 4.6 g to 4.8 g of sugar per 100 ml in milk.

The addition of whole fruit, fruit purees and fruit juices was also common among yoghurts and quark, dairy drinks and smoothies. These also provide some natural sugar where whole fruit is maintained in the final product. However, ingredients list show that 35% of yoghurt and quark products and 44% of dairy drinks and smoothies also have added sugar.

Differences in serving sizes within and between the 3 product categories contribute to variability in nutrition content. Dietary guidelines recommend a serving size of 200 ml for milk and 125 g for a yoghurt (42, 49). However, some manufacturers suggest 500 ml of high-protein milk and 200 g of high-protein yoghurt as a single serving, which makes the fat, sugar, salt and protein content per serving of these products higher than for other similar products. Drinking 500 ml of milk would provide the same amount of protein as a single serving of these commercial drinks.

People report consuming high-protein products for health and nutrition reasons (3). Research investigating the health benefits of high protein consumption for healthy individuals has not been consistent or conclusive. Positive outcomes for protein intakes above the RNI were only identified for those over 50 years of age.

The positioning (the targeted marketing) of high-protein products makes them appear “healthy” to consumers. It is suggestive that they are a healthier alternative to other foods commonly eaten as snacks, such as confectionery and crisps (50), giving consumers a “halo effect”: perceiving the food to be healthier due to the presence of a nutrition claim (51).

“Eat smarter, think clearer, live better” (Bounce® Protein Energy Ball); “Real energy that lasts” (Trek® protein energy chunks) and “Food for active living” (Vitality® high-protein nutri-bar) are some marketing lines associated with these products. Manufacturers also use the terms “nourishing” and “healthy” to describe these snacks. At a glance, it is easy to understand why consumers perceive these products to be “good for you”.

Milk production has increased on the IOI (52). Milk proteins were traditionally considered by-products of milk production (53) but they are now a valued commodity (53, 54). Protein has become strongly associated with the growing sports industry (55). As a result, high-protein products are now more recognised and are available in supermarkets, where they are accessible to a wide consumer audience. It was clear from the survey that retailers have allocated prominent or noticeable shelf-space to these products, replacing confectionery at checkouts as well as dominating "snack food" sections.

Healthy eating guidelines on the IOI recommend people to get their dietary protein from whole foods. The Department of Health have designed daily meal plans for different population groups (56). The guidelines in both NI and the ROI recommend that protein requirements can be met by eating a range of foods.

Table 18 illustrates foods that are naturally high in protein. Consuming these foods as snacks instead of commercial high-protein products can reduce the intake of added fat, salt and sugar.

Table 8: Calorie and protein content of natural whole food high-protein snacks, compared with recommended daily energy and protein intakes for adults in Northern Ireland and in the Republic of Ireland

Snack (serving size*)	Calories* (kcal) per serving	Protein* (g) per serving
Almonds, other nuts (40 g)	244.8	8.4
2 x boiled egg (100 g)	143.0	14.1
Chicken breast, cooked (50–75 g)	117.0–175.5	8.9–13.3
Glass of semi-skimmed milk (200 g)	92.0	7.0
Low-fat cheese (25 g)	78.5	7.0
Low-fat yoghurt, plain (125 g)	71.3	6.0
Extra lean mince, cooked (100g)	137	24.7
Salmon, grilled (100g)	239	24.6
Baked beans, reduced sugar and salt (100g)	75	5
Chickpeas, boiled (100g)	121	8.4
Lentils, boiled (100g)	100	7.6

* Daily protein requirements in NI depend on the age of the individual (Table 1).

Source: Food composition data acquired from (57). Serving sizes sourced from (42, 49, 58).

Table 9: Calorie and protein requirements for adults

Gender	Daily energy requirements for adults (kcal)	Daily protein requirements for adults (g/day)
Males	2,500	ROI 56.0 NI 53.3–55.5*
Females	2,000	ROI 47.0 NI 45.0–46.5*

* Daily protein requirements in NI depend on the age of the individual (Table 1).

Limitations

Products in this survey were sampled at one time-point meaning the entire range of high-protein products on the market may not have been available.

6 Conclusions

- Adults over 18 years of age on the island of Ireland are consuming enough protein.
- Commercial high-protein products, in particular high-protein bars, are not as healthy as perceived by consumers. These products are considerable sources of total fat, saturated fat and also provide salt and sugar. As such they should be considered a “top-shelf” food.
- There is widespread consumer perception that high-protein bars are healthy.
- There is no consistent or conclusive evidence to suggest that consumption of protein above the recommended intake levels provides healthy individuals with additional health benefits. However, protein intakes above the recommended guidelines may provide small positive effects for the elderly in relation to bone and muscle health.
- People can meet their daily protein intake requirements through consuming a varied diet that includes protein-rich whole foods at each meal.

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8 Appendicies

Appendix 1: Retail outlets surveyed in the Republic of Ireland and Northern Ireland

Store	Republic of Ireland	Northern Ireland
Supermarket (% market share between 27 March 2018 and 9 April 2018) and store sampled	1. Dunnes (23.1%) • 105–107 Saint Patrick's Street, Cork 2. Tesco (22.3%) • Paul Street Shopping Centre, Lavitt's Quay, Centre, Cork	1. Tesco (27.9%) • 369 Lisburn Road, Belfast, BT9 7EP, UK 2. Sainsbury's (16.2%) • Upper Galwally Forestside Shopping Centre, Belfast, BT8 6FX, UK
Convenience store (% market share between 27 March 2018 and 9 April 2018) and store sampled	3. Centra (43.1%) • McHugh House, 83 Grand Parade, Centre, Cork, T12 N660 4. Spar (13.2%) • 48a MacCurtain Street, Victorian Quarter, Cork, T23 DWN8	3. Tesco Express (14.1%) • 307–317 Ormeau Road, Belfast, BT7 3GL, UK 4. Co-Op Food (12.8%) • 390 Ormeau Road, Belfast, BT7 3HX, UK
Discounter (% market share between 27 March 2018 and 9 April 2018) and store sampled	5. Lidl (10.8%) • Unit 5, The Cornmarket Centre, Cornmarket Street, Centre, Cork, T12 K2XT	5. Lidl (5.1%) • Hi Park Centre, High Street, Belfast, BT1 2JZ, UK

Sources: Market share data taken from Kantar Worldpanel (2018); and Euromonitor International (2018) (10-13). Store locations were sourced using Google Maps https://www.google.com/maps/

Appendix 2: Cost of high-protein snack products surveyed

High-protein bars

Product (n = 39)	Cost in Republic of Ireland (€)	Cost in Northern Ireland (£)
Bounce® cacao mint protein energy ball	2.59	/
Bounce® coconut macadamia protein energy ball	2.59	2.1
Fulfil® chocolate caramel & cookie dough vitamin & protein bar	2.49	2
Fulfil® chocolate orange vitamin & protein bar	2.49	2
Fulfil® coconut & chocolate vitamin & protein bar	2.49	2
Fulfil® cookies & cream vitamin & protein bar	2.49	2
Fulfil® dark chocolate & mint vitamin & protein bar	2.49	2
Fulfil® lemon zinger vitamin & protein bar	2.49	2
Fulfil® milk chocolate & mint vitamin & protein bar	2.49	2
Fulfil® peanut & caramel vitamin & protein bar	2.49	2
Fulfil® strawberry & vanilla vitamin & protein bar	2.49	2
Fulfil® triple chocolate deluxe vitamin & protein bar	2.49	2
Fulfil® white chocolate & cookie dough vitamin & protein bar	2.49	2
Grenade® carb killa® caramel chaos high protein bar	2.49	2.49
Grenade® carb killa® cookies & cream high protein bar	2.49	2.49
Grenade® carb killa® fudge brownie high protein bar	2.49	2.49

Grenade® carb killa® white chocolate cookie high protein bar	2.49	2.49
Nature valley™ protein peanut & chocolate	1	0.9
Nature valley™ protein salted caramel nut	1	0.9
Nutramino® protein bar chunky peanut & caramel	3	/
Nutramino® protein bar creamy caramel	2.35	/
Nutramino® protein bar crispy vanilla & caramel	2.35	/
Nutramino® protein bar dark chocolate & orange	2.35	/
Nutramino® protein bar sweet coconut	2.35	/
Sportyfeel® protein+ bar crispy caramel	1.79	/
Sportyfeel® protein+ bar double chocolate & almond	1.79	/
Sportyfeel® protein+ bar mint chocolate	1.79	/
Trek® cocoa peanut peak protein energy chunks	/	1.15
Trek® toffee triumph protein energy chunks	/	1.15
Trek® berry burst wholefood energy bar	1.5	0.9
Trek® cocoa chaos wholefood energy bar	1.5	0.9
Trek® peanut power wholefood energy bar	1.5	0.9
Vitality High Protein Nutri-bar™ chocolate mousse	2.49	/
Vitality High Protein Nutri-bar™ cookies & cream	2.49	/
Vitality High Protein Nutri-bar™ peanut butter crunch	2.49	/
Weider Yippie!® brownie-vanilla	2.39	/
Weider Yippie!® chocolate-lava	2.39	/

Weider Yippie!® cookies-double choc	2.39	/
Weider Yippie!® peanut-caramel	2.39	/
Mean cost	**2.27**	**1.78**
Minimum cost	**1.00**	**0.90**
Maximum cost	**3.00**	**2.49**

/ Price information was not available.

High-protein yoghurts and quarks

Product (n=26)	Cost in Republic of Ireland (€)	Cost in Northern Ireland (£)
Arla® protein blueberry	/	1.1
Arla® protein greens mango-kale-lime	/	1.1
Arla® Protein Passion Fruit and Papaya	/	1.1
Arla® protein strawberry	/	1.1
Arla® skyr icelandic style yogurt mixed berries	/	0.85
Arla® Skyr Icelandic style yogurt with pear, apple & cinnamon	1.29	0.75
Arla® skyr icelandic style yogurt sour cherry	/	0.85
Arla® skyr icelandic style yogurt strawberry	/	0.89
Arla® skyr natural icelandic style yogurt	/	1.25
Fage® total 0% yogurt	3.49	2.99
Glenisk® strained Greek style natural yogurt	1	/
Glenisk® strained Greek style yogurt blueberry	1	/
Glenisk® strained Greek style yogurt coconut	1	/
Glenisk® strained Greek style yogurt mango & passionfruit	1.29	/
Glenisk® strained Greek style yogurt raspberry	1	/
Glenisk® strained Greek style yogurt strawberry	1	/
Glenisk® strained Greek style yogurt vanilla	1	/
Milbona™ skyr natural yogurt	1.39	0.99
Milbona™ skyr blueberry	1.39	0.99

Milbona™ skyr raspberry	1.39	0.99
Milbona™ skyr strawberry	1.39	0.99
Milbona™ skyr vanilla	1.39	0.99
Tesco® high protein natural yogurt	1	1.25
Tesco® high protein natural yogurt with pineapple, mango & lime	0.85	/
The collective™ pro-yo high protein yoghurt berries boysenberry, blueberry & acai	/	1.35
The Collective™ Pro-Yo high protein yoghurt coconut with honey & vanilla	/	1.35
Mean cost	**1.30**	**1.16**
Minimum cost	**0.85**	**0.75**
Maximum cost	**3.49**	**2.99**

/ Price information was not available.

High-protein dairy drinks and smoothies

Product (n = 18)	Cost in Republic of Ireland (€)	Cost in Northern Ireland(£)
Acti-shake® chocolate	/	1
Acti-shake® strawberry	/	1
Avonmore® mooju fresh banana milk	0.79	/
Avonmore® mooju fresh chocolate milk	0.79	/
Avonmore® mooju fresh strawberry milk	1.9	/
Avonmore® mooju hazelnut flavoured chocolate milk (special edition)	1.69	/
Avonmore® protein milk	1.09	/
Avonmore® protein milk chocolate	1.39	/
Avonmore® protein milk vanilla	1.39	/
Fuel10k® protein breakfast milk drink chocolate	/	1
Fuel10k® protein breakfast milk drink strawberry	/	1
Naked® tropical punch high protein tropical juice protein smoothie	4.99	/
Savsé® protein punch protein smoothie	3.79	2.95
Üfit® strawberry high protein milkshake	/	1.9
Upbeat® dairy protein smoothie berry	2.79	2
Upbeat® dairy protein smoothie strawberry	2.79	2

Weetabix® on the go breakfast drink strawberry & raspberry	1.79	1.65
Weetabix® on the go breakfast drink vanilla	1.79	1.65
Mean cost	**2.08**	**1.62**
Minimum cost	**0.79**	**1.00**
Maximum cost	**4.99**	**2.95**

/ Price information was not available.

Appendix 3: Nutrition content of high-protein snack products surveyed

Nutrition content of high-protein bars per 100 grams and per serving

Product name and brand	Store purchased and jurisdiction (NI or ROI)	Serving Size (g)	Energy (kcal) per 100 g	Energy (kcal) per Serving	Total Fat (g) per 100 g	Total Fat (g) per Serving	Saturated Fat (g) per 100 g	Saturated Fat (g) per Serving	Sugar (g) per 100 g	Sugar (g) per Serving	Salt (g) per 100 g	Salt (g) per Serving	Protein (g) per 100 g	Protein (g) per Serving
Bounce® cacao mint protein energy ball	Tesco (ROI)	42	433	182	21	8.7	6.1	2.6	26.0	11	0.82	0.35	22	9.2
Bounce® coconut macadamia protein energy ball	Tesco Express (NI)	40	388	155	18	7.2	6.7	2.7	18.0	7	0.64	0.26	21	8.5
Fulfil® chocolate caramel & cookie dough vitamin & protein bar	Tesco (ROI)	55	342	188	12	6.6	6.4	3.5	4.1	2.3	0.61	0.34	36.4	20
Fulfil® chocolate orange vitamin & protein bar	Tesco (ROI)	55	369	203	13	7.1	7.4	4.1	4.9	2.7	0.22	0.12	36.4	20
Fulfil® coconut & chocolate vitamin & protein bar	Tesco (ROI)	60	344	207	14.1	8.4	10.2	6.1	3.5	2.1	0.19	0.12	34.4	20.6

Fulfil® cookies & cream vitamin & protein bar	Tesco (ROI)	55	379	208	16.9	9.3	8.8	4.8	3.4	1.9	1.04	0.57	36.4	20
Fulfil® dark chocolate & mint vitamin & protein bar	Tesco (ROI)	55	338	186	12.3	6.7	7.2	4.0	2.5	1.4	0.82	0.45	35.5	19.6
Fulfil® lemon zinger vitamin & protein bar	Dunne's (ROI)	55	386	213	13.0	7.2	7.3	4.0	4.2	2.3	0.13	0.07	36.4	20
Fulfil® milk chocolate & mint vitamin & protein bar	Tesco (ROI)	55	344	189	12.5	6.9	7.1	3.9	4.5	2.5	0.86	0.47	35.9	19.7
Fulfil® peanut & caramel vitamin & protein bar	Tesco (ROI)	55	373	205	15.9	8.8	7.9	4.4	3.3	1.8	0.73	0.4	36.3	20
Fulfil® strawberry & vanilla vitamin & protein bar	Tesco (ROI)	60	309	185	8.2	4.9	2.7	1.6	5.4	3.2	0.56	0.34	33.4	20.1
Fulfil® triple chocolate deluxe vitamin & protein bar	Tesco (ROI)	55	395	217	17.0	9.3	9.9	5.4	2.7	1.5	0.2	0.11	36.4	20
Fulfil® white chocolate & cookie dough vitamin & protein bar	Tesco (ROI)	55	355	195	13.2	7.3	7.5	4.1	4.9	2.7	0.72	0.39	38.6	21.2

Grenade® carb killa® caramel chaos high protein bar	Tesco (ROI)	60	357	214	13.2	7.9	6.9	4.2	2.4	1.4	0.75	0.45	38.7	23.2
Grenade® carb killa® cookies & cream high protein bar	Tesco (ROI)	60	362	217	13.7	8.2	7.3	4.4	2.5	1.5	0.72	0.43	38.9	23.3
Grenade® carb killa® fudge brownie high protein bar	Tesco (ROI)	60	359	215	13.3	8.0	7.1	4.2	2.4	1.5	0.75	0.45	38.9	23.3
Grenade® Carb Killa® White Chocolate Cookie High Protein Bar cookie	Tesco (ROI)	60	358	215	13.5	8.1	6.9	4.1	3.3	2	0.61	0.37	37.4	22.4
Nature valley™ protein peanut & chocolate	Dunne's (ROI)	40	495	198	30	12	8.8	3.5	15.5	6.2	0.97	0.39	25.5	10.2
Nature valley™ protein salted caramel nut	Dunne's (ROI)	40	500	200	30.8	12.3	7.7	3.1	13.5	5.4	1.08	0.43	25.8	10.3
Nutramino® protein bar chunky peanut & caramel	Dunne's (ROI)	60	410	246	20	12	9.1	5.5	4.7	2.8	0.47	0.28	35	21

Nutramino® protein bar creamy caramel	Dunne's (ROI)	46	394	181	12	5.3	6.7	3.1	29.0	13	0.45	0.21	33	15
Nutramino® protein bar crispy vanilla & caramel	Dunne's (ROI)	48	413	198	16	7.6	11	5.1	24.0	11	0.57	0.28	32	15
Nutramino® protein bar dark chocolate & orange	Dunne's (ROI)	47	414	195	17	8.1	10	4.8	19.0	8.8	0.44	0.21	30	14
Nutramino® protein bar sweet coconut	Dunne's (ROI)	49	439	215	21	10.0	15	7.4	22.0	11	0.23	0.11	31	15
Sportyfeel® Protein+ Bar Crispy Caramel	Lidl (ROI)	60	396	238	10.6	6.4	6.1	3.7	1.8	1.1	0.45	0.27	40.2	24.1
Sportyfeel® Protein+ Bar Double Chocolate & Almond	Lidl (ROI)	61	370	226	15	9.2	6.5	4	8.0	4.9	0.83	0.51	34.9	21.3
Sportyfeel® Protein+ Bar Mint Chocolate	Lidl (ROI)	61	369	225	14.5	8.8	6.5	4	7.7	4.7	0.88	0.54	35.9	21.9
Trek® cocoa peanut peak protein energy chunks	Sainsbury's (NI)	60	386	232	13.2	7.9	2.1	1.3	35	21	0.9	0.5	20.9	12.5
Trek® toffee triumph protein energy chunks	Sainsbury's (NI)	60	355	213	10.7	6.4	2.1	1.3	36	21.6	1	0.6	21.0	12.6

Trek® berry burst wholefood energy bar	Tesco (ROI)	55	322	177	2.9	1.6	0.3	0.2	44.6	24.5	0.5	0.3	18.2	10
Trek® cocoa chaos wholefood energy bar	Tesco (ROI)	55	330	186	6.3	3.5	1.3	0.7	41.4	22.8	0.5	0.3	18.2	10
Trek® peanut power wholefood energy bar	Tesco (ROI)	55	369	203	10.9	6	1.8	1	38.4	21.1	0.8	0.4	18.5	10.2
Vitality High Protein Nutri-bar™ Chocolate Mousse	Tesco (ROI)	50	322	161	12.0	6	5.0	2.5	11.0	5	0.6	0.3	26	13.0
Vitality High Protein Nutri-bar™ Cookies & Cream	Tesco (ROI)	50	322	161	12	6	5.0	2.5	11.0	5	0.6	0.3	26	13
Vitality High Protein Nutri-bar™ Peanut Butter Crunch	Tesco (ROI)	50	322	161	12	6	5.0	2.5	11.0	5	0.6	0.3	26	13
Weider yippie!® brownie-vanilla	Tesco (ROI)	45	398	179	17	7.8	10	4.5	2.7	1.2	0.52	0.23	36.0	16
Weider yippie!® chocolate-lava	Tesco (ROI)	45	401	180	18	7.9	10.1	4.5	2.7	1.2	0.67	0.3	37.0	17
Weider yippie!® cookies-double choc	Tesco (ROI)	45	396	178	17	7.7	9.8	4.4	2.5	1.1	0.44	0.2	37.0	17

Weider yippie!® peanut-caramel	Tesco (ROI)	45	404	182	18.0	8.3	10.2	4.6	3.1	1.4	0.45	0.2	36.0	16.0
Mean			377	198	14.8	7.6	7.1	3.6	12.4	6.4	0.6	0.3	31.7	16.9
Minimum			309	155	2.9	1.6	0.3	0.2	1.8	1.1	0.1	0.1	18.2	8.5
Maximum			500	246	30.8	12.3	15.0	7.4	44.6	24.5	1.1	0.6	40.2	24.1

Nutrition content of high-protein yoghurts and quark per 100 grams and per serving

Product name and brand	Store purchased and jurisdiction (NI or ROI)	Serving size (g)	Energy (kcal) per 100 g	Energy (kcal) per serving	Total fat (g) per 100 g	Total Fat (g) per serving	Saturated fat (g) per 100 g	Saturated fat (g) per serving	Sugar (g) per 100 g	Sugar (g) per serving	Salt (g) per 100 g	Salt (g) per serving	Protein (g) per 100 g	Protein (g) per Serving
Arla® protein blueberry	Sainsbury's (NI)	200	72	144	Less than 0.5	Less than 0.5	Less than 0.1	0.2	6.3	13	0.15	0.3	10	20
Arla® protein greens mango-kale-lime	Sainsbury's (NI)	200	75	149	Less than 0.5	0.4	Less than 0.1	0.2	6.6	13	0.14	0.28	10	20
Arla® Protein passion fruit and papaya	Sainsbury's (NI)	200	72	145	Less than 0.5	Less than 0.5	Less than 0.1	0.2	6.3	13	0.15	0.3	10	20
Arla® protein strawberry	Sainsbury's (NI)	200	71	142	Less than 0.5	Less than 0.5	Less than 0.1	0.2	6	12	0.15	0.3	10	20
Arla® skyr icelandic style yogurt mixed berries	Sainsbury's (NI)	150	76	114	0.2	0.3	0.1	0.1	7.8	11.7	0.08	0.12	9.4	14.1
Arla® Skyr Icelandic style yogurt with pear,	Tesco (ROI)	150	76	114	0.2	0.4	0.2	0.3	6.0	9	0.07	0.11	10	15.1

apple & cinnamon														
Arla® skyr icelandic style yogurt sour cherry	Tesco Express (NI)	150	79	118	0.2	0.3	0.1	0.1	8.3	12.5	0.02	0.03	9.4	14.1
Arla® skyr icelandic style yogurt strawberry	Sainsbury's (NI)	150	75	112	0.2	0.3	0.1	0.1	7.4	11.2	0.13	0.2	9.4	14.1
Arla® skyr natural Icelandic style yogurt	Sainsbury's (NI)	150	65	98	0.2	0.3	0.1	0.2	4.0	6	0.14	0.21	11	16.5
Fage® total 0% yogurt	Dunne's (ROI)	100	57	/	0	/	0	/	4.0	/	0.1	/	10.3	/
Glenisk® strained Greek style natural yogurt	Tesco (ROI)	150	56	84	0	0	0	0	4.0	6.0	0.10	0.15	10.0	15
Glenisk® strained Greek style yogurt blueberry	Spar (ROI)	150	66	100	0	0.1	0	0	7.7	12.0	0.08	0.12	8.2	12
Glenisk® strained Greek style yogurt coconut	Tesco (ROI)	150	77	116	0	0	0	0	9.4	14.0	0.09	0.13	8.5	13
Glenisk® strained Greek style	Tesco (ROI)	150	66	99	0	0.1	0	0	7.4	11.0	0.08	0.13	8.3	12

yogurt mango & passionfruit														
Glenisk® strained Greek style yogurt raspberry	Tesco (ROI)	150.0	68	102	0	0	0	0	7.5	11	0.08	0.12	8.3	12
Glenisk® strained Greek style yogurt strawberry	Tesco (ROI)	150.0	67	100	0	0	0	0	7.6	11	0.08	0.12	8	12
Glenisk® strained Greek style yogurt vanilla	Tesco (ROI)	150.0	78	117	0	0	0.0	0	10	15	0.09	0.12	8.5	13
Milbona™ skyr natural yogurt	Lidl (ROI)	175.0	62	109	0.2	0.4	0.1	0.2	4	7	0.13	0.23	11	19.3
Milbona™ skyr blueberry	Lidl (ROI)	175.0	56	98	0.2	0.4	0.1	0.2	4	7	0.1	0.18	8.9	15.6
Milbona™ skyr raspberry	Lidl (ROI)	175.0	56	98	0.2	0.4	0.1	0.2	3.9	6.8	0.1	0.18	8.9	15.6
Milbona™ skyr strawberry	Lidl (ROI)	175.0	55	96	0.2	0.4	0.1	0.2	3.8	6.7	0.10	0.18	8.9	15.6
Milbona™ skyr vanilla	Lidl (ROI)	175.0	53	93	0.2	0.4	0.1	0.2	3.3	5.8	0.10	0.18	8.8	15.4
Tesco® high protein natural yogurt	Tesco (ROI)	150.0	68	102	0.4	0.6	0.3	0.5	5.6	8.4	0.2	0.3	10.2	15.3

Tesco® high protein natural yogurt with pineapple, mango & lime	Tesco (ROI)	150.0	73	109	0.3	0.5	0.2	0.3	6.8	10.2	0.2	0.3	8.7	13.1
The Collective™ pro-yo high protein yoghurt berries boysenberry, blueberry & acai	Sainsbury's (NI)	125.0	84	105	0.4	0.5	0.3	0.4	7.8	9.8	0.23	0.29	11.1	13.9
The Collective™ pro-yo high protein yoghurt coconut with honey & vanilla	Sainsbury's (NI)	125.0	92	115	1.3	1.6	1.2	1.5	7.4	9.3	0.23	0.29	11.2	14
Mean			69	111	0.2	0.4	0.1	0.2	6.3	10.1	0.12	0.19	9.5	15.2
Minimum			53	84	0.0	0.0	0.0	0.0	3.3	5.8	0.0	0.0	8	12
Maximum			92	149	1.3	1.6	1.2	1.5	10.0	15	0.2	0.3	11.2	20

Nutrition content of high-protein dairy drinks and smoothies per 100 millilitres and per serving

Product name and brand	Store purchased and jurisdiction (NI or ROI)	Serving size (ml)	Energy (kcal) per 100 ml	Energy (kcal) per serving	Total Fat (g) per 100 ml	Total Fat (g) per serving	Saturated fat (g) per 100 ml	Saturated fat (g) per serving	Sugar (g) per 100 ml	Sugar (g) per serving	Salt (g) per 100 ml	Salt (g) per serving	Protein (g) per 100 ml	Protein (g) per serving
Acti-shake® chocolate	Co-Op (NI)	330.0	58	190	0.5	1.8	0.1	0.3	4.4	14.4	0.13	0.61	8.2	27
Acti-shake® strawberry	Co-Op (NI)	330.0	52	172	0.1	0.4	0.1	0.3	4.6	15.1	0.14	0.45	7.6	25.2
Avonmore® mooju fresh banana milk	Dunne's (ROI)	250.0	70	175	1	2.5	0.6	1.5	10.2	25.5	0.14	0.35	4.4	11
Avonmore® mooju fresh chocolate milk	Tesco (ROI)	250.0	76	190	1.7	4.25	0.8	2	10.3	25.75	0.14	0.35	4.7	11.75
Avonmore® mooju fresh strawberry milk	Co-Op (ROI)	250.0	70	175	1.1	2.75	0.6	1.5	10.4	26.0	0.14	0.35	4.4	11
Avonmore® mooju hazelnut flavoured	Dunne's (ROI)	250.0	76	190	1.7	4.25	0.8	2	10.3	25.75	0.14	0.35	4.7	11.75

chocolate milk (special edition)														
Avonmore® protein milk	Tesco (ROI)	500.0	49	245	1.0	5	0.6	3.0	4.8	24.0	0.11	0.55	5.1	25.5
Avonmore® protein milk chocolate	Tesco (ROI)	500.0	56	280	1.2	6	0.7	3.5	5.7	28.5	0.11	0.55	5.4	27.0
Avonmore® protein milk vanilla	Tesco (ROI)	500.0	50	250	1	5.0	0.6	3.0	4.8	24.0	0.11	0.55	5.4	27.0
Fuel10k® protein breakfast milk drink chocolate	Co-Op (NI)	330.0	67	221	0.2	0.7	0.1	0.3	7.8	26.0	0.2	0.5	6.1	20.0
Fuel10k® protein breakfast milk drink strawberry	Tesco Express (NI)	330.0	58	191	0.1	0.3	Less than 0.1	0.3	6.1	20.0	0.2	0.5	6.1	20.0
Naked® tropical punch high protein tropical juice protein smoothie	Tesco (ROI)	250.0	65	163	0.2	0.5	0.2	0.5	10.7	26.8	0.01	0.03	4.4	11.1

Savsé® protein punch protein smoothie	Dunne's (ROI)	250.0	70	175	2.2	5.5	2	5.0	6.1	15.25	0.09	0.225	4.3	10.75
Üfit® strawberry high protein milkshake	Tesco Express (NI)	310.0	54	166	1	3.2	0.5	1.6	3.3	10.4	0.08	0.2	7.2	22
Upbeat® dairy protein smoothie berry	Tesco (ROI)	330.0	46	152	0.5	1.6	0.3	1.0	3.8	12.5	0.1	0.34	6.0	20
Upbeat® dairy protein smoothie strawberry	Tesco (ROI)	330.0	47	154	0.5	1.7	0.3	1	3.7	12.2	0.12	0.38	6	20
Weetabix® on the go breakfast drink strawberry & raspberry	Dunne's (ROI)	275.0	77	211	1.2	3.2	0.7	2	4.5	12.0	0.23	0.62	7.6	21
Weetabix® on the go breakfast drink vanilla	Dunne's (ROI)	275.0	76	208	1.1	2.9	0.7	2.1	4.5	12.0	0.23	0.62	7.6	21

Mean	62	195	0.9	2.9	0.6	1.7	6.4	19.8	0.1	0.4	5.8	19.1
Minimum	46	152	0.1	0.3	0.1	0.3	3.3	10.4	0	0	4.3	10.8
Maximum	77	280	2.2	6	2	5	10.7	28.5	0.2	0.6	8.2	27.0

Appendix 4: Ingredients lists of high-protein snack products surveyed

Ingredients in high-protein bars

Product	Ingredients List
Bounce® cacao mint protein energy ball	Sunflower seeds, brown rice malts syrup, cacao nibs, whey protein isolate, concentrated grape juice, gluten-free grain dextrins, whey protein concentrate, rice bran, cocoa powder, gluten-free oats, vanilla extract, pea protein concentrate, cocoa extract, stabiliser (guar gum), tapioca starch, sea salt, antioxidant (natural mixed tocopherols), stabiliser (calcium carbonate), emulsifier (sunflower lecithin), mint oil
Bounce® coconut macadamia protein energy ball	Blue agave syrup, inulin, cashews, whey protein isolate, coconut, whey protein concentrate, rice bran, brown rice flour, macadamias, stabiliser (guar gum), tapioca starch, flavourings, whey protein hydrolysate, safflower oil, vanilla extract, sea salt, antioxidant (natural mixed tocopherols), sesame seeds, stabiliser (calcium carbonate), emulsifier (sunflower lecithin)
Fulfil® chocolate caramel & cookie dough vitamin & protein bar	Milk chocolate with fibres and sweeteners (cocoa butter, inulin, oligofructose, cocoa mass, whole milk powder, skimmed milk powder, sweeteners [erythritol, steviol glycosides]), emulsifier (soy lecithin), flavourings (caramel flavoured layer [bulking agent polydextrose, soy oil, skimmed milk powder, xylitol, emulsifier (soy lecithin), salt]), milk protein, gelatine hydrolysate, humectant (glycerol), soy protein, chocolate-flavoured soy crisps (soy protein, low fat cocoa, tapioca starch), cocoa mass, cocoa nibs, flavourings, vitamins (vitamin C, vitamin B3, vitamin E, pantothenic acid, vitamin B2, vitamin B6, vitamin B1, folic acid, vitamin B12), salt
Fulfil® chocolate orange vitamin & protein bar	Milk chocolate (sweetener [maltitol] cocoa butter, milk powder, cocoa mass, emulsifier [soy lecithin], flavour), milk protein, humectant (glycerine, collagen hydrolysate), water, soy nuggets (soy protein isolate, cocoa, tapioca starch), palm fat, orange juice powder (maltodextrin, orange juice concentrate, acidity regulator [citric acid]), candied orange peel (orange peel, glucose fructose syrup, sugar, acidity regulator [citric acid]), vitamins (vitamin C, vitamin B3, vitamin E, pantothenic acid, vitamin B2, vitamin B6, vitamin B1, folic acid, vitamin B12), acidifier (citric acid), flavour, colour (beta carotene), sweetener (sucralose)
Fulfil® coconut & chocolate vitamin & protein bar	Milk chocolate with fibre and sweeteners (cocoa butter, inulin, oligofructose, cocoa mass, whole milk powder, skimmed milk powder, sweetener [erythritol, steviol glycosides], emulsifier [soy lecithin], flavourings), bulking agent (polydextrose), milk protein, gelatine hydrolysate, humectant (glycerol), coconut, sweetener (erythritol, sucralose), colour, vitamins (vitamin C, vitamin B3, vitamin E, pantothenic acid, vitamin B2, vitamin B6, vitamin B1, folic acid, vitamin B12), flavourings, acidulate (citric acid), sweetener (sucralose)

Fulfil® cookies & cream vitamin & protein bar	Soy protein, chocolate with fibres and sweeteners (cocoa mass, dextrin, cocoa butter, sweetener [erythritol, steviol glycosides], inulin, oligofructose, low-fat cocoa, emulsifier [soy lecithin], natural flavourings, bulking agent [polydextrose]), chocolate-flavoured soy crisps (soy protein, low-fat cocoa, tapioca starch), white chocolate with fibre and sweeteners (cocoa butter, whole milk powder, dextrin, sweeteners [erythritol, steviol glycosides], inulin, oligofructose, whey protein, skimmed milk powder, emulsifier [soy lecithin], natural flavourings, vanilla), humectant (glycerol), gelatine hydrolysate, oligofructose, soy oil, cocoa mass, sunflower oil, flavourings, low-fat cocoa, vitamins (vitamin C, vitamin B3, vitamin E, pantothenic acid, vitamin B2, vitamin B6, vitamin B1, folic acid, vitamin B12), salt, emulsifier (soy lecithin)
Fulfil® dark chocolate & mint vitamin & protein bar	Chocolate with fibres and sweeteners (cocoa mass, dextrin, cocoa butter, sweeteners [erythritol, steviol glycosides], inulin, oligofructose, low-fat cocoa, emulsifier [soy lecithin], natural flavourings), mint-flavoured layer (bulking agent [polydextrose], cocoa butter, xylitol, skimmed milk powder, salt, emulsifier, colour, sweetener [sucralose], natural peppermint flavourings), milk protein, gelatine hydrolysate, humectant (glycerol), soy crisps (soy protein, tapioca starch, salt), chocolate-flavoured soy crisps (soy protein, low fat cocoa, tapioca starch), soy oil, low fat cocoa, cocoa nibs, mint-flavoured sugar nibs (sugar, vegetable oils [shea oil, palm oil], flavourings, colour, emulsifier [soy lecithin]), vitamins (vitamin C, vitamin B3, vitamin E, pantothenic acid, vitamin B2, vitamin B6, vitamin B1, folic acid, vitamin B12), salt, flavourings
Fulfil® lemon zinger vitamin & protein bar	White chocolate (sweetener [maltitol], cocoa butter, whole milk powder, emulsifier [soy lecithin], natural flavour), milk protein, humectant (glycerine), collagen hydrolysate, water, lemon peel (lemon peel, glucose-fructose syrup, sugar, citric acid), soya crisps (soya protein isolate, tapioca starch, malt extract, salt), palm fat, vitamins (vitamin C, vitamin B3, vitamin E, pantothenic acid, vitamin B2, vitamin B6, vitamin B1, folic acid, vitamin B12), acidifier (citric acid), natural flavour, sweetener (sucralose)
Fulfil® milk chocolate & mint vitamin & protein bar	Milk chocolate with fibres and sweeteners (cocoa butter, inulin, oligofructose, cocoa mass, whole milk powder, skimmed milk powder, sweeteners [erythritol, steviol glycosides], emulsifier [soy lecithin], flavourings), mint-flavoured layer (bulking agent [polydextrose], cocoa butter, xylitol, skimmed milk powder, salt, emulsifier, colour, natural peppermint flavourings, sweetener [sucralose]), milk protein, gelatine hydrolysate, humectant (glycerol), soy crisps (soy protein, tapioca starch, salt), chocolate-flavoured soy crisps (soy protein, low fat cocoa, tapioca starch), soy oil, low-fat cocoa, cocoa nibs, mint-flavoured cocoa nibs, sugar mint (sugar, vegetable oils [shea oil, palm oil], flavourings, colour, emulsifier [soy lecithin]), vitamins (vitamin C, vitamin B3, vitamin E, pantothenic acid, vitamin B2, vitamin B6, vitamin B1, folic acid, vitamin B12), salt, flavourings (milk)

Fulfil® peanut & caramel vitamin & protein bar	Milk chocolate with fibre and sweeteners (cocoa butter, inulin, oligofructose, cocoa mass, whole milk powder, skimmed milk powder, sweetener [erythritol, steviol glycosides], emulsifier [soy lecithin], flavourings), milk protein, caramel-flavoured layer (bulking agent [polydextrose], palm fat, xylitol, skimmed milk powder, emulsifier [soy lecithin], salt), gelatine hydrolysate, humectant (glycerol), peanuts, soy crisps (soy protein, tapioca starch, salt), cocoa butter, flavourings, low-fat cocoa, soy oil, vitamins (vitamin C, vitamin B3, vitamin E, pantothenic acid, vitamin B2, vitamin B6, vitamin B1, folic acid, vitamin B12), salt, sweetener (sucralose), emulsifier (soy lecithin)
Fulfil® strawberry & vanilla vitamin & protein bar	Milk protein, isomalto-oligosaccharide, bulking agent (polydextrose), oligofructose, white chocolate with fibre and sweeteners (cocoa butter, whole milk powder, dextrin, sweeteners [erythritol, steviol glycosides], inulin, oligofructose, whey protein, skimmed milk powder, emulsifier [soy lecithin], natural flavouring, vanilla), gelatine hydrolysate, sunflower oil, humectant (glycerol), rice flower, strawberry, acidulant (citric acid), flavourings, vitamins (vitamin C, vitamin B3, vitamin E, pantothenic acid, vitamin B2, vitamin B6, vitamin B1, folic acid, vitamin B12), salt, beetroot concentrate, sweetener (steviol glycosides), vanilla, emulsifier (soy lecithin)
Fulfil® triple chocolate deluxe vitamin & protein bar	White chocolate (sweetener [maltitol], cocoa butter, whole milk powder, emulsifier [soy lecithin], natural flavour), milk protein, humectant (glycerine), collagen hydrolysate, water, cocoa nibs, isomalto-oligosaccharide, palm fat, chocolate powder (cocoa powder, cocoa mass, sugar), vitamins (vitamin C, vitamin B3, vitamin E, pantothenic acid, vitamin B2, vitamin B6, vitamin B1, folic acid, vitamin B12), flavour, sweetener (sucralose)
Fulfil® white chocolate & cookie dough vitamin & protein bar	White chocolate with fibres and sweeteners (cocoa butter, whole milk powder, dextrin, sweeteners [erythritol, steviol glycosides], inulin, oligofructose, whey protein, skimmed milk powder, emulsifier [soy lecithin], natural flavourings, vanilla), caramel-flavoured layer (bulking agent [polydextrose], cocoa butter, skimmed milk powder, xylitol, flavourings, emulsifier [soy lecithin], salt), milk protein, gelatine hydrolysate, humectant (glycerol), soy crisps (soy protein, tapioca starch, salt), cocoa nibs, soy oil, low-fat cocoa, flavourings, vitamins (vitamin C, vitamin B3, vitamin E, pantothenic acid, vitamin B2, vitamin B6, vitamin B1, folic acid, vitamin B12), cream powder, salt
Grenade® carb killa® caramel chaos high protein bar	Milk protein (calcium caseinate), milk protein isolate, whey protein isolate, milk chocolate (sweetener [maltitol], cocoa butter, whole milk powder, cocoa mass, emulsifier [soy lecithin], flavourings), bulking agent (polydextrose), gelatine hydrolysate, humectant (glycerol), soy protein, cocoa butter, soy oil, palm fat, sweeteners (xylitol, sucralose), skimmed milk powder, fat-reduced cocoa powder, flavourings, tapioca starch, salt, emulsifier (soy lecithin)
Grenade® carb killa® cookies &	Milk protein (calcium caseinate), milk protein isolate, whey protein isolate, milk chocolate (sweetener [maltitol], cocoa butter, whole milk powder, cocoa mass, emulsifier [soy lecithin], flavourings), bulking agent (polydextrose), gelatine hydrolysate, humectant (glycerol), soy protein, cocoa butter, soy oil, palm fat,

cream high protein bar	sweetener (xylitol, sucralose), skimmed milk powder, fat-reduced cocoa, cream powder, tapioca starch, salt, emulsifier (soy lecithin), flavourings
Grenade® carb killa® fudge brownie high protein bar	Milk protein (calcium caseinate), milk protein isolate, whey protein isolate, milk chocolate (sweetener [maltitol], cocoa butter, whole milk powder, cocoa mass, emulsifier [soy lecithin], flavourings), bulking agent (polydextrose), gelatine hydrolysate, humectant (glycerol), soy crisps (soy protein, tapioca starch, salt), cocoa butter, soy protein, soy oil, fat-reduced cocoa powder, palm fat, sweeteners (xylitol, sucralose), skimmed milk powder, salt, tapioca starch, flavourings, emulsifier (soy lecithin)
Grenade® carb killa® white chocolate cookie high protein bar	White chocolate (sweetener [maltitol], cocoa butter, whole milk powder, emulsifier [soy lecithin], vanilla), milk protein (calcium caseinate), milk protein isolate, whey protein isolate, bulking agent (polydextrose, gelatine hydrolysate), humectant (glycerol), soy protein, soy oil, palm fat, sweeteners (xylitol, sucralose), skimmed milk powder, fat-reduced cocoa, cream powder, tapioca starch, salt, emulsifier (citric acid ester), vanilla, flavouring, sunflower oil, colours (betacarotene, titanium dioxide)
Nature valley™ protein peanut & chocolate	Roasted peanuts, chicory-root extract, isolated soy protein, chocolate pieces (sugar, cocoa mass, cocoa butter, emulsifier [soy lecithin]), sugar, palm fat, whey solids, sunflower oil, fructose, glucose syrup, peanut butter, fat-reduced cocoa powder, tapioca starch, humectant (glycerol), salt, emulsifiers (sunflower and soy lecithin), natural flavourings, maltodextrin
Nature valley™ protein salted caramel nut	Roasted peanuts, chicory-root extract, isolated soy protein, almonds, glucose syrup, palm fat, sugar, whey solids, fructose, maltodextrin, sunflower oil, tapioca starch, humectant (glycerol), salt, caramel powder (sugar, skimmed milk powder), skimmed milk powder, emulsifiers (sunflower and soy lecithin), natural flavourings
Nutramino® protein bar chunky peanut & caramel	Milk chocolate-flavoured coating (sweetener [maltitol], cocoa butter, whole milk powder, cocoa mass, emulsifier [soy lecithins], flavour), milk protein blend (calcium caseinate, whey protein concentrate), collagen peptides, peanuts, caramel-flavour filling (sweetener [maltitol], humectant [glycerol], milk protein, cocoa butter, whole milk powder, emulsifiers [soy and sunflower lecithins]), flavour, colour, plain caramel, humectant (glycerol), water, soy crisps (soy protein isolate, fat-reduced cocoa powder, tapioca starch), cocoa butter, nonhydrogenated sunflower oil, flavour, salt, sweetener (sucralose)
Nutramino® protein bar creamy caramel	Caramel (sweetened condensed milk, glucose syrup, nonhydrogenated vegetable oils [palm oil, rapeseed oil], sugar, caramelised syrup, emulsifier [monoglycerides and diglycerides of fatty acids], salt, natural butter flavour), milk chocolate (sugar, cocoa butter, whole milk powder, cocoa mass, emulsifier [soya lecithin], flavouring), milk proteins (milk protein isolate, whey protein concentrate, emulsifier [soy lecithin]), hydrolysed collagen, humectant (glycerol), partially inverted sugar syrup, soya protein isolate, whole milk powder, glucose syrup, egg

	albumen, flavourings, fat-reduced cocoa powder, barley malt extract
Nutramino® protein bar crispy vanilla & caramel	Milk chocolate (sugar, whole milk powder, cocoa butter, cocoa mass, emulsifier [soy lecithin], vanilla extract), caramel paste (glucose syrup, sugar, condensed milk, invert sugar syrup, cocoa butter, water, humectant [sorbitol], emulsifier [monoglycerides and diglycerides of fatty acids], salt), milk proteins (milk protein isolate, calcium caseinate), hydrolysed collagen, soya crispies (soya protein isolate, rice flour, malted barley extract, salt), humectant (glycerol), soya protein isolate, water, coconut oil, flavouring, bulking agent (microcrystalline cellulose), colour (betacarotene)
Nutramino® protein bar dark chocolate & orange	Dark chocolate (cocoa mass, sugar, cocoa butter, emulsifier [soya lecithin], vanilla extract), caramel paste (glucose syrup, sugar, condensed milk, palm fat, invert sugar syrup, water, humectant [sorbitol], emulsifier [monoglycerides and diglycerides of fatty acids], salt), milk proteins (milk protein isolate, calcium caseinate), hydrolysed collagen, soya crispies (soya protein isolate, rice flour, malted barley extract, salt), humectant (glycerol), soya protein isolate, water, palm fat, orange peel, paprika extract, natural orange flavour, anti-cracking agent (tricalcium phosphate), palm oil, bulking agent (microcrystalline cellulose)
Nutramino® protein bar sweet coconut	Milk chocolate with soy protein (sugar, cocoa butter, soy protein isolate, whole milk powder, cocoa mass, lactose, emulsifier [soy lecithin, sunflower lecithin], natural vanilla flavour), milk protein, sugar syrup, grated coconut, humectants (sorbitol syrup, glycerol), hydrolysed collagen, cocoa butter, glucose syrup, flavours, preservative (potassium sorbate)
Sportyfeel® protein+ bar crispy caramel	Milk chocolate (sweetener [maltitol], cocoa butter, whole milk powder, cocoa mass, emulsifier [soya lecithins], flavouring), milk protein, sweetener (maltitol syrup), humectant (glycerol), pork gelatine, whey protein isolate, soya extrudate (soya protein isolate, tapioca starch), palm oil, fat-reduced cocoa powder, flavouring, salt, sweetener (sucralose)
Sportyfeel® protein+ bar double chocolate & almond	Soya protein, sweeteners (maltitol, sucralose), dark chocolate-flavoured coating (sugar, vegetable oils [palm, palm kernel and shea oil], cocoa powder, emulsifier [sunflower lecithins, flavouring), almonds, hydrolysed pork gelatine, vegetable oils (palm oil, rapeseed oil), bulking agent (polydextrose), emulsifier (soya lecithins), soya pieces (soya protein, cocoa powder, tapioca starch), cocoa powder, chocolate (cocoa mass, sugar, cocoa butter, emulsifier [soya lecithins], humectant (glycerol), flavourings, salt
Sportyfeel® Protein+ Bar Mint Chocolate	Soya protein, sweeteners (maltitol, sucralose), dark chocolate-flavoured coating (sugar, vegetable oils [palm, palm kernel and shea oil], cocoa powder, emulsifier [sunflower lecithins], flavouring), hydrolysed pork gelatine, almonds, vegetable oils (palm oil, rapeseed oil), bulking agent (polydextrose), emulsifier (soya lecithins), cocoa powder, dark chocolate (cocoa mass, sugar, dextrose, emulsifier [soya lecithins], soya pieces (soya

	protein, cocoa powder, tapioca starch), humectant (glycerol), flavourings, salt
Trek® cocoa peanut peak protein energy chunks	Dates, grape juice concentrate, peanuts, soya protein crunchies (soya protein, tapioca starch, salt), peanut butter, raisins, soya flour, cocoa, rice starch, gluten-free oats, salt, natural flavouring
Trek® toffee triumph protein energy chunks	Dates, cashews, soya protein crunchies (soya protein, tapioca starch, salt), apple juice concentrate, soya flour, raisins, rice starch, gluten-free oats, salt, natural flavouring
Trek® berry burst wholefood energy bar	Dates, raisins, soya protein crunchies (soya protein, tapioca starch, salt), fruit juice concentrates (apple, grape, pear), gluten-free oats, soya flour, freeze-dried raspberries, natural flavourings, rice starch
Trek® cocoa chaos wholefood energy bar	Dates, soya protein crunchies (soya protein, tapioca starch, salt), fruit juice concentrates (apple, grape, pear), raisins, gluten-free oats, cashews, cocoa powder, soya flour, natural flavourings, rice starch
Trek® peanut power wholefood energy bar	Dates, soya protein crunchies (soya protein, tapioca starch, salt), fruit juice concentrates (apple, grape, pear), peanut butter, raisins, peanuts, gluten-free oats, soya flour, natural flavourings, rice starch, salt
Vitality High Protein Nutri-bar™ Chocolate Mousse	Protein mix (whey protein concentrate, sodium caseinate), sweetener (sorbitol and maltitol), chocolate coating (sugar, hydrogenated vegetable fat [palm kernel oil], whey, skimmed milk powder, cocoa powder, stabiliser [E492], emulsifier [soya lecithin, E476], vanilla flavouring), almond butter, glucose, cocoa powder, dates, soya crisps (isolated soy protein rice flour, barley malt extract, salt), dark chocolate flavouring, vitamins and minerals
Vitality High Protein Nutri-bar™ Cookies & Cream	Protein mix (whey protein concentrate, sodium caseinate), almond butter, sweetener (sorbitol and maltitol), milk chocolate coating (sugar, hydrogenated vegetable fat [palm kernel oil], whey, skimmed milk powder, cocoa powder, stabiliser [E492], emulsifier [soya lecithin, E476], vanilla flavouring), glucose, dates, soya crisps (isolated soy protein, rice flour, barley malt extract, salt), cookies-and-cream flavouring, vitamins and minerals
Vitality High Protein Nutri-bar™ Peanut Butter Crunch	Protein mix (whey protein concentrate, sodium caseinate), peanut butter, sweetener (sorbitol, maltitol), milk chocolate coating (sugar, hydrogenated vegetable fat [palm kernel oil], whey, skimmed milk powder, cocoa powder, stabiliser [E492], emulsifier [soya lecithin, E476], vanilla flavouring), glucose, dates, soya crisps (isolated soy protein, rice flour, barley malt extract, salt), peanut flavouring, vitamins and minerals

Weider yippie!® brownie-vanilla	Milk protein, sweetener (maltitol), humectant (glycerol), cocoa butter, collagen hydrolysate, isolated soya protein, whole milk powder, cocoa powder, cocoa mass, palm fat, flavouring, tapioca starch, emulsifier (E322), salt, sweetener (sucralose)
Weider yippie!® chocolate-lava	Milk protein, sweetener (maltitol), humectant (glycerol), collagen hydrolysate, cocoa butter, isolated soya protein, cocoa mass, whole milk powder, cocoa powder, palm oil, tapioca starch, flavouring, cocoa nibs, salt, emulsifier (E322, E442), clarified butter, sweetener (sucralose)
Weider yippie!® cookies-double choc	Milk protein, sweetener (maltitol), humectant (glycerol), collagen hydrolysate, cocoa butter, whole milk powder, isolated soya protein, cocoa mass, palm oil, rice flour, cocoa powder, flavouring, tapioca starch, flavouring, emulsifier (E322, E442), salt, clarified butter, sweetener (sucralose)
Weider yippie!® peanut-caramel	Milk protein, sweetener (maltitol), humectant (glycerol), collagen hydrolysate, cocoa butter, whole milk powder, isolated soya protein, roasted peanuts, cocoa mass, palm fat, flavouring, tapioca starch, emulsifiers (E322, E442), salt, cocoa powder, clarified butter, sweetener (sucralose)

Ingredients in high-protein yoghurts and quark

Product name	Ingredients
Arla® protein blueberry	Quark (milk), blueberry, fruit juice concentrate, corn starch, natural flavouring, gelling agent (pectin), sweetener (steviol glycosides), acidity regulator (sodium citrate), lactase enzyme
Arla® protein greens mango-kale-lime	Fat-free quark (milk), fruit extracts, mango puree concentrate, kale puree, corn starch, lime juice concentrate, lemon juice concentrate, natural flavouring, colours (safflower and spirulina concentrate), lactase enzyme
Arla® Protein Passion Fruit and Papaya	Fat-free quark (milk), white grape juice concentrate, passion fruit, papaya concentrate, corn starch, natural flavouring, gelling agent (pectin), acidity regulator (sodium citrate), sweetener (steviol glycosides), lactase enzyme
Arla® protein strawberry	Quark (milk), strawberry, white grape juice concentrate, corn starch, natural flavouring, colour (aronia concentrate), lemon balm extract, gelling agent (pectin), sweetener (steviol glycosides), lactase enzyme
Arla® skyr icelandic style yogurt mixed berries	Skyr yoghurt (skimmed milk), mixed berries (redcurrants, lingonberries, strawberries, blueberries, sour cherries), sugar, maize starch, lemon juice from concentrate, natural flavouring
Arla® Skyr Icelandic Style Yogurt with Pear, Apple & Cinnamon	Skyr yoghurt (skimmed milk), apple, pear, sugar, maize starch, natural flavouring, cinnamon
Arla® skyr icelandic style yogurt sour cherry	Skyr yoghurt (skimmed milk), sour cherries, sugar, maize starch, natural flavouring
Arla® skyr icelandic style yogurt strawberry	Skyr yoghurt (skimmed milk), strawberries, sugar, maize starch, lemon juice from concentrate, natural flavouring
Arla® skyr icelandic style yoghurt natural	Natural Skyr yoghurt (milk)
Fage® total 0% yogurt	Pasteurised skimmed milk, live active yoghurt cultures

Glenisk® strained Greek style natural yogurt	Skimmed milk, cultures
Glenisk® strained Greek style yogurt blueberry	Skimmed milk, blueberry, water, sugar, maize starch, natural flavouring, acidity regulator (lemon juice concentrate), cultures
Glenisk® strained Greek style yogurt coconut	Skimmed milk, water, sugar, maize starch, desiccated coconut, natural flavouring, acidity regulator (lemon juice concentrate), cultures
Glenisk® strained Greek style yogurt mango & passionfruit	Skimmed milk, water, mango, sugar, passion fruit, maize starch, natural flavouring, cultures
Glenisk® strained Greek style yogurt raspberry	Skimmed milk, raspberry, water, sugar, maize starch, natural flavouring, black carrot concentrate, cultures
Glenisk® strained Greek style yogurt strawberry	Skimmed milk, strawberry, water, sugar, maize starch, natural flavouring, acidity regulator (lemon juice concentrate), cultures
Glenisk® strained Greek style yogurt vanilla	Skimmed milk, agave syrup, maize starch, natural vanilla flavouring, natural flavouring, cultures, acidity regulator (lemon juice concentrate), vanilla pods
Milbona™ skyr natural yogurt	Skimmed milk
Milbona™ skyr blueberry	Skimmed milk, water, blueberries, modified starch, lemon juice from concentrate, thickeners (pectins, xanthan gum, carrot concentrate), acidity regulators (calcium citrates, citric acid), natural flavouring, sweeteners (aspartame, acesulfame k)
Milbona™ skyr raspberry	Skimmed milk, water, raspberries, raspberry puree from concentrate, modified starch, lemon juice from concentrate, thickeners (pectins, xanthan gum, carrot concentrate), acidity regulators (citric acid, calcium citrates), natural flavouring, sweeteners (aspartame, acesulfame k)
Milbona™ skyr strawberry	Skimmed milk, water, strawberries, modified starch, lemon juice from concentrate, thickeners (pectin, xanthan gum, carrot

	concentrate), acidity regulators (calcium lactate, citric acid), natural flavouring, sweeteners (aspartame, acesulfame k)
Milbona™ skyr vanilla	Skimmed milk, water, modified maize starch, lemon juice from concentrate, vanilla extract, thickeners (pectins, xanthan gum), acidity regulators (calcium citrates, citric acid), natural cream flavouring, vanilla pods, sweeteners (aspartame, acesulfame K)
Tesco® high protein natural yogurt	Low-fat natural yoghurt (milk)
Tesco® High protein natural yogurt with pineapple, mango & lime	High protein yoghurt (milk), pineapple, mango and lime compote (water, mango, pineapple juice, concentrated apple juice, pineapple pulp, lime juice from concentrate, maize starch, flavourings, colour [betacarotene])
The collective™ pro-yo high protein yoghurt berries boysenberry, blueberry & acai	Live quark, live yoghurt, apple extract, boysenberries, blueberries, acai juice from concentrate, concentrated grape juice, corn flour, natural flavouring, lemon juice, cultures
The collective™ pro-yo high protein yoghurt coconut with honey & vanilla	Live quark, live yoghurt, coconut milk, honey, apple extract, corn flour, natural vanilla flavouring, natural flavourings, lemon juice, cultures

Ingredients in high-protein dairy drinks and smoothies

Product name	Ingredients
Acti-shake® chocolate	Skimmed milk, milk proteins, water, fat (reduced cocoa powder), stabilizers (cellulose, cellulose gum, carrageenan), sweetener (sucralose)
Acti-shake® strawberry	Skimmed milk, milk proteins, water, stabilisers (cellulose, cellulose gum, carrageenan), flavouring, sweetener (sucralose), colour (carmine)
Avonmore® mooju fresh banana milk	1% fat milk, skimmed milk powder, sugar, fructose, banana juice concentrate, flavourings, stabiliser (carrageenan), natural colour (mixed carotene)
Avonmore® mooju fresh chocolate milk	1% fat milk, skimmed milk powder, sucrose, fructose, milk chocolate powder (soya lecithin), fat-reduced cocoa powder (soya lecithin), flavourings, stabiliser (carrageenan)
Avonmore® mooju fresh strawberry milk	1% fat milk, skimmed milk powder, sugar, fructose, concentrated strawberry juice, flavourings, natural colour (beetroot red), stabiliser (carrageenan)
Avonmore® mooju hazelnut flavoured chocolate milk (special edition)	1% fat milk, skimmed milk powder, sugar, fructose, milk chocolate powder (soya lecithin), fat-reduced cocoa powder (soya lecithin), stabiliser (carrageenan), flavouring
Avonmore® protein milk	1% low fat milk, milk protein, vitamin D3 (cholecalciferol)
Avonmore® protein milk chocolate	1% fat milk, milk protein, milk chocolate powder (soy lecithin), fat-reduced cocoa powder (soy lecithin), stabiliser (carrageenan), natural chocolate flavour, sweetener (sucralose), vitamin D3 (cholecalciferol)
Avonmore® protein milk vanilla	1% fat milk, milk protein, stabiliser (carrageenan), natural vanilla flavour, sweetener (sucralose), vitamin D (cholecalciferol)

Fuel10k® protein breakfast milk drink chocolate	Skimmed milk, water, milk protein, sugar, maltodextrin, fat-reduced cocoa powder, inulin, flavouring, thickeners (modified tapioca starch, carrageenan), vitamins (vitamin C, vitamin B3, vitamin B6, vitamin B1, vitamin A, folic acid), stabiliser (sodium phosphate), acidity regulator (sodium citrate), sweetener (sucralose)
Fuel10k® protein breakfast milk drink strawberry	Skimmed milk, water, milk protein, sugar, maltodextrin, inulin, flavourings, thickeners (modified tapioca starch, carrageenan), colour (natural lycopene), vitamins (vitamin C, vitamin B3, vitamin B6, vitamin B1, vitamin A, folic acid), stabiliser (sodium phosphate), acidity regulator (sodium citrate), sweetener (sucralose)
Naked® tropical punch high protein tropical juice protein smoothie	Fruit juices from concentrate, banana puree, isolated soy protein, natural flavouring
Savsé® protein punch protein smoothie	Pineapple, coconut water, coconut milk, lime, whey protein (milk), maca, vanilla
Üfit® strawberry high protein milkshake	Skimmed milk, water, whole milk, milk protein, chicory dietary fibre, flavour, vegetable oils (sunflower oil, corn oil), colour (carmine), stabiliser (carrageenan), oat fibre, salt, sweetener (sucralose), acidity regulator (trisodium citrate), vitamin C (sodium ascorbate), vitamin E (DL-Alpha tocopheryl acetate), selenium (sodium selenite), vitamin D3 (cholecalciferol)
Upbeat® dairy protein smoothie berry	Whey protein concentrate (milk), blueberry puree, raspberry puree, concentrated raspberry juice, stabiliser (pectin), acidity regulator (lactic acid), natural blueberry flavouring with other natural flavourings, milk calcium complex, sweetener (sucralose)
Upbeat® dairy protein smoothie strawberry	Whey protein concentrate (milk), strawberry juice from concentrate, strawberry puree, natural strawberry flavouring with other natural flavourings, beetroot concentrate, stabiliser (pectin), acidity regulator (lactic acid), sweetener (sucralose)

Weetabix® on the go breakfast drink strawberry & raspberry	Skimmed milk, water, milk protein, wheat fibre, milk cream, starch, sugar, malted wheat flour, fruit purees, flavourings, stabilisers (gellan, carrageenan), colour (carmine), vitamin B3 (niacin), iron, vitamin B2 (riboflavin), vitamin B1 (thiamine), folic acid
Weetabix® on the go breakfast drink vanilla	Skimmed milk, water, milk protein, wheat fibre, milk cream, sugar, starch, malted wheat flour, flavourings, stabilisers (gellan, carrageenan), vitamin B3 (niacin), iron, vitamin B2 (riboflavin), vitamin B1 (thiamine), folic acid

Appendix 5: "Traffic-light" labelling criteria for food and drink

"Traffic-light" labelling criteria per 100 grams of food

Nutrient	Low	Medium	High
Total fat	3.0 g or less per 100 g	From 3.0 g to 17.5 g per 100 g	Over 17.5 g per 100 g
Saturated fat	1.5 g or less per 100 g	From 1.5 g to 5.0 g per 100 g	Over 5.0g per 100 g
Total sugars	5.0 g or less per 100 g	From 5.0 g to 22.5 g per 100 g	Over 22.5 g per 100 g
Salt	0.3 g or less per 100 g	From 0.3 g to 1.5 g per 100 g	Over 1.5 g per 100 g

Source: Department of Health, Food Standards Agency (2013) (14)

"Traffic-light" labelling criteria per 100 millilitres of drink

Nutrient	Low	Medium	High
Total fat	1.5 g or less per 100 ml	From 1.5 g to 8.75 g per 100 ml	Over 8.75 g per 100 ml
Saturated fat	0.75 g or less per 100 ml	From 0.75 g to 2.5 g per 100 ml	Over 2.5 g per 100 ml
Total sugars	2.5 g or less per 100 ml	From 2.5 g to 11.25 g per 100 ml	Over 11.25 g per 100 ml
Salt	0.3 g or less per 100 ml	From 0.3 g to 0.75 g per 100 ml	Over 0.75 g per 100 ml

Source: Department of Health, Food Standards Agency (2013) (14)

Appendix 6: Categorisation of products surveyed, using "traffic-light" labelling criteria

Number of products in each category with a high, medium or low fat, saturated fat, sugar and salt content

Nutrient content (g)	Low	Medium	High
High-protein bars (n = 39)			
Total fat	1	31	7
Saturated fat	2	7	30
Sugar	20	11	8
Salt	5	34	0
High-protein yoghurts and Quark (n = 26)			
Total Fat	26	0	0
Saturated Fat	26	0	0
Sugar	8	18	0
Salt	26	0	0
High-protein dairy drinks and smoothies (n = 18)			
Total fat	15	3	0
Saturated fat	15	0	3
Sugar	0	18	0
Salt	18	0	0

Appendix 7: List of databases and search terms used for literature review

Database	Search Terms
PubMed, ScienceDirect, Web of Science, Google Scholar	(“high protein” OR “protein diet” OR “protein consumption” AND “health”) (“high protein intake” OR “high protein diet” OR “high protein” AND “health risks” OR “negative health outcomes”) (“high protein diet” OR “high protein intake” AND “weight loss”) (“high protein diet” OR “high protein intake” AND “lipids”) (“high protein diet” OR “high protein intake” AND “bone health”) (“high protein diet” OR “high protein intake” AND “kidney health”) (“function” OR “importance” AND “dietary protein”) (“high protein diet” AND “older adults” AND “sarcopenia”) (“high protein diet” AND “renal health” AND “kidneys”) (“high protein diet” AND “kidney disease”) (“high protein diet” AND “GFR”) (“high protein diet” AND “weight management” OR “weight loss”) (“high protein diet” AND “weight loss”) (“high protein diet” AND “CVD”)

Sarcopenia: Loss of skeletal muscle mass and strength as a result of ageing.

Renal: Relating to the kidneys.

GFR: Glomerular filtration rate – a test that is used to check how well the kidneys are functioning.

CVD: Cardiovascular disease – diseases that affect the heart and blood vessels.

Appendix 8: Health outcomes associated with a high-protein diet:

Results from literature review

Health outcome	Report author	Study characteristics	Main conclusions
Bone	Santesso and colleagues (2012) (21)	• Systematic review and meta-analysis of 5 studies (296 participants). • Male and female subjects, 18 years of age and over. Median age (the midpoint of the range) of 45 years. • Median protein content of higher-protein diets was 27% of total energy intake (range between 16% and 45%). • Only 15% of studies included reported the protein source. This was identified as either animal or vegetable. • Follow-up period in studies was between 4 to 6 months.	• No difference in bone mineral density (BMD) following a high-protein diet.
Bone	Calvez and colleagues (2012) (19)	• Systematic review. • "High-protein" defined as an increase in protein intake of between 20 and 160 g per day. • Animal and vegetable protein sources were included.	• Impacts of a high-protein diet on bone health were conflicting. • Bone health was not significantly benefited, nor impaired.

		• Male and female subjects, 20 years of age or over. • Study duration ranged from 4 days to 6 months.	
Bone	Darling and colleagues (2009) (20)	• Systematic review and meta-analysis. • Male and female subjects. • Age of participants varied across studies, ranging between 18 and 98 years. • Difficult to define "high-protein" due to how studies represented intakes. Intakes across studies ranged from 0.35 g/kg body weight/ day to 71.2 g/kg body weight/day; or from 12.6 g/day to 158 g/day. • Animal and vegetable protein sources were included.	• The effects of high-protein intakes on bone health were not consistent or conclusive. • Bone health was not significantly benefited, nor impaired.
Bone	Shams-White and colleages (2017) (22)	• Systematic review and meta-analysis. • Healthy male and female subjects, 18 years of age and over. • "High-protein" defined as more than 90 g/day of protein, or 1.4 g/kg body weight/day of protein; or 25% to 30% of total daily energy intake from protein sources.	• No evidence that high-protein intakes either significantly benefit or impair bone health.

		• Protein from animal and vegetable sources was included. • Intervention duration ranged from 6 months to 2 years across studies.	
Bone	Wallace and colleagues (2017) (23)	• Systematic review and meta-analysis of 31 studies. • Healthy adults, 18 years of age and over. • "High-protein" was defined as intakes between 0.8 and 2.5 g/kg body weight/day. • Protein from animal and vegetable sources was included.	• 16% reduction in hip fracture and improved BMD was identified at several sites in the body.
Bone	Wu and colleagues (2015) (24)	• Meta-analysis of 12 prospective cohort studies with 407,104 participants. • Male and female subjects. • Age of subjects across studies ranged from 18 to 89 years of age. • "High-protein" defined as intakes ranging from 50.11 g/day to greater than 98g /day. • Total protein from both animal and vegetable sources.	• Statistically significant reduction in the risk of hip fracture by 11% when total dietary protein intakes exceeded 90 g/day. • No significant differences found for all other fractures and limb fractures.
Bone	Curneen and colleagues (2018) (18)	• Review of 14 studies. • Male and female subjects over 50 years of age	• Protein is a major constituent of bone, contributing to its mass and volume.

		• Difficult to define "high-protein" due to how studies represented intakes. Different definitions used include: intakes greater than or equal to 1 g protein per ideal body weight (kg); 18.16% to 29.14% of total energy intake from protein; protein intake greater than 87.0 g per day; between 1.24 and 2.78 g/kg body weight/day; 96 (give or take 22) g/day; and 19.8% (give or take 0.12%) of daily total energy from protein sources. • Source of protein was not identified.	• Higher BMD was found in the femoral neck, lower back, spine, hip and total body. • Reduced risk of fracture was found.
Bone	Cuenca-Sanchez and colleagues (2015) (32)	• Review article.	• High protein intakes may benefit bone through several mechanisms: • Supplying bone with protein (amino acids) for collagen synthesis • Increasing insulin-like growth factor (IGF-1) for bone growth • Increasing calcium absorption and reducing breakdown of bone tissue.

Bone	Cao (2017) (59)	• Review article.	• High protein intakes may benefit bone through several mechanisms: • Supplying bone with protein (amino acids) for collagen synthesis • Increasing insulin-like growth factor (IGF-1) for bone growth • Increasing calcium absorption and reducing breakdown of bone tissue. • High protein intakes may also lead to bone demineralization by: • Reducing calcium reabsorption • Increasing calcium excretion and bone breakdown.
Muscle	Koshland and Haurowitz (2018), Arentson-Lantz and colleagues (2015), Bauer and colleagues (2013), Baum and colleagues (2016), Wolff	• Review articles.	• Protein is an important component of muscle, contributing to 30% of its mass. • Adults over 60 years of age experience a progressive decline in muscle function and mass. • Declining muscle mass results in sarcopenia, which 50% of men and 60% of women over the

	(2012) and Wu (2016) (25-30)		age of 60 are at risk of developing. • It has been suggested that high protein intakes above the RNI of 0.75 g/kg body weight/day may help to preserve muscle mass within this population group by enhancing muscle synthesis.
Weight management and satiety	Santesso and colleagues (2012) (21)	• Systematic review and meta-analysis. • Male and female subjects 18 years of age and over. Median age was 45 years. • Median BMI was 33 kilograms per metre squared (kg/m²), ranging between 22 and 43 kg/m². • Median protein content of higher-protein diets was 27% of total energy intake, ranging between 16% and 45%. • Results for weight loss were based on 38 studies with 2,326 participants. • Results for changes in BMI were based on 16 studies with 887 participants. • Results for changes in waist circumference were based on 15 studies with 1,214 participants.	• Greater weight loss of 1.21 kg after 3 months was identified. • Greater decrease in BMI of 0.51 kg/m² after 3 months was identified. • Greater loss in waist circumference of 1.66 centimetres (cm) after 3 months was identified. • Higher protein intakes resulted in greater weight loss among those with a greater BMI at the start of the study.

		• Outcomes were measured after 3 months.	
Weight management and satiety	Lepe and colleagues (2011) (33)	• Systematic review of 8 studies. • Male and female subjects. • Age of subjects ranged from 18 to 70 years. • The BMI of subjects ranged from 25 to 43 kg/m^2. • "High protein" was defined as 25% to 40% of total daily energy intake from protein sources. • Study period ranged from 6 to 24 months.	• Studies with the longest intervention period show no statistically significant difference in weight loss.
Weight management and satiety	Schwingshackl and Hoffmann (2013) (34)	• A systematic review and meta-analysis. • Male and female subjects 19 years of age and over. • "High-protein" defined as protein intakes contributing to 25% or more of total daily energy intake. • Fat intake was restricted to 30% or less of daily total energy intake. • Study duration ranged from 12 to 24 months.	• No statistically significant changes in weight or waist circumference of fat mass were found.

Weight management and satiety	St Jeor and colleagues (2001) (31)	• Review article.	• High-protein diets have been supported since the 1960s. The Atkins, Stillman, Sugar Busters, Protein Power and Zone diets have all advocated a high protein intake. • It has been suggested that the initial weight loss observed with a high-protein diet is caused by increased fluid loss due to reduced carbohydrate consumption, limited calorie intake and appetite suppression prompted by high ketone production.
Weight management and satiety	Wu (2016) and Cuenca-Sanchez and colleagues (2015) (30, 32)	• Review articles.	• High-protein diets have been hypothesized to promote weight loss by supressing the release of hormones that promote appetite and encouraging the release of hormones that reduce appetite.
Blood lipids, blood pressure and glycaemic control	Santesso and colleagues (2012) (21)	• Systematic review and meta-analysis. • Male and female subjects over 18 years of age. Median age was 45 years. • Median BMI was 33 kg/m^2, ranging from 22 to 43 kg/m^2.	• A decrease of 3.2 millimetres of mercury (mm Hg) in systolic blood pressure and a 1.75 mm Hg decrease in diastolic blood pressure after 3 months was found. • No difference in total cholesterol and LDL

		• Protein content of higher protein diets was 27% of total energy intake, Ranging from 16% to 45% of total energy intake. • Changes in systolic and diastolic blood pressure were measured in 15 studies with 1,186 participants. • Change in total cholesterol were measured in 21 studies with 1,368 participants. • Changes in HDL cholesterol were measured in 23 studies with 1,555 participants. • Changes in LDL cholesterol were measured in 23 studies with 1,576 participants. • HbA1c was measured in 3 studies with 87 participants. • Changes in fasting blood glucose were measured in 15 studies with 1,089 participants. • Changes in triglycerides were measured in 24 studies with 1,623 participants.	cholesterol after 3 months was found. • A significantly greater increase in HDL cholesterol of 0.04 millimoles per litre (mmol/l) was identified. • No difference in glycated haemoglobin (HbA1c) levels after 2 to 6 months was found. • No difference in fasting blood glucose was found. • A decrease in fasting blood insulin was observed after 3 months. • A 0.24 mmol/l decrease in triglycerides after 3 months was identified.

		• Changes in fasting insulin were measured in 11 studies with 718 participants.	
Blood lipids, blood pressure and glycaemic control	Schwingshackl and Hoffmann (2013) (34)	• Systematic review and meta-analysis. • Male and female subjects over 19 years of age. • "High protein" defined as protein intakes contributing to 25% or more of total daily energy intake. • Fat intake was restricted to 30% or less of daily total energy intake. • Study duration ranged from 12 to 24 months.	• No significant changes in total cholesterol, HDL cholesterol, LDL cholesterol or triglycerides were found. • No significant differences were found in systolic and diastolic blood pressure. • A significant decrease in fasting insulin was identified. • No significant difference in fasting glucose or HbA1c was found.
Liver and kidneys	Macmillan (2017) and ScienceDaily (2017) (36, 37)	• 3,400 subjects were involved. • Mean age was 71 years. • 70% of subjects were overweight. • "High protein" defined as intakes above the RNI.	• Those who consumed the greatest proportion of total daily energy from protein were 37% more likely to develop fatty liver disease than those who consumed least protein.
Liver and kidneys	Knight and colleagues (2003) (60)	• Prospective cohort study with 1,624 female participants. • Age of participants ranged from 42 to 68 years. • Study period of 11 years. • The highest protein intakes ranged from 86.5 to 163.7 g/day. The lowest	• Increasing protein intake by 10 g did not modify renal (kidney) function in women with normal renal health. • Renal function was compromised in women with an established renal impairment (existing

		intakes of protein ranged from 19.1 to 66.2 g/day.	kidney dysfunction or disease).
Liver and kidneys	PubMed Health (2016) (35)	• Review article.	• The liver converts amino acids in food so that they can be used to produce energy or transform them into other macronutrients. Ammonia is a by-product of this process and a toxic substance. The liver has the ability to convert ammonia to urea, which is released into the bloodstream, transported to the kidneys and excreted in urine.

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