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Gluten-free Products in the UK Retail Environment. Availability, Pricing, Consumer Opinions in a Longitudinal Study

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Abstract Gluten free products are essential for people who suffer from coeliac disease or have a more generic gluten intolerance. In both instances people are forced to resort to consuming gluten free (GF) foods. We carried out two online surveys to gauge the sentiments from people purchasing GF produce, and we carried out two retail observation studies. These studies were carried out in 2015 and repeated again 2019. Bread was the most commonly purchased GF product, but also the most complained about GF product, both from a quality and a price point of view. These sentiments did not change much from 2015 to 2019. One clear set of trends was that people purchased less specialty flour and raising agent when comparing 2019 to 2015, and they did less home-baking over the same period. Furthermore, the decrease in home-baking coincided with a relative increase in satisfaction in the quality of GF products. With regards to observations made across 11 supermarkets, we observed an overall increase in the number of GF line items, with the budget supermarkets offering a very small selection of produce labelled as GF in 2019 only. Our research shows that the relative cost of GF items increased from 2015 to 2019, with the average price ratio of GF food to non-GF foods rising from 3.2 to 4.1 across all UK supermarkets. Ultimately, GF produce cost significantly more compared to similar, gluten-containing foods, while many of the GF products, especially GF breads, still underperform when it comes to the perceived quality and value for money.

Keywords: *longitudinal, availability, range, price, free-from, price discrimination, shopping-basket*

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1. Introduction

Coeliac disease (CD) is a chronic autoimmune disorder that affects approximately 1% of the UK population and is caused by the exposure to gluten and gluten-like proteins [1]. The proportion of the UK population clinically diagnosed with CD is approximately 0.24% [2]. For those with CD the ingestion of gluten damages the mucosal lining of the small intestine causing pain and discomfort, which in turn, means that the body is unable to absorb sufficient nutrients [3]. Currently, the only way of treating CD is though adopting a strict gluten free (GF) diet [3,4]. There are several risks associated with not following a GF diet if a person has CD because, as well as the usual symptoms of CD occurring, there may be other impacts on health such a dermatitis herpetiformis, type 1 diabetes and osteoporosis [5]. Those suffering with CD are reliant on GF products being available for them to purchase, either as ingredients or as ready-to-eat foods.

The free-from market in the UK nearly doubled (195%) from 2013 to 2019, with a significant proportion (~45%) being in the GF segment. The GF market value increased from £m160 in 2013 to £m416 in 2019 [6]. A substantial amount of research exists that relates to the cost and nutritional elements related to GF produce [4,7-13], whereas this research also investigated the range, availability and cost of GF produce in the UK retail market. Furthermore, in order to be able to understand this from a consumer perspective and attempt to understand their expectations of the market, this study will also have a focus on their views in conjunction with observations of the market. This was undertaken in order to establish contentment with the range of GF products by consumers of GF produce; whether consumers feel there is anything missing from the products available; whether they are satisfied with the quality of produce on sale; and whether consumers of GF produce ever experience problems with purchasing specific products.

Due to following a GF diet being the only treatment available for CD, GF product availability is essential. Assessing the availability, cost and range helps to understand the current GF market and how those with CD can easily access suitable produce. As well as this, researching consumer expectations of the GF market assists in understanding what is included in the current market and what is missing [14].

2. Methods

2.1. Consumer Survey

Two online studies were launched, one in 2015 and one in 2019 using the JISC Online Survey system (www.onlinesurveys.ac.uk), targeting people who actively purchase GF produce either as a carer or as sufferer of a gluten intolerance or CD. The survey was distributed via various regional 'Coeliac UK' groups and through various Coeliac-specific social media platforms. The 2015 rollout yielded 120 complete responses while the 2019 rollout yielded 493 complete responses. In both studies, participants were asked to indicate where they purchase their GF produce, and at what indicative frequency (often, sometimes, rarely, never) they purchased GF product groups. Then participants were also asked to indicate their opinion on availability, product range, quality, and various value and trust statements in regards to GF products.

2.2. Retail Observation Study

Eleven individual supermarkets, across seven chains, in the British Midland's area were included in the retail observations. These included outlets from the two principle budget supermarkets and five prominent mainstream supermarkets. Each of the supermarkets were visited once a week for four consecutive weeks in late 2015 and in early 2019 to establish a database of GF products that were stocked, number of products available on the shelves, weight and price per 100g or unit were also recorded to analyse availability and costs. Non-GF products (from the supermarket basket) in the same supermarkets were also recorded in order to compare prices with the GF products.

2.3. Gluten Free Supermarket Basket

Based on the findings of the survey, a supermarket basket was created based on GF products only, which 50% or more of our participants indicated they purchased, as well as GF items previously included in similar 'baskets' [7,11,12]. Furthermore, we included a variety of GF breakfast items that were previously highlighted as being limited in availability [15]. In order to maintain a reasonable variety among the products in the basket, different types of products that apply to the same category were included. The final basket included 21 items: own brand white bread, branded white bread, own brand brown bread, branded brown bread, white rolls, brown rolls, pancakes, crumpets, pasta (penne), spaghetti, cheese crackers, plain flour, plain biscuits, cereal, granola, porridge oats, vegetable stock cubes, beef gravy granules, snack bars, pork sausages and frozen margarita pizzas.

Confectionery was not included in our basket due to there being a wide variety of naturally GF products. Furthermore, the confectionery products in the Free-From sections appeared to be labelled as 'Gluten-Free' purely because of being part of the 'Free-From' brand, where the product was primarily designed to be dairy-free. Where possible products and brands were kept consistent across all supermarkets, but in cases where the supermarket did not stock a particular product or brand, a similar one was chosen if available. For example, the majority of the supermarkets stocked GF cornflakes; therefore, these were used as the 'cereal' option. However, if a supermarket did not stock them, another cereal of similar packaging size was used.

2.4. Price Discrimination (Price Ratio)

In order to investigate the occurrence of price-discrimination with regards to GF produce, the cost of GF products with non-GF products and determine whether GF products were more or less expensive, a Price Ratio (PR) calculation was carried out. The calculation comprised of dividing the price per 100g or price per unit of GF items to non-GF items. A Price Ratio of '1.00' indicates that both the GF product and non-GF are the same cost, a Price Ratio below '1.00' indicates that the GF product costs less and a Price Ratio in excess of '1.00' indicates that the GF product costs more than its gluten containing equivalent.

3. Results and Discussion

The vast majority of people purchasing GF produce did so because they declared that they were diagnosed with CD. When also considering people who declared that they were diagnosed with a gluten intolerance; 82% of purchasers of GF products had a diagnosed gluten related issue in 2015, with 84% in 2019 (Table 1).

Table 1. Underpinning reasons for why people purchase GF products, reported as percentage (%) of respondents in each year (2015: n=120, 2019: n=493)

Reasons for purchasing gluten free	2015	2019
I have been diagnosed with Coeliac Disease	61%	76%
I have been diagnosed with a gluten intolerance	21%	8%
I am the carer of someone with Coeliac Disease or gluten intolerance	6%	10%
Other	12%	6%

3.1. Participants' Gluten-free Purchasing Behaviour

In both years' survey, respondents were asked which GF produce they purchased with an indication of their frequency of their purchases. GF bread, -pasta, -biscuits, -crackers, -cereals, and -sausages were the most frequently purchased items; while GF ready-meals, -ice-cream, and -beers were not frequently purchased (Table 2). These GF produce purchasing frequencies were similar to those reported by do Nascimento and coworkers [9].

Table 2. Frequency of GF products being purchased based on broad product categories in 2016 and 2019 (2015: n=120, 2019: n=493)

GF product	Frequency of Purchase							
	Never (%)		Rarely (%)		Sometimes (%)		Often (%)	
	2015	2019	2015	2019	2015	2019	2015	2019
Bread	7	5	14	10	33	29	47	57
Cakes	10	15	32	35	43	37	15	13
Pasta	7	8	14	12	43	34	36	45
Pastry	45	43	36	37	18	17	2	3
Crackers	16	14	16	30	47	36	22	21
Crisps	38	19	19	17	27	32	16	33
Flour	8	14	18	23	42	37	33	26
Raising agents	22	28	30	31	33	31	15	10
Biscuits	5	6	18	18	48	41	30	35
Rice cakes	34	31	25	22	23	27	18	20
Cereals	16	11	15	13	30	25	39	51
Porridge oats	36	26	14	13	26	25	24	36
Snack bars	23	20	20	26	36	35	21	19
Sauces	39	28	24	32	28	29	8	11
Soup	50	41	22	22	19	24	9	13
Stock cubes	26	13	11	15	33	41	31	32
Ready meals	42	36	26	31	26	27	7	7
Burger paties	50	46	19	24	28	23	3	7
Sausages	17	14	16	18	38	39	29	30
Pizza	28	20	21	28	33	35	18	16
Ice-cream	43	31	21	29	31	28	5	11
Beer	68	61	21	18	8	14	3	7

3.2. Participants' Concerns Regarding Availability and Quality of Gluten-free Produce

The survey participants were asked to indicate whether they experienced availability issues with GF products such as not being available or out of stock. The most common GF product with availability issues was bread. In both 2015 and 2019 66% of people raised bread availability as an issue (Figure 1), availability issues related to GF bread has previously been raised by consumers as a typical shortcoming in supply [9,16]. However, overall, issues of unavailability diminished over the 3 year period, which indicates that supermarkets have become more capable or more willing to ensure that GF produce are in general more readily available. Survey participants were also asked to indicate whether they experienced quality issues with GF produce. The single most commonly criticised product was bread, with 35% of people raising quality issues related to bread in 2015 which reduced to 30% in 2019 (Figure 2A). Biscuits, pastries, crackers and pasta were the next most commonly criticised GF products with quality issues. Texture, taste, and shelf life were the most commonly raised quality issues (Figure 2B). In both year's participants were invited to leave specific comments in relation to quality issues. In 2015 people made comments like: "Poor texture of bread" (Coeliac patient, 2015), "Bread often contains holes and falls apart" (Coeliac patient, 2015), "Massive holes in the bread, dry and crumbly" (Coeliac patient, 2015), "Bread with great big air holes" (Carer of coeliac patient, 2015), "Gluten free bread tastes like cardboard" (general purchaser of gluten free products, 2015), "Bread, cakes and biscuits are often dry" (diagnosed with gluten intolerance, 2015), "crispbreads are so hard they could break your teeth" (Coeliac patient, 2015), "some bread can taste a bit like cardboard" (Coeliac patient, 2015), and "breads often fall apart in packet" (general purchaser of gluten free products, 2015). In 2019 some people did comments that "Gluten free bread is so much better than it was in the past" (Carer for coeliac patient, 2019)", however, in 2019 the same sentiments were still being voiced: "Bread is improving all the time - but after the first day - it still has to be toasted to make it edible" (Coeliac patient, 2019), "Texture is often cardboard-like" (Coeliac patient, 2019), "Some breads and crackers we have tried taste like cardboard/polystyrene" (Carer for coeliac patient, 2019), "Gluten free bread always fall apart!" (Coeliac patient, 2019), "Bread that is full of holes or dry and disintegrates" (Coeliac patient, 2019), or "gluten-free bread can be awful, very stodgy or very crumbly" (Coeliac patient, 2019). In both years people also raised issues related to shelf life of the GF products: "Sometimes the gluten free products go mouldy before their best before date" (Coeliac patient 2019), "Often find that crackers are not fresh and crisp - although still in date", (Coeliac patient, 2015), "Gluten free bread has a short shelf life" (Carer for coeliac patient, 2019); "Some shops (viz) have shocking stock rotation. I often find mouldy gluten-free bread on their shelves (Coeliac patient, 2015), and "Sometimes the gluten free crumpets or bread go mouldy before their best before date" (Coeliac patient, 2019). These comments are very similar to the GF consumer comments reported elsewhere [16,17,18], who reported that loaf integrity (bread falling apart) was the most common complaint about quality attribute of commercially available GF bread, followed by dryness, poor shelf life, poor texture and poor taste [16]. Product quality related complaints involving GF pasta were much less compared to GF bread (Figure 2A), which is a sentiment echoed by consumers reported elsewhere [18]. In the Xhakollari and Canavari study [18], some long-term coeliacs mentioned that there were some GF pastas that were very similar to the conventional, gluten based pastas.

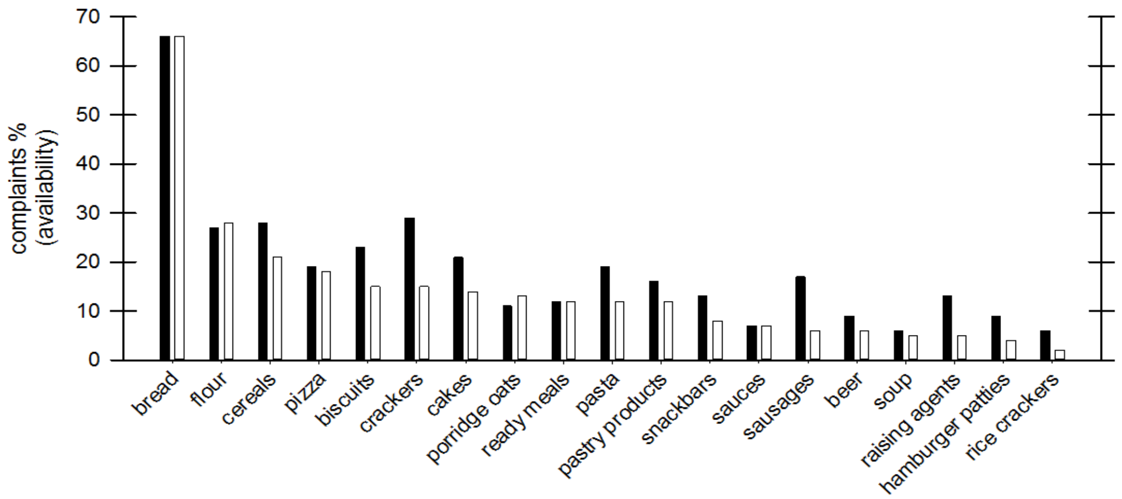

Figure 1. Availability issues with GF products (2015, black bars: n=90; 2019, while bars: n=391).

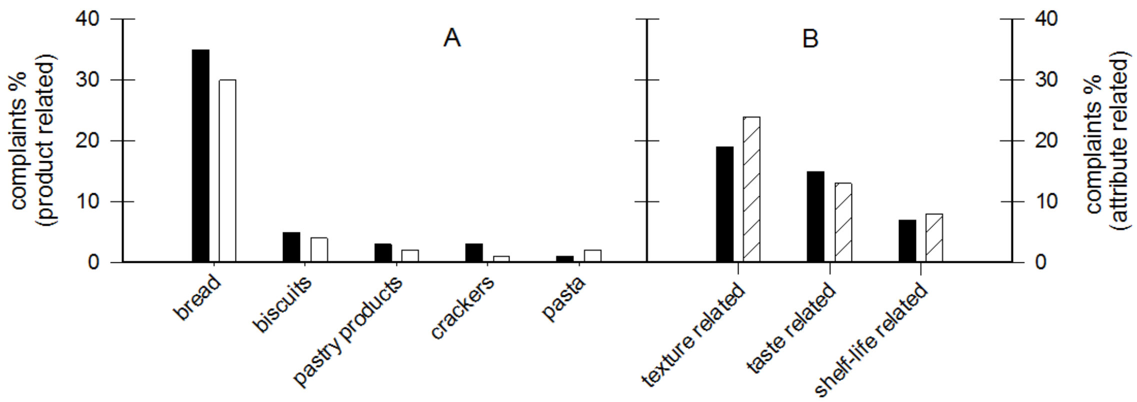

Figure 2. Quality issues with GF products. A: main products with quality issues, black bars 2015; white bars 2019. B: main quality issues related to baked products, black bars 2015, hatched bars, 2019. (2015: n=90, 2019: n=391)

3.3. Participants' Concerns Regarding Product Range and Cost of Gluten-free Produce

Participants were also asked to respond to a range of statements that addressed issues related to product range and cost of GF food product. With regards to the range of available GF products, approximately a quarter of respondents were not content with the range of products on offer with very little improvement in responses from 2015 to 2019 (Table 3). More specifically, in 2015, only 14% of respondents agreed that the supermarket shelves were 'well stocked' in the free-from sections; however, this sentiment nearly doubled in 2019 (p<0.05). In order to fulfil people's GF requirements, in both 2015 and 2019, nearly two-thirds of people indicated that they had to visit multiple stores in order to obtain all GF produce they were after (p>0.05). People started to enjoy their GF products more over the 3-year period of this study (Table 3), however more than half of people indicated that the quality of GF products was not as good compared to their gluten-containing equivalents (p>0.05). Despite the notion that these sentiments had not changed over the three-year period, there was a notable increase in the contentment with the quality of GF produce available in the supermarkets (p<0.05). Extrapolating from older data, it appears that the contentment with the quality of GF produce has been steadily increasing over the last 15 years [19,20,21]. Furthermore, the vast majority of people (79% in 2015 and 75% in 2019) dismissed the notion that GF products were 'good value for money' (p>0.05). This sentiment was also echoed in the comments people left in both years' surveys: "gluten-free bread often contains enormous holes … for £3 per loaf that's an expensive mistake" (Coeliac patient, 2015), "the prices of the products, I feel, is extortionate, and far too expensive" (diagnosed with gluten intolerance, 2015), "The prices are shocking! Nearly 3x more expensive than "normal" foods" (diagnosed with gluten intolerance, 2019), "Gluten free products are far more expensive than their gluten containing counterparts" (Coeliac patient, 2015), "Expensive, expensive, expensive …" (Irritable Bowel Syndrome sufferer, 2019), "The range and quality has improved immensely over the past years but is still expensive" (Coeliac patient, 2019), "Very poor value for money--far too expensive" (Coeliac patient, 2019), "Gluten-free food is far more expensive than non-gluten-free equivalents" (Carer of coeliac patient, 2019), "gluten free products are too expensive" (Coeliac patient, 2019), "I have no choice but accept what is available even though it's more expensive and seems second rate" (Coeliac patient, 2019), and "Much better availability now, but so expensive. It's a rip off" (Coeliac patient, 2019). These cost-related sentiments were also expressed by consumers elsewhere [9], were two-thirds of GF consumers indicated dissatisfaction with the price they had to pay for GF produce.

Table 3. Participant responses to range, quality and cost statements in 2015 and 2019. Participants were asked to score the various statements on a 5-point Likert scale ranging from 'strongly agree' to 'strongly disagree' with 'neither agree nor disagree' as the neutral point. For convenience sake, all positive and all negative responses are reported as 'agree' and 'disagree' respectively. (2015: n=120, 2019: n=493).

Statements	Disagree %		Neither %		Agree %		Score	
	2015	2019	2015	2019	2015	2019	2015	2019
I am happy with the range of GF products available in supermarkets.	28	25	35	36	37	39	3.09 (1.04)	3.18 (1.02)
I am happy with the quality of GF products available in supermarkets.	34	22	33	38	33	39	2.95 (1.01)	3.19 (0.98)
GF products are as good as their gluten containing alternatives.	54	51	28	29	18	18	2.43 (1.14)	2.50 (1.08)
I enjoy the GF products that I purchase.	24	14	38	38	38	48	3.27 (1.00)	3.42 (1.07)
I trust the labelling of GF products.	14	14	28	21	58	65	3.60 (1.00)	3.75 (1.07)
I prefer to make my own GF products where possible.	21	30	18	22	61	49	3.70 (1.28)	3.32 (1.41)
I get good value for money on GF products I purchase.	79	75	14	17	7	8	1.73 (1.02)	1.90 (1.04)
I often have to visit several stores to get the GF products that I need.	18	19	14	15	68	66	3.93 (1.26)	3.78 (1.25)
The shelves in 'free-from' sections of supermarkets are well stocked.	47	33	39	40	14	27	2.53 (0.99)	2.89 (0.99)

The trust in the labelling of GF produce has remained high (Table 3) with no significant differences in that perception of the three years monitored in this study (p>0.05). This high level of trust in the labelling of GF produce has been reported before [9,21]. It is very likely that this high level of trust is due to the government regulations regarding the labelling of GF foods beyond basic allergen labelling [18]. While it has been argued that the front of label messages on GF produce might lead to a decline in product literacy [22]. However, that comment was made in a comparison to a potential decline in product literacy seen in products labelled as 'organic'. This is an unlikely to be a valid comparison, since people avoiding gluten from their diet do this almost without fail from a direct health perspective, while consumers of organic foods tend to do this driving by more holistic and sustainability point of views [23,24].

Our data shows that GF consumers purchased flour and raising agents less frequently in 2019 compared to 2015 (Table 2), and did less home-based baking of GF foods over the three-year period (p<0.05) (Table 3). This decrease in home baking seem to align with an increase in the satisfaction in the quality of GF products available in the supermarket together with a perception that the supermarket shelves are better stocked with free-from product.

3.4. Retail Observations

Eleven individual supermarkets, across seven chains, including all of the large national supermarket chains plus two budget chains were included in this study. To maintain anonymity with regards to the grocery businesses the stores are identified by letters, with duplicate stores from the same business by a secondary number. In 2015 all of the large national supermarkets carried between 117 and 343 GF line items, while none of the budget stores carried dedicated GF line items (Table 4). The lack of GF items in 2015 in the budget supermarket chains agrees with the observations by Burden and co-workers [10] who, in 2014, found that none of the UK budget supermarkets carried GF items. By 2019, the GF provision on offer by most supermarkets had markedly improved, especially the budget supermarkets who were found to consistently offer a limited range of dedicated GF line items (Table 4). Most supermarkets had improved their GF offerings; however, some shops had decreased their GF range. For two of the supermarket chains the changes in the range of GF line items brought about a greater consistency in GF line items on offer within the same supermarket chain, bringing the GF line items from 117 and 343 in 2015 to 249 and 244 in 2019 for chain 'B', and from 157 and 339 in 2015 to 215 and 214 in 2019 for chain 'D'.

Table 4. Number of Gluten Free line items on the supermarket shelfs and the availability of GF items in our GF basket. The number of GF line items were as observed over four consecutive visits in the respective years, and the percentage of available of GF products that we allocated to our GF basket (see Table 5)

Supermarket		GF line items			GF basket Items available		
		2015	2019	% change	2015	2019	% change
Regular superstore	A1	240	355	+47.9%	95%	100%	+5%
	A2	220	274	+24.5%	95%	100%	+5%
	B1	117	249	+112.8%	90%	85%	-5%
	B2	343	244	-28.9%	85%	80%	-5%
	C	225	246	+9.3%	95%	100%	+5%
	D1	157	215	+36.9%	85%	95%	+10%
	D2	339	214	-36.9%	95%	95%	0%
	F	215	186	-13.5%	90%	85%	-5%
Budget	X1	0	27		0%	15%	+15%
	X2	0	27		0%	10%	+10%
	Y	0	21		0%	20%	+20%

Based on both the input from the survey participants in 2015 and taking into account products highlighted as being limited in availability [9,15] we created a GF shopping basket containing 21 items (Table 5 and Table 6, left column). None of the supermarkets had the full range of GF items in the shopping basket available in 2015, usually missing one or two product lines (Table 4). However, by 2019 at least three regular supermarkets were offering the full range of GF product lines (Table 5). In 2019, the budget supermarkets carried a very limited range of GF product lines (Table 6).

Table 5. Price ratios and availability of basket items for each regular superstore in 2015 and 2019

Basket items	Regular supermarkets															
	A1		A2		B1		B2		C		D1		D2		F	
	2015	2019	2015	2019	2015	2019	2015	2019	2015	2019	2015	2019	2015	2019	2015	2019
Own brand white bread	5.45	4.00	5.45	4.00	--	4.43	--	4.43	8.89	5.57	3.88	3.86	3.23	3.86	3.66	3.85
Branded white bread	2.31	5.86	2.31	4.14	2.61	5.86	2.68	5.86	2.68	4.14	3.47	5.93	2.74	5.93	2.71	4.71
Own brand brown bread	3.97	4.00	3.97	4.00	--	--	--	--	8.89	5.57	3.88	4.71	3.23	4.71	3.57	3.13
Branded brown bread	2.25	3.92	2.25	3.92	2.61	2.42	2.61	2.42	3.00	3.71	4.34	3.36	3.61	3.36	2.71	3.43
White rolls	2.86	4.22	2.86	4.22	7.32	8.25	7.32	--	4.29	3.83	7.25	3.54	7.25	3.46	2.12	3.85
Brown rolls	1.88	5.56	1.88	4.44	7.11	5.63	7.11	--	2.22	3.67	6.69	3.85	6.69	3.85	2.19	3.85
Pancakes	--	4.00	--	4.00	2.73	3.00	2.73	3.00	--	4.13	3.81	3.67	3.81	3.67	4.00	3.30
Crumpets	3.36	6.57	2.83	6.57	3.76	4.75	3.76	7.45	7.50	8.50	3.37	8.33	3.37	8.33	3.64	3.00
Penne	2.29	2.22	2.29	2.22	2.26	5.83	2.26	5.83	1.76	2.27	2.03	2.30	2.03	2.30	2.22	2.35
Spaghetti	2.29	2.22	2.29	2.22	2.23	2.50	2.23	2.50	1.76	2.27	--	2.30	2.03	2.30	2.22	2.35
Cheese crackers	2.91	5.77	2.91	7.62	2.27	8.00	2.27	8.00	10.10	7.53	2.96	8.85	2.96	8.85	4.35	7.83
Plain flour	3.21	5.00	3.21	5.00	3.27	3.40	3.27	3.40	3.28	4.25	3.19	4.25	3.19	4.25	3.19	3.40
Biscuits	3.25	3.03	3.25	3.61	3.00	--	3.00	1.50	3.40	2.02	3.00	0.94	3.00	0.94	3.37	--
Cereal	2.27	1.94	2.27	1.94	2.18	2.58	2.18	2.58	2.67	2.50	2.53	4.80	2.53	4.80	5.00	3.57
Granola	2.35	2.00	2.35	3.00	2.97	3.20	1.53	3.20	3.44	5.33	--	6.00	2.41	6.00	3.75	3.39
Porridge oats	4.10	4.89	4.10	4.44	2.50	5.00	4.27	5.00	3.97	2.93	3.42	4.00	3.42	4.00	3.20	3.21
Vegetable stock cubes	1.08	4.63	1.08	4.48	0.92	--	1.11	--	0.86	3.04	1.03	--	1.03	--	0.88	--
Gravy granules	4.37	2.03	4.37	20.3	1.71	2.59	--	2.59	3.89	11.10	8.33	3.03	--	3.03	--	--
Snack/Breakfast bars	3.29	1.71	1.71	1.71	1.08	1.69	1.08	1.69	1.29	0.95	1.68	1.31	1.35	1.31	1.33	0.98
Pork sausages	1.89	1.38	1.89	1.38	1.49	1.22	1.71	1.22	2.27	2.74	2.27	1.19	2.27	1.19	2.43	1.89
Pizza	1.74	4.55	1.74	4.55	3.37	3.16	3.37	3.16	2.57	3.33	--	1.65	1.87	1.65	--	1.60
Basket items available	*95%*	*100%*	*95%*	*100%*	*90%*	*85%*	*85%*	*80%*	*95%*	*100%*	*85%*	*95%*	*95%*	*95%*	*90%*	*85%*

Table 6. Price ratios and availability of basket items for each budget supermarket in 2015 and 2019

Basket items	Budget supermarkets					
	Y1		Y2		X	
	2015	2019	2015	2019	2015	2019
Own brand white bread	--	--	--	--	--	--
Branded white bread	--	--	--	--	--	3.77
Own brand brown bread	--	--	--	--	--	--
Branded brown bread	--	--	--	--	--	4.08
White rolls	--	--	--	--	--	--
Brown rolls	--	--	--	--	--	--
Pancakes	--	--	--	--	--	--
Crumpets	--	--	--	--	--	--
Penne	--	--	--	--	--	--
Spaghetti	--	8.13	--	8.13	--	--
Cheese crackers	--	--	--	--	--	--
Plain flour	--	--	--	--	--	--
Biscuits	--	--	--	--	--	--
Cereal	--	--	--	--	--	--
Granola	--	--	--	--	--	--
Porridge oats	--	--	--	--	--	--
Vegetable stock cubes	--	3.73	--	--	--	4.97
Gravy granules	--	--	--	--	--	--
Snack/Breakfast bars	--	1.66	--	1.66	--	3.75
Pork sausages	--	--	--	--	--	--
Pizza	--	--	--	--	--	--
Basket items available	*0%*	*15%*	*0%*	*10%*	*0%*	*20%*

3.5. Cost of Gluten Free Products in Shopping Basket

As mentioned before, overall there has been an improvement in the total number of GF line items held by supermarkets. However, one of the largest bones of contention has been the cost of GF produce compared to 'normal' foods. We found that in almost all instances the cost of GF products was between 2 and 4 times more expensive compared to the equivalent non-GF items (Table 5 and Table 6, and Figure 3). Table 5 and Table 6 show the price ratios (PR) for each stocked GF line item in both 2015 and 2019 for the general supermarkets and budget supermarkets respectively. The smallest PR was actually a negative factor where GF 'vegetable stock cubes' were cheaper than their non-GF counterparts on three occasions (Table 5). Whereas the largest PRs were associated with cheese crackers, gravy granules, and crumpets. The overall impact of PRs over the 4-year period showed that in 15 out of 21 product lines the PR went up and only on 6 product lines did the PR decrease. These changes in PRs were predominantly due to the greater increase in retail prices of the GF items rather than a decrease in the cost of non-GF products. The upward shift in the cost of GF products in the shopping basket is further highlighted taking into account the entire range of PRs per year (Figure 3B). The full range of PRs in 2015 moved from

1.0-5.2 to 1.5-6.7 in 2019, with the interquartile range (central 50% of PR range) moving from 2.5-3.9 in 2015 to 3.1-4.4 in 2019. Furthermore, the increase in PRs did vary from supermarket to supermarket, with increases in average PRs ranging from 3% by one supermarket to 38% by another (Table 7).

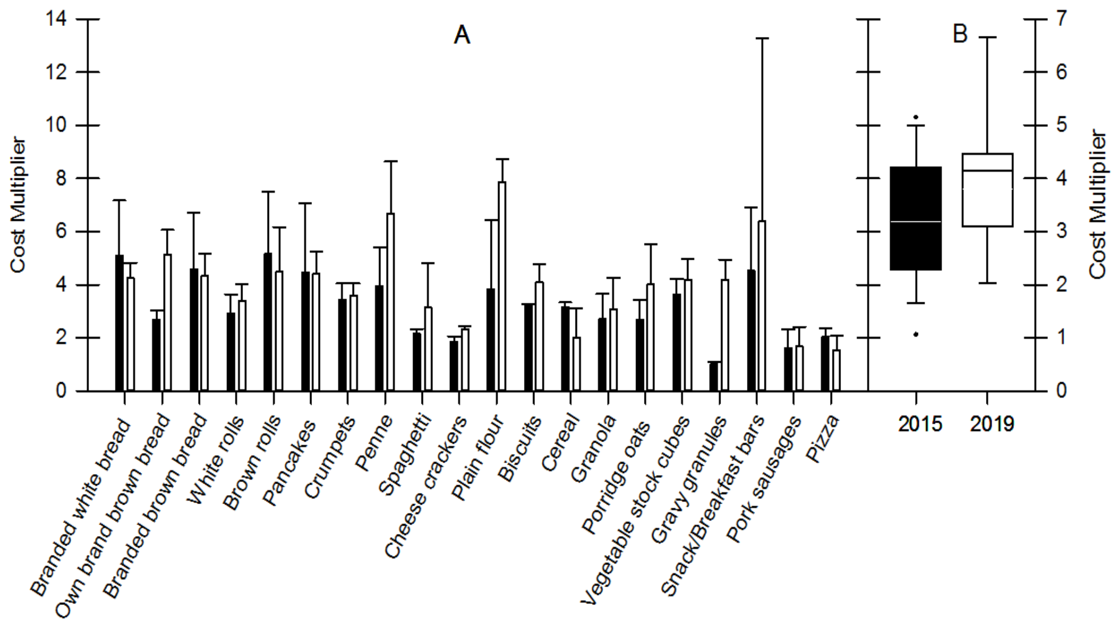

Figure 3. Price ratios (PRs) of GF items in the shopping basket across all supermarkets included in this study. 'A', average PRs in relation to each available GF items in the shopping basket across all supermarkets included in this study. Error bars represent the standard deviation of the PR per line item. 'B', the spread of PRs of each available GF items in the shopping basket across all supermarkets included in this study. The box represents the interquartile range (central 50%) of the data, while the whiskers (viz. error bars) represent either the upper or lower 25 % of the average PRs. Black bars, 2015; white bars, 2019

Table 7. Price ratios comparison from 2015 to 2019 by supermarket

Supermarket	Average PR 2015	Average PR 2019	Percentage change from 2015 to 2019
A1	2.86	3.77	+ 32%
A2	2.75	3.59	+ 31%
B1	3.03	3.55	+ 17%
B2	2.92	4.02	+ 38%
C	3.94	4.13	+ 5%
D1	3.73	3.83	+ 3%
D2	3.10	3.78	+ 22%
F	2.98	3.20	+ 7%

It is difficult to gauge the extend of availability of GF produce from previous studies, mainly because exact numbers have rarely been reported, or reported only per very board product categories and/or store categories [2,9,10,11,15]. However, the notion of a GF food basket has been coined before [10,11,12,25]. We used our GF shopping basket to investigate the availability of GF produce and the price differentiation between GF and non-GF produce (Table 5, Table 6, Table 7 and Figure 3). The notion of looking at PRs between GF and non-GF has been undertaken before [2,7,8,10,12,13,25,26,27,28,29]. However, while the same sort of data was collected (price of GF food vs price of an equivalent gluten-containing food), different food ranges and products were included in the various research carried out. In order to compare the historically published PR data, we focussed on a small number of GF food products only that we deemed to be common among most, but not all, studies (Table 8 and Figure 4). Bread was the only GF product common to all studies. Across all previous studies (including the two sets of data from this study) the reported PR of GF bread varied from 1.21 to 6.28, however over time (2006-2019) the reported values significantly varied without a clear trend. The Pearson's correlation coefficient (R) for bread of that period was 0.327 representing a weak positive trend (Table 8), meaning that the progressively reported PRs varied considerably, but that the relative price for gluten free bread went up slightly over time when considering all of the available global data. The largest single country for the reported research data was the UK (Figure 4 and Table 8). When taking into the UK data only for bread, the correlation coefficient was —0.364 representing a weak negative trend (Table 8), meaning that relative price for gluten free bread in the UK went down slightly over time. Other than bread, flour, sweet biscuits, pasta, pizzas, and breakfast cereals also had very low correlation efficiencies when looking at the global set of data (Table 8). This tend was similar for the UK set of data, except for sweet biscuits, which had a R value of —0.786, indicating that GF sweet biscuit have progressively become cheaper since 2006 moving from six-times the cost of gluten-containing sweet biscuits in 2006 to approximately twice the price of gluten-containing sweet biscuits in 2019. However, while the same sort of data was collected (price of GF food vs price of an equivalent gluten-containing food), different food ranges and products were included in the various research carried out. Especially when considering the available global data, not all GF produce are available to the same extend in all countries. Hence, discrepancies with regards to GF availability and variation and costs between countries is to be expected.

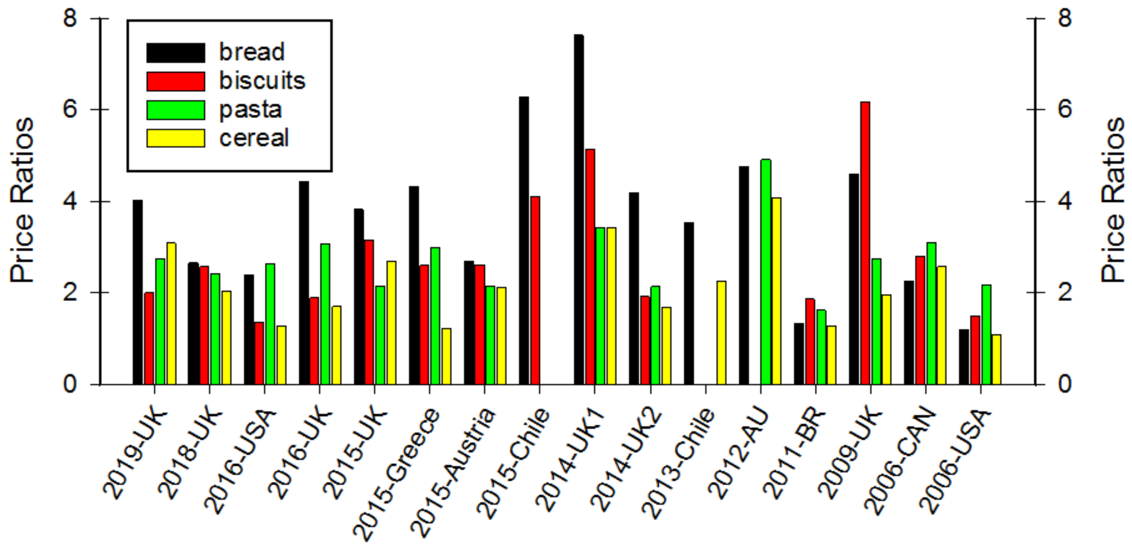

Figure 4. Variation in price ratios of gluten-free foods compared to gluten containing foods (bread, sweet biscuits, pasta and breakfast cereals). *Data shown are a cumulation of data from various publications and this work. Data sets presented are from: 2019-UK = this work; 2018-UK = [2], 2016-USA = [29]; 2016-UK = [13]; 2015-UK = this work; 2015-Greece = [26]; 2015-Austria = [30]; 2015-Chile = [11]; 2014-UK1 = [31]; 2014-UK2 = [10]; 2013-Chile = [32]; 2012-AU = [12]; 2011-BR = [9]; 2009-UK = [8]; 2006-CAN = [27]; 2006-USA = [7]. The dates given in the data labels on the graph are the reported years in which the data was collected, which might not be the same as the year of publication*

Table 8. Pearson's correlation coefficients (R) of Price Ratios for common GF produce as derived from the literature

	Bread	Flour	Sweet biscuits	Pasta	Pizza	Breakfast cereals
UK (n=7)	—0.364	0.015	—0.786	—0.080	0.258	0.239
Global (n=16)	0.327	—0.417	—0.158	—0.030	0..288	0.126

4. Conclusions

People who purchase GF foods, predominantly purchase GF bread, pasta and other GF cereal-based products, while GF ice-cream and GF beers are not commonly purchased. The most common concern regarding availability is in regards to GF bread with ⅔ of people raising this issue in both 2015 and 2019. GF bread also featured prominently as the main GF product with regards to complaints, however, over the period of this study there was a decrease in the number of complaints between 2015 and 2019. The most commonly specific quality related complaints were about the texture, taste, and poor shelf life with many strongly expressing their dissatisfaction. However, very strong dissatisfaction was also expressed with regards to the costs of GF produce, especially in light of the poor quality, GF products were not seen as 'good value for money'. These sentiments did not change much from 2015 to 2019. One clear set of trends was that people purchased less specialty flour and raising agent when comparing 2019 to 2015, and they did less home-baking over the same period. Furthermore, the decrease in home-baking coincided with a relative increase in satisfaction in the quality of GF products.

With regards to observations made across 11 supermarkets, we observed an overall increase in the number of GF line items, with the budget supermarkets offering a very small selection of produce labelled as GF in n2019 while no GF items were available in the budget supermarkets in 2015. The created a GF basket based on GF items identified by consumers and previous examples. In 2015 none of the supermarkets stocked all of the GF basket items, however 3 out of 8 major supermarkets stocked all GF basket products. While the budget supermarkets stocked some GF basket items, these constituted only between 10-20% of the GF basket items. Our research shows that the relative cost of GF item increase from 2015 to 2019, with the average price ratio of GF food to non-GF foods rising from 3.2 to 4.1 across all UK supermarkets. When comparing our data with previously published GF price ratio data, we found that in the UK the greatest change over time (2009-2019) was a strong decrease in the cost of sweet biscuits and a moderately weak decrease in the price ratio of GF bread. The global trends in GF price ratios is somewhat different from the UK situation many greater variations over time (2006-2019), which might be due to inherent discrepancies in availability, variation and cost of production and distribution of GF products in different countries.

Ultimately, GF produce cost significantly more compared to similar, gluten-containing foods, while many of the GF products, especially GF breads, still underperform when it comes to the perceived quality of products

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