

1 An Investigation of the Consumer Perception of the Quality of the Gluten and
2 Wheat Free Breads available on the UK market

3 Ruth Potter¹, Valentina Stojceska^{1,2*} & Andrew Plunkett¹

4

5 ¹The Manchester Metropolitan University, Department of Food and Tourism
6 Management, Hollings Faculty, Old Hall Lane, Manchester, M14 6HR, UK

7 ² Brunel University, School of Engineering and Design, Uxbridge, Middlesex, UB8
8 3PH, UK

9 *: Corresponding Author. Tel +44(0)1895 267328; Fax +44(0)1895269803

10 E-mail address: Valentina.Stojceska@brunel.ac.uk (V.Stojceska)

11 **1. Abstract**

12 There is a growing demand for bread and other baked products that are gluten and
13 wheat free due to the increased diagnosis and self-diagnosis of adverse reactions to
14 wheat and gluten and an increase in the number of people who perceive a gluten or
15 wheat free diet as a healthy lifestyle option. The removal of wheat from bread
16 presents a number of technological challenges resulting in quality issues and
17 nutrition. The increased consumer demand and growing industry response to these
18 demands has meant that consumers will no longer accept compromise on taste or
19 quality when purchasing gluten and wheat free bread. There is little information
20 available that demonstrates customers' expectations in terms of quality of gluten and
21 wheat free breads. The aim of this research was to establish whether gluten and
22 wheat free breads currently on the market are meeting consumer expectations and if
23 not the key areas for product improvement and new product development. The
24 research indicates that there are still significant improvements needed to produce
25 gluten and wheat free bread that meets consumer expectations.

26 Key words: Adverse reactions to wheat – wheat and gluten free bread – market
27 research - bread quality

29 **2. Introduction**

30 For several thousands of years bread has been one of the major constituents of the
31 human diet and baking leavened bread is one of the oldest biotechnical processes
32 (Hathorn, Biswas, Gichuhi, & Bovell-Benjamin, 2008). Whilst a variety of grains
33 have been used wheat is one of the most important cereals in bread making. This is
34 in part due to its unique ability to form a visco-elastic dough that exhibits the
35 properties necessary for the production of leavened bread (Battais et al. 2008). As a
36 result the term “bread” is usually used to refer to yeast leavened wheat products.

37 Bread was used by 96.7% of adults in the UK in 2011 and has been described as the
38 “quintessential staple food” (Mintel 2012). The bread and baked goods market in the
39 UK was estimated to be worth £3.5 billion in 2011. Pre-packaged white bread
40 dominates the UK market, with pre-packaged sales making up 65% of sales and
41 white bread making up 54% of such sales (Mintel, 2012).

42 There is an increasing demand for bread products which are wheat free. This has
43 arisen because of the growing awareness and diagnosis of conditions caused by
44 adverse reactions to wheat including wheat allergy, coeliac disease and gluten
45 sensitivity.

46 Another factor which has influenced demand for wheat free bread products is the
47 perceived but scientifically unproven benefit amongst some consumers of avoiding
48 wheat as a healthy lifestyle choice. In research into the “free from” market, it was
49 reported that some 14% of consumers choose “free from” products because they
50 believed them to be healthier compared with 6% of consumers purchasing because
51 of allergy or intolerance (Mintel, 2011).

52 There is also an impetus for reformulation of gluten free products based on wheat
53 starch. It was believed that the gluten component of wheat could be completely
54 removed from wheat starch and as a result in Europe many products have been
55 developed based on wheat starch and marketed as “gluten free” and suitable for
56 coeliacs. However, it is now thought that this is not possible and concern has been
57 raised as to the long-term effects of coeliac patients consuming small amounts of
58 gluten from products based on wheat starch (Chartrand, Russo, Duhaime, &

59 Seidman, 1997). As a result many coeliacs may prefer to exclude wheat completely
60 and manufacturers are looking to develop products which are free of any wheat.

61 In the UK certain staple foods, including bread, are available on prescription, funded
62 by the NHS, for those diagnosed with coeliac disease. Traditionally the manufacture
63 and supply of gluten free goods has been undertaken by specialist manufacturers. In
64 the last few years, the increase in self-diagnosis of allergies and in diets based on the
65 avoidance of wheat have opened up opportunities in the retail market for staple
66 food, such as bread. Since 2010 retail sales of gluten and wheat free breads have
67 increased substantially with the entry into the market of specialist free from
68 manufacturers, traditional bakers and supermarkets under own labels. According to
69 Euromonitor data, it is estimated that the retail gluten and wheat free bread market
70 in 2011 was worth £67.6million (Marian, 2011). The availability of retail products
71 is impacting on the market for gluten and wheat free breads both in terms of giving
72 consumers a choice of where they obtain products and increasing customers'
73 expectations in terms of quality.

74 The removal of wheat from bread gives rise to a number of technological challenges
75 resulting in quality issues. Absence of gluten has high influence on dough rheology,
76 the production process and the final product. Gluten free doughs are much less
77 cohesive and elastic than wheat dough. They are difficult to handle, being sticky
78 and less elastic, and are more like a cake batter than a wheat flour dough (Cauvain
79 & Young, 1998). Because of this the doughs cannot be kneaded and are generally
80 mixed using mixing machines (Moore, Schober, Dockery, & Arendt, 2004). The
81 final products show some defects in quality when compared with wheat flour
82 breads.

83

84 A review by Arendt et al. (2002) found that most wheat and gluten free breads were
85 of low quality, exhibiting poor mouth feel and very often showing off flavours. The
86 structure of products is mainly crumbly and very dry (Arendt, O'Brien, Schober,
87 Gallagher, & Gormley, 2002) and the volume less due to the low carbon dioxide
88 (CO₂) holding activity during rising (Houben, Höchstötter, & Becker, 2012). Gluten
89 and wheat free breads often exhibit firmer crumb and softer crusts as the water
90 molecules are not as tightly bound due to the missing interaction with gluten and as

91 a result water diffuses much faster to the crust. The removal of wheat also has other
92 implications in terms of appearance and shelf life as well as having an effect on the
93 nutritional quality of the product (Houben et al., 2012; Mariotti, Lucisano,
94 Ambrogina Pagani, & Ng, 2009). Currently as well as taste, texture and freshness,
95 gluten and wheat free breads come at a significant price premium to regular bread.
96 This price differential is attributed, by manufacturers, to the processes and raw
97 materials being more expensive.

98

99 Heller (2009) reported that the increased consumer demand and a growing industry
100 response to meet these demands has meant that people will no longer accept to
101 compromise on taste or quality when purchasing wheat and gluten free breads.
102 However, there is little information available that demonstrates consumer's
103 requirements in terms of gluten and wheat free breads and whether these
104 requirements are met by today's products. Therefore, the aim of this study was,
105 through market research, to identify the consumer's perception of the quality of
106 fresh white gluten and wheat free breads currently on the market. The findings of
107 the market research could then be utilised to inform new product development and
108 product improvement process.

109 **3. Methodology**

110 A data gathering exercise was conducted to identify what characteristics are
111 considered important in the development of gluten and wheat free breads and what
112 problems consumers encounter with gluten and wheat free breads currently on the
113 market.

114 *3.1. Data Available in the Market*

115 Ingredients listings and nutritional profiles were collated for gluten and wheat
116 free fresh white bread currently available in the market place.

117 *3.2. Coeliac UK Volunteers' Conference Discussion Group and Questionnaire*

118 A discussion group was held at the Coeliac UK Volunteers Conference on 8th October
119 2011 in London. The discussion focused on considerations in choosing gluten free
120 products. In addition to participating in the discussion attendees were asked to complete
121 a questionnaire (Figure 1) which considered buying habits in relation to gluten and

122 wheat free products and quality issues relating to gluten and wheat free breads. The
123 questionnaire was completed by 60 respondents.

124

125 *3.3. Sensory Evaluation and Questionnaire*

126 A sensory panel was held at the sensory facilities in Hollings Faculty, Manchester
127 Metropolitan University. The number of participants who took part in this study was
128 32, which is in agreement with the recommended minimum of 25-50 subjects (Stone
129 and Sidel, 2004). All the participants were coeliacs recruited via the Manchester
130 Coeliac Society. Prior to participating the participants were provided with details of the
131 research project, the requirements of the test and full ingredients listings. Participants
132 were required to consent to participation. The participants were asked to complete a
133 short questionnaire covering participant profile, gluten free bread and gluten free mix
134 (home baking) usage and to sample five fresh white bread loaves (two of which were
135 gluten free and the remainder of which were gluten and wheat free) and evaluate a
136 number of attributes. The breads chosen for evaluation were the two major prescription
137 brands (Juvela and Glutafin) and the leading retail brands (Genius and Warburtons) plus
138 a major supermarket own brand product (Sainsburys). Samples of the breads for
139 presentation to the taste panel were prepared immediately prior to the test. The samples
140 were standardised. All five samples were presented at the same time. The samples were
141 marked with random three digit numbers and assessed in random order. The panellists
142 were asked to rate the products by reference to attributes on an unstructured line scale.
143 The attributes had anchors at each end of the scale. The attributes and anchors were as
144 follows:

145 *Appearance: dislike extremely/like extremely*

146 *Texture: dislike extremely/like extremely*

147 *Moistness: dry/moist*

148 *Taste: dislike extremely/like extremely*

149 *Aftertaste: dislike extremely/like extremely*

150 *Overall liking: dislike extremely/like extremely*

151 The sensory evaluation and preliminary questionnaire were administered and the
152 resulting data collected and analysed using Fizz software (Biosystemes, Couternon,
153 France).

154 Statistical analysis was conducted to establish whether there was a significant difference
155 between the samples of bread. The tests commenced by assuming a “no difference”
156 condition – the null hypothesis – and the proposition of an alternative hypothesis (that is
157 a difference between samples) which would be accepted if the null hypothesis was
158 rejected. An analysis was carried out to test the evidence obtained from the samples,
159 against the null hypothesis and a statistic was calculated in the form of a probability
160 value. Where the probability of the result was significantly low then the null hypothesis
161 was rejected, the alternative hypothesis accepted and a significant result was concluded.
162 The significance level refers to the probability level at which the test was operated. The
163 conventional and most conservative significance level of 5% (0.05) was chosen. This
164 means that there is confidence that similar samples drawn from the population will
165 show such significance 95% of the time. There is therefore still a possibility, albeit
166 small that the results were purely down to chance alone. There are risks associated with
167 significance testing one is the risk of wrongly concluding a significant result which is in
168 fact absent (type I error) and the other the risk of not concluding a significant result
169 which is actually present (a type II error). These risks depend on the magnitude of the
170 differences between the samples. The larger the differences are the easier to detect and
171 therefore lessen the risk. Both risks can be reduced by increasing the sample size. The
172 sample size in this case was 32. As the data was derived from scoring on a scale and
173 therefore ratio in nature with normal distribution the data was considered to be
174 parametric data. As there was more than two samples an analysis of variance test
175 (ANOVA) was selected to analyse the data. The ANOVA test consists of a variance
176 ration test (F test) to determine whether all groups are the same. Where a significant F
177 test suggests differences between samples further analysis in the form of a post hoc test
178 was conducted to determine where the differences were between samples. The post hoc
179 test utilised by the Fizz software programme is Duncan’s post hoc test. As the data
180 collected was from human subjects there are a number of factors that could have
181 affected the reliability of the data these include psychological factors. Steps were taken
182 to minimise as far as possible issues of reliability in data. These included ensuring all
183 panellists received the same instructions, presenting samples in random order,
184 standardizing samples and ensuring all sampling was done in the same conditions in
185 terms of lighting and temperature.

186 *3.4. Focus Group*

187 Focus groups were held at Hollings Faculty. The participants were the same
188 participants as for the sensory analysis and were recruited as above. Three
189 separate focus groups were held with small group discussions involving 9, 11

190 and 12 participants respectively. The discussion focused on the positive and
191 negative aspects of fresh white gluten and wheat free loaves currently on the
192 market and a consumer “wish list” for such a product. To ensure as far as
193 possible that the focus groups were conducted in a consistent manner and the
194 results from each group would be comparable the focus groups were conducted
195 as follows. All the discussions were led by the same person and the same
196 questions were asked to each group. Participants were asked to record answers
197 on post it notes which were collated and responses shared and discussed with the
198 group. The outcomes of the discussions were recorded on flip charts during the
199 session. The note taker was the same person for all groups.

200 **4. Results and Discussion**

201 *4.1. Data Available in the Marketplace*

202 Tables 1 and 2 contain details of the composition of and nutritional profiles of
203 the two major prescription brands (Juvela and Glutafin), the two leading retail
204 brands (Genius and Warburtons) and two supermarket (Tesco and Sainsburys)
205 gluten and wheat free products that are currently available on the market.

206 A review of the ingredients currently on the market indicated that the following
207 were the most commonly used ingredients: wheat starch (gluten free products
208 only), tapioca, potato and maize starches, rice flour, psyllium husk, protein (in
209 the form of egg white, milk powder or soya) along with stabilisers (xanthan
210 gum, guar gum and hydroxypropylmethylcellulose (HPMC)).

211 A review of the nutritional information indicated that the wheat free products
212 had a considerably higher fat content than the gluten free products with levels of
213 between 8.2 and 11g per 100g compared with 2.6 and 2.7g in the gluten free
214 products. This may be explained by the fact that the removal of wheat starch
215 impacts on the taste, texture and shelf-life of bread. The addition of high levels
216 of fat may improve taste, texture and shelf life and assist in achieving a better
217 end product.

218 *4.2. Coeliac UK Volunteers' Conference Discussion Group and Questionnaire*
219 Respondents were asked to rank in order of importance factors that may
220 influence their decision to consume a product (Figure 2) Taste was ranked as the
221 most important factor by 88% of respondents, nutritional values were ranked as
222 the second most important factor by 32% of respondents and third by 25% of
223 respondents and cost was ranked the second most important factor by 29% and
224 third most important factor by 25% of the respondents.

225 Respondents were asked to identify the most common problems they
226 encountered with gluten and wheat free breads. These are identified in Figure 3.
227 The problem receiving the largest number of mentions was bread breaking up
228 (27 mentions), followed by dryness (14 mentions) and poor shelf life (7
229 mentions). These issues were also common themes in the focus groups the
230 results of which are reported below and are therefore key issues to be addressed
231 in achieving improved quality of wheat free breads. These responses are
232 consistent with the findings of Arendt et al. (2002) and would imply that despite
233 there being a significant amount of research into and investment in improving
234 the quality of gluten and wheat free products, products have not improved
235 sufficiently to meet and satisfy consumer expectation.

236 In terms of improving the nutritional qualities of gluten and wheat free breads
237 the respondents were receptive to the idea of fortification of products with
238 vitamins and minerals. The following vitamins and minerals have been found to
239 be deficient in those following a gluten or wheat free diet: calcium, vitamin B,
240 vitamin D, folate, zinc and iron (Thompson, Dennis, Higgins, Lee, & Sharrett,
241 2005). Figure 4 indicates the percentage of respondents in favour of fortification
242 of products with specific vitamins and minerals. There was overwhelming
243 support for fortification with calcium and vitamin D (which are essential for
244 bone health) and iron. This may be attributable to the fact that coeliacs are
245 better educated as to the importance of these micronutrients because coeliac
246 disease increases the risk of osteoporosis and iron deficiency anaemia or may
247 simply be attributable to the fact there is generally higher awareness of the
248 importance of these micronutrients due to coverage in the press.

249 *4.3. Sensory Evaluation and Questionnaire*

250 Respondents were asked to indicate a preference for white and wholemeal bread.
251 Over half of the respondents (53%) indicated a preference for fibre bread, the
252 remaining 47% preferring white bread. In terms of wheat bread usage white
253 bread is the most highly consumed (white bread making up 54% of pre-
254 packaged bread sales). A number of factors may have influenced the result.
255 These include sample size, the fact that gluten and wheat free fibre products
256 have been of higher quality than their white counterparts or the fact that as
257 sufferers of coeliac disease they have a higher awareness of the importance of
258 fibre in the diet.

259 Respondents were asked where they obtained bread. 16% of the respondents
260 bought bread in the supermarket only whilst 34% obtained products on
261 prescription only. 50% of respondents used both retail and prescription channels.
262 Whilst all the respondents to the questionnaires were diagnosed with coeliac
263 disease and therefore entitled to bread on prescription 16% of participants
264 bought bread in the supermarket only and 50% bought bread both on
265 prescription and in the supermarket. The focus group indicated that there may be
266 several reasons for this including a “stigma” associated with obtaining products
267 on prescription, wider range of products available in the supermarket, perceived
268 improved quality of supermarket products and convenience. Overall in the
269 sensory evaluation, the prescription products scored most highly in the overall
270 liking. It is possible that the perceived improved quality of retail products is
271 attributable to the marketing claims of retail products which are not borne out in
272 reality. However, a caveat to this is that both the prescription products evaluated
273 were gluten free as opposed to wheat free.

274 Figure 5 shows the response to the questions “which brands of gluten and wheat
275 free bread do you use?” The high level of usage of Juvela may be attributable to
276 the fact that is an established prescription brand. Until recently there was very
277 little gluten free bread available through retail channels and therefore
278 prescription brands were dominant. However, the Genius and Warburtons
279 products successfully entered the retail market for gluten and wheat free breads
280 in 2010/2011 and have recently gained NHS listing to allow their products to be
281 available on prescription as well as through the retail route.

282 In the sensory test the participants were asked to assess six attributes
283 (appearance, texture, moistness, taste, aftertaste and overall liking) of five
284 leading gluten or wheat free fresh white breads. Being coeliac, the participants
285 in the sensory evaluation were consumers of gluten and wheat free breads as
286 opposed to wheat containing ones. It might be argued that as such, they may
287 have different perceptions of the products to be sampled than those consuming
288 wheat containing breads. There is very little research in this area. Recent
289 research by Laureati et al. (2012), however, found that there was no significant
290 difference in terms of the sensory and hedonic perception of coeliac and non-
291 coeliac subjects when evaluating gluten free breads.

292 The Juvela and Glutafin products are prescription brands which are gluten free
293 as opposed to wheat free. The formulation therefore includes wheat starch. The
294 Genius, Warburtons and Sainsburys own label products are wheat free. The
295 results are shown in Table 3.

296 Juvela, Glutafin and Warburtons scored similarly in terms of appearance. Whilst
297 Sainsbury scored lower the difference was not significant. The score for
298 appearance for the Genius was statistically lower than the other products
299 ($P < 0.05$). The Genius product looks more like a wholemeal/fibre product as
300 opposed to conventional white bread. This may be attributed to the rice bran in
301 the formulation. Not appearing as a conventional white bread may have affected
302 the perception of the bread in terms of appearance.

303 There was no significant difference between all samples (with the exception of
304 the Genius product) in terms of texture. The Genius product scored lowly for
305 texture. In the focus group a common complaint about the Genius product was
306 its dryness and rate of staling. Both the Juvela and Glutafin product contain
307 wheat starch. In wheat bread wheat starch plays a role in bread texture. The use
308 of wheat starch in a gluten free formulation will assist in achieving a similar
309 texture. Whilst non wheat starches have also been used in the Sainsbury and
310 Warburtons products they are not used in the same proportions. It is possible
311 that the starch combination used in the Genius product has impacted on the
312 texture of the finished product.

313 In terms of moistness the Genius product again scored particularly badly
314 compared to the over samples. It is interesting to note that the Genius product
315 has a higher fat content than the other products (13%). The other retail brands
316 Warburtons, Sainsbury and Genius are also high in fat (8.2-10.1%). The
317 prescription brands are low in fat at a level of 2.6/2.7%. Fat is often used in
318 bakery products to reduce firmness and give a moisture mouth feel. It is
319 therefore interesting to note that the product highest in fat was considered the
320 least moist.

321 In terms of taste there was no significant difference between the Juvela, Glutafin
322 and Warburtons products. The Genius and Sainsbury products were awarded
323 significantly lower scores than the Juvela, Glutafin and Warburtons products.
324 The inclusion of wheat starch in the Juvela and Glutafin products may account
325 for their better scores compared with the Genius and Sainsbury products. Wheat
326 starch is dominated by vanilla, spicy and metallic notes (from vanillin, a
327 furanone and fatty aldehydes) and is one of the factors which contribute to the
328 flavour of wheat bread. The Warburtons product contains a number of products
329 which are not found in the other products might contribute to taste including
330 fruit juice and natural flavouring.

331 In terms of overall liking the Juvela, Glutafin and Warburtons products scored
332 similarly with no significant difference between the three. The scores for the
333 Sainsbury and Genius products were significantly lower ($P < 0.05$). For the
334 consumer, key attributes of bread are flavour and texture (Heiniö, 2007). The
335 results for overall liking reflect this, with the products scoring more highly for
336 taste and texture also scoring better for overall liking.

337 *4.4. Focus Group*

338 The participants in the sensory panels also participated in focus groups that
339 considered the quality of wheat and gluten free breads currently on the market
340 and developed a “wish list” for such products.

341 A number of common themes emerged from the focus group. The wheat free
342 products were criticised for being too dry, for falling apart and staling quickly.
343 The flavour of the gluten free product (wheat starch based) was considered

344 better than the wheat free products. Slice size is an important characteristic for
345 consumers of wheat free and gluten free breads. The price of gluten and wheat
346 free bread is considered high compared with comparable wheat containing
347 products.

348 Participants were also asked to draw up a “wish list” for wheat free and gluten
349 free bread products. Common themes emerged which the principal ones being
350 improved texture i.e. less crumbly more moist bread; improved taste so that
351 gluten free and wheat free breads taste more like wheat bread; larger slices and
352 loaves; longer shelf life; lower cost and greater range of baked products. As
353 would be expected these reflect the problems encountered.

354 There were a large number of comments on the size of the slice of the loaf. The
355 slice size for the brand Genius was the preferred size. However it should be
356 noted that in this respect like is not being compared with like. Genius is a brand
357 available through both retail and prescription channels. In the retail outlets it is
358 available with a loaf weight of 536g, which gives a similar slice size as standard
359 wheat containing loaves. Prescription products are limited to a loaf weight of
360 400g and subsequently have a smaller slice size than those on the retail market.

361 Figure 6 contains a selection of comments made by the focus group participants
362 when asked what problems they commonly encountered with gluten and wheat
363 free breads.

364 *4.5. Overall*

365 Taste was identified as a key attribute in terms of purchase decision. In terms of
366 taste (with the exception of the Warburtons product) the wheat starch containing
367 products scored more highly in the sensory evaluation. In the focus group
368 aftertaste was identified as a problem in both wheat and gluten free products. A
369 number of factors contribute to taste of white breads. The wheat flour itself
370 contributes – it is dominated by vanilla, spicy and metallic notes (from vanillin,
371 a furanone, and fatty aldehydes). Yeast fermentation generates the yeasty
372 character. These flavours develop during proving. Baking contributes the toasty
373 products of the Maillard reaction. (McGee, 2007). The removal of wheat starch
374 will remove the characteristic wheat flavours. The fact that gluten and wheat

375 free breads only undergo one proving may also impact on the development of
376 fermentation flavours.

377 A common problem identified by consumers was the dryness of bread. Again
378 with the exception of the Warburtons product the gluten free brands were
379 viewed by the panellists as significantly ($P<0.05$) moister with a better texture
380 than the wheat free products. It might be expected that the products with a
381 higher fat content would be less dry given fats functional properties in terms of
382 crumb softness and improvement of mouth feel. However this was not the case.
383 Moistness was also associated with softness. In formulating wheat free bread it
384 was therefore important to consider ingredients which increase
385 moistness/softness.

386 Gluten and wheat free breads were also criticised for their crumbly nature.

387 Slice size was considered important by the participants of the focus groups. The
388 desire for a larger slice means that achieving the maximum volume possible for
389 a loaf of 400g is important in the development of a product for the prescription
390 market.

391 Products were also criticised for their short shelf life with products becoming
392 hard and dry over a few days.

393 Nutritional value also ranked highly in the list of factors affecting product
394 choice and there was a high level of support for fortification of bread products
395 with micro nutrients which are commonly deficient in the coeliac diet. Thus any
396 ingredients that can offer nutritional benefit in addition to assisting in the
397 achievement of physical and sensorial are important in the development of new
398 products.

399 The price of products was also an issue. In the retail market the price of a fresh
400 wheat and gluten free loaf is significantly higher than its wheat counterpart
401 retailing at a price of £2.90 for a 535g white loaf (Genius) and £2.38 for a 400g
402 white loaf (Warburtons) compared with a white wheat loaf which retail on
403 average for £1-1.25 for an 800g loaf. Many argue that the high price is attributed
404 to the captive market i.e. those suffering from wheat allergy and coeliac have no
405 alternative but to purchase these products. However a proportion of the higher

406 cost can be attributed to investment in the development of such products and
407 higher ingredients costs.

408 **5. Conclusions**

409 In conclusion, there has been little recent research on the perception of and quality
410 of gluten and wheat free fresh white bread products. This research is valuable in
411 understanding the consumer expectations and achievement (or lack of) of those
412 expectations in terms of product quality in the current market place. Overall the
413 market research in this study confirmed that gluten and wheat free products fresh
414 white bread products are still considered inferior to their wheat containing
415 counterparts and that consumers require the same qualities as those in wheat
416 containing white bread.

417 Despite the technological and market changes, the consumer perception of gluten
418 and wheat free breads have not changed significantly and the problems identified by
419 consumers with today's breads are the same as those identified by Arendt et al.
420 (2002). There are still significant improvements needed to produce bread which is
421 soft and moist, with a pleasant taste, appealing appearance, good volume (and as a
422 result bigger slice size) and improved shelf life. It is evident that further research
423 and development is needed to develop products of acceptable quality to consumers
424 and that such research and development needs to focus on ingredients that can create
425 a system that mimic wheat and the interaction between ingredients in those systems.

426 Nutrition of the products is also considered important with particular emphasis on
427 breads providing fibre and micronutrients which are often deficient in the coeliac
428 diets such as calcium, iron and B vitamins.

429

430

431

432

433 **6. Acknowledgments**

434 The authors would like to express their gratitude to Hero Food UK Limited for
435 supporting this project.

436 **7. References**

- 437 Arendt, E. K., O'Brien, C. M., Schober, T. J., Gallagher, E., & Gormley, T. R.
438 (2002). Development of gluten-free cereal products. *Farm and Food*, 12(2), 21-27.
- 439 Cauvain, S. P., & Young, L. S. (1998). *Technology of breadmaking* (1st ed.).
440 London: Blackie Academic Press.
- 441 Chartrand, L. J., Russo, P. A., Duhaime, A. G., & Seidman, E. G. (1997). Wheat
442 starch intolerance in patients with celiac disease. *Journal of the American Dietetic*
443 *Association*, 97(6), 612-619.
- 444 Hathorn, C. S., Biswas, M. A., Gichuhi, P. N., & Bovell-Benjamin, A. C. (2008).
445 Comparison of chemical, physical, micro-structural, and microbial properties of
446 breads supplemented with sweetpotato flour and high-gluten dough enhancers. *LWT*
447 *- Food Science and Technology*, 41(5), 803-815.
- 448 Heiniö, R. L. (2007). Sensory attributes of bakery products. In Y. H. Hui (Ed.),
449 *Bakery Products* (1st ed., pp. 285-298): Blackwell Publishing.
- 450 Heller, L. (2009). Commercial aspects of gluten free products. In E. Gallagher (Ed.),
451 *Gluten-Free Food Science and Technology* (pp. 99-106). Oxford: Wiley-Blackwell.
- 452 Houben, A., Höchstötter, A., & Becker, T. (2012). Possibilities to increase the
453 quality in gluten-free bread production: an overview. *European Food Research and*
454 *Technology*, 235(2), 195-208.
- 455 Lazaridou, A., & Biliaderias, C. G. (2009). Gluten Free Doughs: Rheological
456 Properties, Testing Procedures- Methods and Potential Problems. In E. Gallagher
457 (Ed.), *Gluten-Free Food Science and Technology* (pp. 52-82). Oxford: Wiley-
458 Blackwell.
- 459 Marian, P. (2011). Category Crunch: The rise and fall of gluten free foods in the
460 UK, just-food: just-food.com.
- 461 Mariotti, M., Lucisano, M., Ambrogina Pagani, M., & Ng, P. K. W. (2009). The role
462 of corn starch, amaranth flour, pea isolate, and Psyllium flour on the rheological
463 properties and the ultrastructure of gluten-free doughs. *Food Research*
464 *International*, 42(8), 963-975.
- 465 McGee, H. (2007). *On Food and Cooking: The Science and Lore of the Kitchen*
466 (2nd ed.). New York: Scribner.
- 467 Mintel. (2011). *Meat Free and Free From Food UK - September 2011*: Mintel.
- 468 Mintel. (2012). *Bread and Baked Goods - UK - January 2012* (Market Intelligence):
469 Mintel.

- 470 Moore, M. M., Schober, T. J., Dockery, P., & Arendt, E. K. (2004). Textural
471 comparisons of gluten-free and wheat-based doughs, batters and breads. *Cereal*
472 *Chemistry Journal*, 81(5), 567-575.
- 473 Thompson, T., Dennis, M., Higgins, L. A., Lee, A. R., & Sharrett, M. K. (2005).
474 Gluten-free diet survey: are Americans with coeliac disease consuming
475 recommended amounts of fibre, iron, calcium and grain foods? *Journal of Human*
476 *Nutrition and Dietetics*, 18(3), 163-169.
- 477 Stone, H. & Sidel, J.L. (2004). *Sensory Evaluation Practices*. Third Edition,
478 Academic, Elsevier, New Yourk.
- 479

480 Table 1 Ingredients listing for leading brands of fresh white gluten and wheat free breads currently on the market

Glutafin Fresh White	Genius Fresh White	Warbutons Fresh White	Sainsburys Fresh White	Tesco Fresh White
Water	Water	Water	Water	Water
Wheat Starch	Potato Starch	Tapioca Starch	Tapioca Starch	Tapioca Starch
Rice Flour	Cornflour	Potato Starch	Rice Flour	Rice Flour
Cellulose	Vegetable Oil	Vegetable Oil	Potato Starch	Potato starch
Fibre	Tapioca Starch	Wholegrain Maize Flour	Sunflower Oil	Sunflower Oil
Thickeners: Guar Gum, HPMC	Egg White	Egg White Powder	Humectant: Glycerine	Yeast
Soya Protein	Rice Bran	Yeast	Vegetable Shortening (Palm Oil, Rapeseed Oil, Palm	Psyllium Husk Powder
Vegetable Fat and Oil	Cellulose	Stabilisers: HPMC;Xanthan	Partially Inverted Refiners	Humectant: Glycerine
Quinoa Flour	Sugar	Cornflour	Yeast	Stabiliser:HPMC
Vegetable Fibre	Yeast	Concentrated Fruit Juice	Psyllium Husk Powder	Dried Egg White
Rice Starch	Stabiliser: Xanthan Gum	Rice Starch	Stabiliser: HPMC	Maize Flour
Millet Flour	Rice Flour	Psyllium	Dried Egg White	Salt
Yeast	Salt	Maize Grits	Maize Flour	Maize Starch
Sugar	Calcium Propionate	Sugar Beet Fibre	Salt	Preservative: Sorbic
Salt			Rice Starch	Rice Starch
Rice Syrup		Natural Flavouring	Maize Starch	
Honey		Preservative	Citric Acid	
Calcium Citrate		Calcium Propionate	Preservative: Sorbic Acid	
Folic Acid		Iron		

482 Table 2 Nutritional profiles for the leading brands of fresh white gluten and wheat free bread currently available in the market place

Per 100g	Juvela Fresh White	Glutafin Fresh White	Genius Fresh White	Warbutons Fresh White	Sainsburys Fresh White	Tesco Fresh White
kcal	203	228	296	276	281	280
kJ	861	960	1236	1160	1181	1165
g	3.4	3.5	8.4	3.1	3.4	3.4
g	41.6	43.5	41.1	44.9	44.4	43.1
g	4.8	2.1	3	0.2	8	4.1
g	2.6	2.7	13	8.2	10.1	10.1
g	1.1	0.8	0.9	0.6	2.3	1.4
g	4.1	7.6	9.7	5.2	4.5	5.9
g	0.41	1	0.63	0.4	0.36	0.4
mg	121	120		523		
mg		30				
mg				4		

483

484 Table 3 Results of sensory evaluation scores by attribute

	Juvela	Glutafin	Genius	Warburtons	Sainsburys
Appearance	5.78 ^a	5.95 ^a	4.27 ^b	5.83 ^a	4.36 ^a
Texture	6.12 ^a	6.01 ^a	3.56 ^c	6.39 ^a	4.65 ^b
Moistness	6.85 ^a	6.76 ^a	2.65 ^c	6.23 ^{ab}	5.58 ^b
Taste	5.95 ^a	5.52 ^a	4.29 ^b	6.37 ^a	4.16 ^b
Aftertaste	6.38 ^a	5.23 ^b	4.96 ^b	5.73 ^{ab}	4.66 ^b
Overall Liking	6.58 ^a	6.19 ^a	4.17 ^b	6.03 ^a	4.77 ^b

Values in the same row bearing the same letter are not significantly different.

485

486 **NUTRITIONAL CONSIDERATIONS IN CHOOSING GLUTEN FREE PRODUCTS**

487

488

489 1. Have you been medically diagnosed as suffering from coeliac disease?

Yes

No

490

491 2. How many years have you been diagnosed? _____

492

493 3. Do you suffer from any other food intolerances or allergies?

494

495

Wheat Dairy Egg Soya Other _____

496

497 4. Do you require products which are

498

Gluten Free Wheat Free Other _____

499

500 5. What type of gluten free products do you consume?

501

Bread Biscuits Cakes Other _____
Cereal Ready Meals Pasta

502

503 6. How do you obtain gluten free products?

504

On prescription Supermarket Both

505

506 7. Which brands do you prefer and why?

507

508

509

510

511

512 8. Please rank the following in order of importance (1 being most important and 5
513 being least important) in your choice of products
514

515

Taste

Appearance

Nutritional Value

Cost

Availability

516

517 9. Do any other factors affect your choice of products?
518

519

520

521

522

523

524

525 **GROUP DISCUSSION REGARDING NUTRITIONAL PROPERTIES**

526

527

PART B – GLUTEN AND WHEAT FREE BREADS

528

529

10. What type of gluten free bread products do you consume?

530

Fresh	Part Baked	Refresh
White	Fibre	
Loaves	Rolls	Other _____

531

532

533

11. How do you obtain your bread?

534

On prescription	Supermarket	Both
-----------------	-------------	------

535

536

12. Which brands do you prefer and why?

537

538

539

540

541

13. What problems do you encounter with gluten free breads?

542

543

544

545

546

547

14. Do you consider that the use of additives acceptable to obtain:

548

Improved appearance	Yes	No
Improved texture	Yes	No
Improved shelf life	Yes	No
Improved nutritional properties	Yes	No

549

550 15. Would you be prepared to participate in research relating to improving the
551 sensorial and nutritional qualities of gluten and wheat free breads?
552

Yes

No

553

554 If yes, please provide your name and email address below:

555

556 Name: _____

557

558 Email address (or telephone number if preferred means of contact):

559 _____

560

561 *The details collected above will only be used for the purposes of contacting you*
562 *with regard to your willingness to participation in further research conducted by*
563 *Manchester Metropolitan University on behalf of Juvela. Full details of the further*
564 *research will be provided and at no time will you be under any obligation to*
565 *participate.*

566

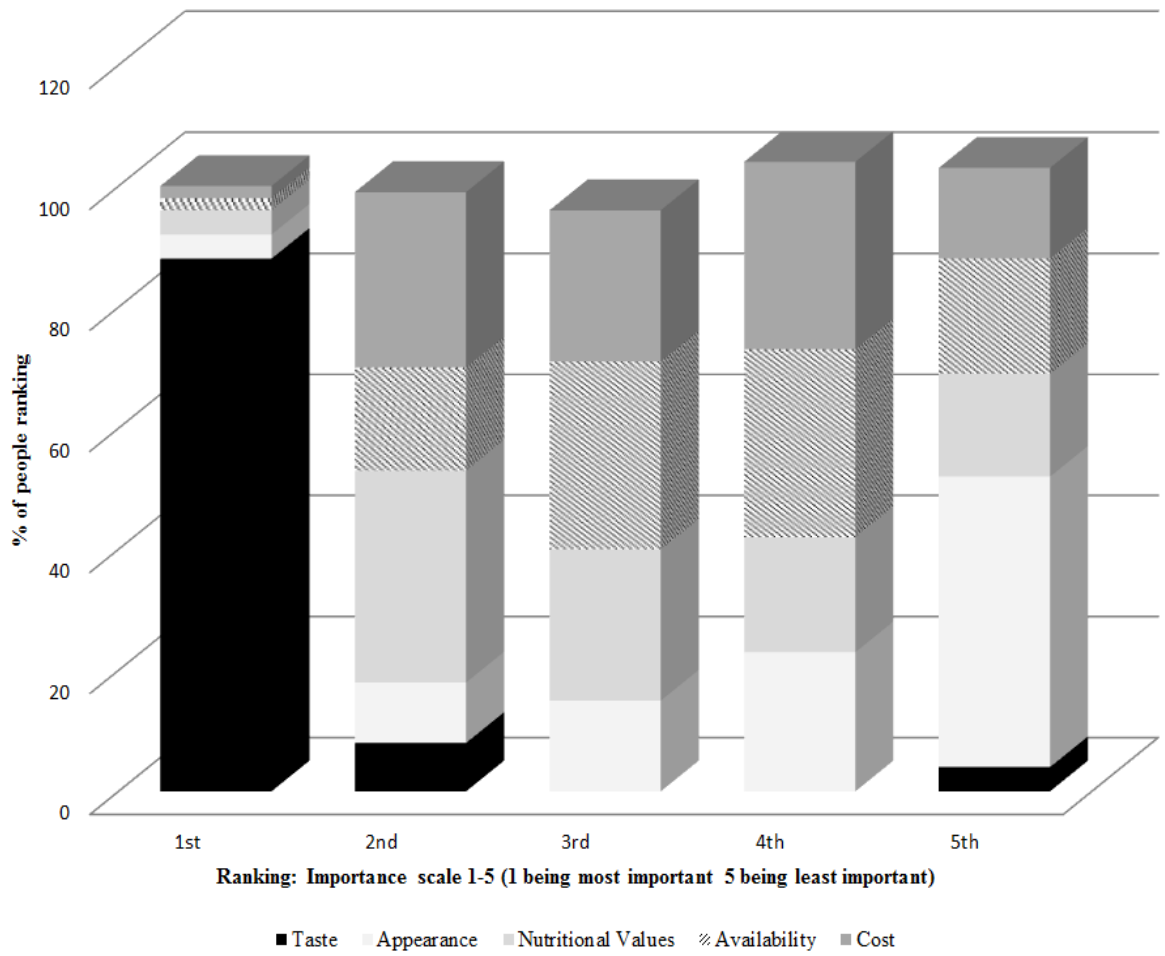
567 **Thank you for your time in completing this questionnaire**

568

569 Fig. 1 Questionnaire completed by Coeliac UK Volunteers

570

571

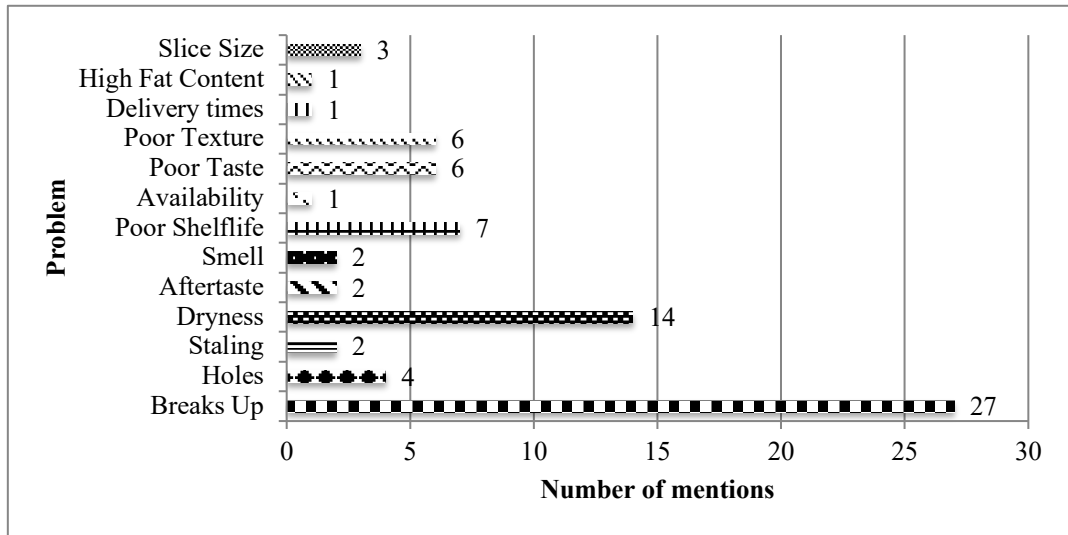


572
573

574 Figure 2 Importance of the factors influencing product choice

575

576



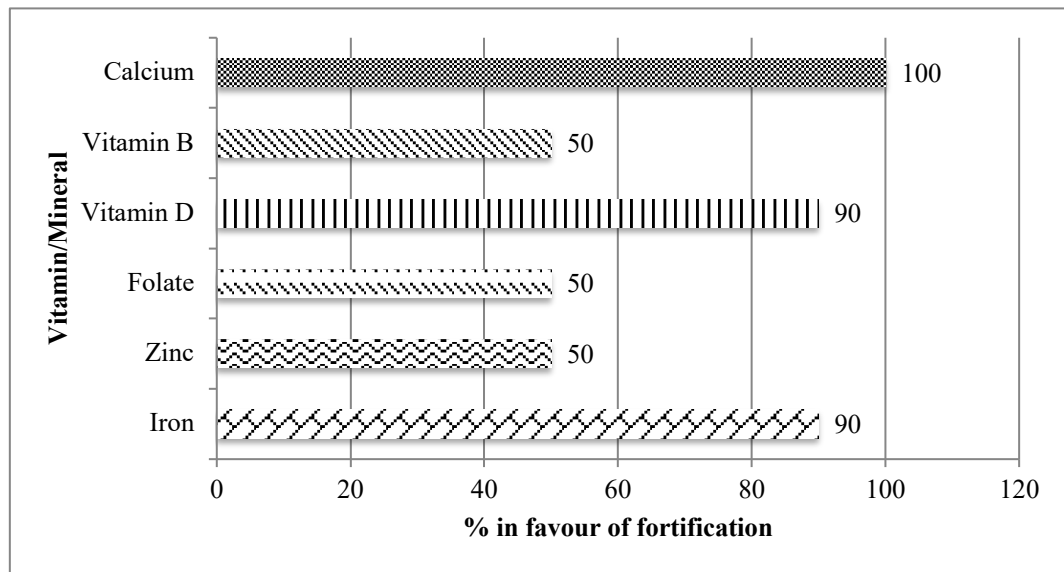
577

578 Figure 3 Response to question “problems encountered with gluten and wheat free
579 breads?”

580

581

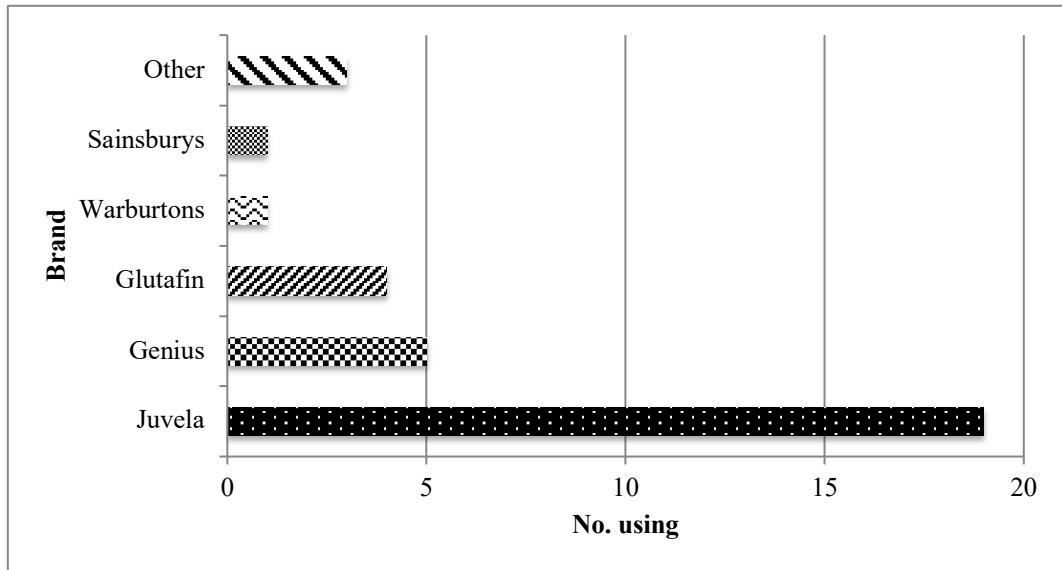
582



583

584 Figure 4 % of respondents in favour of fortification with vitamins and
585 minerals

586



587

588 Figure 5 Response to “which brand of gluten or wheat free breads do you normally
 589 use”?

590

591

Texture	<p><i>"Too dry"</i></p> <p><i>"Crumbly"</i></p> <p><i>"Falls apart"</i></p> <p><i>" Genius crumbly, falls apart"</i></p> <p><i>" Warburton's falls apart"</i></p> <p><i>" Genius dry and falls apart"</i></p> <p><i>" Warburtons dry and falls apart"</i></p> <p><i>" Warburtons horrible sawdust texture , falls to pieces"</i></p> <p><i>"Generally breads break up particularly Genius and Warburtons"</i></p> <p><i>"Texture- too dry in particular Genius and Glutafin"</i></p> <p><i>" Genius large slices - but "holey""</i></p>
Taste	<p><i>"Aftertaste"</i></p> <p><i>"Generally gluten free bread smells and tastes chemical and texture in mouth unpleasant"</i></p> <p><i>" Glutafin fresh bread taste good but sticks to teeth so texture not"</i></p> <p><i>" Juvela - fresh bread rolls- texture and flavour brill"</i></p> <p><i>" Energi bad aftertaste"</i></p> <p><i>" Juvela best bread nice taste good texture"</i></p> <p><i>" Juvela fresh white - flavour more like traditional bread due to use of what starch"</i></p> <p><i>" Glutafin and Juvela better flavour due to wheat starch"</i></p> <p><i>" Juvela fresh white - no after taste, smells like wheat bread, lighter texture"</i></p>
Shelflife	<p><i>"Doesn't keep long"</i></p> <p><i>" Genius - lose texture after 1 day"</i></p> <p><i>" Genius bread very nice at first but get hard lumps after a day or two"</i></p>
Slice Size	<p><i>"Too small"</i></p> <p><i>"Size - can't make a sandwich, not fit toaster, use a lot of loaf in one go"</i></p> <p><i>"Too small slices want to make decent sized sandwiches"</i></p> <p><i>"Inability to use for sandwiches"</i></p> <p><i>"Use for sandwiches limited in some ranges"</i></p> <p><i>" Juvela- size of bread too small"</i></p> <p><i>"Like Genius - size of slice"</i></p>
Cost	<p><i>"Poor quality/high price"</i></p> <p><i>"All brands expensive"</i></p> <p><i>"Cost is high"</i></p>

592
593

Figure 6

Problems encountered with wheat and gluten free bread