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1 **Awareness of alternative gluten-free grains for individuals with coeliac disease**

3 **Abstract**

4 Purpose: Coeliac disease (CD) is a prevalent autoimmune disorder, affecting 1 in 100 of all
5 individuals in the UK. Currently, the only treatment for CD is complete avoidance of gluten, a
6 protein commonly found in wheat, rye and barley. The use of alternative grains (AG) is
7 highly recommended to individuals with CD to improve and diversify their diet. This study
8 aims to determine the current knowledge of the gluten free diet (GFD), consumption rates
9 of AG and awareness of AG, for individuals diagnosed with CD.

10 Methodology: A total of 100 participants were recruited via local coeliac support groups as
11 well as an 'Allergy and Free From Show', to participate in a survey. Consent was obtained
12 from all organisations and all individual participants, prior to collecting data. The
13 questionnaire consists of 10 questions, related to participants' demographic characteristics,
14 knowledge of gluten free food (GFF) and AG and consumption rate of AG. Chi-Square (χ^2)
15 analyses were conducted to compare the variables between gender and time of diagnosis.

17 Findings: Overall, both genders possessed good knowledge of the GFD. Yogurt, vinegar and
18 oats resulted in the highest incorrect responses. It was found that females possessed better
19 knowledge of both GFF and AG. Rice, quinoa and corn were amongst the most popular AG
20 consumed whilst Job's tears, fonio and sorghum were the least consumed grains. Females
21 reported a higher consumption rate of AG than males. Additionally, those more recently
22 diagnosed had poorer knowledge of the GFD, reduced consumption rates of AG and poor
23 awareness of AG.

25 Originality: It can be suggested that the incorporation of AG into the diet, can prove beneficial
26 for coeliacs and that both knowledge and education, play a fundamental role in determining
27 consumption rates amongst individuals.

29 **Keywords:** alternative grains; coeliac disease; diagnosis; gluten free; nutrition

31 **Introduction**

32 Coeliac disease (CD) has now developed into a prevalent autoimmune disorder, affecting 1
33 in 100 of all individuals in the UK (Ciacci et al., 2015). The increased incidence of this
34 chronic inflammatory disease is a growing concern, having increased in fourfold over the last
35 two decades (West et al., 2014). Though initially thought to exist exclusively in European

36 countries, CD is now regarded as one of the most common genetic diseases, with a 0.9%
37 prevalence worldwide (Lionetti et al., 2015).

38

39 CD is developed when gluten, a protein matrix formed by gliadin and glutenin commonly
40 found in wheat, rye and barley is consumed by genetically predisposed individuals, causing
41 damage to the lining of their small intestine. Patients diagnosed with CD possess villous
42 atrophy (flattening of the villi) and crypt hyperplasia (elongated crypts between villi), leading
43 to a reduced absorption of essential nutrients and consequently malnutrition (Fei et al.,
44 2012; Green et al., 2015). Following gluten ingestion, individuals with CD will exhibit several
45 short-term and long-term consequences, which differ in both time (certain symptoms will
46 disappear in hours, while others may persist for weeks) and severity (ranging from barely
47 noticeable to extreme discomfort) (Pulido et al., 2013). Common gastrointestinal symptoms
48 associated with this enteropathy include abdominal discomfort, altered bowel habits, severe
49 diarrhoea and heartburn (Castillo et al., 2015). Whilst destruction of the gut is a major
50 component of the illness that is CD, the issues unfortunately do not stop there. This
51 systematic disease can also have a detrimental effect on many vital organs, such as the
52 heart, skin, liver and brain (Moreno et al., 2014). Examples of extraintestinal manifestations
53 include anaemia, osteoporosis, liver abnormalities and dermatitis herpetiformis (a skin
54 manifestation of CD) (Leffler et al., 2015). This vast array of inevitable symptoms that are
55 associated with this autoimmune disorder, places a heavy burden on any individual with CD.

56

57 Currently, the only proven treatment for CD is avoidance of all gluten containing products.
58 Adherence to this strict diet allows the gut to heal and efficiently absorb nutrients, thus
59 reducing any long-term consequences associated with CD (Jnawali et al., 2016). With 38%
60 of individuals who removed gluten from their diet, showing an immediate improvement in
61 overall health, the positive influence of the gluten free diet (GFD) is clearly illustrated
62 (Gaillard, 2016). In fact, strictly adhering to the GFD has been shown to decrease long-term
63 health risks, such as gastrointestinal malignancies, osteoporosis and anaemia. Moreover,
64 improvement in overall quality of life and consequently psychological wellbeing is a
65 noticeable benefit, for those adhering to the GFD (Hall et al., 2009). Whilst the positive
66 influence of the GFD is clearly illustrated, it is important to note that there are many cases
67 of refractory CD, which unfortunately do not respond to the GFD. In fact Gaillard (2016),
68 found that only 38% of individuals who removed gluten from their diet, showed an
69 immediate improvement in overall health, with all other individuals experiencing persistent
70 symptoms of CD and continual villous atrophy. This is further reinforced by Paarlahti et al.

71 (2013), who found that 25% of individuals continued to suffer from the persistent symptoms
72 of CD, despite committing to a strict GFD. Furthermore, complete compliance to the severely
73 stringent regime that is the GFD, requires constant vigilance and therefore can prove to be
74 much harder than originally thought. Gluten features as a prominent protein in countless
75 foods, including pasta, bread, cereals and confectionary. Gluten has unique structural and
76 functional properties and is known to provide visco-elasticity, taste, texture, ability to bind
77 fat and water, consequently proving gluten as an essential component of many foods (Day
78 et al., 2016). Therefore, with gluten dominating the food industry, it is no surprise why
79 complete avoidance of this persistent protein, is challenging (Makharia, 2014). Hidden
80 sources of gluten can prove to present an additional challenge. . For example, sauces and
81 marinades, processed meats, soups and alcohol, though in minimal amounts, may still
82 contain gluten and thus extra care should be taken when consuming these foods (Lebwohl
83 et al., 2015). Whilst it is common knowledge, that those with CD should avoid all wheat
84 based food products, it is also important to remember that gluten is frequently added to
85 many inconspicuous foods It is clear that gluten free food (GFF) are a necessity, in order to
86 accommodate for the millions of people, who are currently eliminating this life threatening
87 protein from their diet.

88

89 Alternative grain sources to the GFD (including cereals, minor cereals and pseudocereals),
90 can be categorised under three key grains; cereals (rice, corn and sorghum), minor cereals
91 (fonio, teff, millet and job's tears) and pseudocereals (buckwheat, quinoa and amaranth). All
92 are rich in a variety of nutrients, minerals, phytochemicals and dietary fibre and therefore,
93 their consumption has been widely recommended to all individuals (Li et al., 2016).

94 Furthermore, all AG are lacking in gluten, an essential component for coeliacs, thus
95 providing an additional benefit for those with CD. Whilst whole grains are a means of
96 improving the quality of diet, the consequent improvement in quality of life is perhaps the
97 true benefit for coeliacs. Therefore, the use of these alternative grains (AG) is highly
98 recommended to individuals with CD (Comino et al., 2013). Despite this, coeliacs are known
99 to have a low consumption rate of AG. Despite knowing the many benefits of AG,
100 consumption rates amongst coeliacs and non-coeliacs are low and rapidly declining (Nicklas
101 et al., 2013; Mann et al., 2015). The increased expense of grain products, or the preferred
102 convenience of buying readily prepared foods containing refined grains, as opposed to
103 buying and preparing raw grains, may attribute to this damaging consequence (Nicklas et
104 al., 2013).

105

106 Whilst finance and convenience are both influential factors of current diet status for coeliacs
107 and non-coeliacs, research indicates that lack of knowledge is perhaps the most detrimental
108 influencer. Many individuals with CD possess an ingrained belief that all grains contain
109 gluten and this ignorance and fear of contamination is causing reluctance amongst coeliacs,
110 ultimately leading to reduced whole grain consumption (Kmietowicz, 2017). Furthermore,
111 recent research indicates that elimination of grains from the diet, due to poor education, is
112 associated with a range of health problems, specifically the increased incidence of heart
113 attacks (Lebwohl et al., 2017). A further explanation for the reduced consumption rates of
114 AG amongst coeliacs could be due to the distribution of vouchers, which allow individuals to
115 purchase GFF at a discounted price. This particular strategy is utilised in many countries
116 including the UK, to assist coeliacs in managing their condition. GFF are made available on
117 prescription to patients with CD. In fact, 90% of patients with CD relied on prescriptions for
118 GFF (Robins et al., 2008). However, this may prove to be more disadvantageous and
119 detrimental to overall health, as offering coeliacs GFF at discounted prices, discourages the
120 consumption of AG (Muhammad et al., 2017). This is an issue, as the consumption of AG,
121 provides a clear alternative for coeliacs, which is both proven and tolerable. Thus, this study
122 aims to determine the knowledge of individuals diagnosed with CD, on their current
123 knowledge of the GFD, their consumption rates of AG and awareness of AG that could
124 positively influence their health status.

125

126 **Materials and methods**

127 Subject recruitment

128 This particular research targeted both male and female individuals of ≥ 18 years old, who
129 were diagnosed with CD (Table 1). A total of 100 participants were recruited to take part in
130 this study. Previous study looking into a similar area of research recruited 50 participants
131 and found that the use of AG was more beneficial in improving the nutritional profile of
132 individuals with CD (Lee et al., 2009). This coupled with the time restraints and the
133 participation of an extremely targeted population (individuals diagnosed with CD), indicates
134 that a minimum of 100 participants is sufficient. Participants were recruited via local coeliac
135 support groups, as well as an 'Allergy and Free From Show'. Whilst attending the show,
136 additional support groups such as Coeliac UK and Allergy Awareness were approached, to
137 recruit further participants. Consent was obtained from all organisations and all individual
138 participants, prior to collecting data. The study was approved by the University ethics
139 committee prior to subject recruitment.

140

141 Questionnaire development

142 The questionnaire was composed of 10 short questions, related to participants' demographic
143 characteristics (7 questions), knowledge of GFF and AG (2 questions with sub-choices) and
144 consumption rate of AG (1 question with sub-choices). Participants were asked to select
145 correct GFF from a checklist. All 15 food items were compared with the Coeliac UK Gluten
146 Free (GF) Checklist (Coeliac UK, 2018), to positively determine which items were GF. To test
147 the awareness of AG participants were asked to identify if it was possible for three different
148 GF grains (amaranth, quinoa and buckwheat), to be used in the production of six generic
149 food items (chocolate cake, vegetable soup, tomato pasta, porridge, blueberry muffins and
150 rice pudding). Description and photos of the grains were included in the survey for
151 participants who may not have heard of the AG. Based on Haros and Sanz-Penella (2017),
152 all three types of grains can be utilised to make the six food items. The questionnaire given
153 to all participants was adapted from others used in similar studies (Simpson et al., 2011;
154 Silvester et al., 2016). A pilot test was also conducted with 10 CD patients, prior to collecting
155 main data, to assess the feasibility, clarity and time taken to complete the questionnaire.
156 After completion of the pilot study, slight modifications were made to the questionnaire. The
157 number of questions was reduced from 14 to 10, in an effort to allow participants to focus
158 purely on their knowledge and awareness of AG.

159

160 Statistical analyses

161 Statistical analyses were conducted using IBM SPSS Statistics Version 23. A Chi-Square (χ^2)
162 analysis was carried out, to test for a number of different variables.

163

164 **Results and Discussion**

165 A total of 100 participants (23 males and 77 females) completed the survey. All participants
166 were diagnosed with CD (Table 1). The large gender difference within participants is
167 plausible, as CD is more prevalent in women than men, with 60-70% of individuals
168 diagnosed with CD being women (Shah and Leffler, 2010). The fact that women, on
169 average, are more likely to use healthcare services than men, can also explain this
170 (Pinkhasov et al., 2010). More than 60% of the participants reported that they adhered to
171 strict GFD while slightly less than 20% follow GFD most of the time.

172

173 Insert Table 1 here

174

175 **Knowledge of GFF and ingredients**

176 Statistical analysis highlighted that of the fifteen different food items, there was a significant
177 difference between males and females in five of the food items. These included semolina,
178 vinegar, buckwheat, cocoa and eggs (Table 2). Both genders scored equally (100%) on
179 three of the fifteen food items (milk, chicken and rye). Males scored 17% higher on one
180 food item (oats), than females. Females scored higher on all other food items, indicating
181 that overall, females possess an increased knowledge of the GFD. It is important to note,
182 that adequate knowledge of the GFD is the key to successfully managing CD and that, this
183 knowledge is essential for dietary compliance. Without sufficient knowledge, patients are at
184 risk of accidental consumption of gluten and consequently continued villous atrophy (Ciacci
185 et al., 2015). Overall, both genders possessed good knowledge of the GFD. This is
186 justifiable, since most participants had been confirmed with CD through clinical diagnosis, as
187 opposed to self-diagnosis. Hence, it can be assumed that patients would have received
188 some form of information regarding their condition and management. This, coupled with the
189 fact that all individuals were recruited at a place where they were actively seeking out
190 information (i.e. "Allergy and Free From Show" and coeliac support groups), indicates that
191 all participants should possess enough knowledge of GFF.

192

193 Insert Table 2 here

194

195 Furthermore, this study found that females had an increased knowledge of the GFD, than
196 males and is consistent with previous research, which suggests that females have a higher
197 adherence to the GFD, due to their increased knowledge (Leffler et al., 2008). Yoghurt
198 produced the most incorrect responses by both genders. This could be due to misconception
199 by participants and lack of specificity of the question ("Is yoghurt GF?"), as although plain
200 yoghurt is considered to be GF, yoghurt which is flavoured or has added grains cannot be
201 consumed by coeliacs (Coeliac UK, 2018). Oats produced the third most incorrect answers
202 and was the only food item, whereby females scored lower than males. There has been
203 much controversial evidence surrounding the addition of oats in the GFD. Whilst the
204 consumption of pure oats has been deemed safe for consumption, oats contaminated with
205 gluten are harmful (Fric et al., 2011). However, studies have reported that oats may be
206 immunotoxic in patients with CD (Arentz-Hansen et al., 2004; Tuire et al., 2012). Among
207 patients that reacted to oats, the abnormal immunological response against avenins may
208 have been triggered by a similar mechanism to that of gluten (Comino et al., 2015). Other
209 studies revealed that coeliac patients who consumed oats showed no signs of intestinal
210 inflammation (Kaukinen et al., 2013; Lionetti et al., 2018). This demonstrates the

211 importance of ensuring the safety of oats (prevention of cross contamination with gluten
212 containing cereals) and the need to identify oat varieties with no toxicity towards patients
213 with CD (Comino et al., 2011).

214 Times of diagnosis may also affect the level of awareness of GFF. Results indicated that
215 there was a significant difference in four of the food items. These included yoghurt ($\chi^2(3) =$
216 $26.984, p = < 0.001$), vinegar ($\chi^2(3) = 29.779, p = < 0.001$), buckwheat ($\chi^2(3) = 7.827, p$
217 $= < 0.05$) and soy sauce ($\chi^2(3) = 15.283, p < 0.05$). In three of these food items (vinegar,
218 buckwheat and soy sauce), it was found that those individuals diagnosed before 2003, had
219 the highest percentage of correct answers. Additionally, for these three food items, those
220 diagnosed in 2017 had the lowest percentage of correct answers. Patients diagnosed at an
221 earlier stage (before 2003) had better knowledge than those diagnosed later. A difference
222 does exist in adherence, between newly diagnosed individuals and those who have observed
223 the GFD long-term and that this difference is due to lack of knowledge exhibited by newly
224 diagnosed individuals (Ludvigsson et al., 2014). In this case, it is recommended that at the
225 time of diagnosis, individuals with CD should be referred to a registered dietitian and
226 encouraged to join coeliac support groups, in order to attain this knowledge and
227 consequently improve their nutritional profile (Ciacci et al., 2015).

228

229 **Consumption of alternative grains**

230 Participants were asked how often they consume AG on a weekly basis.

231 Table 3 highlights the % of grain consumption for both genders on a weekly basis. Job's
232 tears, fonio and sorghum were the least consumed grains. Both amaranth and millet were
233 consumed at a higher rate than the above three grains although their consumption were still
234 relatively low. Quinoa and corn were relatively popular amongst both genders. Rice was the
235 most popular grain, with all males consuming it at some point during the week and only a
236 small population of females, not consuming it at all. Of the 10 grains, there was a significant
237 difference between male and females in only one of the grains – buckwheat ($\chi^2(2) = 9.105,$
238 $p < 0.05$). More than 90% of males reported never having consumed buckwheat while
239 slightly more than 20% of females reported consuming buckwheat once per week.

240

241 Insert Table 3 here

242

243 Time of diagnosis revealed a significant difference in consumption rates of three types of
244 grains. These were quinoa ($\chi^2(6) = 10.467, p < 0.001$), teff ($\chi^2(6) = 46.490, p < 0.001$)
245 and millet ($\chi^2(6) = 30.262, p < 0.001$). This suggests that for these three grains, there was

246 a varied consumption rate amongst individuals diagnosed at different times, as opposed to
247 all other grains, whereby consumption rates were similar, regardless of time of diagnosis.
248 For individuals diagnosed in 2017, amaranth, sorghum, fonio and millet were not consumed
249 at all. Individuals diagnosed prior to 2003 to 2016 did not consume job's tears.

250

251 Females reported a higher consumption rate than males and those diagnosed earlier were
252 more inclined to consume AG, than those more recently diagnosed. This could simply be
253 because, females and those diagnosed earlier, have an increased awareness of the nutrient
254 deficient GFD and consequently possess better knowledge of the influence of AG (Leffler et
255 al., 2008). Furthermore, the increased consumption rate of AG exhibited by females can also
256 be explained by the fact that females, in general, are more interested in cooking as well as
257 trying new foods and recipes, as opposed to males (FSA, 2014). For all participants,
258 regardless of gender and time of diagnosis, rice was the most frequently consumed grain.
259 Valitutti et al. (2017), who also found increased rice consumption in individuals with CD,
260 supports this.

261

262 Overall AG consumption for all participants was quite low. This is consistent with previous
263 research, which indicates that those from the coeliac community have low consumption
264 rates of AG (Nicklas et al., 2013). Misconceptions, such as, believing a grain contains gluten
265 when it is actually GF, could potentially play a role in explaining this low rate of consumption
266 (Kmietowicz, 2017). However, for this particular study, the true reasons for the avoidance of
267 AG is unknown (a limitation), and hence further research into this area could prove
268 beneficial for health care professionals, as a means of educating the coeliac community,
269 thus increasing adequate grain consumption and subsequently improving overall nutritional
270 status (Valitutti et al., 2017).

271

272 **Awareness of utilisation of AG in different food items**

273 Overall, females had a higher percentage of correct responses for foods made with
274 amaranth and buckwheat. In contrast, males had a higher percentage of correct responses
275 for foods made with quinoa; however the difference was relatively small for most food
276 items, suggesting that females have a higher awareness of AG. Additionally, both males and
277 females had a higher incorrect response rate for blueberry muffins, in comparison to all
278 other food items. Food uses of rice pudding were better known by males and females, with
279 both genders producing a higher percentage of correct responses (Table 4).

280

281 Insert Table 4 here

282

283 Overall, it can be said that those diagnosed before 2003, have a much higher correct
284 response rate than those diagnosed after this time, suggesting their increased awareness of
285 AG (Table 5). All participants diagnosed in 2003, scored 78% or higher. In contrast, those
286 who were more recently diagnosed (2017), had poorer awareness of AG, with all individuals
287 diagnosed in 2017 producing the highest percentage of incorrect responses. Most
288 individuals, regardless of time of diagnosis, were more aware of the food uses of quinoa,
289 with participants having a high correct response rate for this grain.

290

291 Insert Table 5 here

292

293 Females had a greater awareness of AG in comparison to males. Additionally, newly
294 diagnosed individuals had poorer awareness when compared to those diagnosed before
295 2003. This can again be explained by the fact that these individuals already possess an
296 increased knowledge regarding the nutritional limitations of the GFD and as such have
297 become aware of potential pseudocereals that could provide a healthy alternative (Leffler et
298 al., 2008). Also, the increased awareness of AG exhibited by females can again be due to
299 their increased likelihood of both cooking and trying new recipes, in comparison to males
300 (FSA, 2014). Another explanation could be due to the increased commercialisation of these
301 grains (Moreno et al., 2014). The prevalence of CD has greatly increased and hence further
302 scrutiny has been placed on the GFD, steering coeliacs towards viable alternatives (Ciacci et
303 al., 2015). This has warranted food industries to produce and advertise a range of GFF
304 incorporated with these versatile grains. Hence, this global publicity has provided a means of
305 education for coeliacs (Boukid et al., 2017).

306

307 **Limitations**

308 All participants were recruited via an 'Allergy and Free From Show' and coeliac support
309 groups and thus may already possess a heightened awareness of the GFD and AG, when
310 compared to other coeliacs. Moreover, participants' place of recruitment increases the
311 likelihood of individuals having an interest in the study and being more positively motivated.
312 Therefore, results may not be an accurate representation of the overall coeliac community.
313 Furthermore, all data was collected via self-reported questions.

314

315 **Conclusion**

316 There is overwhelming evidence that the GFD is the only proven treatment for CD. However
317 it can be challenging to adhere to and CD patients should ensure they consume a varied
318 GFD to ensure they meet their nutritional requirements. This study found that females
319 possessed better knowledge of both GFF and AG. Additionally, those more recently diagnosed
320 had poorer knowledge of the GFD and AG and reduced consumption rates of AG.

321 Pseudocereals are alternative sources of grains that can be incorporated into the diet.
322 Whilst incorporation of pseudocereals into the diet can provide an essential alternative for
323 coeliacs, results from this study clearly implicate that grain consumption is far from
324 adequate. It seems that knowledge plays a fundamental role in determining consumption
325 rates of AG. Therefore, the need for sufficient education is not only recommended but is
326 absolute necessary, to improve the current nutritional status, of those suffering from the
327 chronic autoimmune disorder that is CD.

328

329 **Recommendations for future research**

330 To further improve the study, research into the current diet status of the participants can be
331 beneficial in establishing if individuals are able to meet their daily nutritional requirements.
332 Dietary status can also be utilised, to influence the incorporation of specific AG into the diet,
333 if individuals are lacking in key nutrients. Additionally, an analysis into the reasons behind
334 avoidance of certain grains, could prove beneficial in increasing consumption rates amongst
335 coeliacs. Long-term follow up studies among adults with CD and the uptake of AG and GF
336 sources rich in nutrients should be carried out. It is also recommended that further studies
337 on the ignorance of AG and GFF be conducted as this can directly affect adherence to GFD.

338

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518
519 **Table 1** Demographic characteristics of participants (n=100)

Characteristics	%
Gender	
Male	23
Female	77
Age	
18 to 24	29
25 to 34	16
35 to 44	8
45 to 54	10
55 to 64	19
65 to 74	18
When were you diagnosed with coeliac disease?	
2017	28
2010 – 2016	20
2003 – 2009	11
< 2003	41
How have you been diagnosed with coeliac disease?	
Duodenal biopsy	59
Bloodwork	26
Gene testing	13
Self-diagnosis	2
Please describe your current diet.	
Unrestricted diet	1
Gluten free diet occasionally	10
Gluten free diet most of the time	18
Strict gluten free diet	61
Trying to follow a strict gluten free diet, but not always sure	10
How long have you restricted the amount of gluten in your diet?	
Less than or equal to 5 years	48
Between 6 – 10 years	5
11 – 15 years	12
16 – 20 years	19
More than 20 years	16
Do you avoid or restrict any other foods?	
Yes	44
No	56

521

522 **Table 2** Knowledge of GFF and ingredients (n=100 and represents number of participants

523 who answered correctly)

Food Items	Is it gluten free? ^a	Males n (%)	Females n (%)	χ^2
Oats	✓	21 (91.3)	57 (74.0)	3.1
Milk	✓	23 (100)	77 (100)	NC
Chicken	✓	23 (100)	77 (100)	NC
Semolina	X	19 (82.6)	75 (97.4)	6.87*
Potatoes	✓	21 (91.3)	77 (100)	6.83

Yoghurt	✓	8 (34.8)	29 (37.7)	0.06
Rye	X	23 (100)	77 (100)	NC
Vinegar	X	21 (91.3)	52 (67.5)	5.08*
Buckwheat	✓	16 (69.6)	75 (97.4)	16.75*
Couscous	X	21 (91.3)	74 (96.1)	0.86
Cocoa	✓	19 (82.6)	75 (97.4)	6.87*
Soy Sauce	X	19 (82.6)	65 (84.4)	0.04
Tomatoes	✓	21 (91.3)	77 (100)	6.83
Quinoa	✓	22 (100)	77 (100)	3.38
Eggs	✓	20 (87.0)	77 (100)	10.35*

524 Note: ^a indicates the correct answers; NC – not computed as both males and females scored 100%
525 (correct answers) for the particular food items; * denotes significant difference, $p < 0.05$
526
527
528

Table 3 Percentage of grain consumption on a weekly basis (n=100)

Grains	Once/Week		3 Times/Week		Not at All		χ^2
	Males (%)	Females (%)	Males (%)	Females (%)	Males (%)	Females (%)	
Buckwheat	0	22.1	4.3	0	95.7	77.9	9.11*
Amaranth	17.4	11.7	0	0	82.6	88.3	0.51
Quinoa	65.2	49.4	8.7	16.9	26.1	33.8	1.96
Rice	60.9	53.2	39.1	45.5	0	1.3	0.65
Corn	65.2	54.5	17.4	31.2	17.4	14.3	1.67
Sorghum	0	11.7	4.3	2.6	95.7	85.7	3.07
Fonio	0	11.7	0	0	100	88.3	2.95
Teff	30.4	45.5	8.7	2.6	60.9	51.9	2.86
Millet	4.3	24.7	4.3	3.9	91.3	71.4	4.59
Jobs Tears	0	0	0	1.3	100	98.7	0.30

529 *significant difference at $p < 0.05$
530
531
532

Table 4 Awareness of utilisation of AG in different food items (n=100)

Grains	Amaranth			Quinoa			Buckwheat		
	Males (%)	Females (%)	χ^2	Males (%)	Females (%)	χ^2	Males (%)	Females (%)	χ^2
Chocolate cake	43.5	71.4	6.08*	47.8	61	1.27	43.5	80.5	12.05**
Vegetable soup	47.8	62.3	1.54	78.3	67.5	0.97	43.5	70.1	5.46*
Tomato pasta	43.5	58.4	1.60	73.9	75.3	0.02	39.1	63.6	4.37
Porridge	60.9	68.8	0.51	82.6	59.7	4.07*	56.5	74	2.58

Blueberry muffins	30.4	63.6	7.92*	78.3	66.2	1.1	21.7	75.3	21.82**
Rice pudding	73.9	72.7	0.01	91.3	76.6	2.39	56.5	66.2	0.73

533 *significant difference at $p < 0.05$; ** $p < 0.001$

534

535

536 **Table 5** Time of diagnosis and awareness of utilisation of AG in food items (n=100)

Food Items	Amaranth χ^2 (df)	Quinoa χ^2 (df)	Buckwheat χ^2 (df)
Chocolate cake	χ^2 (3) = 7.809	χ^2 (3) = 18.806**	χ^2 (3) = 4.430
Vegetable soup	χ^2 (3) = 14.729*	χ^2 (3) = 12.988*	χ^2 (3) = 20.466**
Tomato pasta	χ^2 (3) = 18.331**	χ^2 (3) = 6.173	χ^2 (3) = 12.275*
Porridge	χ^2 (3) = 16.874*	χ^2 (3) = 32.764*	χ^2 (3) = 21.030*
Blueberry muffins	χ^2 (3) = 16.961*	χ^2 (3) = 12.142*	χ^2 (3) = 9.229*
Rice pudding	χ^2 (3) = 18.655**	χ^2 (3) = 14.437*	χ^2 (3) = 20.363**

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