

1 **How much is ‘5-a-day’?: A qualitative investigation into consumer understanding of fruit and**  
2 **vegetable intake guidelines**

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12 **Key words:** Fruit and vegetables, Guidelines, Portion size, Knowledge, 5-a-day message

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14 **Authorship**

15 CR contributed towards the design of the PS questionnaire, conducted qualitative data collection,  
16 carried out all analyses and drafted the manuscript. JVV designed the study and was Principal  
17 Investigator on the grant. ISY, MCMcK and KMA were co-investigators on the grant application,  
18 and MCMcK assisted with the analysis and interpretation of the qualitative data. KMA developed  
19 the first draft of the PS questionnaire and provided advice on its analysis. CRD, LLH and AJMcG  
20 were responsible for participant recruitment and completion of the study protocol. CRD and  
21 AJMcG also assisted with the FG discussions. All authors critically reviewed and approved the  
22 manuscript.

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24

25 **ABSTRACT**

26

27 **Background:** Despite the known health benefits of fruit and vegetables (FV), population intakes  
28 remain low. One potential contributing factor may be a lack of understanding surrounding  
29 recommended intakes. This study aimed to explore understanding of FV intake guidelines among a  
30 sample of low FV consumers.

31 **Methods:** Six semi-structured focus groups were held with low FV consumers (n=28, age range 19-  
32 55 years). Focus groups were digitally recorded, transcribed verbatim, and analysed thematically  
33 using NVivo to manage the coded data. Participants also completed a short questionnaire assessing  
34 knowledge on FV intake guidelines. Descriptive statistics were used to analyse responses.

35 **Results:** Discussions highlighted that although participants were aware of FV intake guidelines,  
36 they lacked clarity with regards to the meaning of the '5-a-day' message, including what foods are  
37 included in the guideline, as well as what constitutes a portion of FV. There was also a sense of  
38 confusion surrounding the concept of achieving variety with regards to FV intake. The sample  
39 highlighted a lack of previous education on FV portion sizes, and put forward suggestions for  
40 improving knowledge, including increased information on food packaging, in supermarkets and  
41 through health campaigns. Questionnaire findings were generally congruent with the qualitative  
42 findings, showing high awareness of the '5-a-day' message, but a lack of knowledge surrounding  
43 FV portion sizes.

44 **Conclusions:** Future public health campaigns should consider how best to address the gaps in  
45 knowledge identified in this study, and incorporate evaluations that will allow impact of future  
46 initiatives on knowledge, and ultimately behaviour, to be investigated.

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## 57 INTRODUCTION

58 Research has shown that a diet rich in fruit and vegetables (FV) may provide protection against  
59 certain chronic illnesses such as cardiovascular diseases [1]. Based on this evidence, the World  
60 Health Organisation (WHO) set a minimum daily target of 400 g FV (the equivalent of five 80 g  
61 portions), which has since been translated into the ‘5-a-day’ public health message within the UK  
62 [2,3]. However, despite these guidelines, current population intakes remain suboptimal, with recent  
63 figures suggesting average national intakes of 4.1 portions/day amongst adults (19 – 64 years) [4].

64 One factor which has previously been suggested to be a potentially important predictor of FV intake  
65 is adequate knowledge [5-8]. However, minimal studies have thus far investigated consumer  
66 understanding of the meaning of the ‘5-a-day’ FV intake recommendations, including which foods  
67 are included in the guidelines, and what counts as a portion of FV. It could be hypothesised that  
68 greater awareness on details, such as the specific amounts and types of foods needed to achieve the  
69 recommended guidelines, might have positive implications in terms of better adherence and  
70 increased intake. For example, improved comprehension of the ‘5-a-day’ guidelines, including how  
71 to achieve a portion of FV, may enhance consumers’ capability and motivation to achieve the  
72 recommendations [9]. It might also better allow individuals to accurately assess their current FV  
73 intake which could consequently impact upon their intentions for future consumption. A further  
74 justification for investigating this topic is based on evidence which shows discordant findings  
75 between people’s perception of their FV intake and their actual intake. For instance, one study [10]  
76 found that amongst 426 elderly participants, 83% were aware of FV intake guidelines, and 35% felt  
77 they were eating enough FV. However, a closer examination (using a dietary recall of typical FV  
78 intake) of the latter group showed that some individuals were consuming as little as two portions of  
79 FV per day. A possible reason for this discrepancy is that there was a misunderstanding with  
80 regards to FV intake guidelines, and in particular the nature of a portion of FV according to the ‘5-  
81 a-day’ message.

82 The few studies which have been conducted to date on consumer understanding surrounding FV  
83 intake guidelines have primarily investigated knowledge amongst American [8, 11–14], Australian  
84 [9, 15–17] and New Zealand consumers [18]. Only two studies [19, 20] have investigated  
85 knowledge within the UK, and these studies used samples of University students and socially-  
86 deprived individuals. Given that FV-based public health campaigns, intake recommendations and  
87 portion size (PS) guidance vary greatly between countries (see Supporting Information, Table S1),

88 the majority of evidence to date cannot necessarily be generalised to a UK context. Hence, the  
89 objective of the current paper was to explore awareness and understanding of FV intake guidelines,  
90 with a particular emphasis on sources of FV and FV portion sizes (PSs), within a sample of low FV  
91 consumers.

## 92 **MATERIALS AND METHODS**

### 93 **Study Sample and Recruitment**

94 The current sample comprised participants taking part in a pilot randomised controlled feeding  
95 study, entitled the Biomarkers of Fruit and Vegetable (BIOFAV) study. Full details of the pilot trial  
96 have been published elsewhere [21], but, in brief, it was designed to investigate novel biomarkers of  
97 FV consumption amongst 32 healthy, habitually low FV ( $\leq 2$  portions) consumers (identified by a  
98 7-day diet recall). Participants were recruited through an intranet advertisement published within  
99 [University name removed for blinding purposes], and through word-of-mouth. The study was  
100 approved by the [School name removed for blinding purposes] research ethics committee of  
101 [University name removed for blinding purposes], and participants provided written informed  
102 consent.

### 103 ***Focus Group Discussions***

104 Six focus groups (FGs) were conducted between August 2011 and May 2012. The FGs, which  
105 ranged in size between four and six participants, were conducted in the first week of the four week  
106 BIOFAV study. The discussions lasted between 45 to 60 minutes and digital recordings were taken.

107 The FGs were moderated by CR, who was assisted by another member of the research team  
108 (CRD/AJMcG). Moderators received formal training in conducting FGs. To ensure consistency, a  
109 semi-structured topic guide was developed based on a prior literature search. The script was piloted  
110 on a group of four research students (aged between 20-30 years). Sample questions from the final  
111 topic guide are illustrated in Table 1. The co-moderator ensured all topic areas were covered within  
112 each session and volunteers were encouraged to fully express their views, provided the conversation  
113 was relevant to the aims of the research. At the end of each session, participants were thanked for  
114 their time and asked if they had any other issues that they would like to raise.

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## 117 *Questionnaire*

118 Prior to the FGs, demographic information was collected on the sample. A questionnaire  
119 comprising questions surrounding the '5-a-day' FV guideline was also administered. Given the  
120 small sample size, the intended use of the questionnaire was not to derive generalisable conclusions  
121 about consumer knowledge of FV guidelines, but rather to provide some context on the sample, and  
122 to aid with the interpretation of participant responses during the qualitative discussions.  
123 Additionally, the small sample size did not permit the use of statistical testing between responses  
124 and demographic variables.

125 The questionnaire covered four areas; awareness of the '5-a-day' message, knowledge on foods that  
126 are classified as a fruit or vegetable according to the '5-a-day' message, PSs of commonly  
127 consumed FV and knowledge on portions provided by combinations of FV (to reflect normal  
128 dietary consumption patterns). Participants were firstly asked 'Are you aware of the '5-a-day'  
129 message about FV consumption?', to which they could answer 'yes', 'no' or 'not sure'. Secondly,  
130 participants were given a categorisation task which required them to identify foods which counted  
131 as a fruit or vegetable according to the '5-a-day' message from a list of 39 commonly consumed  
132 foods. A third question showed a list of 27 FV with specific quantities (e.g. four spears of broccoli)  
133 and asked participants to record how many portions of fruit or vegetables each would contribute  
134 towards the '5-a-day' message (e.g.  $\frac{1}{2}$  portion). Finally, the questionnaire presented seven  
135 combinations of FV (e.g. one medium apple, one medium pear and two medium glasses of fruit  
136 juice) and asked participants to specify how many portions each set would equate to if eaten within  
137 the course of one day.

## 138 *Statistical Analysis*

139 FGs were transcribed verbatim by CR. The study technician listened to the audio recordings and  
140 checked this against the transcripts. Data were analysed using Braun and Clarke's inductive  
141 thematic analysis framework [22]. This involved a six-step process i) familiarisation with data, ii)  
142 initial descriptive coding of data, iii) search for themes, iv) review of themes, v) naming and  
143 defining of themes and vi) writing up of results. CR carried out this process, and the transcripts  
144 were then read by MCMcK and the codes were checked and compared. Only a small number of  
145 between-researcher discrepancies were found and consensus was reached through discussion. QSR  
146 NVivo 8 was used to facilitate data coding and management.

147 Questionnaire responses were analysed using PASW (SPSS Inc, Chicago, IL). Descriptive statistics  
148 were used to describe the demographic profile of participants. Categorical data are presented as  
149 frequencies and percentages, while continuous data are shown as the median and interquartile range  
150 (IQR) (due to the small sample size). To analyse the questionnaire on FV intake guidelines, correct  
151 responses were given a score of one, whilst incorrect and ‘don’t know’ responses were given a  
152 score of zero, making a maximum possible score of 74. Participants’ percentage of correct  
153 responses were calculated for the overall questionnaire, and for each of the four questionnaire  
154 domains separately. Simple descriptive statistics were used to establish the frequency of correct and  
155 incorrect responses, and percentage knowledge scores for the sample are presented as the median  
156 and interquartile range (IQR).

## 157 **RESULTS**

158 Twenty-eight participants took part in the FGs (sample characteristics are shown in Table 2). The  
159 following section presents a description of the main themes which emerged from the analysis of the  
160 transcripts; (i) knowledge, (ii) education and (iii) suggestions for improving FV PS knowledge (see  
161 Supporting Information Table S2 for a full list of themes, subthemes and quotations).

### 162 ***Knowledge***

163 Whilst the majority of participants claimed to be aware of the ‘5-a-day’ campaign, a lack of  
164 knowledge was evident regarding the specifics of the message (Quote 1, Table 3). For example,  
165 most participants were confused as to which foods counted as a fruit or vegetable according to the  
166 ‘5-a-day’ message. Additionally, when prompted by the moderator, some expressed their surprise at  
167 foods such as tomato-based sauces, which they would not have previously classified as a fruit or  
168 vegetable (Quote 2, Table 3). Some participants also said they were unaware that potatoes did not  
169 classify as a vegetable according to the guidelines. However, most ambiguity existed with regards  
170 to composite foods (e.g. spaghetti bolognese and stew), with many participants claiming that they  
171 did not normally count these foods towards their FV intake (Quote 3, Table 3). One participant also  
172 indicated that they were uncertain about what conditions a food needed to satisfy to be classified as  
173 a fruit or vegetable (Quote 4, Table 3).

174

175 Most participants also expressed a lack of awareness surrounding PSs for FV, and this was the  
176 prevailing topic of conversation during the FG discussions about the ‘5-a-day’ message.  
177 Respondents mentioned varieties they deemed particularly difficult, including lettuce, and the

178 heterogeneity in PSs for different FV was highlighted as a factor which made it more difficult to  
179 decipher what a portion of FV equated to (Quote 5, Table 3). When additional FV guideline rules  
180 were discussed, for example surrounding pure fruit juice (i.e. that it can only count towards a  
181 maximum of one portion per day) some participants questioned the reasoning behind this rule  
182 (Quote 6, Table 3). Generally, it was suggested by participants that PSs for fruit were easier to  
183 establish than vegetables, with some mentioning fruit as “*more discrete*” (FG1, M, 19yrs) and the  
184 fact that you could “*use the whole thing*” (FG2, M, 20yrs). The majority of participants claimed  
185 that composite food dishes including FV (e.g. sandwiches, stew and soup) were particularly difficult  
186 to quantify in terms of the number of portions that were provided in one serving (Quote 7, Table 3).

187

188 Variety was a key concept discussed in multiple FGs. Firstly, some participants claimed that they  
189 had misinterpreted the ‘5-a-day’ message as meaning five portions of fruit, plus five portions of  
190 vegetables a day (Quote 8, Table 3). Many participants also alluded to the fact that they were not  
191 previously aware that FV intake should ideally be comprised of a variety of FV, with some stating  
192 that they thought eating five of the same type of fruit or vegetable would be sufficient to meet  
193 recommendations (Quote 9, Table 3).

194

195 Finally, it was evident that participants had difficulty estimating their current intake of FV as a  
196 result of their lack of knowledge on FV PS. Some believed they had been overestimating their  
197 intake (Quote 10, Table 3), whilst others thought the contrary (Quote 11, Table 3).

198

### 199 ***Education***

200 Overall, findings from the FGs suggested that participants had received little or no information on  
201 what constituted a portion of FV according to intake guidelines. However, some sources of  
202 education mentioned included front-of-pack labelling, school and magazine articles (Quote 12 &  
203 13, Table 3). There were mixed opinions with regards to the preferred method of communication  
204 for FV PSs. Some believed conveying FV portions in terms of grams was superior as this is a  
205 universal measurement, and such information could be used in conjunction with weights of FV  
206 provided on packaging (Quote 14, Table 3). However, other participants stated that working in  
207 grams presented additional problems in terms of the ‘hassle’ of having to weigh FV before eating  
208 them. Some also expressed concern that they were not familiar with grams as a form of  
209 measurement. There was also a sense of complacency in terms of how precise FV portions needed

210 be (Quote 15, Table 3). Tablespoons and handfuls were both generally perceived as more useful  
211 and relevant measures for FV PS. For example, tablespoons were seen as less effort in comparison  
212 to grams (Quote 16, Table 3). However, despite this, two participants believed that handfuls were  
213 confusing, based on the concept that the size of individual's hands differ (Quote 17, Table 2). In  
214 two FGs, participants stated that they preferred to guess FV PSs based on the size of well-known  
215 FV such as an apple (Quote 18, Table 3).

216

217 Similarly, there were varied opinions on whether having increased knowledge of FV PS would  
218 increase FV intake. On the whole, participants agreed that having more information on what  
219 constitutes a portion of FV would impact positively on their current FV consumption (Quote 19 &  
220 20, Table 3). For example, some people suggested that they were not motivated to meet the '5-a-  
221 day' recommendations as they were unsure of how their current intake compared to the guidelines.  
222 With increased information some said they would feel 'more informed' and 'more aware', and that  
223 the guidelines would be 'more achievable'. However, other participants said that they do not think  
224 about FV PS, instead preferring to eat depending on their appetite. Additionally, some said that they  
225 would not measure portions in spite of increased information (Quote 21 & 22, Table 3). Two female  
226 participants suggested that increased FV PS information would not overcome other barriers towards  
227 FV consumption, including routine and preparation (Quote 22, Table 3).

228

### 229 *Suggestions for Improving Portion Size Knowledge*

230 Participants contributed multiple ideas on how information surrounding achieving a portion of FV  
231 according to '5-a-day' guidelines could be conveyed to the public in the future. Suggestions  
232 included increased information on packaging and displays in the FV produce section of  
233 supermarkets. Two participants said they would like personal assistance whilst shopping for FV  
234 (i.e. somebody to inform you of how much you need to make up a portion of FV) (Quote 23, Table  
235 3), although this idea was refuted by younger participants who felt they would not welcome such an  
236 approach (Quote 24, Table 3).

237

238 Other proposals included increased FV PS information in eateries which could be used when  
239 ordering food, governmental campaigns and more promotional material, including leaflets or  
240 posters (Quote 25 & 26, Table 3). Many participants suggested that key messages which should be



241 communicated are increasing people's knowledge on how to easily incorporate more portions of FV  
242 into daily routine, as well as increasing awareness of the number of portions provided by commonly  
243 consumed composite meals (Quote 27, Table 3). Assistance with meal planning and FV PS  
244 information in recipe books were also suggested as possible motivators for increasing FV intake  
245 (Quote 28, Table 3).

246

## 247 **Questionnaire Results**

248 A summary of the scores from each domain of the FV guidelines questionnaire are illustrated in  
249 Table 4. All participants within the sample stated they were aware of the '5-a-day' FV intake  
250 guidelines. The majority of participants were able to correctly identify foods which counted as a  
251 fruit or vegetable (median knowledge score 91%). However, as shown in Supporting Information  
252 Table S3, for two foods, less than half of the sample scored correctly; jacket potatoes (39.3%  
253 correct) and potatoes (42.9% correct). Other foods for which 80% or less of the sample correctly  
254 identified as FV were; chips (78.6), chickpeas (75% correct), lentils (75% correct), tomato soup  
255 (75% correct) and vegetable lasagne (60.7% correct).

256 The sample's median knowledge score for identifying the portions provided by different amounts of  
257 individual types of FV was 37% (Supporting Information Table S4). For most foods (59%), less  
258 than half of the sample correctly answered the portions provided by the stated quantities of FV.  
259 More than 50% of participants correctly identified the portions provided by ten foods only. These  
260 were mostly in the form of one 'piece' of fruit or vegetable (e.g. one apple, one banana).

261 Apart from one combination of FV (1 apple, 1 banana, 1 glass of fruit juice), the majority of  
262 participants ( $\geq 50\%$ ) incorrectly assessed the number of portions provided by different selections of  
263 FV (Supporting Information Table S5). The median knowledge score for this task was 21.4%.

## 264 **DISCUSSION**

265 Despite awareness of the UK government's '5-a-day' recommendation for FV, this study has  
266 demonstrated a lack of knowledge with regards to the specifics of the message. Some mis-  
267 understandings of the '5-a-day' message exist, notably the belief that it recommends five fruit and  
268 five vegetables per day, and not appreciating the importance of variety. There were also some

269 knowledge gaps regarding what is included in the FV recommendation, and a lack of knowledge  
270 about what constitutes a portion of FV, or how to actually achieve the recommended intake target.

### 271 **Identification of FV within the Context of the ‘5-a-day’ Guidelines**

272 The FG discussions highlighted a lack of clarity with regards to which foods count as a fruit or  
273 vegetable according to the ‘5-a-day’ message. Specifically, individuals illustrated a deficit of  
274 knowledge on whether certain composite foods counted towards FV guidelines. This is in line with  
275 findings from another study [14] which suggested that FV consumed in composite dishes were the  
276 most difficult to classify for American consumers. The exclusion of composite foods whilst  
277 assessing FV intake can have important implications in terms of the conclusions that are reached  
278 regarding current consumption. For example, a study [23] showed that excluding composite foods  
279 from FV estimates can misclassify participants as low/non-consumers of FV. This notion may also  
280 provide a possible explanation for the increase in FV consumption amongst detected 19-64 year  
281 olds from the 2002 National Diet and Nutrition Survey [24] to the most recently published survey  
282 [4] (2.8 portions FV/day versus 4.1 portions FV/day respectively). In comparison to the 2002  
283 survey, the more recent survey used disaggregated data for a wider range of composite dishes.  
284 These findings, alongside evidence which shows that composite foods are accountable for as much  
285 as 20-30% of vegetable intake and 10% of fruit intake, illustrate the need for consumers to be better  
286 informed of the value of FV-rich meals in relation to achieving FV guidelines [25]. Additionally,  
287 the public should be made aware of how to easily incorporate portions into commonly consumed  
288 meals. Such information could have a positive impact in terms of making the ‘5-a-day’ target seem  
289 more achievable; a point which was strongly advocated in the FGs within this study.

290 Interestingly, findings from the questionnaire showed that the sample scored well when asked to  
291 identify foods which are classified as a fruit or vegetable. However, while participants were able to  
292 identify common FV, as voiced in the FGs, some uncertainty was evident with regards to other  
293 foods including potatoes, as well as chickpeas and lentils. With regards to potatoes, this is  
294 unsurprising, given the international variation in the classification of potatoes, with some countries,  
295 such as the USA, including potatoes as a vegetable, and others, such as the UK, excluding potatoes  
296 from their FV guidelines (as per recommendations set by the WHO/FAO). Hence, it could be  
297 speculated that the continuing debate over potatoes may have contributed towards the confusion  
298 amongst the current sample. Regardless of the reason, this is an important finding as it highlights

299 that some consumers may count potatoes towards their daily intake of FV, and thus they may not be  
300 adequately assessing or reporting their intake of FV. Future education resources should endeavour  
301 to clarify this for the general public.

### 302 **Understanding of FV Portion Sizes within the Context of the ‘5-a-day’ Guidelines**

303 Another key finding from the focus groups was that the majority of participants had trouble  
304 conceptualising a portion of different types of FV, which is a key skill required in understanding the  
305 ‘5-a-day’ message. This finding is consistent with previous studies conducted in the area [8, 12, 14,  
306 15, 18–20]. Participants generally found it more challenging to decipher the portions provided by  
307 FV which were not in the form of one whole food/piece, with some stating that this was the main  
308 reason why vegetables were often more difficult to determine in terms of portions in comparison to  
309 fruit. The questionnaire responses served to reinforce this finding, and also revealed that, when  
310 faced with a list of FV, most respondents in the current sample were unable to tell how many  
311 portions the combination would provide if consumed within one day. When translated into a normal  
312 day-to-day dietary context, this suggests that these consumers are unlikely to be able to accurately  
313 assess their own daily intake of FV. This concept was acknowledged by various participants within  
314 the FGs. Hence, it is possible that this sample are making dietary choices regarding FV  
315 consumption based on ill-informed perceptions about their current intake. Another key finding from  
316 this study was that some participants believed that the ‘5-a-day’ guidelines stipulated the  
317 consumption of five portions of fruit in addition to five portions of vegetables per day. This notion,  
318 which has also been alluded to by individuals elsewhere [26], could potentially be very  
319 demotivating, and thus might suggest a need for the refinement of current UK FV guidelines in  
320 order to facilitate better consumer understanding. There may be some merit, for example, in  
321 providing separate intake recommendations for FV, as is the case in Australia (Go for 2&5  
322 campaign).

323 From a nutrition research perspective, the lack of PS knowledge presented within this study  
324 emphasises the complexities of measuring FV intake using self-report measures. For example, some  
325 measures of dietary intake, including FFQs, require respondents to report their frequency of  
326 consumption of FV based on an ‘average portion’. However, this research has highlighted that  
327 people are not necessarily aware of what a standard portion of FV equates to according to UK  
328 guidelines, and hence the validity of such data might be compromised. In terms of implications for

329 the assessment of FV intake in the future, researchers should seek to use detailed measures (e.g. diet  
330 histories/food diaries) and should provide assistance to respondents when quantifying FV intake  
331 (e.g. through the use of a food PS atlas), rather than relying on individuals' perceptions of FV  
332 portions. Alternatively, if using FFQs, examples of standard portions for each type of FV should be  
333 provided in an attempt to increase accuracy of reporting.

334 One of the key messages advocated by the '5-a-day' campaign is the importance of consuming a  
335 variety of FV. Conversely, this work showed that one of the prime misunderstandings surrounding  
336 FV consumption is related to misconceptions about variety. For example, during the FGs, a number  
337 of individuals indicated that they had previously thought eating five of the same FV would suffice  
338 in terms of achieving the '5-a-day' guidelines. Similarly, Carter *et al.* [16] also found that a sample  
339 of Australian participants were unclear as to whether FV intake guidelines stipulated that five  
340 different FV needed to be consumed each day. These are again important findings in terms of the  
341 probability that people are misjudging the adequacy of their FV intake. Participants in the current  
342 study also conveyed the notion that eating five of the same FV was unappealing and an unrealistic  
343 target in relation to their satiety. Hence education on consuming a variety of FV, particularly within  
344 meals, could make the guidelines more achievable.

345 In terms of why consumers lack understanding on FV intake guidelines including PSs, there are a  
346 number of proposed explanations. The first, and perhaps most obvious reason, could simply be a  
347 result of a lack of education. Within the current study, for example, the majority of participants  
348 claimed to have had received limited information about FV PSs, except occasionally from packaged  
349 FV sources. A second potential reason, which was raised by participants in this study, is the  
350 confusion generated by the substantial variation in the amounts of FV needed to make up one  
351 portion.

352 In terms of the future, and how knowledge on achieving a portion of FV could be increased, the  
353 results from the FGs suggested a collaborative effort is required from the food industry (e.g.  
354 packaging), retailers (e.g. supermarket displays and eateries) and health promotion bodies (e.g.  
355 campaigns and promotional material). With regards to PS information on packaged FV, it is perhaps  
356 worth noting that, at present, no regulations exist within the UK in relation to making claims on the  
357 portions provided by FV products. Manufacturers are not obliged to display such details, and thus  
358 there is great inconsistency with regards to the level of information currently provided.

359 Furthermore, there is evident variability in the methods used to communicate PS information to  
360 consumers (e.g. various logos have been employed). In order to increase consumer awareness and  
361 confidence in the accuracy of such information, there is a need for clear guidance and regulation to  
362 be provided to the UK food industry regarding FV PS.

363 What was ambiguous from the current study was how PS information would best be communicated  
364 in terms of grams/household measures. Future studies should seek to clarify this issue. Last but not  
365 least, future public health campaigns should investigate not only whether increasing PS information  
366 can reduce confusion and increase understanding (knowledge), but also whether it has the potential  
367 to facilitate long-term increases in FV consumption (behaviour).

### 368 **Strengths and Limitations**

369 This study provides some of the first evidence surrounding consumer understanding of FV  
370 guidelines within the UK, including the novel topic area of FV PSs. However, the findings should  
371 be interpreted in light of some limitations. Firstly, the generalisability of the sample is questionable,  
372 as it comprised a small number of mostly of well-educated individuals with normal BMIs. The  
373 former may have had implications in terms of how knowledgeable the participants were about FV  
374 guidelines. However, the sample of low FV consumers represented an ideal opportunity to  
375 investigate understanding of intake guidelines. Secondly, whilst the FGs were held as close as  
376 possible to the start of the four week intervention, participants may have sought information on FV  
377 from the research team during prior feeding sessions which could have influenced their attitudes.  
378 Similarly, although the quantitative questionnaire was distributed at the beginning of the study, it is  
379 possible that participants may have acquired some information on FV at screening visits. However,  
380 this was unavoidable as the questionnaire could not have been distributed before individuals were  
381 deemed eligible, and consented onto the study. Furthermore, the question assessing knowledge of  
382 the '5-a-day' message may have facilitated guessing which could have potentially inflated the  
383 accuracy score. Finally, the questionnaire was not validated nor formally piloted prior to use. Whilst  
384 one existing validated questionnaire contains questions on FV PS knowledge [20], it assessed  
385 knowledge on a limited number of foods and did not examine understanding surrounding sources of  
386 FV, which was a key aspect of the current paper. In comparison to most previous studies assessing  
387 knowledge surrounding FV intake guidelines, including FV sources and FV PS, the questionnaire

388 used in the current study measured knowledge based on a greater number of items, making it one of  
389 the most comprehensive measures to date.

390 In conclusion, this study showed some mis-understanding surrounding the UK ‘5-a-day’ message,  
391 including what foods are included within the guideline. It also emphasised a lack of knowledge with  
392 regards to FV PS, although further studies are needed to replicate these findings in larger, more  
393 diverse samples. Future public health campaigns should attempt to address these mis-conceptions  
394 and gaps in knowledge, and incorporate evaluations that will allow impact of future initiatives on  
395 knowledge, and ultimately behaviour, to be investigated.

### 396 **AWKNOWLEDGEMENTS**

397 The authors declare that they have no conflicts of interest. Funding for the BIOFAV study was  
398 provided by the Medical Research Council (G0901793) to investigate the development of novel  
399 biomarkers of fruit and vegetable consumption. We also gratefully acknowledge the [removed for  
400 blinding purposes] for providing the funding to write this manuscript. We are very grateful for the  
401 volunteers who took part in this research. Thanks also to the technical assistance of Drs [removed  
402 for blinding purposes] and [removed for blinding purposes].

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