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Title: Measuring consumer emotional response and acceptance to sustainable food products

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Abstract

With current global challenges such as population growth, climate change and water scarcity, it is critical to develop sustainable strategies to achieve food security. One way to tackle this is by developing new products that use alternative and more sustainable ingredients. Bambara groundnut is a low-impact African legume as it can be grown on marginal soils and is resistant to high temperatures. The aim of this study was to investigate UK consumer acceptability and emotional response to snack products containing Bambara groundnut flour as an alternative sustainable ingredient. A key objective was to understand the contribution that measuring emotional response would reveal. Additionally the impact of extrinsic information on consumer acceptability and emotional response to snack products was investigated by sharing information concerning Bambara groundnut's sustainability and nutritional credentials. 100 UK participants were recruited to evaluate two biscotti and two cracker products. For each category a standard product made from standard ingredients sourced commercially, and one made replacing some of standard flour with Bambara flour were obtained. For each sample, participants were asked to rate their overall liking and emotional response based on sensory properties of the product (the blind condition). Participants were invited back for a second session, where they were informed about global resource challenges, and the sustainable features and nutritional value of Bambara,

and which products contained this as an ingredient (informed condition). Under the blind condition, no significant differences in overall liking were observed between standard and Bambara products, indicating UK consumers accept the sensory properties of products that contain Bambara flour. Interestingly, the extrinsic information shifted consumer emotional response towards more positive emotions and less negative emotions when consuming products containing Bambara flour. It also made them felt less *guilty* when consuming the Bambara products, suggesting consumers engage with the idea of sustainable ingredients, and that this sustainable ingredient has potential for future new product development. It also highlighted the value of measuring emotional response for novel products to understand what may drive purchase behaviour when products are matched for liking. Food neophobia status did not impact product acceptability and emotional response between Bambara and standard products, however overall a lower emotional response was found for medium neophobic consumers in general who are more likely to evade novel products.

Key words: Bambara groundnut, emotion response, liking, food neophobia, sustainable ingredient

1. Introduction:

Food security is defined by the United Nations as where 'all people, at all times have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life' (World Food Summit, 1995). With current global population growth and a prediction that this will reach over 10 billion people by 2050 (FAO, 2009), the goal of improving global food security faces a number of challenges including climate change (Cox, Betts, Jones, Spall, & Totterdell, 2000) and water scarcity (Butler, 2017). Sustainable strategies that enable agricultural production increase, waste reduction, and development of alternative sustainable novel ingredients for food processing are urgently needed. With increased public interest in sustainable food products, consumer attitude and acceptance of novel sustainable food products or ingredients is an important determinant of a novel product's implementation and commercialisation.

Global demand for rice and wheat is projected to increase one third by 2025 (FAO, 2017). With climate change, water sacrifices and land degrading, sustainable crop

production is crucial. Rice and wheat crops represent one of the largest agricultural productions in the world, however, both crops require intense labour, water, capital and energy to maintain a good yield, especially in hot climates (Bhatt, Kukal, Busari, Arora, & Yadav, 2016). Much research has been conducted to increase the yield of rice and wheat cropping systems to achieve more sustainable agriculture (Bhatt et al., 2016; Chauhan, Mahajan, Sardana, Timsina, & Jat, 2012) but another approach could be exploring alternative sustainable crops that require less water and energy.

Sensory properties of food are known as one of the most important factors in consumer food choice (Carrillo, Varela, Salvador, & Fiszman, 2011). However, other extrinsic characteristics including health related claim, ethics, brands, product origin, production method and product description, have also been demonstrated to influence food acceptability and choice (Annunziata & Vecchio, 2013; Binninger, 2015; Morris, Beresford, & Hirst, 2018; Wansink, van Ittersum, & Painter, 2004). Research has shown that health related claims increase consumer liking of processed bread (Johnson & Anderson, 2010) and exotic fruit juice (Vidigal, Minim, Carvalho, Milagres, & Gonçalves, 2011). However, limited or opposite effects have been found for other products categories such as biscuits (Carrillo, Varela, & Fiszman, 2012), and alcohol-free wine (Meillon, Urbano, Guillot, & Schlich, 2010), indicating the effect of health claims is dependent on product type (Fernqvist & Ekelund, 2014). Sustainable information such as fair trade and animal welfare have also been shown to have a significant effect on consumer liking (Carrillo et al., 2012; Grankvist, Marmendal, & Lekedal, 2007). However, limited studies have investigated the impact of global challenge information on products containing sustainable ingredients.

With a global competitive market and increasing consumer wants and needs, food and beverage companies face challenges of developing new products to meet increasing consumer demands but the failure rate of new food products is particularly high (above 80%) (Castellion & Markham, 2013). For unfamiliar products this could partly be due to a psychological trait – food neophobia. Food Neophobia is defined as the unwillingness or refusal to try or eat new or unfamiliar food (Pliner & Hobden, 1992). Research has also found that neophobic tend to have lower acceptance to food in general (Henriques, King, & Meiselman, 2009). Barrena and Sánchez (2013) reported that food consumption has an emotional component more pronounced in neophobic

using laddering interviews techniques, however so far no research has explored Food neophobia status quantifying emotional response associated with novel food.

The majority of research investigating the impact of extrinsic characteristics and psychological traits on consumer response focuses on consumer liking and purchase intention (Lange, Martin, Chabanet, Combris, & Issanchou, 2002; Mueller Loose, Osidacz Williamson, Francis, & Lockshin, 2010) rather than emotional response. The interest in measuring emotional response to foods and beverages has increased dramatically in the field of sensory and consumer science in the last decade. The motivation behind this is that it has been shown that emotional response to foods and beverages provides additional information beyond classic food preference testing (King & Meiselman, 2010; Ng, Chaya, & Hort, 2013a; Yang, Dorado, Chaya, & Hort, 2018). Sensory properties of food have been shown to elicit different emotions, for example, non-added sugar squash elicited more negative emotions, whereas standard squash elicited more positive emotions (Ng, Chaya, & Hort, 2013a). In order to measure emotional response elicited by food, several self-report questionnaires have been developed (Chaya et al., 2015; Mora, Giussani, Pagliarini, & Chaya 2019; King, Meiselman, & Thomas Carr, 2013; Nestrud, Meiselman, King, Lesher, & Cardello, 2016; Ng et al., 2013a). The most popular used emotional questionnaire EsSense 25 is a shorter version of EsSense profile, which is applicable for evaluation of a wide range of food and beverages (Nestrud et al., 2016).

Bambara groundnut (Vigna subterranea (L.) Verdc.) is one of the most important legumes in terms of consumption and socioeconomic impact in semi-arid Africa (e.g. Zimbabwe and Nigeria) and can also be found in Asian countries (e.g. Indonesia, Malaysia and Thailand) (Hillocks, Bennett, & Mponda, 2012; Murevanhema & Jideani, 2013; Okpuzor, Ogbunugafor, Okafor, & Sofidiya, 2010). Bambara can be cooked directly e.g. boiled, eaten as a nut snack (Aviara, Lawal, A Atiku, & A Haque, 2013; Murevanhema & Jideani, 2013) or roasted and used in preparing soup (Adu-Dapaah & Sangwan 2004). It is also used as a food ingredient by grounding the nuts into a flour to make bread, cake or Okpa (Linnemann, 1993, Okpuzor, Ogbunugafor, Okafor, & Sofidiya, 2010). Bambara puts limited demands on the soil and is capable of growing in nutrient poor soils where most crops would not thrive (Chibarabara, Modo, & Mabhaudhi, 2015). With the effects of climate change and reduced rainfall

patterns, Bambara groundnut is believed to be a climate-resilient crop due to its high efficiency of resource capture and conversion which contributes to crop productivity under drought, thus Bambara groundnut could be an alternative crop in severe climate change situations (Mwale, Azam-Ali, & Massawe, 2007, Mayes, Ho, Massawe, Mayes, 2019; Mayes et al., 2019). However, intensive production using fertilisers could lead to negative impact on ecosystem, where a long term strategy for monitoring and managing soil quality is also needed (Chojnacka et al., 2019). In addition to its hardy sustainable nature, Bambara also has a relatively good nutrient profile that is comparable to wheat; it is high in carbohydrate (65%) and relatively high in protein (18%), as well as having sufficient quantities of fat (6.5%) (Murevanhema & Jideani, 2013). Furthermore, research has suggested Bambara flour can be used as a wheat replacement in certain products, as a gluten free ingredient (Hillocks et al., 2012). Bambara could be an alternative ingredient to rice and wheat flour for some food products, and has become a popular plant with researchers and food producers as a potential way to tackle food security (Aviara et al., 2013; Fasoyiro, Widodo, & Taiwo, 2012). In the UK, however, Bambara remains a novel ingredient.

The aim of this study was to investigate UK consumer acceptability of snack products containing a novel sustainable ingredient: Bambara flour. A key objective was to investigate the value of measuring consumer emotional response when evaluating products containing novel ingredients. In addition, the impact of informing the consumer about the sustainable/nutritional credentials of Bambara in the context of global security on product acceptability and consumer emotional response was also of significant interest. Finally, the role of food neophobia in consumer acceptability and emotional response to products with novel ingredients was also evaluated.

2. Materials and Methods:

2.1. Subjects:

This study was approved by the University of Nottingham Medical School ethics committee (approval code: 90-1706). All participants were gave written informed consent and were offered a disturbance allowance for taking part in the study. In total, 100 healthy British adults (76F, 24M), ages 18 to 74 yrs, stratified into three age groups (18-30yrs, 31-50yrs, 51-74yrs), were recruited, subject characteristics are shown in

Table 1. British subjects were selected to represent western consumers who would be unfamiliar with a novel sustainable crop. Participants who were allergic/intolerant to nuts, eggs, and/or gluten were excluded from this study.

2.2. Products

A number of successful recipes substituting Bambara with other ingredients have previously been developed at Crops for the Future Research Centre (CFF) Malaysia. From these, a sweet snack (biscotti) and a savoury snack (cracker) were selected for this study as they are popular products in the UK, and they allowed the examination of any differences between sweet and savoury products. In total, four samples, across two product categories (sweet biscotti and savoury crackers), were evaluated (Figure 1). Using an initial recipe obtained from colleagues at the CFF Malaysia, traditional wheat or rice flour was partially replaced with Bambara flour to make more sustainable snack products in the Food Processing Facility at University of Nottingham (Figure 1a &1c). The final formulation for the Bambara biscotti was 29% egg white, 25% caster sugar, 21% wheat flour, 7% Bambara flour, 18% almond and salt. The final formulation for the Bambara crackers was 71% Bambara flour, 18% rice flour, 11% vegetable oil, salt and pepper. The second product in each category, the standard product [biscotti (Sapori Siena, Colussi Group, Italy) and crackers (Peter's Yard, UK)), Figure 1b & 1d)], was sourced commercially to be close to the sensory properties of Bambara products. However, it is worth noting that the sensory properties were perceived to be different by consumers and a brief description of the differences reported by consumers is given in Section 3.2. Estimated nutrition composition were illustrated in Table 2.

2.3. Overall Liking

Subjects were asked to rate how much they liked each sample on a labelled affective magnitude (LAM) scale (Schutz & Cardello, 2001).

2.4. Emotional response

EsSense25 (Nestrud et al., 2016) was employed to collect emotional response data. It consists of 16 positive (*active, adventurous, calm, enthusiastic, free, good, good-natured, happy, interested, joyful, loving, nostalgic, pleasant, satisfied, secure* and *warm*), 3 negative (*bored, disgusted*, and *worried*), and 6 unclassified emotional terms (*aggressive, guilty, mild, tame, understanding* and *wild*). For each emotional term, a

line scale labeled “not all at” on the left and “extremely” on the right was presented. Participants were instructed to mark the very left of the scale if the emotional term did not apply.

2.5. Food Neophobia Status

Participants were requested to complete the Food Neophobia questionnaire (FNQ) (5 neophobic statements and 5 neophillic statements) using 7-point scales increasing from strongly disagree to strongly agree (Pliner & Hobden, 1992). Scores for items with neophilic statements were reversed and included ‘I am constantly sampling new and different food’, ‘I like foods from different cultures, ‘At dinner parties, I will try new foods’, ‘I will eat almost anything’, and ‘I like to try new ethnic restaurant’. The range of neophobic scores obtained from this study was 10 to 47. The higher the score the more neophobic an individual is. Participants were classified as low neophobic (score ≤ 21, mean score = 16.2) and medium neophobic (score >21, mean score = 29.3) according to the group median score.

2.6. Procedure

Participants were invited to attend two sessions in sensory booths at the sensory laboratory at the University of Nottingham lasting approximately 30 minutes each. As the look of the Bambara samples had not been commercially optimised, product evaluation was performed under red light to mask differences in product appearance. Participants were instructed to refrain from eating and drinking any strong flavoured food and drink an hour before the tasting session.

Each sample, as shown in Figure 1, was broken into two equal pieces before serving and four pieces of each product were provided to each participant. In the first session participants were asked to consume one piece of each product and rate how much they liked the product, then consume at least another two pieces of the samples and rate how the samples made them feel using the EsSense25 questionnaire. The presentation order of the emotion items was randomised across participants, but the same order was kept for each consumer (King et al., 2013).

In the second session, a 10 minutes presentation (presentation slides were included in supplementary data) was given to participants to inform them of the challenges in global food security including the impact of population growth, climate change and water scarcity on food production. The key sustainable features of the Bambara plant, including drought resistance, ability to produce a reasonable crop on poor soils and long shelf life were also introduced. Finally, the nutritional benefits of Bambara were briefed, such as high carbohydrate (65%), relatively high protein (18%) and fat content (6%). Participants were subsequently asked to rate their overall liking and emotional response to each product following the same procedure as the first session, apart from the fact that participants received a message on their computer screen to inform them if the product was made using Bambara or not. Samples were presented monadically and followed a randomised balanced design during both sessions. An additional comment box was provided after the overall liking question asking participants to indicate why they liked/disliked the products. Data were collected using Compusense Cloud (Compusense, Canada). A two-minute break and water (Evian, France) were given as a palate cleanser between samples.

2.7. Data analysis:

In order to examine the impact of the product and extrinsic information on emotional response and overall liking, a two-factor mixed model analysis of variance (ANOVA), with participants as a random effect, was applied for each product category (biscotti and cracker) respectively. Two-way interactions were included in the ANOVA to determine if a product and condition (extrinsic information) interaction existed. Where significant interactions were observed, further fisher's least significant difference (LSD) tests were applied to identify the specific differences. A multiple factor analysis (MFA) was used to visualise the impact of information on consumer response to the two products.

A Chi-square analysis was used to examine for association between Food Neophobia group (FNG) and age/gender. In order to examine the impact of FNG on overall liking and emotional responses, a three-factor ANOVA was applied for each product category, with product, condition and FNG as factors.

3. Results and Discussions:

3.1. UK consumer acceptability of Standard v Bambara formulated products

As shown in Figure 2, no significant difference in overall liking between the standard and Bambara products were observed for both product categories ($p>0.05$). This indicates that UK consumers accept the sensory properties of the products made by replacing some of the flour with Bambara flour.

3.2. Consumer emotional response to Standard and Bambara products in blind condition

Although no differences were observed for acceptability, some emotional responses were significantly different ($p\leq0.1$). For biscotti, participants felt significantly more *good_natured* ($p=0.01$), *happy* ($p=0.03$) and *joyful* ($p=0.05$), and increased feelings of *enthusiastic* (0.07), *good* (0.08), *interested* ($p=0.1$), *satisfied* ($p=0.08$) and *warm* ($p=0.06$) were approaching significance when consuming standard biscotti (Figure 3a). The standard crackers evoked significantly higher *calm* ($p=0.01$), *mild* ($p=0.04$) and *tame* ($p=0.003$) emotions, but less *disgusted* ($p=0.05$) and *aggressive* ($p=0.03$) emotions than Bambara crackers (Figure 3b).

Agreeing with previous findings (Chaya et al., 2015; King et al., 2013; Spinelli, Masi, Zoboli, Prescott, & Monteleone, 2015; Yang et al., 2018), this suggests that emotional response is more discriminating than overall liking. It also indicates that emotional response is better to help developers understand consumer enjoyment of food products and subsequent engagement/purchase compared to measuring liking alone.

In the blind condition, the differences in emotional response between standard and Bambara samples will be evoked due to differences in their sensory characteristics. Although sensory properties were not characterised in this study, the comments box provided for participants demonstrated that Bambara biscotti were perceived to be more nutty and hard than standard biscotti. Bambara crackers were perceived as more peppery, nutty and grainy than commercial crackers, whereas commercial crackers were perceived as more bland. This indicates that Bambara flour may add an additional nutty flavour to the products and has an impact on the texture of the final product which could contribute to consumer emotional engagement with the products. More insights are required, but this suggests any new product development, as would

usually be the case, would need to take into consideration the changes using Bambara groundnut as an ingredient would bring to the sensory properties.

When looking at the two product categories (biscotti and cracker) in general, as expected, overall liking was rated significantly higher for biscotti (63.9 and 66.8 for Bambara and standard biscotti) than for crackers (46.5 and 49.5 for Bambara and standard crackers). Biscotti also evoked higher positive emotional responses (12 out of 14) than crackers (data not shown here), indicating consuming sweet foods triggered more positive emotions than consuming savoury foods. This aligns with Rousmans, Robin, Dittmar, and Vernet-Maury (2000)'s findings that out of all the tastes, consumers typically like sweetness most. Interestingly, the findings from the current study showed participants also felt *guiltier* when consuming sweet snacks over savoury snacks. This supports a recent finding where a sweet ice tea evoked a much higher *guilty* emotion than less sweetened ice tea (Yang, Kraft, Shen, MacFie, & Ford, 2019).

It should be noted that use of a continuous line scales for emotional measures and a labelled magnitude scale, although still a continuous line scale, for liking, could impact participant use of scale and is a potential question for future research.

3.3. The impact of extrinsic information (global challenges and product sustainable features) on overall liking and emotional response

For overall liking, no significant *product*condition* interaction was found for either product category (biscotti (p=0.16) and cracker (p=0.12)), indicating extrinsic information did not impact on consumer acceptability (liking) of the samples. This indicates that knowledge of the use of the novel Bambara flour has no detrimental effect on liking.

However, when looking at emotional response to biscotti, a significant *product* condition* interaction was observed on 6 positive emotions (*active* (p=0.02)*, adventurous* (p=0.02)*, happy* (p=0.005)*, good* (p=0.05)*, good-natured* (p=0.008)*, interested* (p=0.003), and one unclassified emotion (*guilty*) (p=0.03) (Figure 4). Interestingly, when participants were informed, they felt significantly less *guilty* when consuming Bambara biscotti (p=0.001), but no significant difference was found

between the two products when tasted in the blind condition (p=0.2). In the blind condition, standard biscotti evoked significantly higher *active* (p=0.03), *good_natured* (p=0.0001), *happy* (p=0.002), *good* (p=0.02) and *interested* (p=0.02) emotions than Bambara biscotti. However, after participants were informed, no such different emotional responses were found (p>0.05). It should be noted that previous studies have reported a tasting order effect on acceptability and emotional response measures (Dorado, Pérez-Hugalde, Picard, & Chaya, 2016; Macfie, Bratchell, Greenhoff, & Vallis, 1989), however, balancing the two sessions was not possible in this study. Repeated exposure has been shown to increases liking of novel food such as vegetables (Appleton, Hemingway, Rajska, & Hartwell, 2018; Lakkakula, Geaghan, Zanovec, Pierce, & Tuuri, 2010). However, this is unlikely to be the reason behind the differences here. When participants were informed, Bambara biscotti evoked significantly higher *active* (p=0.01), *good_natured* (p=0.03) and *adventurous* (p=0.05) emotions than when tasted blind, but no significant differences were found for *active* and *good_natured (p>0.05)* for standard biscotti. Instead, a significantly lower *adventurous* (p=0.04) score was observed after participants were informed for standard biscotti. In addition, standard biscotti also evoked significantly lower *happy* (p=0.05) and *interested* (p=0.02) emotions when informed, but no significant difference was found for Bambara biscotti (p>0.05). The condition effect was different between standard and Bambara biscotti, thus it is unlikely differences are due to order effect or repeated exposure in this investigation.

For crackers (Figure 5), a significant *product*condition* interaction was found for two positive emotions (*interested* (p=0.005) and *good_natured* (p=0.007)*,* one negative emotion *(disgusted (p=0.02)) and* two unclassified emotions *(aggressive (p=0.02)* and *guilty*) (p=0.005)). In line with biscotti's finding, in the blind condition, Bambara crackers evoked a significantly higher *guilty* emotion than standard crackers (p=0.05), however, after participants were informed, participants felt significantly less *guilty* when consuming the Bambara product (p=0.05). In the blind condition, the Bambara sample evoked significantly higher *disgusted (p=0.009)*, *aggressive* (p<0.001) emotions, but such differences diminished when participants were informed (p>0.05). Interestingly, after participants were informed, Bambara crackers evoked a significantly higher *interested* emotion than standard crackers (p=0.001), but no significant difference was found for standard cracker (p=0.7).

One of the limitations of this experiment is that no dummy sample is used in this experiment. First position has shown to have a strong effect on liking and emotional response previously (Dorado, Pérez-Hugalde, Picard, & Chaya, 2016; Macfie, Bratchell, Greenhoff, & Vallis, 1989). However, the presentation order is balanced across commercial and Bambara products, and across product categories (biscotti and cracker), the first order effect is counterbalanced across different samples.

The application of MFA enabled an overall comparison of the two conditions to be obtained on a single map. The correlation circle, as shown in Figure 6, indicates that the blind and informed conditions heavily loaded on the first dimension, which accounted for 72.65% of the variance. The second dimension accounted for 19.85% of the variance. The first dimension (F1) was positively correlated with all positive and most of unclassified emotion items, and negatively correlated with *bored, disgusted, worried*, and *aggressive* emotions. The second dimension (19.85%) positively correlated with unclassified emotion *wild* and *adventurous*, and negatively correlated with *tame* and *mild* emotions.

As shown in Figure 7, after participants were informed, the Bambara biscotti and cracker shifted towards the right on the first dimension, indicating sharing the global challenges, sustainable features and nutritional content of Bambara flour made consumers feel more positive about the products. Interestingly, an opposite trend was found for standard products, the informed condition shifted consumer emotional response towards the left on dimension 1, indicating consumers felt more negative about the standard products if the ingredients were not as sustainable as those with Bambara.

It is well known that product information affects consumer perception of a product. Cardello (2003) found that a safety and benefit statements have a positive impact on expected product liking with novel food processing technologies. Choi and Lee (2019) reported that extrinsic information (packaging) increased product liking for those products that were familiar to consumers. The results from the current study failed to find a significant impact of extrinsic information on liking; however, emotional response

demonstrated that presenting extrinsic information about global challenges and bambara, shifted consumer emotional response towards more positive emotions.

One of the limitations of this study is that the extrinsic information presented contained three different pieces of information (global challenge, sustainable features and nutritional content), making it difficult to identify which element was the driver behind consumer response changes, or indeed, which combination of elements. However, this study adds evidence to the current literature that product information could improve consumer emotional response toward a new product containing sustainable ingredients, indicating consumers are generally interested in sustainable ingredients.

Liking data frequently fails to discriminate between products of a similar quality and is often unsuccessful in predicting consumer product engagement and purchase. It is increasingly evident that collecting measures of consumer emotional response provides further insights into the consumer-products relationship. However, the increase in positive emotional response for the Bambara products, despite equity in liking with the standard product, once they were informed of its global credentials means that consumers are not simply judging on sensory experience alone. This suggest consumers would want to engage with the Bambara product, assuming a similar price point. Measuring and understanding the emotional response to a product's eating experience alongside its sustainability credentials appears to be an important step for product developers. Understanding the interplay between the influence of the sensory properties and external factors appears to be an important step for developers and marketers when introducing future sustainable foods.

3.4. The impact of food neophobia on overall liking and emotional response

A significant association between FNG and age group was found (p=0.03), where older participants were more likely to be medium neophobic (76% of 51 -75yrs), compared to 43% of the younger participants (18 – 30yrs) (Table 1). This finding supports previous findings that young people are more willing to accept unfamiliar food compared to older adults (Tuorila, Lähteenmäki, Pohjalainen, & Lotti, 2001; van den Heuvel, Newbury, & Appleton, 2019). In other words, food neophobia may be a barrier for novel food consumption, especially in older adults. However, caution needs to be taken when interpreting the data, as there was only a small sample size (n=16 and 17

in the middle and older groups). It would be interesting to investigate the effect of age on liking and emotional response to food with novel ingredients, however this investigation is challenged with an unbalanced sample size and the confounding effect with Food Neophobia. Further study with balanced numbers of participants in each age group would be needed to investigate this further. In addition, no significant association was found between FNG group and gender distribution ($p=0.8$) in the current sample size. But it is worth noting that the gender is unbalanced in the current study.

No significant *FNG*condition* and *FNG*product* interactions were found for each product category ($p>0.05$), thus the data were pooled together within each product category to explore the overall food neophobia effect. For overall liking, no significant FNG effect was found for either product category ($p>0.05$), indicating Food Neophobia did not affect the acceptability of these two product categories.

Tuorila, Lähteenmäki, Pohjalainen, & Lotti (2001), a larger cohort study (n=1083), classified low neophobia group scores between 10 to 22.4, medium neophobia group scores between 22.5 to 45.3 and high neophobia group scores between 45.4 to 70. In the current study, the range of food neophobia scores is between 10 to 47, suggesting the participants here were generally low to medium neophobics, rather than high neophobics. This is not surprising as those willing to participate in a sensory study are more likely to have the willingness to try new foods.

When looking at emotional response, low-neophobic participants rated biscotti significantly higher on *adventurous, enthusiastic, aggressive, enthusiastic, good, interested, loving, nostalgic, secure, bored, aggressive tame* and *wild* emotions, compared to medium neophobic participants ($p<0.05$) (Figure 8a). For crackers, low neophobic participants rated *adventurous, enthusiastic, good, happy, interested, joyful, loving, nostalgic, pleasant, satisfied, warm, worried, aggressive, tame, understanding* and *wild* significantly higher than medium neophobic participants ($p<0.05$) (Figure 8b). This finding is interesting, as a heightened emotional response was observed for low neophobic participants regardless of positive or negative emotions, but a stronger effect was generally found for positive emotions. Laureati et al., (2018) found that low

food neophobic participants (score ≤18) liked strong tasting vegetables and beverages (e.g. bitter, sourness, astringent and alcohol) significantly higher than medium and high food neophobic participants did. A lack of significant difference on overall liking was found in this study, which could be due to the cohort in this study being more aligned to a low neophobic population (Low (mean score =16.2) and Medium (mean score = 29.3)), whereas, in Laureati et al., (2018)'s study, three food neophobia groups were identified (Low (mean score = 14.2), Medium (mean score = 26.1) and high (mean score = 43.3)). To date little research has investigated the link between food neophobia and emotional response to food, although one study has found a link between food neophobia and food disgust (Hartmann & Siegrist, 2018). More research is now needed to investigate this possible relationship.

4. Conclusion

This study found no significant difference in liking for standard and Bambara products within both biscotti and cracker categories respectively, indicating the sensory properties of products made with Bambara flour are acceptable for UK consumers, and that Bambara flour and wheat/rice flour are interchangeable, at least to the extents used here.

However, differences were observed between standard and Bambara products regarding emotional response, indicating emotional response is a more sensitive approach to measure consumer perception to products. Interestingly, extrinsic information (global challenge, sustainable features and nutritional content of the ingredient) shifted consumer emotional response toward more positive feelings for Bambara products, indicating consumers generally felt more positive when consuming products that contained sustainable ingredients. This implies that including such information in product promotion can improve consumer engagement with sustainable products.

This highlighted an important opportunity to understand the relative emotional drivers that engage consumers to consume more sustainable food products. Food neophobia status did not further interact with acceptability and emotional response of Bambara and standard products, however, a general lower emotional response was found for

medium neophobic individuals, indicating medium neophobic individuals may have a lower interest or emotional response to food products in general which has not been reported in the literature before.

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5. Reference:

Annunziata, A., & Vecchio, R. (2013). Consumer perception of functional foods: A conjoint analysis with probiotics (Vol. 28).

Appleton, K. M., Hemingway, A., Rajska, J., & Hartwell, H. (2018). Repeated exposure and conditioning strategies for increasing vegetable liking and intake: systematic review and meta-analyses of the published literature. *The American Journal of Clinical Nutrition, 108* (4), 842-856.

Aviara, N. A., Lawal, A., A Atiku, A., & A Haque, M. (2013). Bambara groundnut processing, storage and ultilisation in north estern nigeria (Vol. 8).

Barrena, R., & Sánchez, M. (2013). Neophobia, personal consumer values and novel food acceptance. *Food Quality and Preference, 27* (1), 72-84.

Bhatt, R., Kukal, S. S., Busari, M. A., Arora, S., & Yadav, M. (2016). Sustainability issues on rice–wheat cropping system. *International Soil and Water Conservation Research, 4* (1), 64-74.

Binninger, A.-S. (2015). *Perception of Naturalness of Food Packaging and Its Role in Consumer Product Evaluation* (Vol. 53).

Butler, D. (2017). Global Challenges: Water. *Global Challenges, 1* (1), 61-62.

Cardello, A. V. (2003). Consumer concerns and expectations about novel food processing technologies: effects on product liking☆. *Appetite, 40* (3), 217-233.

Carrillo, E., Varela, P., & Fiszman, S. (2012). Packaging information as a modulator of consumers' perception of enriched and reduced-calorie biscuits in tasting and non-tasting tests. *Food Quality and Preference, 25* (2), 105-115.

Carrillo, E., Varela, P., Salvador, A., & Fiszman, S. (2011). Main factors underlying consumers' food choice: A first step for the understanding of attitudes toward 'healthy eating'. *Journal of Sensory Studies, 26* (2), 85-95.

Castellion, G., & Markham, S. K. (2013). Perspective: New Product Failure Rates: Influence of Argumentum ad Populum and Self-Interest. *Journal of Product Innovation Management, 30* (5), 976-979.

Chauhan, B. S., Mahajan, G., Sardana, V., Timsina, J., & Jat, M. L. (2012). Chapter Six - Productivity and Sustainability of the Rice–Wheat Cropping System in the Indo-Gangetic Plains of the Indian subcontinent: Problems, Opportunities, and Strategies. In D. L. Sparks (Ed.), *Advances in Agronomy* (Vol. 117, pp. 315-369): Academic Press.

Chaya, C., Eaton, C., Hewson, L., Vázquez, R. F., Fernández-Ruiz, V., Smart, K. A., & Hort, J. (2015). Developing a reduced consumer-led lexicon to measure emotional response to beer. *Food Quality and Preference, 45*, 100-112.

Chibarabada, T. P., Modi, A. T., & Mabhaudhi, T. (2015). Water use characteristics of a bambara groundnut (Vigna subterranea L. Verdc) landrace during seedling establishment. *Water SA, 41*, 472-482.

Choi, Y., & Lee, J. (2019). The effect of extrinsic cues on consumer perception: A study using milk tea products. *Food Quality and Preference, 71*, 343-353.

Chojnacka, K., Kowalski, Z., Kulczycka, J., Dmytryk, A., Gorecki, H., Ligas, B., & Gramza, M. (2019). Carbon footprint of fertilizer technologies. *J Environ Manage, 231*, 962-967.

Cox, P. M., Betts, R. A., Jones, C. D., Spall, S. A., & Totterdell, I. J. (2000). Acceleration of global warming due to carbon-cycle feedbacks in a coupled climate model. *NATURE, 408* (6809), 184-187.

Demattè, M. L., Endrizzi, I., Biasioli, F., Corollaro, M. L., Pojer, N., Zampini, M., Aprea, E., & Gasperi, F. (2013). Food neophobia and its relation with olfactory ability in common odour identification. *Appetite, 68*, 112-117.

Dorado, R., Pérez-Hugalde, C., Picard, A., & Chaya, C. (2016). Influence of first position effect on emotional response. *Food Quality and Preference, 49*, 189-196.

FAO. (2009). How to feed the world in 2050, FAO.

FAO. (2017). The future of food and agriculture, Trends and challenges. FAO, Rome.

Fasoyiro, S., Widodo, Y., & Taiwo, K. (2012). Processing and Utilization of Legumes in the Tropics. In.

Feldman, A., Ho, W. K., Massawe, F., & Mayes, S. (2019). Bambara Groundnut is a Climate-Resilient Crop: How Could a Drought-Tolerant and Nutritious Legume Improve Community Resilience in the Face of Climate Change? In A. Sarkar, S. R. Sensarma & G. W. vanLoon (Eds.), *Sustainable Solutions for Food Security : Combating Climate Change by Adaptation* (pp. 151-167). Cham: Springer International Publishing.

Fernqvist, F., & Ekelund, L. (2014). Credence and the effect on consumer liking of food – A review. *Food Quality and Preference, 32*, 340-353.

Grankvist, G., Marmendal, M., & Lekedal, H. (2007). Values and eco‐ and fair‐trade labelled products. *British Food Journal, 109* (2), 169-181.

Hartmann, C., & Siegrist, M. (2018). Development and validation of the Food Disgust Scale. *Food Quality and Preference, 63* (Supplement C), 38-50.

Henriques, A. S., King, S. C., & Meiselman, H. L. (2009). Consumer segmentation based on food neophobia and its application to product development. *Food Quality and Preference, 20* (2), 83-91.

Hillocks, R., Bennett, C., & Mponda, O. (2012). *Bambara nut: A review of utilization, market potential and crop improvement* (Vol. 20).

Johnson, G. H., & Anderson, G. H. (2010). Snacking Definitions: Impact on Interpretation of the Literature and Dietary Recommendations. *Critical Reviews in Food Science and Nutrition, 50* (9), 848-871.

King, S. C., & Meiselman, H. L. (2010). Development of a method to measure consumer emotions associated with foods. *Food Quality and Preference, 21* (2), 168-177.

King, S. C., Meiselman, H. L., & Thomas Carr, B. (2013). Measuring emotions associated with foods: Important elements of questionnaire and test design. *Food Quality and Preference, 28* (1), 8-16.

Laureati, M., Spinelli, S., Monteleone, E., Dinnella, C., Prescott, J., Cattaneo, C., Proserpio, C., De Toffoli, A., Gasperi, F., Endrizzi, I., Torri, L., Peparaio, M., Arena, E., Bonello, F., Condelli, N., Di Monaco, R., Gatti, E., Piasentier, E., Tesini, F., & Pagliarini, E. (2018). Associations between food neophobia and responsiveness to "warning" chemosensory sensations in food products in a large population sample. *Food Quality and Preference, 68*, 113-124.

Lakkakula, A., Geaghan, J., Zanovec, M., Pierce, S., & Tuuri, G. (2010). Repeated taste exposure increases liking for vegetables by low-income elementary school children. *Appetite, 55* (2), 226-231.

Lange, C., Martin, C., Chabanet, C., Combris, P., & Issanchou, S. (2002). Impact of the information provided to consumers on their willingness to pay for Champagne: comparison with hedonic scores. *Food Quality and Preference, 13* (7), 597-608.

Macfie, H. J., Bratchell, N., Greenhoff, K., & Vallis, L. V. (1989). Designs to balance the effect of order of presentation and first-order carry-over effects in hall tests. *Journal of Sensory Studies, 4* (2), 129-148.

Mayes, S., Ho, W. K., Chai, H. H., Gao, X., Kundy, A. C., Mateva, K. I., Zahrulakmal, M., Hahiree, M. K. I. M., Kendabie, P., Licea, L. C. S., Massawe, F., Mabhaudhi, T., Modi, A. T., Berchie, J. N., Amoah, S., Faloye, B., Abberton, M., Olaniyi, O., & Azam-Ali, S. N. (2019). Bambara groundnut: an exemplar underutilised legume for resilience under climate change. *Planta, 250* (3), 803-820.

Meillon, S., Urbano, C., Guillot, G., & Schlich, P. (2010). Acceptability of partially dealcoholized wines – Measuring the impact of sensory and information cues on overall liking in real-life settings. *Food Quality and Preference, 21* (7), 763-773.

Mora, M., Giussani, B., Pagliarini, E., & Chaya, C. (2019). Improvement of an emotional lexicon for the evaluation of beers. *Food Quality and Preference, 71*, 158-162.

Morris, C., Beresford, P., & Hirst, C. (2018). Impact of food retailer branding on expectation generation and liking. *Journal of Sensory Studies, 33* (2), e12322.

Mueller Loose, S., Osidacz Williamson, P., Francis, I., & Lockshin, L. (2010). *The relative importance of extrinsic and intrinsic wine attributes: Combining discrete choice and informed sensory consumer testing*.

Murevanhema, Y. Y., & Jideani, V. A. (2013). Potential of Bambara groundnut (Vigna subterranea (L.) Verdc) milk as a probiotic beverage-a review. *Crit Rev Food Sci Nutr, 53* (9), 954-967.

Nations, U. (1975). Report of the World Food Conference. In. New York.

Mwale, S. S., Azam-Ali, S. N., & Massawe, F. J. (2007). Growth and development of bambara groundnut (Vigna subterranea) in response to soil moisture: 2. Resource capture and conversion. *European Journal of Agronomy, 26* (4), 354-362.

Nestrud, M. A., Meiselman, H. L., King, S. C., Lesher, L. L., & Cardello, A. V. (2016). Development of EsSense25, a shorter version of the EsSense Profile®. *Food Quality and Preference, 48, Part A*, 107-117.

Ng, M., Chaya, C., & Hort, J. (2013a). Beyond liking: Comparing the measurement of emotional response using EsSense Profile and consumer defined check-all-that-apply methodologies. *Food Quality and Preference, 28* (1), 193-205.

Ng, M., Chaya, C., & Hort, J. (2013b). The influence of sensory and packaging cues on both liking and emotional, abstract and functional conceptualisations. *Food Quality and Preference, 29* (2), 146-156.

Okpuzor, J., Ogbunugafor, H. A., Okafor, U., & Sofidiya, M. O. (2010). Identification of protein types in Bambara nut seeds: Perspectives for dietary protein supply in developing countries. *Excli j, 9*, 17-28.

Pliner, P., & Hobden, K. (1992). Development of a Scale to Measure the Trait of Food Neophobia in Humans. *Appetite, 19* (2), 105-120.

Rousmans, S., Robin, O., Dittmar, A., & Vernet-Maury, E. (2000). Autonomic nervous system responses associated with primary tastes. *Chem Senses, 25* (6), 709-718.

Schutz, H. G., & Cardello, A. V. (2001). A labeled affective magnitude (LAM) scale for assessing food liking/disliking. *Journal of Sensory Studies, 16* (2), 117-159.

Spinelli, S., Masi, C., Zoboli, G. P., Prescott, J., & Monteleone, E. (2015). Emotional responses to branded and unbranded foods. *Food Quality and Preference, 42*, 1-11.

Tuorila, H., Lähteenmäki, L., Pohjalainen, L., & Lotti, L. (2001). Food neophobia among the Finns and related responses to familiar and unfamiliar foods. *Food Quality and Preference, 12* (1), 29-37.

van den Heuvel, E., Newbury, A., & Appleton, K. M. (2019). The Psychology of Nutrition with Advancing Age: Focus on Food Neophobia. *Nutrients, 11* (1).

Vidigal, M. C. T. R., Minim, V. P. R., Carvalho, N. B., Milagres, M. P., & Gonçalves, A. C. A. (2011). Effect of a health claim on consumer acceptance of exotic Brazilian fruit juices: Açaí (Euterpe oleracea Mart.), Camu-camu (Myrciaria dubia), Cajá (Spondias lutea L.) and Umbu (Spondias tuberosa Arruda). *Food Research International, 44* (7), 1988-1996.

Wansink, B., van Ittersum, K., & Painter, J. E. (2004). How Diet and Health Labels Influence Taste and Satiation. *Journal of Food Science, 69* (9), S340-S346.

World Food Summit. (1996), Rome Declaration on World Food Security.

Yang, Q., Dorado, R., Chaya, C., & Hort, J. (2018). The impact of PROP and thermal taster status on the emotional response to beer. *Food Quality and Preference*.

Yang, Q., Kraft, M., Shen, Y., MacFie, H., & Ford, R. (2019). Sweet Liking Status and PROP Taster Status impact emotional response to sweetened beverage. *Food Quality and Preference*.

Figure 1: Product appearance for a- Bambara biscotti, b- standard biscotti, c- Bambara cracker, and d- standard cracker

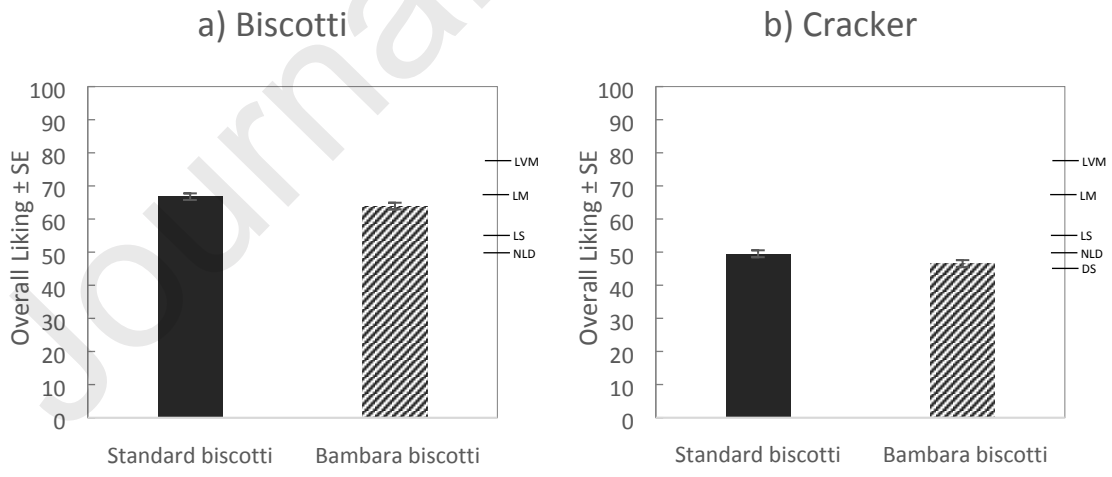

Figure 2: Overall liking between standard and Bambara product for a) biscotti and b) cracker product category. *LVM-Like very much, LM- Like moderately, LS – Like slightly and NLD- Neither like or dislike, DS- Dislike slightly*

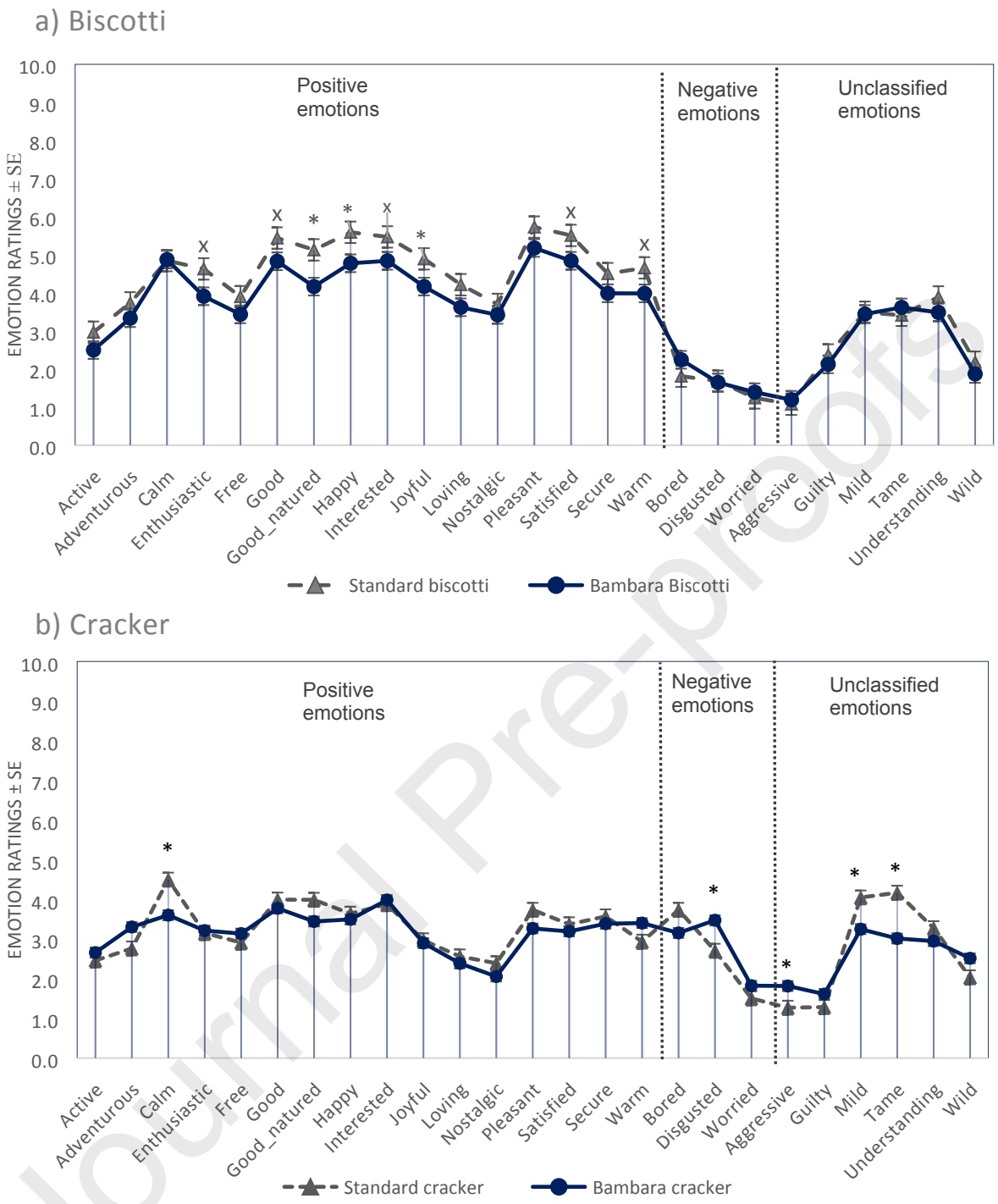

Figure 3: Effect of product on emotional response (Mean scores ± SE) for a) biscotti and b) cracker. *Symbols indicate significant difference at* $^{x}p<0.1$, $^{*}p<0.05$.

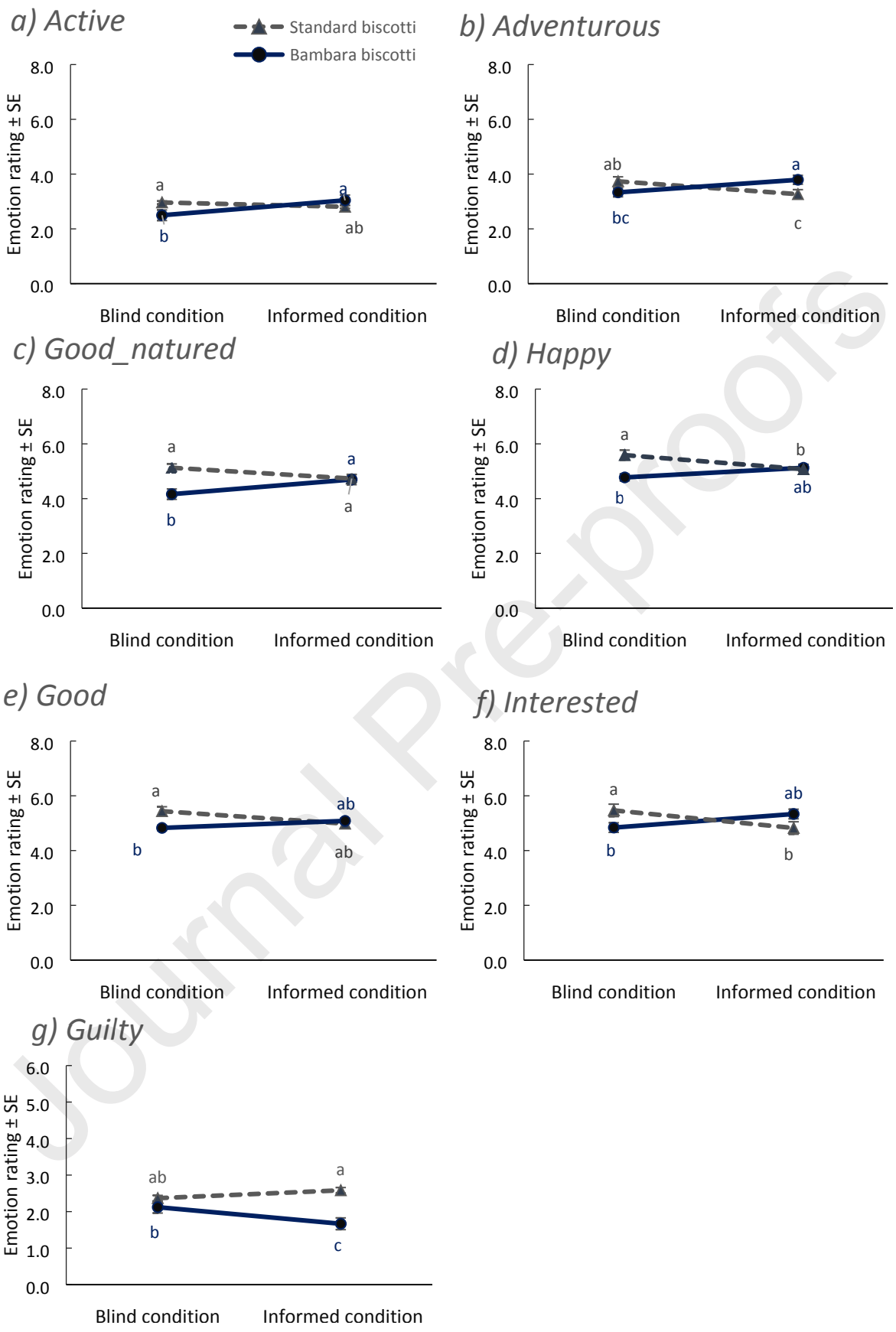

Figure 4: *Product*Condition* interaction plots of biscotti category for a) *active*, b) *adventurous*, c) *good_natured*, d) *happy*, e) *good*, f) *interested*, and g) *guilty*. ^{abc} *indicates significant difference at p<0.05.*

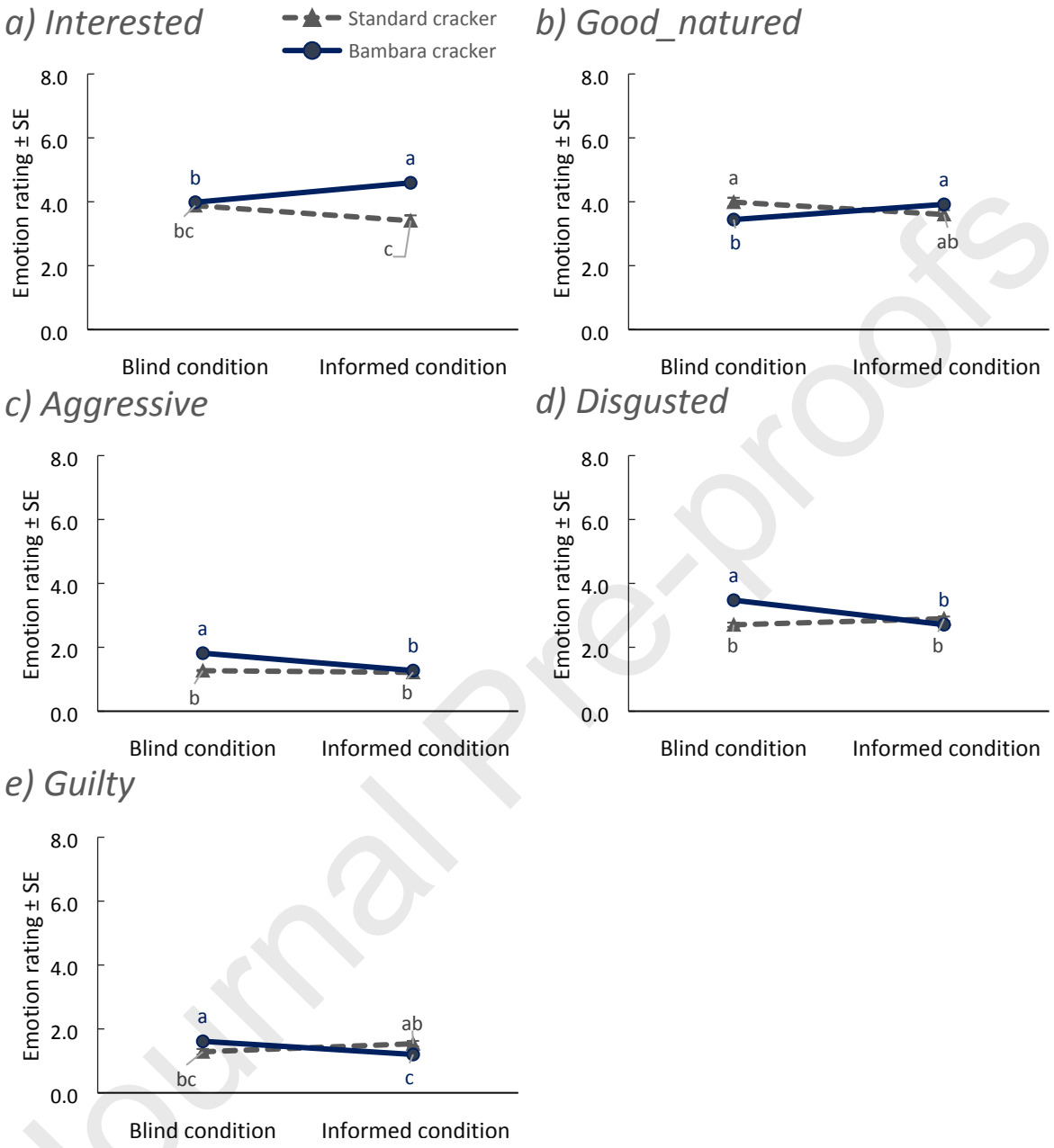

Figure 5: *Product*Condition* interaction plots of cracker category for a) *interested*, b) *good_natured*, c) *aggressive*, d) *disgusted* and e) *guilty*. ^{abc} *indicates significant difference at p<0.05.*

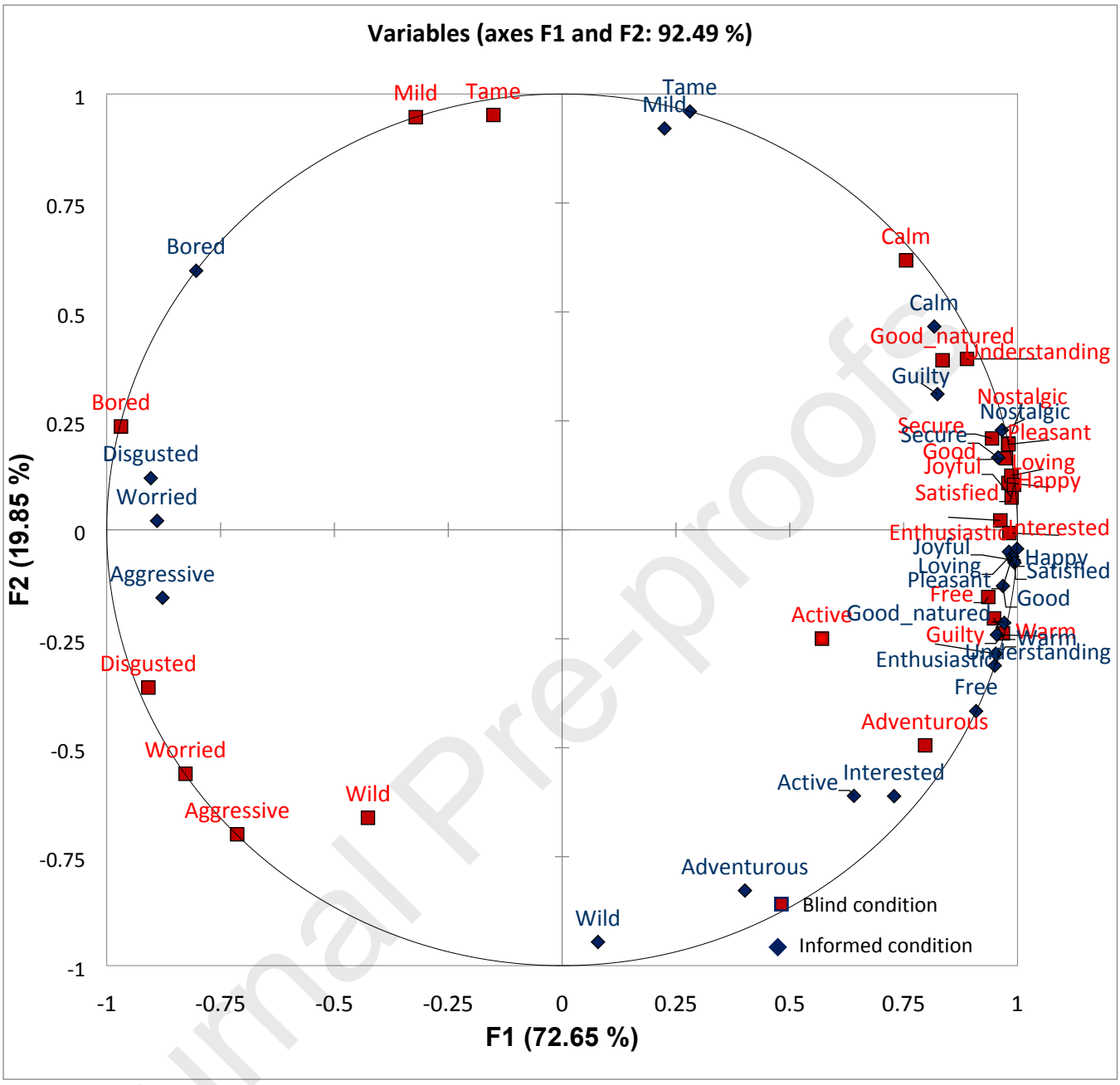

Figure 6: Correlation circle of the emotions between blind and informed condition with the first two MFA dimensions. ■ are emotions from blind condition, ◆ are emotions from informed condition.

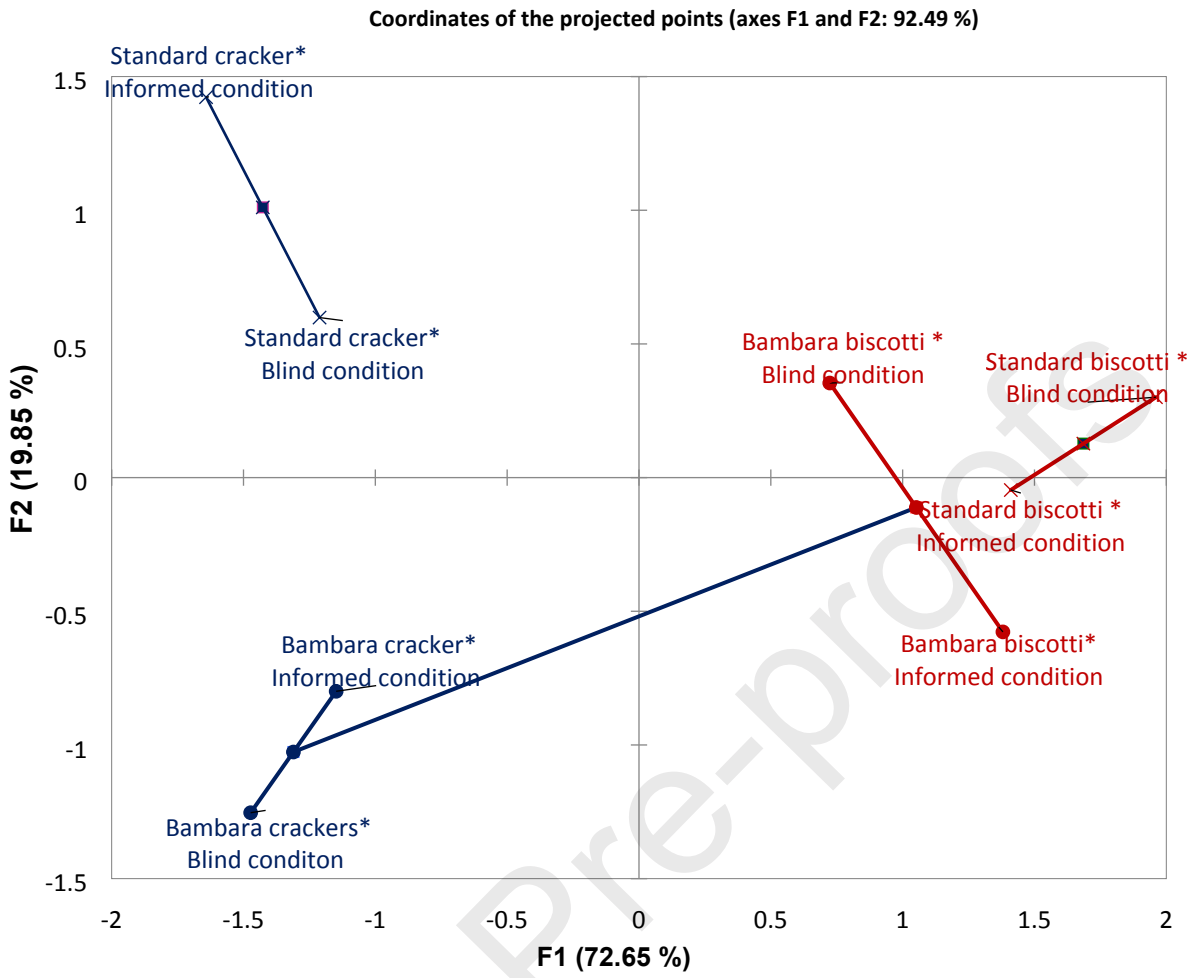

Figure 7: Superimposed representation of products in the MFA space taking in to account both sessions (each product is represented using two point corresponding to each session (blind and informed) and its compromise position in the middle)

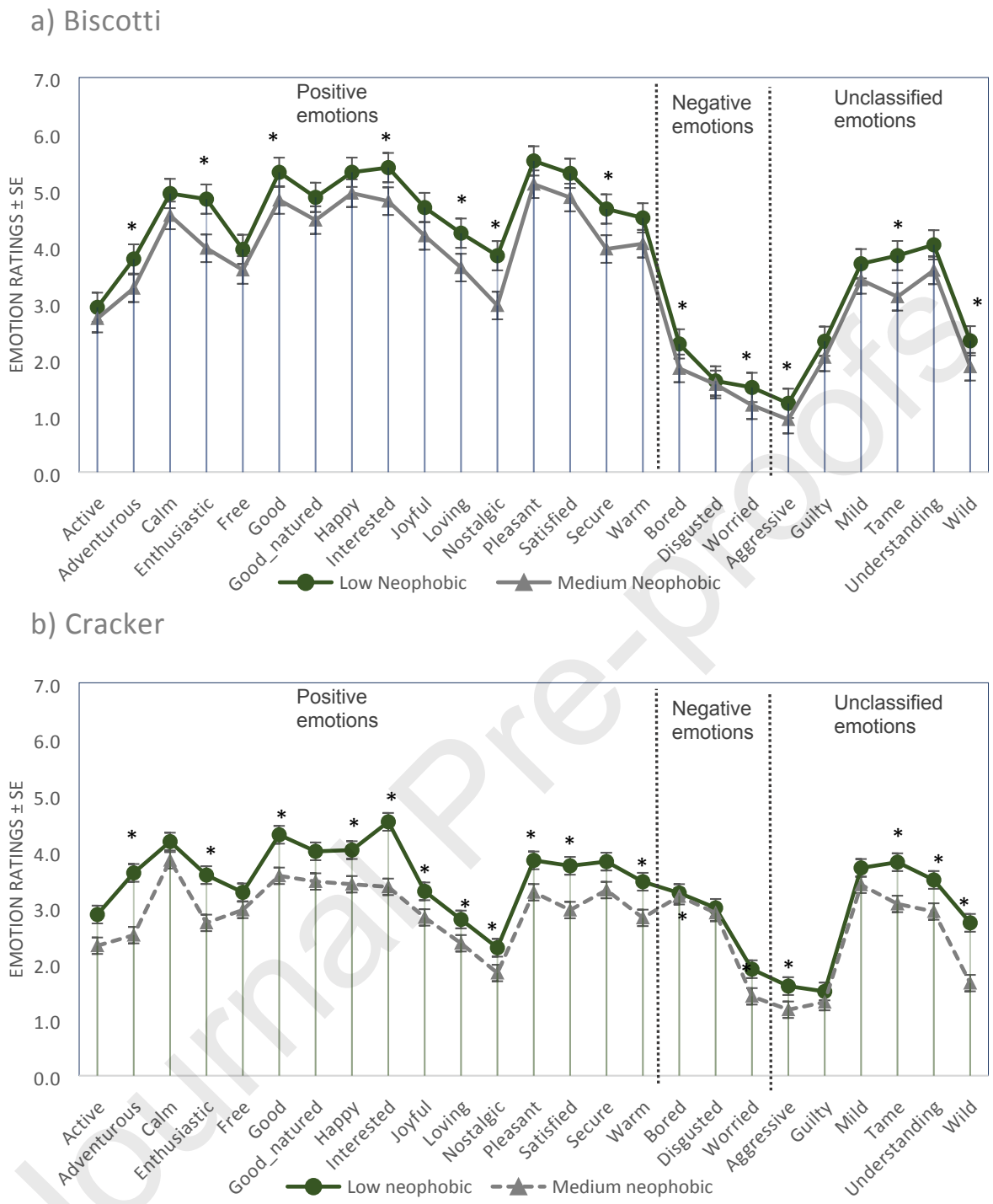

Figure 8: Effect of food neophobia group on emotional response (Mean scores ± SE) for a) Biscotti and b) Cracker. ** indicate significant difference at p<0.05.*

Table 1: Summary of subject characteristics.

Total (n=100)		Food Neophobia group		
Gender, n (%)		Medium-Neophobic	Low-Neophobic	p value (Chi-square)
Female	76 (76)	36 (47)	40 (53)	p=0.8
Male	24 (24)	12 (50)	12 (50)	
Age, (n (%)				
Group 1 *(18-30 yrs)*	67 (67)	29 (43)	38 (57)	p=0.03
Group 2 *(31 -50 yrs)*	16 (16)	6 (38)	10 (63)	
Group 3 (51 - 74 yrs)	17 (17)	13 (76)	4 (24)	

Table 2: Estimated nutrition composition for all products.

	Bambara biscotti	Standard biscotti	Bambara cracker	Standard cracker
Energy (kcal)	328	463	427	381
fat (g)	10	18	15	3.5
of which saturated(g)	0.9	4.3	0.7	1.1
Carbohydrate(g)	47	63	58	79.4
of which sugar(g)	26	32	0	8
Fibre(g)	3.7	4.7	0.8	0.9
Protein(g)	10	10	14	11.8
Salt(g)	0.29	0.75	1.3	1.7

Estimated nutrition composition for Bambara products were calculated using Nutritics (v5.095) (Nutritics, Dublin)

Qian Yang – Methodology, Software, Investigation, Formal analysis, Writing – Original draft, Rewriting – review and editing, Yuchi Shen – Methodology, Software, Investigation, Formal analysis, Project administration, Writing –Original draft, Tim Foster – Supervision and Conceptualisation, Joanne Hort – Methodology, Conceptualisation, Writing – reviewing and editing, Funding acquisition.

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: