



An exploratory consumer study of 3D printed food perception in a real-life military setting

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ABSTRACT

3D printing has the potential to produce on-demand food tailored to individuals' needs and preferences. The present study explored 3D printed food acceptance in a real-life military setting. Over a period of 4 weeks, soldiers consumed and evaluated multiple recovery snack bars. In week 1, participants received a benchmark bar that was created with conventional manufacturing processes. In week 2 to 4 participants received a 3D printed snack bar with increasing customisation options: choice of texture (soft or crunchy) in week 2; choice of texture and taste (sweet or savoury) in week 3; and choice of texture, taste and ingredients (4 types of dough, 13 types of filling) in week 4. Attitudes towards 3D food printing and potential drivers of 3D printed food acceptance were assessed in weeks 1 and 4 before and after repeated consumption of the snack bars.

After repeated consumption participants judged 3D printed food to be significantly better as compared to before consumption ($t = 2.86, p = 0.015$). Food neophobia, food technology neophobia and food choice motives did not change during the experiment (all $p > 0.05$). The benchmark bar was liked better than the 3D printed bars. However, among the 3D printed bars, mean scores on overall liking, and liking of taste and texture were highest for the version that was customized most (week 4). Our findings illustrate that consumer empowerment, desired degree of personalisation, state of development and appropriateness of 3D food printing technology all play a role in 3D printed food acceptance.

1. Introduction

Three-dimensional (3D) printing, also known as additive manufacturing (AM), is an upcoming technology which uses a layer-by-layer material deposition mode to manufacture 3D objects. Originally this technology was intended for the prototyping industry, but nowadays 3D printing is applied as a manufacturing technique for products with complex functionalities, unique or personalized properties, or in a decentralized location. Although the major application still being non-food, opportunities to apply the technology to food manufacturing are also being explored (Brunner, Delley, & Denkel, 2018; Liu, Zhang, Bhandari, & Wang, 2017; Manstan & McSweeney, 2020). Printing food is rather complex, as food ingredients are biological materials with a large variability in composition and physical properties. However, in the past decade 3D extrusion printers have been successfully used to print edible matter, such as doughs (Severini, Derossi, & Azzollini, 2016), chocolate (Mantihal, Prakash, Godoi, & Bhandari, 2017), food pastes (Severini, Derossi, Ricci, Caporizzi, & Fiore, 2018), and gels (Wang, Zhang, Bhandari, & Yang, 2018).

Up to date, the primary use of 3D food printing is to create custom-

designed culinary decoration or food with unique 3D shapes. However, the potential of 3D printing in food production goes far beyond fun shapes and colour. Unlike conventional food manufacturing, 3D printing has the potential to produce on-demand food tailored to individuals' dietary habits, lifestyle behaviour, health status and taste preferences (Sun et al., 2015). Additionally, 3D printing increases consumer empowerment as it allows consumers to take part in the food production process by choosing specific product characteristics. This may have a positive impact on consumer satisfaction (King, Weber, Meiselman, & Lv, 2004; Parizel et al., 2016).

In view of its potential, the application of 3D printing technology is of great interest in specialised food sectors, such as military food. In military settings, the main added values of 3D printing are increasing flexibility in the supply chain, increased consumer satisfaction and morale and enhanced performance of individual soldiers by adequately fulfilling their specific needs.

Whereas 3D printing thus offers new perspectives towards personalised food and consumer empowerment, its success largely depends on acceptance by consumers. To date, however, very little is known about consumer acceptance of 3D printed foods. As far as we know,

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published data so far origin from sensory evaluations of 3D printed food (Mantihal, Prakash, & Bhandari, 2019; Severini, Derossi, Ricci, Caporizzi, & Fiore, 2018) or from studies that addressed consumer acceptance of 3D food printing rather abstractly by examining consumer responses to pictures of 3D printed food (Brunner et al., 2018; Manstan & McSweeney, 2020).

The present study aims to explore the potential for applying 3D printing technology to food manufacturing by investigating end users' attitudes towards 3D printed food. In a real-life, military setting, soldiers consume and evaluate multiple 3D printed recovery snack bars over a period of 4 weeks. We explored to what extent consumers' attitudes towards 3D food printing relate to (a) their knowledge about 3D food printing technology and (b) repeated exposure to 3D printed food products. Prior research suggests that consumer attitudes towards novel food technologies improve as their knowledge of and experience with these technologies increases (Jaeger, Knorr, Szabó, Hámori, & Bánáti, 2015). At the same time, consumers are often suspicious and fear novel foods (food neophobia; Pliner & Hobden, 1992) and their associated novel technologies (food technology neophobia; Cox & Evans, 2008). It is hypothesised that consumers' attitudes towards 3D printed foods will become more positive as they gain more knowledge about and/or experience with 3D printed food. In addition, the role of consumer empowerment in the acceptance of 3D printed food will be explored by allowing soldiers to increasingly personalise their 3D printed snack bars over time.

2. Materials and methods

2.1. Participants

Participants were recruited among elite air assault soldiers with a highly active task belonging to the 11th Airmobile Brigade in Schaarsbergen, the Netherlands. This brigade was selected as 3D food printing seems a promising technology for providing military rations to these soldiers in the future. All members of the brigade received an invitation for study participation including a general description of the study and its purpose. Those interested signed an informed consent form before the start of the study, which was executed at the Dutch army base *Oranjekazerne* in Schaarsbergen. Afterwards they completed a short screening questionnaire to evaluate eligibility for study participation. Soldiers were eligible for participation if they regularly consumed snacks, and had no allergies, intolerances or other nutrition-related conditions (self-reported). Finally, 12 Dutch men with a mean age of 32.1 y (SD 7.6) were included in the study.

2.2. Methods

A variety of snack bars was created specifically for this study. All bars had a portion size and nutritional profile (caloric values, sugar, fat and protein content) similar to snacks that are commonly consumed by soldiers after training, such as chocolate or nutrition bars. The bars were prepared in line with food safety regulations to ensure consumers' health and safety.

One bar served as a benchmark product and was created following a conventional food manufacturing process. This benchmark snack consisted of a vanilla cookie bar with chocolate chips (95x35x15mm) weighing approximately 55 g. The benchmark cookie dough was prepared the day before tasting, stored at 4 °C, and baked just before serving, with an Air Fryer (Philips®, The Netherlands), at 180 °C for 10 min.

The other bars were created using 3D printing technology. The 3D printed snacks had a portion size similar to the benchmark product (95x40x15mm) and consisted of 30 g of cookie dough filled with 25–30 g of filling, all made from food grade commercial ingredients. Examples of printed samples are shown in Fig. 1. The printable cookie doughs were made using a Hobart® N50 mixer with a B flat beater;

fillings were prepared using a Thermomix® (Vorwerk, Germany). To allow for personalisation of the food products, multiple sweet and savoury flavours were developed for both fillings and doughs. An overview of all flavour combinations is presented in Table 1. All freshly made doughs and fillings were transferred into food grade syringes (30 cc volume, Farnell®, United-Kingdom) and stored in the refrigerator (4 °C) for maximally 24 h. Just before serving, the bars were printed by syringe-based extrusion using a lab-scale Fused Deposition Modelling printer (FDM, by TNO®, the Netherlands). The dough was extruded out ($F = 1000 \text{ mm} \cdot \text{min}^{-1}$) from a 2 mm nozzle to build the 3D design which was uploaded using the open source software Pronterface®. This printing process took about 15 min. Next, the dough was cooked with an Air Fryer XXL (Philips®, The Netherlands) at 170 °C for 7 to 10 min, or a steamer (Philips®, The Netherlands) at 100 °C for 10 min, depending on the desired texture (crunchy or soft). To optimise the eating experience, sweet doughs were cooled down at room temperature for 10 min before adding the filling(s), while savoury doughs were immediately filled with savoury filling(s) which were warmed up beforehand (in a water-bath at 63 °C for 30 min).

Food samples were served to the participants at room temperature (around 20 °C) within 15 min after production on plates labelled with 3-digit numbers with a glass of water as palate cleanser.

2.3. Design and procedure

An overview of the study design and procedure is presented in Fig. 2. At the start of the study, participants completed a questionnaire that assessed their initial attitude towards 3D printed food based on Brunner et al. (2018). Participants were asked to indicate on a six-point scale (1 = not at all, 6 = very much) to what extent they believed 3D printed food to be (1) good, (2) important, and (3) attractive. Next, a short presentation was given about 3D food printing technology, in which its potential application for personalised nutrition for soldiers in the battlefield was emphasised. After the presentation, participants' attitude towards 3D printed food was assessed a second time. In addition, participants completed three questionnaires measuring potential drivers of acceptance of 3D printed food, namely the Food Neophobia Scale (FNS; Pliner & Hobden, 1992, 10 items), the Food Technology Neophobia Scale (FTNS; Cox & Evans, 2008, 6 items), and a reduced version of the Food Choice Questionnaire (FCQ; Steptoe, Pollard, & Wardle, 1995) assessing the health (6 items), natural content (4 items) and familiarity motives (4 items). In each questionnaire, participants were asked to indicate their agreement with the statements on a 7-point Likert scale (1 = "Strongly disagree", 7 = "Strongly agree"). The FCQ was reduced to decrease the burden on the respondents.

Next, over a period of 4 weeks, eight tasting sessions were organised (two sessions per week) during which participants tasted and evaluated a snack bar. Participants were asked to customize their snack by choosing from the options offered via an online platform (Eye Question®) up to 48 h before each tasting session. The options for customisation increased every week, starting with no choice (the benchmark bar) in week 1; choice of texture (soft or crunchy) in week 2; choice of texture and taste (sweet or savoury) in week 3; and choice of texture, taste and ingredients (4 types of dough, 13 types of filling) in week 4.

During a tasting session, participants consumed their customized snack bar and evaluated it in terms of overall liking and liking of specific attributes (taste, appearance and texture) on semantic differential scales ranging from 1 ("Not at all") to 9 ("Very much").

At the end of the 4-week period, participants' attitudes towards 3D printed food, food neophobia, food technology neophobia and food choice motives were assessed again. Finally, a short structured face-to-face interview with open-ended questions was conducted to gain additional qualitative insights in participants' attitudes and wishes regarding the 3D printed snack bars provided in the current study and regarding 3D food printing in general. All questionnaires were provided

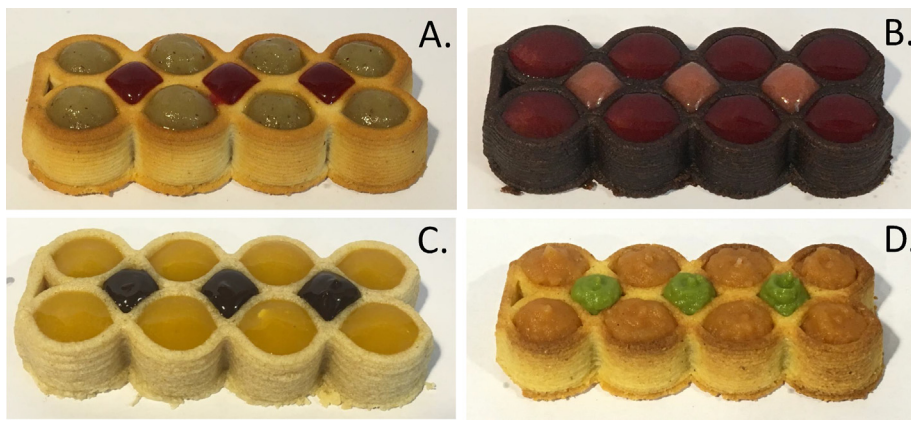


Fig. 1. Some examples of 3D printed snacks; A. Vanilla biscuit with crunchy texture, kiwi and raspberry fillings; B. Chocolate biscuit with crunchy texture, raspberry and rhubarb fillings; C. Oat biscuit with soft texture, mango and chocolate fillings; D. Savoury biscuit with crunchy texture, carrot and green peas fillings. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 1
Flavours of dough and fillings developed for the 3D printed snack bars.

Taste	Doughs	Fillings
Sweet	Vanilla Oat Chocolate	Chocolate
		Blueberry
		Lemon
		Coconut
		Mango
		Kiwi
		Rhubarb
		Banana
		Raspberry
		Red pepper
Savoury	Corn and parmesan	Egg plant
		Carrots
		Green peas

in Dutch.

2.4. Analyses

Due to the limited number of participants (n = 12), no outliers were removed from the data. Analyses were performed using IBM SPSS software (version 25). To assess whether increased knowledge about and/or experience with 3D food printing affected participants' attitudes towards 3D printed food, paired sample t-tests were performed to compare their scores on the items 'good', 'important' and 'attractive' before vs. after the presentation about 3D printing, as well as before vs.

after the tasting sessions.

Mean scores on food neophobia, food technology neophobia and food choice motive scores for health, natural content and familiarity were calculated for each participant after reverse-coding of neophilic statements. Correlations between these scores and attitudes were evaluated to explore their relation. To evaluate whether increased experience with 3D printed food affected participants' food (technology) neophobia or food choice motives, scores were compared before vs. after repeated exposure to the 3D printed food using paired-samples t-tests.

Repeated measures analysis were used to determine whether and how the degree of customisation (week 1 vs week 2 vs week 3 vs week 4) affected 1-participant's liking of the 3D printed snack bars (overall, appearance, taste and texture) and 2-the perceived value of customisation and appropriateness of 3D-printed foods for military applications (8 statements). To evaluate differences between the different levels of customisation, we performed pair wise comparisons with a Bonferroni correction to adjust for multiple comparisons. Face to face interviews were analysed using content analysis.

3. Results

3.1. Attitudes towards 3D food printing

At start of the study, attitudes towards 3D printed foods were rather neutral. The presentation did not affect participants' attitudes (p > 0.05, data not shown). Table 2 presents mean attitude scores

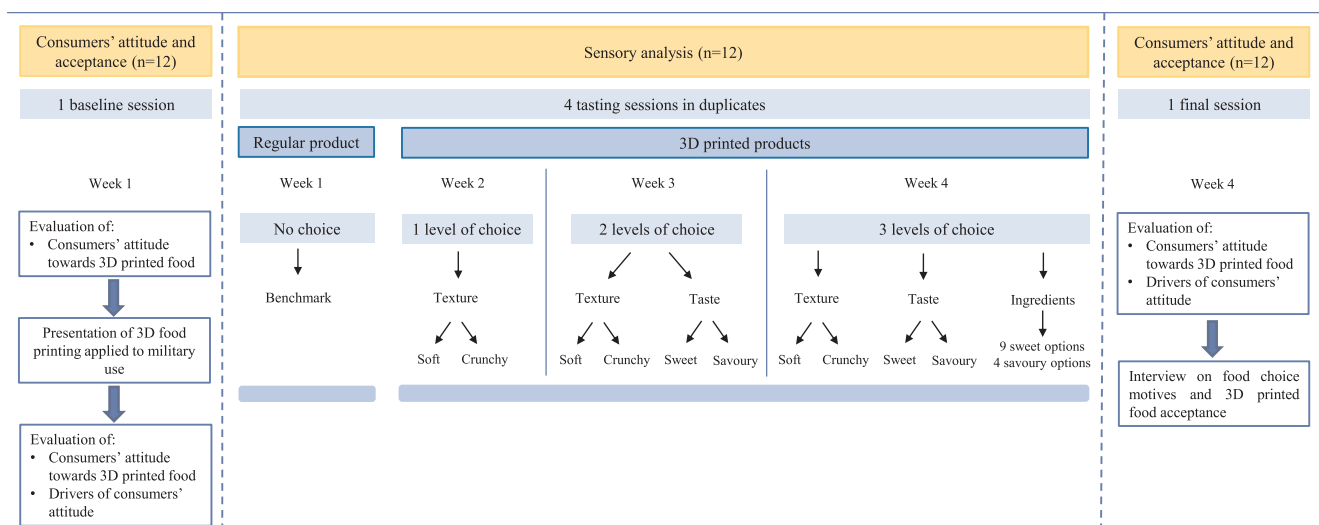


Fig. 2. Experimental design used during the study.

Table 2
Participants' attitude towards 3D printed food (mean \pm SD) before and after repeated consumption of 3D printed snack bars.

	Before tasting sessions*	After repeated consumption	t-value, p
<i>I think that foods produced with 3D printers are generally:</i>			
Good	3.50 \pm 0.90	4.58 \pm 1.00	2.86, 0.02
Importance	4.17 \pm 1.64	3.92 \pm 1.24	-0.54, 0.60
Attractiveness	3.08 \pm 0.79	3.50 \pm 1.24	0.96, 0.36
Food Neophobia	2.07 \pm 0.77	2.47 \pm 0.88	-1.37, 0.20
Food Technology Neophobia Scale (FTNS)	2.83 \pm 1.23	2.79 \pm 0.89	0.15, 0.88
<i>Food Choice Questionnaire</i>			
Health interest	4.97 \pm 1.34	5.77 \pm 0.29	-1.94, 0.08
Natural	4.70 \pm 1.25	4.48 \pm 1.08	1.02, 0.33
Familiarity	3.00 \pm 1.51	2.76 \pm 1.43	0.57, 0.58

*After the presentation on 3D food printing technology

towards 3D printed food before and after repeated exposure to 3D printed snacks. Repeated consumption of 3D printed snacks seemed to positively impact participants' attitude towards 3D food printing: participants judged 3D printed food to be significantly better after the tasting sessions as compared to before consumption ($t = 2.86$, $p = 0.015$). Mean scores for attractiveness also increased over tasting sessions, however this change was not significant.

At start of the study, mean score for both food neophobia ($M = 2.07$, $SD = 0.77$) and food technology neophobia ($M = 2.83$, $SD = 1.23$) were low, indicating that participants in our sample were relatively neophilic, i.e., willing to try novel foods and food technologies. In terms of food choice motives, healthiness of products received highest scores ($M = 4.97$, $SD = 1.34$), followed by natural content ($M = 4.70$, $SD = 1.25$) and familiarity ($M = 3.00$, $SD = 1.51$). Neither score significantly changed after repeated exposure to 3D printed food (all $p > 0.05$, Table 2).

Correlation analysis showed that participants rating 3D printed foods as good, also gave higher scores on the food choice motives health (Pearson's correlation = 0.61, $p = 0.035$) and familiarity (Pearson's correlation = 0.58, $p = 0.046$). Evaluating 3D printing as important was negatively correlated with food technology neophobia (Pearson's correlation = -0.75, $p = 0.005$).

3.2. Evaluation of 3D printed snack bars

Table 3 presents mean scores for overall liking and liking of appearance, taste and texture for the benchmark and the 3D printed snacks. Repeated measures analysis showed a significant effect of time on liking of taste ($F = 3.28$, $p = 0.03$), however pairwise comparisons did not reveal any significant differences between different levels of customisation ($p > 0.05$). Overall, mean liking scores for the benchmark snack bar were higher than for the 3D printed snacks, except for appearance. Furthermore among the 3D printed snacks, mean liking scores were highest in the full choice condition (choice of texture, taste and ingredients).

Table 3
Consumer satisfaction with the recovery snack bars consumed during the 4-week study period. (mean \pm SD).

Satisfaction*	Benchmark [†]	3D printed bars			F-value, p
	No choice	Choice of texture	Choice of texture and taste	Choice of texture, taste and ingredients	
Overall liking	6.47 \pm 1.50	5.69 \pm 1.69	5.48 \pm 1.33	5.88 \pm 1.53	1.39, 0.27
Liking of appearance	5.73 \pm 1.89	5.89 \pm 1.24	5.93 \pm 1.17	5.27 \pm 1.51	0.63, 0.60
Liking of taste	6.78 \pm 1.61	5.43 \pm 1.64	5.40 \pm 1.32	6.28 \pm 1.59	3.28, 0.03
Liking of texture	6.25 \pm 1.61	5.42 \pm 2.13	5.30 \pm 1.50	5.61 \pm 1.52	1.10, 0.36

*Each item was measured on a 9-point scale anchored from 1 = "Not at all" to 9 = "Very much".

[†]Created with conventional manufacturing processes.

3.3. Qualitative insights

During face-to-face interviews participants were asked to rank criteria that were relevant for food choice. Mean ranks indicated the following order of relevance: taste ($M = 1.2$), portion size ($M = 3.0$), texture ($M = 3.3$), shape ($M = 3.7$) and colour ($M = 3.8$). However, there was no consensus on the ideal taste, texture or shape of a snack bar. Participants did share a preference regarding the ideal portion size: they preferred bigger portion sizes than the ones provided in the current study, which in turn would be divisible into smaller pieces. In addition, they would have liked more diversity in food customisation, particularly in terms of macro- and micronutrient content. Nutritional content was mentioned as an important factor influencing their food choices in general; information about and customisability of this attribute was missed most in the current study. Although participants acknowledged the potential of 3D food printing technology, they reported to be currently unwilling to use the 3D printed snacks as recovery product substitutes, due to the current state of technology which is not yet capable of fulfilling all their personal needs.

4. Discussion

The aim of the present study was to explore the potential of applying 3D printing technology to food manufacturing by investigating consumers' attitudes towards 3D food printing and 3D printed food samples in a real-life military setting. Specifically, we asked to what extent (a) increased knowledge of 3D food printing and (b) repeated consumption of 3D printed recovery snack bars affected soldiers attitudes towards 3D printed food and 3D food printing technology.

Our findings suggest that our four-week study yielded a positive change in soldiers' attitudes towards 3D printed food. This is in line with recent literature showing that information and repeated exposure positively influence consumers' perception of novel food and their associated technology (Bruhn, 2007; Brunner et al., 2018; Cardello, Schutz, & Leshner, 2007; Jaeger et al., 2015). As for information provision, statements about the potential of 3D printing for military personnel (particularly to produce on-demand personalised food) increased participants' awareness of associated benefits of 3D printed food. Frewer, Scholderer, and Lambert (2003) suggest that awareness of such perceived benefits influences acceptance of 3D printed food. Our findings provided no strong evidence to corroborate this claim: more than knowledge gain, it was repeated consumption of 3D printed food that positively impacted participants' attitudes, an effect that has been shown previously for unfamiliar foods (Hoek et al., 2013).

The present study focused on the intrinsic and extrinsic factors influencing 3D printed food acceptance, including the role of consumer empowerment, the desired level of customisation, the state of technology development and the appropriateness of 3D food printing technology. Regarding empowerment, participants in our study were able to customise their snacks from a gradually increasing set of pre-determined options (e.g. texture, taste, ingredients). Parizel et al., 2016 previously demonstrated that increasing choice options enhanced consumer satisfaction with the chosen food. This is in line with the increase

in liking scores we observed with increasing customisation options for the 3D printed snacks bars. Still, the conventionally manufactured snack was better appreciated than the personalised 3D printed snacks. This corroborates the results of Bruhn (2007), showing that consumers' satisfaction tends to be lower when food products are manufactured by new technology.

We tentatively relate the lack of evidence for an effect of consumer empowerment to limitations of the current state of 3D food printing technology. Our consumer sample was found to be nutrition-conscious, and reported health-related motives as their main food choice drivers. Participants hence looked primarily for a customisable snack in terms of nutritional profile, whereas the current study did not allow for customisation of these attributes. Given that participants were only able to customise the sensory profile of the 3D printed snacks, the 3D printing technology hence failed to meet the consumers' demands in terms of personalisation. Assuming that perceived benefits are among the key factors towards novel technology acceptance (Siegrist, 2008), this inability to fulfil the core demand of participants in terms of personalisation may have negatively impacted consumers' attitudes towards 3D printed food.

Apart from the desired degree of customisation, food acceptance also depends on perception and liking of sensory attributes such as taste, flavour and texture (Cardello, 2003). Our findings showed that participants were moderately satisfied with the snacks provided. Printing food is complex as ingredients are biological materials, with a large variability in composition and physical properties. Consequently, the variation in materials to be printed, and the type of textures that can be created, are still limited. Product optimisation in terms of sensory attractiveness is likely to enhance acceptance of 3D printed food. However, product- and technology development is not possible without consumer consultation. Empowering consumers requires understanding of the consumers' desire for variety and food choice motives to effectively shape the available food choices. Product development and consumer research therefore need to go hand in hand.

4.1. Limitations and recommendations

The main limitation of the current study is its small-scale set-up. Our participant sample was limited to a group of 12 male, nutrition-conscious soldiers with specific nutritional requirements and expectations. This small sample size prevents us from drawing strong conclusions, and from generalizing to the population at large. To further understand and generalise consumer acceptance of 3D printed food, it is hence important to compare other groups from varied genders, nutritional requirements and operational contexts.

5. Conclusion

The present study explored consumers' attitudes towards 3D printed food in a real-life military setting and gained deeper insight in the potential drivers of 3D printed food acceptance. Findings demonstrated that repeated consumption of 3D printed food increased consumers' acceptance of 3D printed food, but our results also highlight that experience with 3D printed food is not the sole factor of influence. Consumer empowerment, desired degree of customisation, state of development and appropriateness of 3D food printing technology also play a role in 3D printed food acceptance. Understanding consumers' desired level of personalisation and food choices, sensory profile optimisation, and consideration of the situational aspects of serving 3D printed food are key towards the acceptance of 3D printed food. In sum, this study highlights the interdependence of consumer research and product development: the acceptance of 3D printed food can only be

ensured by simultaneous progress in both fields.

CRedit authorship contribution statement

Sophie Caulier: Conceptualization, Methodology, Investigation, Formal analysis, Writing - original draft. **Esmée Doets:** Supervision, Formal analysis, Writing - review & editing, Data curation. **Martijn Noort:** Supervision, Writing - review & editing.

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References

- Bruhn, C. M. (2007). Enhancing consumer acceptance of new processing technologies. *Innovative Food Science & Emerging Technologies*, 8(4), 555–558.
- Brunner, T. A., Delley, M., & Denkel, C. (2018). Consumers' attitudes and change of attitude toward 3D-printed food. *Food Quality and Preference*, 68, 389–396.
- Cardello, A. V. (2003). Consumer concerns and expectations about novel food processing technologies: Effects on product liking☆. *Appetite*, 40(3), 217–233.
- Cardello, A. V., Schutz, H. G., & Leshner, L. L. (2007). Consumer perceptions of foods processed by innovative and emerging technologies: A conjoint analytic study. *Innovative Food Science & Emerging Technologies*, 8(1), 73–83.
- Cox, D., & Evans, G. (2008). Construction and validation of a psychometric scale to measure consumers' fears of novel food technologies: The food technology neophobia scale. *Food Quality and Preference*, 19(8), 704–710.
- Frewer, L., Scholderer, J., & Lambert, N. (2003). Consumer acceptance of functional foods: Issues for the future. *British Food Journal*, 105(10), 714–731.
- Hoek, A. C., Elzerman, J. E., Hageman, R., Kok, F. J., Luning, P. A., & de Graaf, C. (2013). Are meat substitutes liked better over time? A repeated in-home use test with meat substitutes or meat in meals. *Food Quality and Preference*, 28(1), 253–263.
- Jaeger, H., Knorr, D., Szabó, E., Hámori, J., & Bánáti, D. (2015). Impact of terminology on consumer acceptance of emerging technologies through the example of PEF technology. *Innovative Food Science & Emerging Technologies*, 29, 87–93.
- King, S. C., Weber, A. J., Meiselman, H. L., & Lv, N. (2004). The effect of meal situation, social interaction, physical environment and choice on food acceptability. *Food Quality and Preference*, 15(7–8), 645–653.
- Liu, Z., Zhang, M., Bhandari, B., & Wang, Y. (2017). 3D printing: Printing precision and application in food sector. *Trends in food science & technology*, 69, 83–94.
- Manstán, T., & McSweeney, M. B. (2020). Consumers' attitudes towards and acceptance of 3D printed foods in comparison with conventional food products. *International Journal of Food Science & Technology*, 55(1), 323–331.
- Mantihal, S., Prakash, S., & Bhandari, B. (2019). Texture-modified 3D printed dark chocolate: Sensory evaluation and consumer perception study. *Journal of Texture Studies*, 50, 386–399.
- Mantihal, S., Prakash, S., Godoi, F. C., & Bhandari, B. (2017). Optimization of chocolate 3D printing by correlating thermal and flow properties with 3D structure modeling. *Innovative Food Science & Emerging Technologies*, 44, 21–29.
- Parizel, O., Sulmont-Rossé, C., Fromentin, G., Delarue, J., Labouré, H., Benamouzig, R., & Marsset-Baglieri, A. (2016). The structure of a food product assortment modulates the effect of providing choice on food intake. *Appetite*, 104, 44–51.
- Pliner, P., & Hobden, K. (1992). Development of a scale to measure the trait of food neophobia in humans. *Appetite*, 19(2), 105–120.
- Severini, C., Derossi, A., & Azzollini, D. (2016). Variables affecting the printability of foods: Preliminary tests on cereal-based products. *Innovative Food Science & Emerging Technologies*, 38, 281–291.
- Severini, C., Derossi, A., Ricci, I., Caporizzi, R., & Fiore, A. (2018). Printing a blend of fruit and vegetables. New advances on critical variables and shelf life of 3D edible objects. *Journal of Food Engineering*, 220, 89–100.
- Siegrist, M. (2008). Factors influencing public acceptance of innovative food technologies and products. *Trends in food science & technology*, 19(11), 603–608.
- Step toe, A., Pollard, T. M., & Wardle, J. (1995). Development of a measure of the motives underlying the selection of food: The food choice questionnaire. *Appetite*, 25(3), 267–284.
- Sun, J., Peng, Z., Zhou, W., Fuh, J. Y., Hong, G. S., & Chiu, A. (2015). A review on 3D printing for customized food fabrication. *Procedia Manufacturing*, 1, 308–319.
- Wang, L., Zhang, M., Bhandari, B., & Yang, C. (2018). Investigation on fish surimi gel as promising food material for 3D printing. *Journal of Food Engineering*, 220, 101–108.