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Are meat substitutes liked better over time? A repeated in-home use test with meat substitutes or meat in meals

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ABSTRACT

The overall aim of this study was to explore long-term consumer acceptance of new environmentally sustainable alternatives to meat. We investigated whether meat substitutes, which are relatively new food products, would be better appreciated after repeated consumption. Eighty-nine non-vegetarian participants joined an in-home use test and consumed one type of product with their self-selected hot meal for 20 times during 10 weeks: Quorn (meat-like), tofu (not meat-like) or a meat reference (chicken filet). Initial liking (100-mm line scale) for chicken was higher (81 ± 19) than for Quorn (60 ± 28) and tofu (68 ± 21). On a product group level, boredom occurred with all three products and after 20 exposures there were no significant differences in product liking anymore. However, there were noticeably different individual responses within the three product groups, showing both 'boredom' and 'mere exposure' patterns. Mere exposure occurred significantly more frequent with tofu, with more than half of the participants showing an increased liking over time. We also found that meal patterns were related to boredom: bored persons used more different types of meals, probably to alleviate product boredom. This study demonstrates that liking of meat substitutes can be increased by repeated exposure for a segment of consumers. In addition, it indicates that the meal context should be considered in future in-home repeated exposure studies.

1. Introduction

'Eating less meat may slow climate change'. This is not a claim on a meat package. . .yet. . . as recent publications underpinned the impact of meat production on the environment (e.g. De Boer, Helms, & Aiking, 2006; McMichael, Powles, Butler, & Uauy, 2007; Vinnari & Tapio, 2009). Therefore, options are investigated to reduce meat consumption by the use of plant-based meat substitutes (Aiking, De Boer, & Vereijken, 2006; Jongen & Meerdink, 2001). This will only succeed when meat substitutes are attractive to consumers, being directly competitive and substitutable for meat, and are *consumed at sufficient amounts over a long period of time*. However, this has not been the case so far: the consumption frequency of meat substitutes is relatively low in the Netherlands and market share is only a fraction of the total meat market (Aurelia, 2002; De Bakker & Dagevos, 2010). In order to establish a durable replacement of meat by new meat substitutes, it is therefore necessary to investigate which factors are important in long-term acceptance.

1.1. Factors in long-term acceptance

Consider these actual comments about meat substitutes in a qualitative study (unpublished results):

(a) 'First you have to get used to it, but after a while I really got to like it more each time.'
(b) 'At first I liked the product, but when I ate it for the fourth time, it got bored with it'

Repeatedly consuming a food can change liking for it by showing an increase in liking (see comment A) or decrease in liking (see comment B) or no systematic changes (as reviewed by Zandstra, Weegels, Van Spronsen, & Klerk, 2004). An increase in liking response has been firstly explained by Zajonc (1968) who described that mere exposure to an unfamiliar stimulus can enhance one's attitude toward it. In contrast, liking seems to remain often constant with more familiar products, such as staple foods (Schutz & Pilgrim, 1958). The development of a decrease in liking after re-

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peated exposure is less well understood (Chung & Vickers, 2007). Repetitively eating the same food over time, may result in a lowered food acceptance, which is also referred to as product boredom (Lévy & Köster, 1999; Moskowitz, 2000; Porcherot & Issanchou, 1998; Siegel & Pilgrim, 1958; Zandstra et al., 2004). Chung and Vickers (2007a) listed the multitude of factors involved: the complexity of the food, initial liking, flavour intensity, hunger/fullness, and the amount of choice allowed. A change in liking over time is obviously not just a time-dependent process but depends on the type of food, by whom and how this is received. We therefore considered the characteristics of the product, the person, and the context, in studying consumer acceptance of meat substitutes over time.

1.2. The role of the product

Meat substitutes are typical products with respect to the initial liking, complexity and newness. In general, non-vegetarian consumers judge the overall sensory quality of meat substitutes lower than meat (Elzerman, 2006; Hoek et al., 2011; McIlveen, Abraham, & Armstrong, 1999) and prefer a meat-like meat substitute (Hoek et al., 2011). Mimicking meat, a highly complex product with a well appreciated distinctive flavour and texture, is still a technological challenge (Aiking et al., 2006; Grunert, Bredahl, & Brunsø, 2004; Issanchou, 1996; Jongen & Meerdink, 2001). Therefore, current meat substitutes are likely to be perceived as less complex than meat, which may affect liking over time. Previous studies have demonstrated that food products with less complexity than the initial individual optimal level may result in a decrease in liking after repeated exposure (Lévy, MacRae, & Köster, 2006; Weijzen, Zandstra, Alfieri, & De Graaf, 2008). Meat substitutes are also relatively new foods in the assortment of protein-rich foods in Western European countries (Davies & Lightowler, 1998; McIlveen et al., 1999; Sadler, 2004). The degree of product newness[1] plays an important role in initial acceptance and acceptance over time (Pliner, Pelchat, & Grabski, 1993; Raudenbush & Frank, 1999; Tuorila, Meiselman, Bell, Cardello, & Johnson, 1994; Tuorila, Meiselman, Cardello, & Lesher, 1998; Van Trijp & Van Kleef, 2008). New food products are often initially rejected, but with repeated exposure this initial rejection can be changed into acceptance (Birch & Marlin, 1982; Birch, McPhee, Shoba, Pirok, & Steinberg, 1987; Pliner, 1982). However, this does not mean 'the newer the better'. Similar to complexity, newness contributes to the arousal potential of a product. According to optimal arousal theories, consumers look for stimuli that result in a moderate level of stimulation. This implies there is an optimal level of newness, with consumers preferring *moderately* new products over products that are very, or not at all, new (Berlyne, 1960; Köster & Mojet, 2007; Michaut, 2004; Van Trijp & Van Kleef, 2008). Unfamiliar foods that resemble familiar foods that are already part of an individual's diet seem more likely to be accepted (Tuorila et al., 1998). Taken into account that *moderately new and complex* food products may be preferred; we expected that eventually a meat-like meat substitute would be more acceptable than a meat substitute dissimilar to meat.

1.3. The role of the person

Food specific personality traits, such as food neophobia, and the opposite – a high willingness to try new foods, have shown to have an effect (negative and positive, respectively) on new food acceptance (e.g. Henriques, King, & Meiselman, 2009; Olabi, Najm, Baghdadi, & Morton, 2009; Tuorila, Lähteenmäki, Pohjalainen, & Lotti, 2001). Although there are stable individual differences in the tendency to be neophobic, the exposure to novel foods can reduce food neophobia and increase the willingness to try different novel products (Pliner et al., 1993). Product newness is therefore a relative notion and will also depend on a person's previous experiences with new foods (Michaut, 2004; Van Trijp & Van Kleef, 2008). Another personal factor that may play a role in long-term acceptance is variety seeking. Consumers may switch between products because they are intrinsically motivated to experience variety (Van Trijp, Hoyer, & Inman, 1996). Variety seeking is a means to increase stimulation to the individually preferred level (Berlyne, 1960), which may occur when the level of stimulation is too low, as in the case of boredom. Therefore, we expected that certain personal characteristics, such as prior product experience, food neophobia, and variety seeking, would influence how persons hedonically respond to repeated exposure to meat substitutes. Consumers that are more experienced with meat substitutes would initially be more positive towards meat substitutes, and show less change in liking over time. High variety seekers might get bored with the same product after repeated exposure, while food neophobics would initially like meat substitutes less but demonstrate an increase in liking over time.

1.4. The role of the meal context

Meat substitutes are usually eaten together with other foods as part of a meal, so the context of the meal should also be considered. The sensory experience of a single product is noticeably different from that by a combination of foods eaten in a meal context (Fischer, 2007; Meiselman, 2000; Rozin & Tuorila, 1993). Elzerman, Hoek, van Boekel, and Luning (2011) demonstrated the strength of this contextual effect with meat substitutes: products that differed in liking when eaten separately were equally liked when eaten in a meal. Besides the influence of the meal context on the sensory experience at one time point, the different components in a meal may also offer a level of variety – referred to as within-meal variety (Meiselman, De Graaf, & Lesher, 2000). This source of variation might be very relevant for the acceptance of products that are consumed repeatedly. Zandstra, De Graaf, & Van Trijp, 2000b) showed earlier how product variation resulted in less product boredom after repeated exposure. It is expected that meal variety (by varying the accompanying meal components) may alleviate boredom with meat substitutes. Therefore, we also monitored the meal context in studying long-term acceptance of meat substitutes by an in-home use study.

In summary, several factors related to the product, the person and the meal context play a role in long-term acceptance of food products. Some foods require experience before appreciation, while other foods may become boring after extended use. It is important to have insight into which of these scenarios corresponds with current meat substitutes, as to guide the development of new sustainable alternatives to meat. Therefore, the aim of this study was to investigate the hedonic effects of repeated exposure to meat substitutes and meat.

[1] In this paper we use the words newness (or new) and novelty (or novel) in relation to meat substitutes. For ease of reading we do not set them strictly apart, although some authors might use separate definitions. The Oxford dictionary illustrates how these concepts are intertwined and defines novel as 'interestingly new or unusual' and novelty as 'the quality of being new, original, or unusual' (Oxford dictionary, 2012). Van Trijp and Kleef (2008) describe in their review that newness might refer to the time on the market (a firm's perspective) or how the consumer perceives a product. The latter refers in a stricter sense to the arousing property novelty (Berlyne, 1960), indicating a unique differentiation and level of surprise. A similar situation occurs with novelty/newness or unfamiliarity. These concepts are not strictly opposites (Lévy et al., 2006), but they are highly related since newness refers to a deviation from what is considered 'familiar' to the consumer (Van Trijp & Van Kleef, 2008). The Oxford dictionary (2012) refers to unfamiliarity as 'not having knowledge or experience of'. In this paper we therefore refer to a person's unfamiliarity with the product as a function of 'previous experience', as described in the next paragraph The role of the person and in the Methods section.

2. Methods

2.1. Study design

We performed a consumer study aiming for realistic conditions: a long-term in-home use test of 10 weeks, with twice-a-week consumption of selected meat substitutes or a reference meat product. The repeated exposure thus consisted of 20 exposures, which has shown to be sufficient in other studies to demonstrate boredom effects and increase validity compared to a single taste test (see Zandstra et al., 2004). For this study we considered boredom as a decrease in liking over time.

Three products were carefully selected for the study, as described in Section 2.3. The design of the study was a between-subject design: study participants were assigned to one of three product groups: two meat substitute groups [group A ($n = 30$) and group B ($n = 31$)] and one meat reference group [group C ($n = 28$)]. Each person was repeatedly exposed to one type of product during the study. The current study was preceded by a central location test, in which several types of meat substitutes were tested separately and in different meal combinations (as described in Elzerman et al., 2011). These included the products selected for the in-home use test. After the in-home use test we held semi-structured interviews to gain more insight in the participants' experiences with the product over time. The outcomes of these interviews are briefly discussed in the discussion.

2.2. Participants

Participants were 89 relatively highly educated Dutch-speaking residents of Wageningen, aged between 18 and 66 years (20 males; sample mean age was 35 years). Persons with specific food allergies like soy allergy were excluded from the study. Vegetarians were also excluded because they are not the intended target group for new sustainable meat substitutes (Aiking et al., 2006) and because every participant had to eat a meat product in the central location test that preceded the study. Participants were subsequently randomly assigned to product group A, B or C, balanced for ratings for the Food Neophobia Scale, prior experience with meat substitutes (based on habitual consumption of meat substitutes), age and sex (Table 1).

2.3. Products

We wanted to test whether there were differences in changes in liking over time between meat and meat substitutes that are similar and dissimilar to meat. Therefore, 2 meat substitute products and 1 meat reference product were selected by the following criteria:

(a) Actual products that were commercially available
(b) Similar product form (e.g. meal ingredients, hamburger, cold cuts)
Meal ingredients, such as pieces and strips, were chosen since we wanted to ensure that the product was used as part of the main hot meal, which was the aim of the overall research program. We also wanted to offer participants the opportunity to vary the other meal components, as would happen in the real world.
(c) Similar product type (chicken vs. beef like products)
Amongst other flavours, mainly 'white' (referring to chicken) or 'brown' (referring to ground beef) types of meat substitutes were available. Due to criteria below, we selected 2 products from the 'white' range to compare with chicken filet pieces hereafter referred to as chicken.
(d) Mean initial liking scores above 50 on a 100-mm VAS scale. The product had to reach a certain level of acceptability in order to be able to comply with an exposure of twice a week for 10 weeks.
(e) Meat substitute products that varied extremely in the perceived similarity to meat.

As part of the product selection procedure we performed an exploratory study with 22 non-vegetarian consumers to test six different meat substitutes and chicken for, amongst other things, overall liking and perceived similarity to meat. The consumers that participated in this exploratory study did not participate in the 10-week in-home use study. Amongst these products were Quorn stir-fry pieces and lightly seasoned tofu stripes (brand SoFine). Quorn is a mycoprotein, a meat substitute derived from a fungus (McIlveen et al., 1999; Wiebe, 2004). Tofu is a vegetable protein source, made from soy bean curd (McIlveen et al., 1999). These products are hereafter referred to as Quorn and tofu. In the exploratory study, Quorn and tofu scored in similar ranges for acceptance (liking on a 100-mm scale Quorn mean 63 ± 29, tofu mean 52 ± 26) but scored very different in similarity to meat. Quorn was found to be most similar (mean 62 ± 27 on a 100-mm scale) and tofu least similar to meat (mean 26 ± 19). Five out of the 22 participants actually thought that Quorn was a meat product while none of the participants thought this was the case for tofu. This is line with other reports (McIlveen et al., 1999; Rodger, 2001) in which Quorn has been described as a meat substitute product with a meat-like texture and comparable textural complexity as chicken. Tofu is a soft and homogenous product and less similar to meat in comparison to Quorn (McIlveen et al., 1999). Besides the differences in *complexity* (Quorn being more complex than tofu) we assumed that Quorn was perceived as *less new* than tofu, because it is more similar to meat. Thus, according to the selection criteria c and d, tofu and Quorn were selected as test products (Table 2). Before distribution to participants, chicken filet pieces were pre-cooked in order

Table 1
Personal characteristics of participants.

	A. Tofu group ($n = 31$)	B. Quorn group ($n = 30$)	C. Chicken group ($n = 28$)
Age y (mean ± SD)	34 (16)	35 (15)	36 (16)
Sex (% female)	81%	77%	75%
Food neophobia scores (mean ± SD)	23 (7)	24 (5)	24(7)
Variety seeking scores (mean ± SD)	45 (8)	46 (5)	44(9)
Prior experience: consumption of meat substitutes			
never or once	37%	40%	43%
<once a week	40%	33%	36%
⩾once a week	23%	28%	21%
Chicken consumption			
<once a month	35%	18%	7%
<once a week	24%	39%	39%
⩾once a week	41%	43%	54%

Personal characteristics were not significantly different between groups.
Note that one person in the Quorn group dropped out after 7 sessions, due to boredom with the product.

Table 2
Nutritional composition of the test products.

g/100 g unprepared product	Tofu[a]	Quorn[b]	Chicken[c]
Energy (kCal)	196	103	110
Protein	17,5	14,0	23,3
Fat	13,5	2,6	1,8
Carbohydrate	1	5,8	0

[a] SoFine manufacturer's data.
[b] Quorn manufacturer's data.
[c] NEVO table 2006 (NEVO, 2006).

to achieve a standard at home preparation procedure for all 3 products (stir-fry for 5 min) and because of food-safety concerns. Since the meat substitutes contained some flavouring, the chicken filet pieces were slightly flavoured with chicken spices (brand Verstegen) before pre-cooking as well. The products were consequently re-packaged and portioned in unlabeled bags of 150 g.

2.4. Procedure

Twice a week, participants collected their cooled test product with enclosed questionnaire from the research location. The minimum amount to consume was one third of the provided amount (50 g). Participants were not informed about the selected test products, neither the type of products (meat or meat substitutes), nor that the same product was tested over time. They were instructed to use the product as a meal component within the hot meal at the same or following day according to preparation guidelines: stir frying for 5 min in sunflower cooking oil in a separate cooking pan. The test product was only to be consumed by the study participants, although it was allowed to combine this with other meal components that fellow household members were having (excluding meat or meat substitutes). There were no limitations to the accompanying hot meal components except for the use of strong masking flavouring or very spicy sauces. In order to fix exposure across product groups, it was not allowed to eat any other meat substitutes and chicken filet on the remaining five days of the week during the entire study period.

2.5. Questionnaires

Questionnaires were used to assess participants' hedonic evaluations of products over time and to explore the role of personal factors and varying meal context.

2.5.1. Product-related measures

The hedonic product questions were filled out by the participants at home and are listed in Table 3. The amount eaten was self-reported (see Table 3). Subjects also rated the degree of hungriness (100-mm VAS scale) before consumption and whether their taste or smell was affected that day.

2.5.2. Meal-related measures

Participants reported which meal components accompanied the test product in specific categories (type of carbohydrates, vegetables and type of sauce or adding). Questions for the whole meal were comparable to the hedonic product questions listed above, namely desire to eat, liking and boredom on a 100-mm line scale. In the actual questionnaire, questions about the meal were listed before the product ratings.

2.5.3. Personal factors

The following personal characteristics were recorded before enrolment in the study: age, sex, prior experience with meat substitutes in general (recorded as the habitual consumption of meat substitutes in 7 categories: never, a single time, less than once a month, less than once a week, once or twice a week, three or four times a week, 5 times or more a week), and habitual consumption of chicken filet. As a measure for food neophobia, the Food Neophobia Scale (FNS) with 7-point Likert scale was included (Pliner & Hobden, 1992) which assesses the tendency of people to try new foods. The questionnaire was translated into Dutch by a translation-back translation procedure by a professional agency. As a measure for variety seeking, the VARSEEK-scale was used which assesses consumers' variety seeking tendency with respect to foods in applied settings (Van Trijp, 1995). The original Dutch version of the VARSEEK was used with a 7-point Likert scale.

2.6. Data-analysis

Data were analyzed with SPSS 14.0 and 19.0 for Windows and p-values <0.05 were considered to show statistical significance.

2.6.1. Acceptance of products over time

The relation between liking, desire to eat, and boredom ratings was considered by calculating Spearman's correlation coefficients at individual level, which were subsequently averaged for all participants. Before looking into the course over time, we investigated whether there were differences between Quorn, tofu and chicken ratings (liking, desire to eat, boredom and eaten amount) at the start of the study (session 1) and at the end of the study (session 20) by using ANOVA with Post Hoc analyses (Games-Howell). Possible differences between the product groups in smell/taste ability during the study were also checked by ANOVA. Smell/taste ability, which could have influenced hedonic scores, did not differ between product groups during the study. The influences of repeated exposure on product acceptance ratings (measures: liking, desire to eat, and boredom) and eaten amount were analyzed by repeated measures ANOVA (Greenhouse-Geisser correction applied) for which time (session number), product (product group) and the interaction time x product were used as independent variables. Hedonic changes over time (measures: liking, desire to eat, and boredom) were further considered by calculating individual slopes using regression analyses with session (by forced entry) and hunger (by stepwise method) as independent variables. For some individuals hunger was excluded from the model. Individual slopes were subsequently compared across product groups with ANOVA with Post Hoc analyses (Games-Howell).

2.6.2. Variety in individual responses

We inspected the individual plots of product liking scores over the 20 sessions and matched those with the calculated individual regression coefficients. Based on this visual inspection, showing that individuals with regression coefficients $B \geqslant \pm 0.1$ trended towards an increased or decreased liking over time, we set a cut-off at $B = \pm 0.1$. We subsequently assigned a pattern for each individual, reflecting his/her hedonic response over time: $B \leqslant -0.1$ = 'boredom pattern'; $B \geqslant 0.1$ = 'mere exposure pattern'; $-0.1 < B < 0.1$ = 'no change pattern'. Chi-square tests were used to examine whether the number of boredom or mere exposure patterns was different between the product groups. Due to cell counts below five, 'No change pattern' was excluded from analysis.

Table 3
Hedonic product-related questions.

Desire to eat product[a]	How much desire do you have to eat this meat (substitute) product at this moment?	No desire at all – desire extremely (on 100 mm VAS)
Liking of product	How much did you like the meat (substitute) product?	Not at all liked – extremely liked (on 100 mm VAS)
Boredom of product	How bored are you with this meat (substitute) product?	Not at all bored – extremely bored (on 100 mm VAS)
Eaten Amount	How much did you eat of the meat (substitute) product?	Categories (''less than 1/3, 1/3, 1/2, 2/3, more than 2/3, all''),

[a] 'Desire to eat' was filled out before eating; the other questions were rated after finishing the meal.

2.6.3. Influence of the meal

The role of the meal was investigated in two ways, firstly we examined the hedonic ratings for the meals, and secondly we analyzed the behavioral meal data (the different types of meals that were consumed over time). The difference between liking ratings for the overall meal and liking ratings for the product during the 20 in-home sessions was analyzed by a paired t-test for each product group. Similar to analysis of the product data, influences of repeated exposure on hedonic ratings for the overall meal were analyzed by a repeated measures ANOVA (Greenhouse-Geisser correction applied). Individual regression coefficients were calculated for liking of the meal over time and subsequently compared across product groups with ANOVA. Using the same approach as with the product data, we assigned a pattern describing the hedonic response for meals over time ($B \leqslant -0.1$ = 'boredom pattern'; $B \geqslant 0.1$ = 'mere exposure pattern'; $-0.1 < B < 0.1$ = 'no change pattern'). The number of mere exposure and boredom patterns were compared between product groups with a Chi-square test. The difference between the individual regression coefficients of product liking and the individual regression coefficients of meal liking was compared within each product group by a paired t-test. The behavioral meal data was analyzed as follows; three types of variables were assessed from the meal recordings: type of meal, number of different meals, number of switches between different meals. Meal components that accompanied the product were analyzed to appoint *type of meal* based on carbohydrate source in 9 categories: rice, potato, pasta, noodles, pizza, beans, soup, meal salad, and other. Frequencies of the types of meals used were compared across the product groups by a Chi-square test. As an indicator of level of variety sought, for each individual *the number of different meals* was computed based on how many types of meals (categorized following the description above) were used during the in-home use period. How many times individuals changed from one type of meal to another type of meal between consecutive sessions was used to determine the *meal switches*. The numbers of different meals and meal switches were compared between product groups by ANOVA.

2.6.4. Influence of food neophobia, variety seeking, and prior experience

In order to investigate the effect of food neophobia, the sample was divided into two categories based on a split at group median level (low FNS $\leqslant$ 23, high FNS > 24)[2]. The same procedure was done with variety seeking (low VARSEEK $\leqslant$ 45, high VARSEEK > 46).[2] We used the three categories of prior experience with meat substitutes as described in Table 1. We investigated the effect of the personal variables on product liking over time in two ways. Firstly, the number of displayed boredom/mere exposure patterns were compared between the different categories by a Chi-square test (comparing low versus high FNS, low versus high VARSEEK, and the prior experience categories). Secondly, the role of each personal variable was analyzed by an ANOVA (GLM) with the individual regression coefficients (product liking over time) as independent variables and the personal variable, product group, and their interaction as factors.

2.6.5. Main effects on product liking

To assess the relative contribution of different factors on overall product liking, a linear regression model was constructed with the pooled data. Product liking was set as the dependent variable and the independent variables were prepared and selected as follows; to reduce multicollinearity the numerical variables FNS, VARSEEK, prior experience, number of meals, and meal switches were centered by subtracting the mean value of these variables. The categorical variable product was coded from least similar to meat (tofu) to meat (chicken) and therefore treated as a numerical variable. The interaction terms number of meals x product and meal switches x product were calculated, in addition to the interaction of each of the personal variables (FNS, VARSEEK, and prior experience) with product and time x product. For the selection of variables, we first investigated for each of variables (including the interaction terms) the contribution to a simple regression model with product liking as the dependent variable. Only the variables that were significantly contributing to the simple regression model were selected: time (session number), product, prior experience with meat substitutes, hunger, number of different meals, number of meal switches, FNS x product, VARSEEK x product x time, number of different meals x product, number of meal switches x product. Finally the overall regression analysis was run with time submitted to the model by forced entry, and all other variables by stepwise method.

3. Results

3.1. Acceptance of products over time

The results for liking, boredom and desire to eat ratings followed the same trend and were correlated (r liking & boredom = −0.58, $p < 0.001$; r liking & desire to eat = 0.49, $p < 0.001$; r boredom & desire to eat = -0.38, $p < 0.001$). We mainly describe the results of liking over time, and report the results of the boredom and desire to eat ratings more extensively in the Appendix A.

At the start of the in-home use test, both meat substitute products tofu and Quorn were significantly liked less than chicken [tofu (68 ± 21), Quorn (60 ± 28), chicken (81 ± 19); $F(2,86) = 6.27$, $p < 0.004$], see also Fig. 1. However, after the repeated exposure period, the liking scores between the product groups were not significantly different anymore [tofu (60 ± 29), Quorn (54 ± 29), chicken (68 ± 26); $F(2,82) = 1.57$, $p = 0.22$]. Fig. 1 illustrates that liking for the three products generally decreased over time (based on product group mean data). Repeated measures analysis confirmed that liking for all 3 products decreased significantly over time ($F(10,734) = 3.27$; $p < 0.001$) and that there was a significant difference in liking between product groups ($F(2,75) = 3.58$; $p < 0.04$). The decrease in liking over time was not significantly different between the product groups (time x product effect: $F(20,734) = 1.28$; $p = 0.19$).

The relative change over time was considered by individual slopes of liking scores (Table 4). The relative decrease in liking was highest for chicken, although differences between groups were not statistically significant ($F(2,86) = 2.53$; $p = 0.085$) due to the large inter-individual differences.

With respect to the other acceptance measures, we observed similar effects but less pronounced (see Appendix A). Regarding the eaten amount we found that on average participants ate 2/3 (100 g) of the provided product during the study. Over time, the eaten amount of product slightly decreased, although not statistically significant ($F(11,679) = 1.68$; $p = 0.075$). The amount of product eaten over time did not differ between the product groups [time x product effect: $F(23,679) = 1.40$; $p = 0.10$].

3.2. Variety in individual responses

The error bars in Fig. 1 and the ranges in individual regression coefficients (Table 4) show that there were significant differences between hedonic responses of individuals within product groups. Closer examination of the individual responses revealed that

[2] Compared to the general population, the convenience sample used for this study is relatively food neophilic and high in variety seeking. Throughout this paper the description low/high food neophobia groups or low/high variety seeking groups refers to the lower and upper split of this study sample.

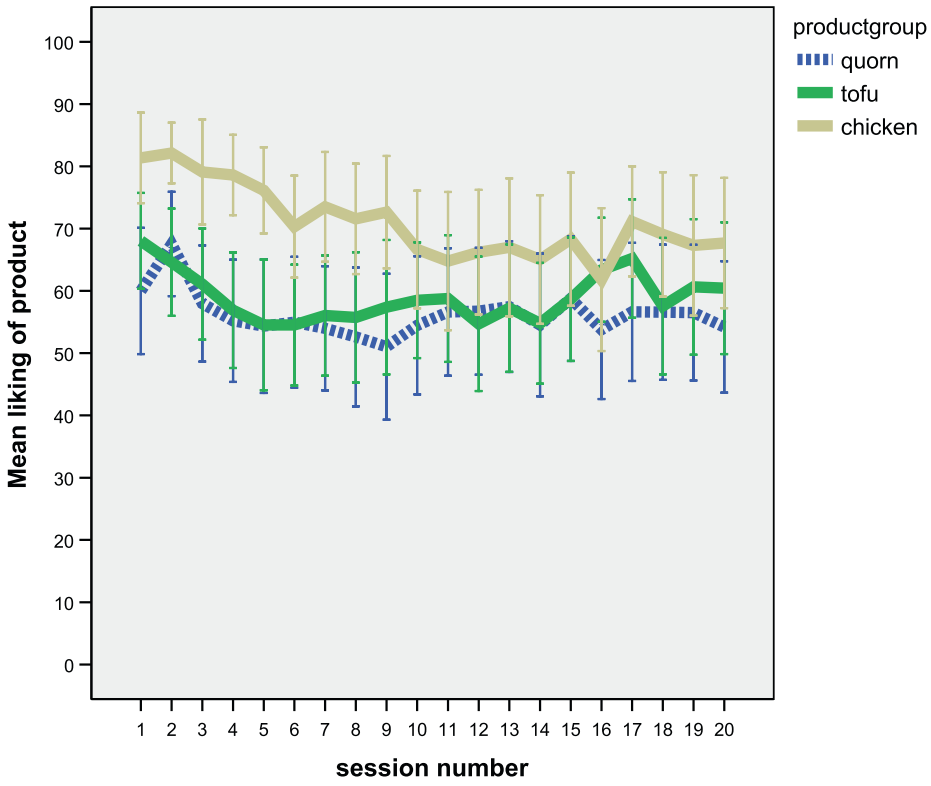

Fig. 1. Product liking over time with repeated exposure to either Quorn, tofu or chicken (mean ± 2SE).

Table 4
Mean individual regression coefficients (*B*) for product liking and meal liking.

	Tofu (n = 31)		Quorn (n = 30)		Chicken (n = 28)	
	B (SE)	Range	*B* (SE)	Range	*B* (SE)	Range
Product liking	−0.07 (0.23)	−3.4–2.9	−0.22 (0.22)	−2.5–2.3	−0.78 (0.24)	−3.8–1.2
Meal liking	−0.03 (0.69)	−1.9–1.1	0.07 (0.13)	−1.4–1.5	−0.24 (0.77)	−2.4–0.8

SE = Standard error of the mean.
A negative *B* value indicates a decrease in ratings over time.

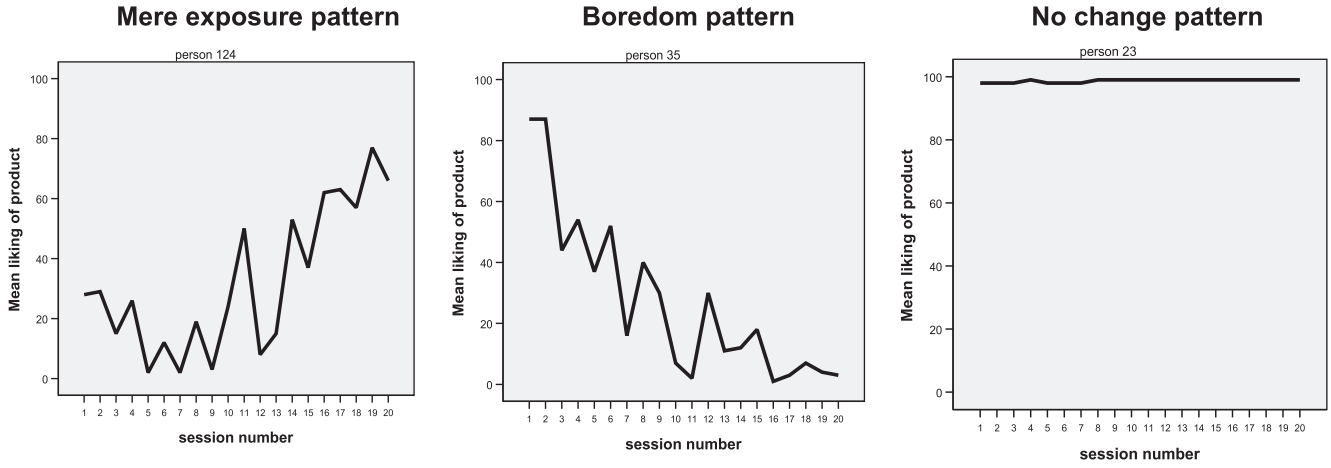

Fig. 2. Different individual responses on repeated exposure of products. The figures illustrate three typical individual response patterns: mere exposure, boredom and no systematic changes.

within each product group, typical responses as shown in Fig. 2 were observed. While some participants liked the product better over time, called 'Mere exposure pattern' others showed a reversed reaction and got bored, called 'Boredom pattern'. There were also a few persons who did not vary their scores for the product, called 'No change pattern'.

Table 5 shows the number of persons with a certain response and how that varied depending on the product eaten. We found that the number of boredom and mere exposure patterns significantly differed between the three products ($X^2(2,79) = 7.10$; $p < 0.03$). The majority of the individuals who ate tofu showed a mere exposure pattern in contrast to individuals from the chicken group in which boredom was obviously the dominant pattern. The Quorn group took an intermediate position with a slight majority of the individuals displaying a boredom pattern.

3.3. Influence of the meal

Table 6 shows how liking scores for the meals differed from the liking scores for the test products, particularly at the tofu and Quorn group. The entire meal was liked significantly better than the products [tofu $t(613,614) = 16.01$; $p < 0.001$, Quorn: $t(597,598 = 16.85$; $p < 0.001$, chicken: $t(552,553) = 4.71$; $p < 0.001$].

Liking ratings for the entire meal did not decrease over time and there were no significant differences between product groups [time effect: $F(2,185) = 1.13$; $p = 0.33$, product effect: $F(2,74) = 1.21$; $p = 0.31$, time x product effect: $F(5,185) = 0.76$; $p = 0.58$]. Similarly, there was no decrease in the desire to eat or increase in boredom ratings for the meal (see Appendix A). The mean individual regression coefficients of meal liking over time were not significantly different between product groups and were smaller than the coefficients for product liking over time (see Table 4). This difference between product liking and meal liking regression coefficients was largest and significantly different at the chicken group ($t(27) = -2.47$; $p < 0.03$). In addition, the number of boredom and mere exposure patterns based on liking of the entire meal was not significantly different between product groups ($X^2(2,78) = 1.06$; $p = 0.59$).

We analyzed the meal data (1765 recorded freely chosen meals) by looking at three variables: (1) the type of meal (type of main carbohydrate component), (2) the number of different meals used during the study period, (3) meal switches (how many times participants switched type of meal between consecutive test sessions). The types of meals participants used to combine with the product were not significantly different between product groups. Most of the time, the product was applied to a rice meal (Quorn 39%, tofu 35%, chicken 33%). The second meal type was a potato dish (Quorn 27%, tofu 26%, chicken 30%), followed by a pasta combination (Quorn 15%, tofu 19%, chicken 18%).

The number of different meals used by participants during the study period varied from 1 type of meal (rice dish) to 8 different types of meals (rice, potato, pasta, egg noodle, pizza, beans, soup, salad). There was no significant difference between the number of different meals between the product groups. However, we found a significant inverse correlation of 0.3 between individual regression coefficients of product liking and the number of different meals used ($p < 0.02$). Thus, participants showing a larger decline in product liking over time used more types of meals during the study.

Concerning the switches between types of meals, we found that participants in the chicken group switched more than those in meat substitute groups (borderline significance, $F(2,86) = 2.95$; $p = 0.058$). Overall, the number of meal switches and the individual regression coefficients for product liking were inversely related ($r = 0.4$; $p < 0.001$). Thus, participants with a higher decrease in product liking over time also switched more during the study.

Table 5
Number of participants with a boredom pattern, no change or mere exposure pattern.

	Tofu ($n = 31$)	Quorn ($n = 30$)	Chicken ($n = 28$)
Boredom pattern	13	16	19
No change pattern	1	3	4
Mere exposure pattern	17	11	5

Table 6
Overall liking of products and meals (mean ± SD).

	Tofu	Quorn	Chicken
Product liking	59 ± 27	56 ± 28	71 ± 25
Meal liking	74 ± 16	70 ± 21	75 ± 18

The data shows group mean values of the 20 sessions.

3.4. Influence of food neophobia, variety seeking and prior experience

All participants in this study were relatively food neophilic and high variety seekers: food neophobia scores of participants ranged from 12 to 39, and VARSEEK from 26 to 56 (total scores on 7 point-scales). Higher food neophobia scores were not related to less product boredom: we found that the number of boredom/mere exposure patterns occurring in the low/high food neophobia groups were not significantly different ($X^2(1,77) = 0.003$, $p = 0.96$). There was not an effect of food neophobia on the individual regression coefficients of product liking over time ($F(1,80) = 0.21$, $p = 0.89$), nor a significant interaction effect of food neophobia x product group ($F(2,80) = 1.27$, $p = 0.29$). We also did not find an effect of variety seeking on liking over time: the number of boredom/mere exposure patterns occurring in low and high variety seekers were not significantly different ($X^2(1,79) = 0.002$, $p = 0.96$). Similarly, there was no effect of variety seeking on the product liking individual regression coefficients [main effect ($F(1,82) = 0.06$, $p = 0.82$), interaction effect variety seeking x product group ($F(2,82) = 1.53$, $p = 0.86$)]. In addition, prior experience with meat substitutes was not related to the boredom/mere exposure patterns displayed ($X^2(2,79) = 2.78$, $p = 0.25$). There was not a significant main effect of prior experience ($F(2,79) = 0.34$, $p = 0.72$), nor a significant interaction effect of prior experience x product group ($F(4,79) = 1.18$, $p = 0.33$), on the individual regression coefficients of product liking over time.

3.5. Main effects on product liking

The sections above described the effect of different factors on product liking and boredom over time separately. The question arises which of these product, personal and contextual factors have the most effect on overall product liking ratings. Table 7 shows that in this study the type of product was the most important determinant of liking. Besides time and hunger, the personal factor 'prior experience with meat substitutes' and contextual factor 'number of different meals used' had the most dominant effect on product liking. Thus, having previous experience with meat substitutes was associated with higher liking scores for the product, while using more types of meals was associated with lower liking scores. Food neophobia did not have an effect on overall product liking, and variety seeking only in interaction with product and time.

4. Discussion

This study investigated the hedonic effects of repeated exposure to two types of meat substitutes (tofu and Quorn) and a meat reference product (chicken). The overall aim was to get insight in factors that influence long-term acceptance of new environmentally sustainable meat substitutes. We considered the role of the product, the person, and the meal context in studying consumer acceptance over time.

4.1. The influence of product characteristics on product acceptance over time

On a group level, both meat substitutes and chicken dropped significantly in liking over time, and the decrease in liking was similar for the three test products. However, a different picture emerged when individual responses were investigated. Tofu was found to be least boring and the majority of the individuals in the tofu group began to like this product better over time. This was against our expectations; we hypothesized that the *moderately* new and complex food product, the meat-like meat substitute Quorn, would be more acceptable over time than tofu, which is a meat substitute very dissimilar to meat.

The results show that mere exposure effects occurred after repeated consumption of tofu, which also occurred to a lesser extent with Quorn. The fact that mere exposure was observed more frequently at the most distinct product tofu, indicates that initial product unfamiliarity and newness influenced the increase in liking over time. Recent studies among adults have demonstrated mere exposure effects with other relatively unfamiliar foods or drinks, such as with spinach, green tea and soft drinks (Bingham, Hurling, & Stocks, 2005; Son, Hong, & Kim, 2010; Sulmont-Rossé, Chabanet, Issanchou, & Köster, 2008). Confirming this effect for meat substitutes is encouraging for the strategy to use of novel sustainable products to reduce meat consumption. Repeated exposure might thus be a way to decrease consumer uncertainty on these unfamiliar foods and to 'breed familiarity' (Bingham et al., 2005; Stang, 1975; Sulmont-Rossé et al., 2008; Van Trijp & Van Kleef, 2008).

Although it seems evident that product novelty played a role, it is not possible to exactly pinpoint which product properties of meat substitutes determined liking over time. Different product properties related to the arousal level might play a role: besides novelty, also intensity and complexity (Berlyne, 1970). Previous studies have usually focussed on one of these properties and had participants directly rate the test products, such as for perceived complexity. Various ratings have been used until so far, for example with scales anchored simple – complex, or composed from few – a lot of ingredients (Chung & Vickers, 2007b; Lévy et al., 2006; Porcherot & Issanchou, 1998; Sulmont-Rossé et al., 2008; Vickers & Holton, 1998; Weijzen et al., 2008; Zandstra et al., 2004). How to measure these properties has been given little attention (Lévy et al., 2006), and one can question whether a complexity can be easily evaluated by consumers. In our study the products were rated for 'similarity to meat', which fits better with consumers' own language (Elzerman, 2006). Since we were aiming for a realistic study with real products, we also did not consistently vary intensity, complexity, and novelty, but used two commercially available meat substitutes that varied in their overall resemblance to meat. Hence, products varied along different properties and our results cannot be deduced at the level of newness or complexity alone, as discussed by Lévy et al. (2006).

Table 7
Predictors of product liking.

	B	SE	*t*	*p*-value
Product	6.5	0.8	8.6	<0.001
Different meals used	−4.1	0.4	−9.7	<0.001
Prior experience with meat substitutes	2.7	0.4	6.3	<0.001
Hunger	0.5	0.03	14.8	<0.001
Time	−0.3	0.1	−2.9	<0.005
Variety seeking x product x time	−0.01	0.003	−0.08	<0.001
Constant	13.8	3.0	4.6	<0.001

Variance explained by the model is 21% (Adjusted R^2 = 0.21).

4.2. The influence of personal factors on product acceptance over time

We did not find support for an effect of food neophobia and variety seeking on the hedonic response over time, which is in line with a previous study of Chung and Vickers (2007a). Considering the liking data overall, the regression analysis did show that the degree to which someone liked a product, was more determined by *prior* experience with meat substitutes than the time effect of this study. Although many surveys and single exposure studies demonstrated a significant effect of personal characteristics on new food acceptance (e.g. Henriques, King, & Jaeger & Harker, 2005; Meiselman, 2009; Olabi et al., 2009; Tuorila et al., 2001), it thus seems to be uncertain whether and how these personal characteristics affect product acceptance in repeated exposure studies. It must be noted however, that our data was based on a convenience sample which was relatively food neophilic and high variety seeking, e.g. the mean FNS score of a representative Finnish sample was 34 (Tuorila et al., 2001) compared to the mean FNS of 24 of our Dutch sample.

It is obviously important to go beyond group-level data-analysis and to consider individual responses in repeated consumption studies (see also studies of Chung & Vickers, 2007a; Zandstra et al., 2004). Persons differ in how they respond and we found a wide range of individual responses for each of the products in our study; both boredom and mere exposure patterns. Why some persons got bored and others got to like the same test products is still unclear. This could be related to factors that were not assessed in this study, such as individual differences in optimal arousal levels (Berlyne, 1960; Köster & Mojet, 2007; Lévy et al., 2006; Michaut, 2004; Van Trijp & Van Kleef, 2008) and certain attitudes towards nutrition, health, and ecological aspects (Hoek, Luning, Stafleu, & De Graaf, 2004; Janda & Trocchia, 2001; Lea & Worsley, 2001; Sadler, 2004; Santos & Booth, 1996).

4.3. The influence of meals on product acceptance over time

This study indicates that the meal context is very relevant for repeated exposure studies and that overall meal acceptance measures should be included. Meals containing either one of the three test products were equally liked, in contrast to the product ratings, which showed that meat substitutes were generally liked less than chicken. In addition we found that the meals containing these products were not boring over time, as opposed to the products. It thus seems that the other self-selected meal components were able to lift the final judgement for the meal, despite a less liked item in it. These results are in line with a previous study on meat substitutes, showing how the meal context influences overall liking (Elzerman et al., 2011).

To our knowledge, there are only a few studies that took the meal context into account during repeated exposure studies (Bingham et al., 2005; Zandstra, De Graaf, & Van Trijp, 2000b). Bingham et al. (2005) did not describe the impact of the other meal components in detail, while Zandstra et al. 2000b introduced meal variety as a controlled factor in the intervention. The latter study demonstrated that freedom and variety in meals resulted in less boredom. In our in-home use study all participants were allowed to vary the meal components, and a comparable relation between boredom and variety was observed. We found that individuals that were more bored actively sought more variety in meals, either by eating a lot of different meals, or just by changing the type of meal across consecutive test days. Participants probably used the self-selected meal components to introduce variety and increase the complexity of the meal. However, this repeated in-home use study was not designed to test how and to what degree a single product is influencing the appreciation for the entire meal, and vice versa. It would be

interesting to further investigate boredom at the level of the meal and how different meal components interact to a certain level of variety and complexity to compensate for boredom. Although it is now widely recognized that meal acceptability, food combinations, and appropriateness are of importance, (e.g. Eindhoven & Peryam, 1959; King, Meiselman, Hottenstein, Work, & Cronk, 2007; King, Weber, Meiselman, & Lv, 2004; Köster, 2003; Marshall & Bell, 2003; Meiselman, 2000; Meiselman, 2009), there is still limited data available and more work needs to be done in this area, particularly in the light of meat substitution (Elzerman, 2006; Elzerman et al., 2011; Schösler, De Boer, & Boersema, 2012).

4.4. The definition and measurement of boredom

In this paper, we defined boredom as a decrease in liking after repeated exposure (Schutz & Pilgrim, 1958; Siegel & Pilgrim, 1958) in line with previous repeated exposure studies (e.g. Son et al., 2010; Weijzen et al., 2008). However, what is exactly meant with boredom, how to conceptualize and measure this in repeated exposure studies, is not so straightforward and more complex (Köster, 2003; Moskowitz, 2000; Zandstra et al., 2004). There is currently no universally accepted definition of boredom (Vodanovich, 2003). In his review on psychometric measures on boredom, Vodanovich (2003) discusses the different definitions used across disciplines. These might focus on the actual result of repeated exposure; 'a unique psychophysical state that is somehow produced by prolonged exposure to monotonous stimulation' (O'Hanlon, 1981), or more on a subjective state when 'stimuli are construed as monotonous' combined with a high level of frustration (Hill & Perkins, 1985). Considering this subjectivity and the array of moods and vague feelings that consumers experience, it seems unlikely that a single-item (e.g. a liking or boredom rating) is a reliable and valid measure of boredom (Moskowitz, 2000; Vodanovich, 2003). This was confirmed by our evaluative interviews in which participants could not characterize boredom in detail except for describing a feeling or situation. In addition, boredom has different subsets and can be related to a neural/physiological response (a decrease in actual liking caused by specific product attributes) or a cognitive response (a decrease in desire to eat the food) (Finlayson, King, & Blundell, 2007; Mela, 2000; Zandstra et al., 2004). Consequently a range of different measures have been applied, from behavioral measures (product intake), time to recovery, to a decrease/increase in ratings for liking, boredom, pleasantness, desire-to-eat, probability of choosing a food, and interest in the product (Chung & Vickersa, 2007; Meiselman et al., 2000; Moskowitz, 2000; Zandstra et al., 2004). In our study we also incorporated different measures (the eaten amount, and desire to eat, liking, and boredom ratings) and found a correlation between the ratings. However, we were not set out to thoroughly investigate the relation between these measures. Other studies did report on different patterns of liking and wanting (desire to eat) following repeated exposure to foods (Chung & Vickers, 2007a; Stubenitsky, Aaron, Catt, & Mela, 1999; Zandstra, De Graaf, Mela, & Van Staveren, 2000a). The recent discussion amongst researchers whether liking and wanting should be distinguished or not (Finlayson & Dalton, 2012; Havermans, 2011) illustrates the importance to have a common definition and operationalization of boredom, liking, and wanting, in order to investigate their roles in food choice and consumption.

4.5. Further methodological considerations

A strong point of our study is the performance under relatively natural conditions, regardless of the logistical challenges that come with such an in-home use test (Boutrolle & Delarue, 2009). We avoided the use of manipulated foods and an artificial lab situation, in order to better predict ultimate product acceptance by consumers (Meiselman, 1992). Commercially available products were used, participants prepared and used the products at home in a dinner setting, and were free to decide on the other meal components. However, inevitably there were some study guidelines that may have influenced normal cooking and eating: there was a restriction in the use of hot spices and we had to serve pre-fried chicken pieces instead of uncooked chicken filet. These issues were also reported back in the evaluative interviews with participants after the study. While Köster and Mojet (2007) suggest to take only questionnaires at the first and final session and to include unexpected home visits, our study relied on self-reported data and required participants to fill out questionnaires at each session. One has to keep in mind that this type of repeated in-home testing is still a forced exposure in a test situation that deviates from actual consumer behavior.

The data needs to be interpreted in line with the experimental set-up used in this study. For example, a different consumption frequency of the selected products, once a week instead of twice a week, may result in a different hedonic response. The current vast decrease in liking of chicken also needs to be considered in line with other reports showing that highly liked foods display a larger drop in liking, compared to moderately like foods (Chung & Vickers, 2007a; Hetherington, Bell, & Rolls, 2000; Hetherington, Pirie, & Nabb, 2002). A product that is very acceptable at the start may become more boring than a product that is initially relatively unacceptable because liking can only decrease under specific study conditions (Köster, 2003; Moskowitz, 2000). Our study now ended with mean liking scores of 60 and less (on a 100-mm line scale) for the meat substitutes, which could raise the question whether a bottom plateau was reached for these products. However, that seems unlikely since this figure represents a group mean; with a number of participants actually scoring much lower and higher. Lastly, it is important to point out that the number of participants in each product group was low, which is a considerable limitation of this study.

4.6. Conclusions and implications for new environmentally sustainable meat substitutes

Repeated exposure to food products that are relatively unfamiliar and distinct (like meat substitutes) might increase acceptance by a segment of consumers. However, when initial liking is low compared to familiar products such as meat, most consumers will hardly ever consume these products recurrently in real life. In order to improve long-term acceptance of environmentally sustainable meat substitutes, we suggest to focus mainly on increasing the willingness to try and to establish positive *initial* product experiences. Besides improving the quality of single products, the meal context should be considered in product development of new meat substitutes as well.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.foodqual.2012.07.002.

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