Different liking but similar healthiness perceptions of rye bread among younger and older consumers in Sweden

Abstract

Rye breads, especially those with a chewy texture and sour flavor, have shown several health benefits but their consumption is lower among younger consumers than older. This study explores liking of commercial rye bread in younger and older consumers in relation to socio-demographics, childhood bread-eating habits and food choice motives. Further, sensory attributes are explored in relation to the consumers' concepts of a *rye bread* and *healthiness* in bread.

Nine commercial rye breads, previously profiled by descriptive sensory analysis were tasted by 225 younger (18-44 years) and 173 older (45-80 years) consumers. Internal preference mappings by principal component regression for each age group showed low liking for rye bread with a chewy texture and sour flavor in the younger consumer group. Based on the preference mappings, the age groups were separately clustered. Associations between clusters and background variables were studied using discriminant partial least squares regression. Liking of rye bread with a chewy texture and sour flavor in the younger consumer group was associated with e.g., more education, females, childhood bread consumption and the food choice motive *health*. In the older consumer group, it was related to e.g., more education and childhood bread consumption. Partial least squares regression 1 showed that the combination of sensory attributes such as a light color and soft texture led to the perception of bread being less healthy and not a rye bread, and a dark brown color, chewy texture, sour and bitter flavor to the perception of a *healthier* bread and *rye bread*.

Keywords: Food choice questionnaire, childhood bread consumption, preference mapping, healthiness mapping, consumer test

1 Background

Bread made from rye has been shown in previous research to possess several health benefits and is often included in descriptions of healthy diets (Olsen et al., 2011; Adamsson et al., 2012). Both whole-grain and sifted rye bread with and without sourdough have, for example, shown beneficial effects on blood glucose levels and insulin regulation (Leinonen, Liukkonen, Poutanen, Uusitupa, & Mykkänen, 1999; Rosén et al., 2009). This is especially valuable in relation to the prevention and maintenance of non-communicable, chronic diseases such as diabetes (Augustin et al., 2015). However, for the bread to have health benefits, it also needs to be available, acceptable and eaten by consumers. In the EU there is no food standard for rye bread and it is not known what type of bread consumers may look for when choosing a rye bread. In a previous study, commercial rye breads in Sweden were shown to contain between 15 and 100% rye flour (Sandvik, Marklinder, Nydahl, Næs, & Kihlberg, 2016). Half of the samples indicated to produce beneficial effects on blood glucose levels and insulin regulation by the in vitro measurement fluidity index. These breads were mainly characterized by a chewy, drier texture and a sour flavor.

Bread is a staple in the Swedish diet. In a national dietary food survey, 98% of participants reported having eaten bread (Sandvik, Kihlberg, Lindroos, Marklinder & Nydahl, 2014). Due to the lack of a definition of rye bread and the high prevalence of mixed rye-wheat breads, it is challenging to determine how much rye bread is consumed in Sweden. However, there are data on rye flour. The average per capita consumption of rye flour in 2015 was 9 kg per person and year, and this figure has steadily been decreasing, from 15 kg per person and year in 1960 (BOA, 2016). Most of the rye is incorporated in varied amounts into either dry crisp or soft bread. Soft rye bread is in focus in the present study. Bread types with a high rye content have been shown to be more frequently consumed by older (45-80 years) rather than younger (18-44 years) consumers (Sandvik et al., 2014). Rye bread is often made with whole grain and, in addition to age, a lower consumption of whole-grain bread has also been associated with lower educational levels, children in the household and country of birth (Sandvik et al., 2014). Respondents born in a Nordic country other than Sweden were more likely to have higher consumption of whole-grain bread. An age-related difference has also been seen for the total intake of whole grain in several countries, where lower intake has been observed in younger age groups (Lang & Jebb, 2003). It is uncertain whether these age differences can be explained by changes in attitudes or motives during the course of life, or by a cohort effect whereby consumers born during a given period share experiences, memories and

preferences (Lang, Thane, Bolton-Smith, & Jebb, 2003). Perceived quality is one important factor in food choice decisions and insights into the quality perceptions of rye bread of younger and older consumers could contribute to an understanding of previously identified consumption patterns (Grunert, 2006). The consumer's quality perception of bread is mainly determined by the dimensions taste and health and these dimensions are the focus here (Dewettinck et al., 2008). The present paper has a two-fold scope and addresses i) liking of commercial rye bread among younger and older Swedish consumers in relation to sensory attributes and selected consumer background variables and ii) the association between sensory attributes and consumers' perceptions of a *rye bread* and a *healthy bread*.

Only a few previous studies have focused on consumer liking of rye bread (Heiniö, Urala, Vainionpää, Poutanen, & Tuorila, 1997; Pohjanheimo, Paasovaara, Luomala, & Sandell, 2010) and none of these have explored the preferences of younger and older consumers. The majority of sensory preferences in humans are learned through repeated exposure to particular sensory events and their associated consequences (de Graaf, 2006). Food preferences have been described as being learned unconsciously and unintentionally, and preferences established in childhood have been shown to be important in predicting preferences later in life (Köster, 2009). The cultural and socioeconomic environment is viewed as playing a primary role in creating the opportunities and contexts for particular sensory experiences (Mela, 2001). The learning occurs throughout life and two forms of learning in adulthood have been described: *sensory learning* through, for example, exposure, and more conscious *cognitive learning* through, for example, advice, labeling and risk perception. The high robustness of preferences formed in childhood together with continuous lifelong learning would suggest that both a cohort effect (based on, for example, bread types available during childhood) and changes in attitudes and motives during the course of life could be associated with different preference patterns for rye bread. Hence, the association between liking and socio-demographics, childhood bread-eating habits and food choice motives are explored in the present study. The Food Choice Questionnaire (FCQ) is used to measure the perceived importance of nine motives for food selection in everyday food choices (Steptoe, Pollard, & Wardle, 1995).

Prior to purchase, consumers infer quality expectations of a product from different cues (Grunert, 2005). It has been argued that the communicated impressions used in marketing need to be upheld throughout consumption and that the physical product should therefore be regarded not

only as a source of sensory pleasure, but also as an information source (Grunert, 2015). A food name such as *rye bread* or perceived *healthiness* can be described as concepts which are evaluated by a mental checklist of components that the food, according to the consumer, should possess. These can be divided into propositional components, such as factual knowledge of how much rye a *rye bread* should contain, but also sensory components, which means an immediate recall of the look, taste, smell and texture of rye bread that the consumer has previously encountered (Smith, Møgelvang-Hansen, & Hyldig, 2010). Consumer perceptions of propositional and some sensory components of three food names have previously been studied from a labeling fairness perspective (Smith et al., 2013). In the present study, a further step has been taken by exploring how sensory profiles of Swedish commercial rye breads are related to the consumers' concepts of a *rye bread* and *healthiness* in bread.

The aim of this study is to compare liking of commercial rye bread among younger and older Swedish consumers in relation to socio-demographics, childhood bread-eating habits and food choice motives, and to describe consumers' sensory perceptions of a *rye bread* and *healthiness* in bread.

2 Materials and methods

2.1 Overall study design

Nine commercial rye breads for which sensory profiles have previously been described (Sandvik et al., 2016) were included in a consumer test. Participants indicated liking and degree of agreement with the statements: "*I would gladly eat this bread often*", "*This bread seems healthy*" and "*This is, in my opinion, a rye bread*" for each sample. Sensory profiles of the samples and liking ratings were combined by internal preference mapping using principal component regression (PCR). This was performed separately for younger (18-44 years) and older (45-80 years) consumers and the consumers were then clustered. Associations between clusters and consumer background variables (food choice motives, childhood bread-eating habits and socio-demographics) were explored by discriminant partial least squares regression (DA-PLS). The association between the sensory profiles of the samples and degree of agreement with the statements "*This bread seems healthy*" and "*This is, in my opinion, a rye bread*" were separately explored by partial least squares regression 1 (PLS-1).

2.2 Rye bread sample selection and preparation

Sensory and health-related attributes of commercial bread selected to represent a wide variety of rye bread on the Swedish market were, in a previous study, characterized by general descriptive analysis (24 samples, 11 panelists, 15 attributes), chemical acidity and fluidity index (Sandvik et al., 2016). Fluidity index is an in vitro measure for predicting the quality of the blood glucose and insulin responses to bread (Östman, Rossi, Larsson, Brighenti, & Björck, 2006). For the present study, principal component analysis of the sensory data were used to visually select a representative subset of nine bread samples to be included in the consumer test, as similarly used by Helgesen and Næs (1995). The selected samples and their labels were: sample A3, in the present study labeled as *sour whole grain (WG) rye roll*, B2: *pumpernickel*, B4: *coarse sour rye bread*, C2: *sifted flat bread*, C4: *sifted syrup loaf*, D1: *wheat-rye malt loaf*, E2: *WG rye syrup roll*, E3: *wheat-rye toast bread* (i.e. bread for toasting) and F2: *sour sifted rye bread*. The ingredients and sensory characteristics of the nine samples included in the present study are shown in Table 1 and Table 2. The composition of the included samples varied in for example, rye content (23-100%), whole grain content (0-100%), total sugars (1-10 g/100 g), pH (4.5-6.6) and Fluidity index (50-97) (Sandvik et al., 2016). Four samples in particular (sour WG rye roll, pumpernickel, coarse sour rye bread and sour sifted rye bread) displayed a lower fluidity index which indicates more beneficial effects on blood glucose and insulin levels, and these breads were mainly characterized by a chewy texture and/or sour flavor (Sandvik et al., 2016).

For the present study, data were collected on three consecutive days in a Swedish city with a population density of approximately 200,000 inhabitants. The samples were purchased the day they were delivered to the local supermarkets and stored at –18 degrees Celsius for a maximum of seven days. Prior to each testing day, the breads were thawed at room temperature in plastic bags on bread racks for eight hours. At separate workstations, the samples were cut into bite-sized rectangular pieces (approximately 2.5 x 5.5 cm) including both the crumb and the crust, and were then carefully wrapped in aluminum foil, concealing their appearance. The samples were labeled with randomly assigned 3-digit codes and placed in two transparent plastic boxes with a sealed lid. The serving order was randomized by computer and the samples in each box corresponded to the serving order of a specific questionnaire.

149 *2.3 Consumer test procedure*

150 Four test locations were set up, three at shopping malls in the town center and one at a mall in the
151 outer part of town in order to obtain a wide socio-demographic spread of responding consumers.
152 Consumers between 18-80 years, without any bread-related allergies, who volunteered to
153 participate in the taste test were included in the study. All participants received verbal and written
154 information about the study. Informed consent was obtained orally, and the participants were
155 clearly informed that they could withdraw from the study at any time. Because the study did not
156 include any biological material or sensitive information, approval from the ethical board was not
157 considered necessary, in accordance with the Act on the Ethical Review of Research Involving
158 Humans (2003).

159 Firstly, the consumers indicated overall liking for each bread sample on a nine-point balanced
160 hedonic scale from "extremely dislike" (1) to "extremely like" (9). Secondly, the consumers were
161 asked to indicate degree of agreement from "totally disagree" (1) to "totally agree" (9) with three
162 statements: *"I would gladly eat this bread often", "This bread seems healthy"* and "*This is, in my*
163 *opinion, a rye bread*". The serving order was clearly displayed in the questionnaire and consumers
164 were asked to carefully ensure that the 3-digit number on the sample matched the number on the
165 questionnaire. Water was available for the consumers to rinse their palate.

166 Two additional questions were asked concerning how much rye flour/whole grain the
167 consumers expected a bread labeled "rye bread" or "whole-grain bread" to contain. "*How much*
168 *rye/whole-grain flour should bread labeled as rye bread/whole-grain bread contain, in your*
169 *opinion?".* An unstructured 10 cm line scale was used with 0% "no", 50% "half" and 100% "only
170 rye/whole-grain flour" as anchors. The option "no opinion" was also available.

171 Background questions included gender, year of birth, number of children <18 years in the
172 household, educational level, as well as country of birth and parents' country of birth to study
173 possible influences from other cultures. The consumers were also asked how many slices of bread
174 they ate on average per day and to indicate the type of bread they mostly ate, both when they were
175 growing up and today (multiple choice). Six options were available: 1) white bread such as pan
176 bread or rolls, 2) white sweet loaf such as traditional sifted rye loaf with syrup, 3) medium dark
177 bread with soft texture, 4) dark compact coarse bread, 5) dark compact coarse sour bread and 6)
178 dry crispbread.

The FCQ (Steptoe et al., 1995) was included to further characterize the consumers. The FCQ has not, to our knowledge, been used previously in Sweden, but has been shown to be a suitable tool for exploring food choice motives across different European populations (Markovina et al., 2015). This instrument consists of 36 statements designed to assess the reported importance of nine factors on food choice (convenience, ethical concern, familiarity, health, mood, natural content, price, sensory appeal, body weight). The statements were carefully translated to Swedish and the subjects were asked to evaluate and rate the statement "It is important that the food I eat on a typical day is…" for each of the 36 items from "totally disagree" to "totally agree" (Appendix 1). As an example, three items are included in the factor *natural content* and these are i) contains no additives, ii) contains natural ingredients and iii) contains no artificial ingredients. The ratings of these items for the statements above are subsequently combined into one measurement of importance of *natural content* in food choice. As in previous research, a seven-point scale was used instead of the originally proposed four-point scale to improve discrimination (Pohjanheimo et al., 2010; Carrillo, Varela, Salvador, & Fiszman, 2011). Wrapped candy was offered at the end of the survey as a token of appreciation. The whole session took on average 20 minutes.

2.4 Statistical analyses

Firstly, three-way Analysis of Variance (ANOVA) was used to study the overall effect of age on liking. A model with fixed effects for age group and sample (and their interactions) plus a random consumer effect nested within age group was used. The age groups compared (18-44 years and 45-80 years) were mainly chosen based on the bread consumption structures seen among different age groups in Sandvik et al., 2014. The broader age-span also ensured that the groups were large enough to perform clustering and to study the characteristics of each specific cluster.

Mean ratings for liking and agreement with the statements *"This bread seems healthy*" and "*This is, in my opinion, a rye bread*" were compared for the younger (18-44 years) and older (45-80 years) consumers and between samples using one-way ANOVA and Fisher's least significant difference. These analyses were also subsequently used to compare mean liking between identified clusters. Pearson correlation was used to study the correlations between the statements "*I would gladly eat this bread often*" and *"This bread seems healthy*" and the liking ratings. Chi-square test was used to compare the bread types most often consumed in the younger and the older consumer group, and one-way ANOVA was used for reported differences in number of slices consumed per day.

The mean scores for each of the nine factors in the FCQ were computed for each consumer by averaging the ratings of the items which, according to Steptoe et al. (1995), belong to a specific factor. Subsequently, one-way ANOVA was used to study possible significant differences between the two age groups with regard to the importance of each of the nine specific food choice motives. The reliability of the FCQ was analyzed in line with Pohjanheimo et al. (2010) by Factor analysis (Maximum likelihood with Varimax rotation) with the aim being to combine the 36 items into nine factors according to the original theory of Steptoe et al. (1995) (convenience, ethical concern, familiarity, health, mood, natural content, price, sensory appeal, weight control). The internal reliability of each of the nine factors was tested using Cronbach's alpha and Item-total correlation.

To explore preference patterns among younger and older consumers and to identify consumer clusters, the sensory profiles of the samples and the liking ratings were combined by internal preference mapping using PCR. This was performed separately for each age group. Clusters were visually identified in each age group based on the correlation loadings and score plots (Endrizzi, Menichelli, Johansen, Olsen, & Næs, 2011). In visual clustering, consumers who lie close to each other are defined as belonging to the same segment. Useful segments are obtained by drawing the boundaries between the segments such that the segments are about equal in size, with respect to either number of consumers in each group or the size of the region (Næs, Brockhoff & Tomic, 2010). Visual segmentation has been shown to be useful when the grouping is less clear because automatic segmentation procedures may produce different groups depending on the method chosen (Endrizzi, Gasperi, Rødbotten, & Næs, 2014). DA-PLS was applied to characterize the identified consumer clusters. Cluster membership was used as dependent variables coded as dummy variables and the consumer characteristics were used as explanatory variables and included socio-demographic factors (age, gender, education, children in household, born/parent born outside Sweden), bread type most often eaten when growing up, and food choice motives.

Two PLS-1 analyses were used to explore how sensory impressions influence the consumers' perception that bread is *healthy* and is perceived as a *rye bread* by studying the association between the samples sensory profiles and the mean responses to the statements *"This bread seems healthy*" and "*This is, in my opinion, a rye bread*".

IBM SPSS Statistics version 22, Unscrambler version 10.3 (Camo Software) and SAS 9.4 (SAS institute Inc.) were used to perform the statistical analyses and the level of significance was set at $P<0.05$.

3 Results

3.1 Consumer characteristics

A total of 398 consumers participated in the test, with 225 being classified as younger (18-44 years) and 173 as older (45-80 years). The mean age of the younger consumers was 28 years (SD 7) and of the older 63 years (SD 10). Socio-demographics, bread consumption habits and food choice motives of the younger and the older consumers are shown in Table 3. Among the younger consumers, 34% were born or had at least one parent who was born outside Sweden; this corresponded to 26% among the older consumers. Among the consumers who were born or had a parent who was born outside Sweden, more of the older consumers had a background in countries with strong rye bread cultures such as Finland, Denmark, Poland and Germany (43% of the older and 27% of the younger). Besides these countries, mainly other European, Middle Eastern and South American countries were represented. Younger consumers reported eating significantly fewer slices of bread per day, on average 2.0 (SD 1.5) while the older consumers reported 2.9 (SD 1.8) (*P=<0.001*). Significantly more of the younger consumers had eaten mainly white bread when growing up and more of the older reported to have eaten mainly dry crispbread. Differences between the age groups were also found in the types of bread reported to be eaten most often today (Table 3).

In line with the original theory of Steptoe et al. (1995), the factor analysis of answers from the 36 statements in the FCQ identified nine factors with eigenvalues above 1, which was set as the criteria. The reliability test showed that the internal consistency of the nine food choice factors ranged from Cronbach's alpha 0.69 to 0.83. The item-total correlation varied between 0.38-0.72, with a mean of 0.57. These results are found in detail in Appendix 1. The FCQ showed that, on average, both the younger and older consumer groups rated *sensory appeal* as most important in relation to food eaten on a typical day. Next in importance were *natural content*, *health* and *price* for the younger consumers and *natural content*, *ethical concern* and *health* for the older. *Familiarity* was on average the least important motive. Younger consumers generally scored most of the factors lower than the older and the differences were significant in relation to the importance of *ethical concern*, *health*, *natural content*, *sensory appeal* and *weight control* (Table 3).

3.2 Rye bread liking among younger and older consumers

The three-way ANOVA showed a highly significant interaction for liking between age groups and samples (*P=<0.001*), supporting the age segmentation (data not shown). The mean liking ratings on the nine-point hedonic scale ranged from 4.0 to 7.1 in the younger consumer group and from 4.7 to 6.0 in the older consumer group (Table 4). Significant differences regarding liking were found between the age groups for six of the nine samples (sour WG rye roll, pumpernickel, coarse sour rye bread, sifted flat bread, sifted syrup loaf and wheat-rye toast bread). For example, the sifted syrup loaf displayed the lowest liking among older consumers (mean liking: 4.7), but was one of the most liked among the younger consumers (mean liking: 6.7). The opposite was seen for the samples with the highest content of whole grain rye and sourdough (sour WG rye roll, pumpernickel, coarse sour rye bread). The liking ratings corresponded well with answers to the statement "*I would gladly eat this bread often*" (Pearson correlation 0.84 for younger and 0.86 for the older consumers group, data not shown).

3.3 Internal preference mapping and visual clustering

The two internal preference mappings display different preference patterns for the two age groups. Figures 1a and 1b show the correlation loadings plot for the younger compared to the older consumers. Younger consumers generally showed a preference towards samples on the right on the correlation loadings plot. Samples in this area (sifted flat bread and sifted syrup loaf) display a high cohesiveness of mass, deformability and sweetness. The older consumers showed a more disparate picture in their liking with a tendency for liking breads that display a higher chewing resistance, higher moisture (saliva) absorption, and more rye and sour flavors (sour WG rye roll and coarse sour rye bread). The sour sifted rye bread, showed a tendency, especially among the older consumers, to be placed separately from the other samples in the preference map in an area with few consumers (Figure 1b).

When clustering the consumers, the first principal component in the two separate preference mappings was interpreted according to which products they represented and each age group was visually classified into three adequately sized clusters with similar preference patterns. The mean liking of the samples differed significantly between the clusters except for the sour sifted rye bread among the younger and the WG rye syrup roll among the older (Table 5). The "soft-white clusters" (36% of the younger and 26% of the older consumers) displayed a high liking for samples with a low rye content (sifted flat bread and sifted syrup loaf) and a lower liking for samples with a high

content of whole-grain rye (sour WG rye roll, pumpernickel and coarse sour rye bread). The "dark-chewy clusters" (19% of the younger and 35% of the older consumers) displayed what could be described as an opposite direction of liking from the "soft-white cluster". The "intermediate cluster" (45% of the younger and 40% of the older consumers) displayed intermediate liking for the samples with a high content of whole-grain rye, a higher liking than the "dark-chewy clusters" for e.g. the wheat-rye toast bread, the sifted flat bread and the sifted syrup loaf (Table 5).

3.4 Clusters in relation to consumer background variables

The DA-PLS was performed to study possible associations between the identified consumer clusters and consumer background variables. The explained variance was relatively low, but the loadings plot nonetheless provides graphical representations of the data (Figure 2a and b). When comparing the three clusters, differences in relation to background variables were mainly observed between the "soft-white" and the "dark-chewy" clusters in the younger consumer group. In the older consumer group, it was instead the "soft-white cluster" that differed from the "intermediate" and "dark-chewy" clusters (Figures 2a and 2b). The first factor in the model was mainly important in describing differences between the clusters in both age groups.

Among the younger consumers, the clusters differed according to gender, with male consumers more often in the "soft-white cluster" and females in the "dark-chewy cluster". A higher educational level ($\geq$3 years of post-secondary education) was associated with the "dark-chewy cluster" as well as with eating less white bread, such as pan bread or rolls, and white sweet loaf such as traditional sifted rye loaf when growing up. Regarding the food choice motives explored using the FCQ, the factors *familiarity* and *convenience* were more important for the "soft-white cluster", while *health, ethical concern, natural content* and *mood* were less important. For the "dark-chewy cluster", *health, ethical concern* and *natural content* were instead more important and *convenience* and *familiarity* less important (Figure 2a).

Among the older consumers, the pattern was not as clear and fewer background variables differed significantly between the clusters (Figure 2b). The analysis mainly showed that the "soft-white cluster" was associated with a lower educational level. Consumers in this group perceived *natural content* as less important, and were less often born or had a parent(s) that was born outside Sweden. This group had also consumed less dark coarse bread when growing up.

3.5 The influence of sensory impressions on the perceptions that bread is "healthy" and is a "rye bread"

The samples with the highest content of whole-grain rye (sour WG rye roll, pumpernickel and coarse sour rye bread), were perceived by both age groups as healthiest while the samples with the lowest rye content, the sifted flat bread and the sifted syrup loaf, were perceived as least healthy (Table 4). ANOVA classified the samples into four groups with significantly different perceived healthiness (Table 4). The age groups only disagreed on the healthiness of the wheat-rye malt loaf which older consumers perceived as significantly less healthy than the younger. Healthiness perceptions did not correlate with willingness to eat among younger consumers, yet significantly correlated among the older (Pearson correlation 0.56, data not shown). The PLS-1 was performed on all consumers together, the first factor explained 68% of the variance of X (sensory properties), and 94% of the variance in Y (perceived healthiness) (data not shown). The uncertainty test showed that the sensory attributes that positively correlated with perceived healthiness in the bread samples were: brown color, sour and malty odor, sour and bitter flavor, and rye and roasted aftertaste. With regard to texture: compressibility, chewing resistance, moisture (saliva) absorption and heterogeneity were positively correlated with perceived healthiness. Deformability, cohesiveness of mass and sweet taste were negatively correlated with the perception of healthiness in bread.

The PLS-1, relating the sensory profiles to the expectation of a "rye bread" in the whole sample of consumers, showed a similar pattern as for perceived healthiness of bread, with the exception for sweetness, which was not a significant factor. The first factor explained 68% of the variance in X (sensory properties) and 91% of the variance in Y (rye bread perception), data not shown. There is no standardized definition of a *rye bread* in Sweden and the present study showed that consumers mainly perceived the samples with the highest content of whole grain rye, as *rye breads* (sour WG rye roll, pumpernickel and coarse sour rye bread) and the sifted flat bread and sifted syrup loaf the least like *rye breads* (Table 4). Younger and older consumers disagreed on the wheat-rye toast bread and the sour sifted rye bread. Older consumers perceived these samples more often as rye breads than the younger consumers. The question "*How much rye flour should bread contain to be labeled as a rye bread, in your opinion?"* was answered similarly by both age groups. The mean answer for younger consumers was 71% (SD 19%) and older consumers 72% (SD 18%). In both age groups, six percent answered *"no opinion".* To the question "*How much whole grain should bread contain to be labeled as a whole-grain bread, in your opinion?"* the mean answer for

younger consumers was 72% (SD 18%) and older consumers 73% (SD 18%). In both age groups, seven percent answered *"no opinion"*.

4 Discussion

4.1 Rye bread liking in relation to sensory attributes and health-related aspects

Significant differences were seen for liking of the sampled rye breads amongst all the consumers as a group. However, different liking patterns were identified comparing a younger and an older consumer group, indicating that sensory liking is a possible explanatory factor for the differences previously seen between the age groups for rye and whole-grain bread consumption (Sandvik et al., 2014). Although sourdough whole-grain rye bread was perceived as the healthiest in both age groups, consumers generally do not compromise on taste (Verbeke, 2006; Siró, Kápolna, Kápolna, & Lugasi, 2008). The younger group (18-44 years) displayed a higher liking for breads with a soft texture and a sweet flavor. This is in line with research on wheat bread where a low chewing resistance was the most liked by younger consumers (<30 years) (Kihlberg & Risvik, 2007). Older consumers showed a higher liking for different types of rye breads with a tendency towards more whole-grain-rich rye bread, similar to consumers in the study by Pohjanheimo et al. (2010) who were classified as having traditional values. The samples that were better liked by the younger group had instead a lower rye content, less or no whole grain, more added sugar and no sourdough. Although none of the samples scored extremely low on liking, the least liked samples among the younger consumers (sour WG rye roll, pumpernickel, coarse sour rye bread and sour sifted rye bread) were unfortunately those that have been indicated to have more beneficial effects on blood glucose and insulin levels (Sandvik et al., 2016). Texture-related attributes were central drivers of liking in the rye breads; texture has also previously been shown to be important for consumers' sensory perceptions of bread (Hersleth, Berggren, Westad, & Martens, 2005). The most dominant taste in whole grain has been described to be the bitter note (Heiniö et al., 2016). The flavor attributes that were most important for liking in the present study of commercial rye breads were, however, not bitter flavor, but rye flavor, sour flavor, saltiness and sweetness. Younger consumers showed a particular liking for sweet breads, such as the sifted flat bread, sifted syrup loaf, wheat-rye malt loaf and WG rye syrup roll, which all contain 8-10% sugar. The quite unique Swedish tradition of adding syrup or sugar to bread is said to have its roots in the flour shortage during World War I when the authorities decided that bakeries should increase the energy value in bread

by adding beet sugar (Notaker, 2009). Sourdough fermentation is often used in rye bread baking to improve the texture and has been related to health benefits such as well-regulated postprandial blood glucose. However, it also contributes to a sour taste in the bread (Poutanen, Flander & Katina, 2009). Sour taste was negatively related to liking in the younger consumer group, a result in contrast to a study with sour rye bread among Finnish consumers where different levels of acidity not were associated with liking (Heiniö et al., 1997). The result emphasizes the importance of optimizing the sourdough fermentation process for producing bread with moderate acidity and balanced sensory profiles (Heiniö et al., 2016). One common method to increase the volume and soften the texture of rye bread is to add wheat gluten; this was found in half of the samples in a previous study characterizing commercial rye bread (Sandvik et al., 2016). All of the most-liked rye bread samples among the younger consumers contained added gluten (Table 1). The addition of gluten to rye bread has, however, been shown to remove the beneficial effect of the rye bread on the insulin response (Nordlund, Katina, Mykkänen, & Poutanen, 2016). An alternative could be to use endospermic rye flour, which contributes a less coarse texture and has also been shown to have beneficial effects on postprandial insulin levels (Heiniö, Liukkonen, Katina, Myllymäki, & Poutanen, 2003; Rosén et al., 2009). Bread with a high content of endospermic rye is, however, uncommon on the market. The sour sifted rye bread contained 51% sifted rye flour but there were small differences in liking between the clusters for this bread, perhaps due to consumers being less familiar with this bread type. This sample was also one of the least liked among the older consumers. The mean liking ratings in the older consumer group could not be related as clearly to the health attributes of the samples as in the younger group. Both whole-grain sourdough rye samples as well as samples with less whole grain and rye and a softer texture were among the most as well as the least liked. The WG rye syrup roll showed relatively high liking among both age groups. It contained 63% rye and 68% whole grain, but also had a high total sugar content and a relatively high FI, which would indicate a faster blood glucose response. The sensory profile of this bread could, however, be used as a starting point for developing healthy rye bread with high liking in a broad consumer group.

4.2 Rye bread liking among younger and older consumers in relation to childhood bread eating, food choice motives and socio-demographic factors

Childhood bread-eating habits, food choice motives and socio-demographic factors were related to the clusters in both the younger and the older consumers, and the patterns were similar. There was

a significant difference in several of the bread types consumed in childhood between the younger and older consumers (Table 3) and there were also differences in the clusters (Figure 2). Exposure at a younger age is related to liking in adulthood (Cooke, 2007) and in a national dietary survey of Swedish children it was reported that the type of bread most commonly consumed was classified as white bread (Enghardt Barbieri, Pearson, & Becker, 2006). The results from the present study would therefore suggest that the liking of whole-grain-rich rye bread with a tough texture and sour flavor may further decrease in future generations. Being born or having a parent who was born outside Sweden would also indicate other cultural influences from an early age. This factor was negatively associated with the "white-soft cluster" among the older consumers but not among the younger. More of the older consumers and less of the younger had, however, a connection to countries with strong rye bread cultures, such as Finland, Denmark, Poland and Germany, something that would also suggest a higher exposure earlier in life. These two factors would indicate a cohort explanation for the different consumption patterns seen for age groups.

A change in food choice motives during the course of life could also have an effect on liking. A higher consumption of healthy food (fish) among older age groups was shown to be mediated by an increased interest in health in this group (Olsen, 2003). The importance of health has been shown by using the FCQ to be related to preference for yoghurt with a sourer flavor (Pohjanheimo & Sandell, 2009). Therefore, the importance of the food choice motive *health* would be expected to be associated with a liking for rye bread with a higher chewing resistance and more intense sour flavor, characteristics of samples that were also perceived as most healthy. This was the case for the younger consumers (together with the factors *ethical concern* and *natural content).* Among younger consumers, an attitude change could possibly render an increased liking of rye bread with potential health benefits. For the older consumers, the pattern was similar but not as clear. One explanation could be that the clusters did not differ as much for liking as in the younger consumers (Table 5). In the present study, the range within age groups was broad, but did enable insights into differences in liking between these age groups as well as into the association between liking and consumer background variables. More and narrower age groups were included in the characterization of the different clusters. Although these were not significant, the result indicated a pattern in which older consumers, also within specific age groups, were more likely to be classified into the "dark-chewy clusters" and the youngest closest to the "white-soft cluster" (Figure 2).

Interestingly, gender was only significant among the younger consumers, where females were associated with the dark-chewy cluster and close to the food choice motive *health*. It has previously been shown that females perceive health as more important in food choice than men (Wardle et al., 2004). Educational level differentiated both the younger and older clusters and a lower educational level has earlier been associated with a lower intake of whole-grain bread (Kyrø et al., 2011; Sandvik et al., 2014). Arvola et al. (2007) compared perceptions of refined grain and whole-grain products in Finland, the UK and Italy. In their study, consumers did not perceive the price to differ between the two product groups. The association between a lower education level and the food choice motive *familiarity* is in line with earlier research, and although the price may not differ between more or less whole-grain-rich bread types, one suggested explanation is that this group cannot financially afford to take chances with food selection by buying unfamiliar products (Steptoe & Wardle, 1999). The association between *convenience* and the white-soft cluster corresponds with previous research showing a higher consumption of white bread being related to fast-food bread consumption and eating bread on the go (Sandvik et al., 2014). Encouraging product development of fast food bread that is whole-grain-rich could therefore be one way to increase consumption. Enabling the consumption of different bread types, for example, in preschool and with the free school meal provided in Sweden and other countries, could be another way to increase the exposure in childhood among all socio-demographic groups and thereby broaden the liking.

4.3 Perceived sensory components of healthy bread and rye bread

The consumers' healthiness ratings of breads based on only intrinsic characteristics of the products could be described as fairly accurate, since the samples with more whole grain, rye, fiber and less sugar were rated as healthier. This is in spite of the lack of any information on the packaging, which is generally available to the consumer. Bread texture and flavor attributes, such as sourness, have previously shown potential for use as intrinsic quality cues for more well-regulated blood glucose levels and insulin responses from rye bread on the Swedish market (Sandvik et al., 2016). Although bread cannot usually be tasted before purchase, a description of the sensory profile on the packaging could aid the consumer to create health-related quality expectations of the product. The sour sifted rye bread does not contain whole grain but sifted rye flour and has been indicated as having beneficial effects on blood glucose and insulin levels (Sandvik et al., 2016). However, the color and texture (light and soft) is not in line with consumers' concepts of healthiness in rye bread,

leading to lower perceived healthiness. Results from the present study further show that, with regard to sensory properties, it would be challenging to optimize both the liking and perceived healthiness of bread, especially among younger consumers, since these have shown different directions.

The concept *Rye bread* is used in both research and dietary recommendations, but in Sweden there is no definition of rye bread, for example how much rye it should contain. In general, the samples with the darkest color and the chewiest texture were perceived as rye breads by the consumer (sour WG rye roll, pumpernickel, coarse sour rye bread). Brown color, sour and malty odors, sour and bitter flavors, and rye and roasted aftertaste were positively associated with rye bread. This is similar to Finnish consumers who related higher ash content and acidity to a typical rye bread (Heiniö et al., 1997). Information on food packaging, such as the product name, should not be misleading (EU-regulation No 1169/2011) and with regards to propositional components of a rye bread, both younger and older consumers expected bread labeled "rye bread" to contain on average at least 70% rye flour, which is more than in several commercial rye breads in Sweden (Sandvik et al., 2016). Similarly, the expected amount of whole grain in whole-grain bread was around 70%. A sectoral agreement in Sweden recommends a minimum content of 50% whole-grain flour (Sveriges bagare och konditorer, 2014) but information from the present study could be used in the development of a potential standard for rye breads in Sweden. It has been suggested that the design of the physical product is regarded not only as a source of sensory pleasure, but also as an information source (Grunert, 2015). The present study demonstrates how consumers' expectations of a food can be studied using sensory methodology by mapping consumer perceptions of concepts such as healthiness and names of foods in relation to sensory properties.

The FCQ is a widely used questionnaire that has shown good reliability (Markovina et al., 2015), and in line with the original scale, a nine-factor solution was identified in the present study. Cronbach's alpha is a reliability coefficient that assesses the consistency of a scale, and a value between 0.6-0.7 is deemed to be the lower limit of acceptability (Hair, 2010). The factor *weight control* in the present study showed the lowest Cronbach's alpa, at 0.69. Another reliability measurement, item-total correlation, indicates that the item is measuring the same construct as is measured by the other items in the same subscale. Item-total correlations $\leq$0.4 for some items in the FCQ have been seen in other studies and have been described as low. In the present study, two

items out of the 36 had an item-total correlation of 0.38, while the number of items have previously been as high as nine (Fotopoulos, Krystallis, Vassallo & Pagiaslis, 2009). It has been suggested that this may be explained by different FCQ items possibly having different connotations in different cultures or by an evolution possibly having occurred in the meaning attributed to food characteristics since the development of the questionnaire (Eertmans, Victoir, Notelaers, Vansant, & Van den Bergh, 2006; Pohjanheimo et al., 2010). It should be emphasized that the consumers in the present study not were selected by randomized sampling, but did however represent a wide range of consumers in relation to socio-demographic factors. The type of bread generally consumed whilst growing up was also self-reported and represented the consumers own recalled experiences. Bread is often eaten with spreads and fillings, but the samples in this study were tasted alone since consumers may like different fillings. This and other situational and contextual factors characterized by a less natural eating situation in the specific test may also have affected the liking (King, Meiselman, Hottenstein, Work, & Cronk, 2007). The samples were frozen, which may have affected their sensory properties. This procedure, however, ensured that the samples were equally fresh for each testing day and the same procedure was used in the descriptive analysis (Sandvik et al., 2016).

5 Conclusion

Both the younger and older group of consumers correctly identified the healthier rye breads from tasting the samples. Younger consumers, however, generally displayed higher liking for breads with a soft, juicy texture (low moisture absorption) and sweet flavor, samples that were also perceived as least healthy and not as rye breads. This was especially associated with being male, eating mainly white bread or sweet loaf bread in childhood, and finding *convenience* and *familiarity* important in food choice. A higher educational level, being female and expressing the importance of *health*, *ethical concern* and *natural content* when choosing food were especially associated with a preference for healthier rye bread with a high chewing resistance and a sour flavor among younger consumers. The older consumers generally displayed a somewhat higher liking for bread rich in whole-grain rye. A higher liking for soft-white bread in the older group, was related to a lower educational level, being born in and having parents born in Sweden, a lower consumption of dark chewy bread in childhood and was negatively associated with importance of *natural content* in food choice. The combination of sensory attributes such as a light color and soft texture led to the

perception of bread being less healthy and not a rye bread, and the opposite applied for healthier bread and rye bread i.e. a dark brown color, tough texture, sour and bitter flavor.

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References

The Act concerning the Ethical Review of Research Involving Humans (2003) in SFS 2003:460. The Ministry of Education and Cultural Affairs, Sweden.

Adamsson, V., Reumark, A., Cederholm, T., Vessby, B., Risérus, U., & Johansson, G. (2012). What is a healthy Nordic diet? Foods and nutrients in the NORDIET study. *Food & Nutrition Research, 56.* doi: 10.3402/fnr.v56i0.18189

Arvola, A., Lähteenmäki, L., Dean, M., Vassallo, M., Winkelmann, M., Claupein, E., ... & Shepherd, R. (2007). Consumers' beliefs about whole and refined grain products in the UK, Italy and Finland. Journal of Cereal Science, 46(3), 197-206. doi: 10.1016/j.jcs.2007.06.001

Augustin, L. S. A., Kendall, C. W. C., Jenkins, D. J. A., Willett, W. C., Astrup, A., Barclay, A. W., . . . & Poli, A. (2015). Glycemic index, glycemic load and glycemic response: An International Scientific Consensus Summit from the International Carbohydrate Quality Consortium (ICQC). *Nutrition, Metabolism and Cardiovascular Diseases, 25*(9), 795-815. doi: dx.doi.org/10.1016/j.numecd.2015.05.005

B.O.A, Swedish Board of Agriculture (2016). Food consumption and nutritive values, data up to 2015.

http://www.scb.se/contentassets/999ec4d420ce43f69cd557767fd11b3a/jo1301_2015a01_sm_jo44sm1601.pdf. Accessed 17.02.10.

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. doi: 10.1111/j.1745-459X.2010.00325.x

Cooke, L. (2007). The importance of exposure for healthy eating in childhood: a review. *Journal of Human Nutrition and Dietetics, 20*(4), 294-301. doi: 10.1111/j.1365-277X.2007.00804.x

De Graaf, C. (2006). Sensory influences on food choice and food intake. In L. Frewer & van Trijp, H. (Eds.) *Understanding consumers of food products*, (pp. 30-66). Cambridge, Woodhead Publishing Limited.

Dewettinck, K., Van Bockstaele, F., Kühne, B., Van de Walle, D., Courtens, T. M., & Gellynck, X. (2008). Nutritional value of bread: Influence of processing, food interaction and consumer perception. *Journal of Cereal Science, 48*(2), 243-257. doi: 10.1016/j.jcs.2008.01.003

Eertmans, A., Victoir, A., Notelaers, G., Vansant, G., & Van den Bergh, O. (2006). The Food Choice Questionnaire: Factorial invariant over western urban populations? *Food Quality and Preference, 17*(5), 344-352.

Endrizzi, I., Gasperi, F., Rødbotten, M., & Næs, T. (2014). Interpretation, validation and segmentation of preference mapping models. *Food Quality and Preference, 32*, 198-209. doi: 10.1016/j.foodqual.2013.10.002

Endrizzi, I., Menichelli, E., Johansen, S. B., Olsen, N. V., & Næs, T. (2011). Handling of individual differences in rating-based conjoint analysis. *Food Quality and Preference, 22*(3), 241-254. doi: dx.doi.org/10.1016/j.foodqual.2010.10.005

Enghardt Barbieri, H., Pearson, M., & Becker, W. (2006). Riksmaten–barn 2003. *Livsmedels–och näringsintag bland barn i Sverige [Riksmaten-Children 2003. The food and nutritional intake among children in Sweden]*. Swedish National Food Administration, Uppsala, Sweden.

Fotopoulos, C., Krystallis, A., Vassallo, M. & Pagiaslis, A. (2009). Food Choice Questionnaire (FCQ) revisited. Suggestions for the development of an enhanced general food motivation model. *Appetite*, 52(1), 199-208. doi: 10.1016/j.appet.2008.09.014

Grunert, K. G. (2005). Food quality and safety: consumer perception and demand. *European Review of Agricultural Economics, 32*(3), 369-391. doi: 10.1093/eurrag/jbi011

Grunert, K. G. (2006). How consumers perceive food quality. In L. Frewer & van Trijp, H. (Eds.) *Understanding consumers of food products*, (pp. 181-197). Cambridge, Woodhead Publishing Limited.

Grunert, K. G. (2015). The common ground between sensory and consumer science. *Current Opinion in Food Science, 3*, 19-22. doi: dx.doi.org/10.1016/j.cofs.2014.11.003

Hair, J. F. (2010). *Multivariate data analysis: a global perspective*. Upper Saddle River, N.J: Pearson Education.

Heiniö, R.-L., Liukkonen, K.-H., Katina, K., Myllymäki, O., & Poutanen, K. (2003). Milling fractionation of rye produces different sensory profiles of both flour and bread. *LWT - Food Science and Technology, 36*(6), 577-583. doi: 10.1016/S0023-6438(03)00063-X

Heiniö, R. L., Noort, M. W. J., Katina, K., Alam, S. A., Sozer, N., de Kock, H. L., . . . & Poutanen, K. (2016). Sensory characteristics of wholegrain and bran-rich cereal foods – A review. *Trends in Food Science & Technology, 47*, 25-38. doi: 10.1016/j.tifs.2015.11.002

Heiniö, R. L., Urala, N., Vainionpää, J., Poutanen, K., & Tuorila, H. (1997). Identity and overall acceptance of two types of sour rye bread. *International Journal of Food Science and Technology, 32*(2), 169-178. doi: 10.1046/j.1365-2621.1997.00393.x

Helgesen, H., & Næs, T. (1995). Selection of dry fermented lamb sausages for consumer testing. *Food Quality and Preference, 6*(2), 109-120.

Hersleth, M., Berggren, R., Westad, F., & Martens, M. (2005). Preception of bread: A comparison of consumers and trained assessors. *Journal of Food Science, 70*(2), 95-101. doi: 10.1111/j.1365-2621.2005.tb07123.x

Kihlberg, I., & Risvik, E. (2007). Consumers of organic foods - value segments and liking of bread. *Food Quality and Preference, 18*(3), 471-481. doi: 10.1016/j.foodqual.2006.03.023

King, S. C., Meiselman, H. L., Hottenstein, A. W., Work, T. M., & Cronk, V. (2007). The effects of contextual variables on food acceptability: A confirmatory study. *Food Quality and Preference, 18*(1), 58-65. doi: dx.doi.org/10.1016/j.foodqual.2005.07.014

Köster, E. P. (2009). Diversity in the determinants of food choice: A psychological perspective. *Food Quality and Preference, 20*(2), 70-82. doi: dx.doi.org/10.1016/j.foodqual.2007.11.002

Kyrø, C., Skeie, G., Dragsted, L. O., Christensen, J., Overvad, K., Hallmans, G., . . . Olsen, A. (2011). Intake of whole grains in Scandinavia is associated with healthy lifestyle, socio-economic and dietary factors. *Public Health Nutrition, 14*(10), 1787-1795. doi: 10.1017/S1368980011000206

Lang, R., & Jebb, S. A. (2003). Who consumes whole grains, and how much? *Proceedings of the Nutrition Society, 62*(1), 123-127.

Lang, R., Thane, C. W., Bolton-Smith, C., & Jebb, S. A. (2003). Consumption of whole-grain foods by British adults: findings from further analysis of two national dietary surveys. *Public Health Nutrition, 6*(05), 479-484. doi:10.1079/PHN2002453

Leinonen, K., Liukkonen, K., Poutanen, K., Uusitupa, M., & Mykkänen, H. (1999). Rye bread decreases postprandial insulin response but does not alter glucose response in healthy Finnish subjects. *European Journal of Clinical Nutrition, 53*(4), 262-267.

Markovina, J., Stewart-Knox, B. J., Rankin, A., Gibney, M., de Almeida, M. D. V., Fischer, A., . . . Frewer, L. J. (2015). Food4Me study: Validity and reliability of Food Choice Questionnaire in 9 European countries. *Food Quality and Preference, 45,* 26-32. doi: dx.doi.org/10.1016/j.foodqual.2015.05.002

Mela, D. J. (2001). Why do we like what we like? *Journal of the Science of Food and Agriculture*, 81(1), 10-16. doi: 10.1002/1097-0010(20010101)81:1<10::AID-JSFA779>3.0.CO;2-D

Næs, T., Brockhoff, P. B., & Tomic, O. (2011). *Statistics for sensory and consumer science*. West Sussex: John Wiley & Sons.

Nordlund, E., Katina, K., Mykkänen, H., & Poutanen, K. (2016). Distinct characteristics of rye and wheat breads impact on their in vitro gastric disintegration and in vivo glucose and insulin responses. *Foods, 5*(2), 24.

Notaker, H. (2009). *Food culture in Scandinavia*. Westport, Conn: Greenwood Press.

Olsen, A., Egeberg, R., Halkjær, J., Christensen, J., Overvad, K., & Tjønneland, A. (2011). Healthy aspects of the Nordic diet are related to lower total mortality. *The Journal of Nutrition, 141*(4), 639-644. doi: 10.3945/jn.110.131375

Olsen, S. O. (2003). Understanding the relationship between age and seafood consumption: the mediating role of attitude, health involvement and convenience. *Food Quality and Preference, 14*(3), 199-209. doi: dx.doi.org/10.1016/S0950-3293(02)00055-1

Östman, E., Rossi, E., Larsson, H., Brighenti, F., & Björck, I. (2006). Glucose and insulin responses in healthy men to barley bread with different levels of (1→ 3; 1→ 4)-β-glucans; predictions using fluidity measurements of in vitro enzyme digests. *Journal of Cereal Science, 43*(2), 230-235. doi: dx.doi.org/10.1016/j.jcs.2005.11.001

Pohjanheimo, T., Paasovaara, R., Luomala, H., & Sandell, M. (2010). Food choice motives and bread liking of consumers embracing hedonistic and traditional values. *Appetite, 54*(1), 170-180. doi: 10.1016/j.appet.2009.10.004

Pohjanheimo, T., & Sandell, M. (2009). Explaining the liking for drinking yoghurt: The role of sensory quality, food choice motives, health concern and product information. *International Dairy Journal, 19*(8), 459-466. doi: dx.doi.org/10.1016/j.idairyj.2009.03.004

Poutanen, K., Flander, L. & Katina, K. (2009). Sourdough and cereal fermentation in a nutritional perspective. *Food Microbiology*, 26(7), 693-699. doi: http://dx.doi.org/10.1016/j.fm.2009.07.011

Rosén, L., Silva, L., Andersson, U., Holm, C., Östman, E., & Björck, I. (2009). Endosperm and whole grain rye breads are characterized by low post-prandial insulin response and a beneficial blood glucose profile. *Nutrition Journal, 8*(1), 42. doi: 10.1186/1475-2891-8-42

Sandvik, P., Kihlberg, I., Lindroos, A. K., Marklinder, I., & Nydahl, M. (2014). Bread consumption patterns in a Swedish national dietary survey focusing particularly on whole-grain and rye bread. *Food & nutrition research, 58*. doi:10.3402/fnr.v58.24024

Sandvik, P., Marklinder, I., Nydahl, M., Næs, T., & Kihlberg, I. (2016). Characterization of Commercial Rye Bread Based on Sensory Properties, Fluidity Index and Chemical Acidity. *Journal of Sensory Studies*. doi: 10.1111/joss.12211

Siró, I., Kápolna, E., Kápolna, B., & Lugasi, A. (2008). Functional food. Product development, marketing and consumer acceptance—A review. *Appetite, 51*(3), 456-467. doi: dx.doi.org/10.1016/j.appet.2008.05.060

Smith, V., Green-Petersen, D., Møgelvang-Hansen, P., Christensen, R. H. B., Qvistgaard, F., & Hyldig, G. (2013). What's (in) a real smoothie. A division of linguistic labour in consumers' acceptance of name–product combinations? *Appetite, 63*, 129-140. doi: 10.1016/j.appet.2012.10.020

Smith, V., Møgelvang-Hansen, P., & Hyldig, G. (2010). Spin versus fair speak in food labelling: A matter of taste? *Food Quality and Preference, 21*(8), 1016-1025. doi: dx.doi.org/10.1016/j.foodqual.2010.05.016

Steptoe, 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. doi: 10.1006/appe.1995.0061

Steptoe, A., & Wardle, J. (1999). Motivational factors as mediators of socioeconomic variations in dietary intake patterns. *Psychology & Health, 14*(3), 391-402. doi: 10.1080/08870449908407336

692 Sveriges bagare och konditorer, Märk väl. Guidelines for labeling of bread (2014).
693 http://www.bageri.se/medlem/branschriktlinjer/ Accessed: 16.10.01
694 Verbeke, W. (2006). Functional foods: Consumer willingness to compromise on taste for health?
695 *Food Quality and Preference, 17*(1), 126-131. doi: dx.doi.org/10.1016/j.foodqual.2005.03.003
696 Wardle, J., Haase, A. M., Steptoe, A., Nillapun, M., Jonwutiwes, K., & Bellisie, F. (2004).
697 Gender differences in food choice: the contribution of health beliefs and dieting. *Annals of*
698 *Behavioral Medicine, 27*(2), 107-116.

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701 **Table 1**. Ingredients according to ingredients list and proportion of rye, whole grain and total sugar
702 for the nine rye bread samples included in the consumer test.

Sample[1]	Ingredients	% rye[2]	% WG[3]	Total sugars
Sour WG rye roll (A3)	**Whole-grain rye flour**, whole-grain rye sourdough, wheat flour, water, salt, yeast (roll).	83	91	2
Pumpernickel (B2)	**Whole-grain rye** (partly as sourdough), water, salt (slice).	100	99	3
Coarse sour rye bread (B4)	**Fine whole-grain rye flour**, coarse whole-grain rye flour, water, sourdough (crushed whole-grain rye, water), dark barley malt extract, sea salt, barley flakes, yeast (slice).	100	100	1
Sifted flat bread (C2)	**Wheat flour**, water, sifted rye flour, syrup, sugar, wheat gluten, rapeseed oil, fiber from sugar beet, salt, yeast, potato starch, emulsifier, ammonium carbonate, fructose, sourdough culture, flour treatment agents, enzyme (slice).	23	0	8
Sifted syrup loaf (C4)	Flour (**wheat**, sifted rye), water, syrup, yeast, scalded rye, vegetable fat, wheat sourdough powder, salt, wheat gluten (slice).	35	0	10
Wheat-rye malt loaf (D1)	**Wheat flour**, water, whole-grain rye, syrup, sifted rye, cut whole-grain rye, wheat gluten, rye sourdough, barley wort, rye brewing malt, wheat germs, yeast, rapeseed oil, salt, pre-fermented wheat flour, wheat bran (slice).	47	25	9
WG rye syrup roll (E2)	Water, **whole-grain rye flour**, wheat flour, syrup, whole-grain rye sourdough, yeast, whole-grain wheat, rapeseed oil, salt, wheat gluten (roll).	62	68	10
Wheat-rye toast bread (E3)	Flour (**wheat**, whole-grain wheat, whole-grain rye, water, rye kernels (8,5%), wheat gluten, syrup, rye fiber, vegetable fat, yeast, flaxseed (2%), vinegar, salt, barley malt, wheat sourdough powder, vegetable emulsifier, strewed with rolled rye (slice).	40	25	5
Sour sifted rye bread (F2)	**Rye flour**, wheat flour, sourdough (rye flour, water), water, salt, yeast (slice).	51	0	2

703 [1] In brackets, sample code from Sandvik et al., 2014.
704 [2] Proportion of rye in relation to the total cereal content.
705 [3] Percentage of whole grain (WG) in dry weight.

706 **Table 2.** Definitions of sensory attributes and mean ratings for nine bread samples used in the
707 consumer test evaluated by descriptive analysis in a previous study (trained assessors: *n=11*,
708 samples assessed in duplicates, scale: 0 = little, 10 = much) (Sandvik et al., 2016).

Attributes (Abbreviations) Definitions	Sour WG rye roll	Pumper-nickel	Coarse sour rye bread	Sifted flat bread	Sifted syrup loaf	Wheat-rye malt loaf	WG rye syrup roll	Wheat-rye toast bread	Sour sifted rye bread
Appearance									
Brown color bread crumb (C-Brown) Degree of brown color in the bread crumb. Little: light beige (NCS S 1515Y) – Much: dark brown (NCS 7020-Y50R)	5.4^{d}	9.5^{f}	8.7^{e}	0.1^{a}	0.3^{a}	8.1^{e}	3.6^{c}	3.8^{c}	2.0^{b}
Odor									
Sour (O-Sour) Degree of sour odor typical for sourdough[1]	8.3^{e}	6.7^{d}	8.7^{e}	0.4^{a}	0.3^{a}	4.4^{c}	2.6^{b}	2.5^{b}	7.7^{de}
Malty (O-Malt) Degree of malty odor[1]	3.2^{d}	8.2^{f}	4.9^{e}	0.1^{a}	0.4^{ab}	8.5^{f}	1.5^{bc}	2.2^{cd}	0.5^{ab}
Flavor									
Sweet (F-Sweet): Degree of sweet taste[1]	0.4^{a}	4.7^{c}	0.7^{a}	7.8^{e}	9.6^{f}	6.2^{d}	6.8^{de}	2.6^{b}	0.3^{a}
Salt (F-Salt): Degree of salty taste[1]	7.2^{e}	3.6^{bc}	4.4^{cd}	2.6^{ab}	1.6^{a}	1.6^{ab}	3.8^{bc}	2.6^{ab}	5.5^{d}
Sour (F-Sour): Degree of sour taste[1]	7.9^{e}	7.4^{e}	9.3^{f}	0.2^{a}	0.2^{ab}	4.2^{d}	1.2^{b}	2.4^{c}	8.0^{e}
Bitter (F-Bitter): Degree of bitter taste[1]	6.6^{de}	5.7^{cd}	5.3^{c}	0.5^{a}	2.0^{b}	7.9^{e}	2.1^{b}	5.1^{c}	2.9^{b}
Rye (F-Rye): Degree of aftertaste typical for rye kernels soaked overnight and boiled for 1h[1]	7.0^{ef}	5.7^{de}	7.2^{f}	1.2^{a}	1.2^{a}	2.8^{b}	4.9^{cd}	3.9^{bc}	7.1^{ef}
Roasted cereals (F-Roast): Degree of aftertaste typical for oven roasted whole rye kernels roasted sufficient to cause burnt notes[1]	5.8^{d}	4.5^{c}	3.2^{b}	0.0^{a}	0.6^{a}	6.0^{d}	0.5^{a}	4.1^{bc}	0.3^{a}
Texture, by finger									
Compressibility (T-Comp): Degree of resistance when pressed between fingers. Little: the bread yields totally between fingers – Much: the bread does not yield at all between the fingers	7.0^{d}	9.8^{e}	9.2^{e}	0.8^{a}	0.3^{a}	2.3^{b}	5.9^{c}	0.8^{a}	3.1^{b}
Deformability (T-Def): Degree of deformation from pressure with one finger in the center of the bread. Little: not at all deformable – Much: highly deformable	2.6^{b}	0.1^{a}	0.9^{a}	5.1^{d}	8.8^{f}	7.7^{e}	3.3^{bc}	7.1^{e}	4.0^{c}
Texture, mouthfeel									
Chewiness (T-Chewy): Effort and time needed to chew. Little: little effort and time – Much: a lot of effort and time	6.7^{g}	4.3^{ef}	4.9^{f}	1.8^{b}	0.5^{a}	2.5^{bc}	3.0^{cd}	4.0^{def}	3.5^{cde}
Moisture absorption (T-Moist-abs): Measures the amount of saliva absorbed by the sample when chewing. Little: almost no	6.3^{c}	8.4^{d}	7.5^{d}	0.9^{a}	0.5^{a}	2.4^{b}	5.4^{c}	2.9^{b}	2.4^{b}

saliva is absorbed – Much: a lot of saliva is absorbed									
Heterogeneity (T-hetero): Amount of components bran and whole/pieces of kernels. Little: no perceivable bran or kernels – Much: many clearly perceivable bran/kernels	4.0[c]	7.7[e]	9.8[f]	0.3[a]	0.0[a]	2.7[b]	2.5[b]	6.0[d]	0.8[a]
Cohesiveness of mass (T-cohes): The degree to which the bread forms a coherent bolus during mastication. Little: falls apart in separate pieces – Much: quickly forms a coherent bolus	3.4[b]	1.2[a]	0.9[a]	8.0[e]	9.8[f]	7.9[e]	4.8[c]	6.7[d]	7.3[de]

[1] Little: not at all perceivable - Much: very clearly perceivable**.**

[a-g] Different superscript letters on a row indicate significant differences between samples (Sandvik et al., 2016).

WG: Whole grain

Table 3. Younger (n=225) and older (n=173) and all consumers characterized by socio-demographics, bread consumption habits and food choice motives

	18-44 years[1]	45-80 years[1]	All
	%	%	%
Socio-demographics			
Females	56	67	61
Males	44	34	39
≥1 child <18 years in household	22	20	21
≥ 3yrs post-secondary education	54	59	56
At least one parent born outside Sweden	34	26	30
Bread type eaten most often while growing up[2]			
White bread such as pan bread or roll	36[a]	21[b]	29
White sweet soft loaf such as traditional sifted rye loaf with syrup	29	31	30
Medium dark bread with soft texture	41	35	38
Dark compact coarse bread	12	10	12
Dark and compact coarse sour bread	4[a]	10[b]	7
Dry crispbread	31[a]	50[b]	39
Bread type eaten most often today[2]			
White bread such as pan bread or roll	19[a]	9[b]	14
White sweet soft loaf such as traditional sifted rye loaf with syrup	11[a]	1[b]	7
Medium dark bread with soft texture	46	36	42
Dark compact coarse bread	26	34	29
Dark and compact coarse sour bread	16[a]	30[b]	22
Dry crispbread	38[a]	64[b]	49
	Mean (SD)	Mean (SD)	Mean (SD)
Food choice motives[3]			
Sensory appeal	5.8 (0.9)[a]	6.1 (0.9)[b]	5.9 (0.9)
Natural content	5.1 (1.5)[a]	5.9 (1.3)[b]	5.4 (1.4)
Health	5.1 (1.0)[a]	5.5 (1.0)[b]	5.3 (1.0)
Ethical concern	4.6 (1.6)[a]	5.7 (1.3)[b]	5.1 (1.5)
Price	5.0 (1.4)	5.0 (1.3)	5.0 (1.3)
Mood	4.9 (1.0)	4.9 (1.2)	5.0 (1.3)
Convenience	4.8 (1.3)	5.0 (1.1)	4.9 (1.2)
Weight control	4.0 (1.4) [a]	4.7 (1.3)[b]	4.3 (1.3)
Familiarity	3.5 (1.5)	3.4 (1.5)	3.5 (1.4)

[1] Mean age of the younger consumers were 28 (SD 7) years and of the older 63 (SD 10) years.

[2] Multiple choice questions.

[3] Mean values for a total of 36 statements from the Food Choice Questionnaire read "It is important to me that the food I eat on a typical day..." Answered on a scale from: Totally disagree (1) – Totally agree (7) (Steptoe et al., 1995).

[a-b] Different superscript letters in a row indicate significant difference between age groups (P=<0.05). Chi-square test used for *bread type* and One-way ANOVA for *food choice motives*.

Table 4. Mean ratings of liking and degree of agreement with two statements for nine rye bread samples in younger (n=225) and older (n=173) consumers.

	Sour WG rye roll	Pumper-nickel	Coarse sour rye bread	Sifted flat bread	Sifted syrup loaf	Wheat-rye malt loaf	WG rye syrup roll	Wheat-rye toast bread	Sour sifted rye bread
Liking[1]									
All	5.3^{bc}	4.5^{a}	5.1^{b}	6.4^{e}	5.8^{d}	5.7^{cd}	6.0^{de}	6.0^{de}	5.0^{ab}
18-44 years	5.0^{b}	4.0^{a}	4.5^{ab}	7.1^{e}	6.7^{de}	5.8^{c}	6.1^{cd}	6.4^{cd}	5.1^{b}
45-80 years	5.7^{cd}	5.2^{abc}	5.8^{cd}	5.5^{bcd}	4.7^{a}	5.5^{bcd}	6.0^{d}	5.5^{bcd}	4.8^{ab}
P-value[2]	**.005**	**<.001**	**<.001**	**<.001**	**<.001**	.224	.553	**<.001**	.339
This bread seems healthy[3]									
All	7.3^{d}	7.2^{d}	7.4^{d}	3.3^{a}	3.1^{a}	5.2^{b}	6.0^{c}	5.3^{b}	5.1^{b}
18-44 years	7.4^{d}	7.4^{d}	7.5^{d}	3.2^{a}	3.1^{a}	5.4^{b}	6.1^{c}	5.3^{b}	5.1^{b}
45-80 years	7.2^{d}	7.0^{d}	7.3^{d}	3.4^{a}	3.1^{a}	4.9^{b}	5.9^{c}	5.2^{b}	5.1^{b}
P-value[2]	.198	.082	.241	.222	.809	**.019**	.591	.389	.782
This is, in my opinion, a rye bread[3]									
All	7.1^{d}	7.0^{d}	7.1^{d}	3.1^{a}	2.6^{a}	4.9^{b}	6.0^{c}	4.9^{b}	4.7^{b}
18-44 years	7.2^{d}	7.1^{d}	7.3^{d}	2.9^{a}	2.5^{a}	4.8^{b}	5.8^{c}	4.6^{b}	4.4^{b}
45-80 years	7.0^{c}	7.0^{c}	6.8^{c}	3.3^{a}	2.8^{a}	5.1^{b}	6.3^{c}	5.3^{b}	5.1^{b}
P-value[2]	.337	.502	.072	.201	.241	.279	.050	**.008**	**.003**

[1] Liking was indicated on a scale from dislike extremely (1) to like extremely (9).

[2] P-value <.05 indicates significant difference between age groups for a specific bread sample measured with one-way ANOVA.

[3] Degree of agreement with the statements from: Totally disagree (1) to: Totally agree (9).

[a-d] Different superscript letters in a row indicate a significant differences between samples for a specific age group measured with Fisher's least significant difference, P-value <.05

Table 5. Mean ratings of liking for nine rye bread samples in identified liking clusters among younger (n=225) and older (n=172) consumers[1].

	n	Sour WG rye roll	Pumper-nickel	Coarse sour rye bread	Sifted flat bread	Sifted syrup loaf	Wheat-rye malt loaf	WG rye syrup roll	Wheat-rye toast bread	Sour sifted rye bread
18-44 years										
White-soft	81	3.4[a]	2.1[a]	2.4[a]	7.9[a]	7.6[a]	5.9	5.5[a]	6.8[a]	5.0
Intermediate	102	5.3[b]	4.4[b]	5.1[b]	7.3[b]	6.8[b]	6.0	6.4[b]	6.5[a]	5.1
Dark-chewy	42	7.2[c]	6.9[c]	7.0[c]	5.3[c]	4.5[c]	5.2	6.4[b]	5.3[b]	5.1
P-value[2]		**<.001**	**<.001**	**<.001**	**<.001**	**<.001**	.116	**.003**	**<.001**	.851
45-80 years										
White-soft	44	3.4[a]	3.1[a]	3.5[a]	6.9[a]	6.4[a]	6.4[a]	5.9	6.1[a]	4.3[a]
Intermediate	68	5.8[b]	4.8[b]	5.8[b]	5.8[b]	4.9[b]	5.7[a]	6.3	5.6[ab]	4.6[a]
Dark-chewy	60	7.1[c]	7.1[c]	7.5[c]	4.2[c]	3.3[c]	4.6[b]	5.7	4.8[b]	5.5[b]
P-value[2]		**<.001**	**<.001**	**<.001**	**<.001**	**<.001**	**<.001**	.331	**<.001**	**.011**

[1] Liking was indicated on a scale from dislike extremely (1) to like extremely (9). One respondent in the older group was excluded due to displaying no variance in liking between samples.

[2] P-value <.05 and superscript letters indicates significant difference between clusters in age group for a specific bread sample measured with one-way ANOVA and Fisher's least significant difference.

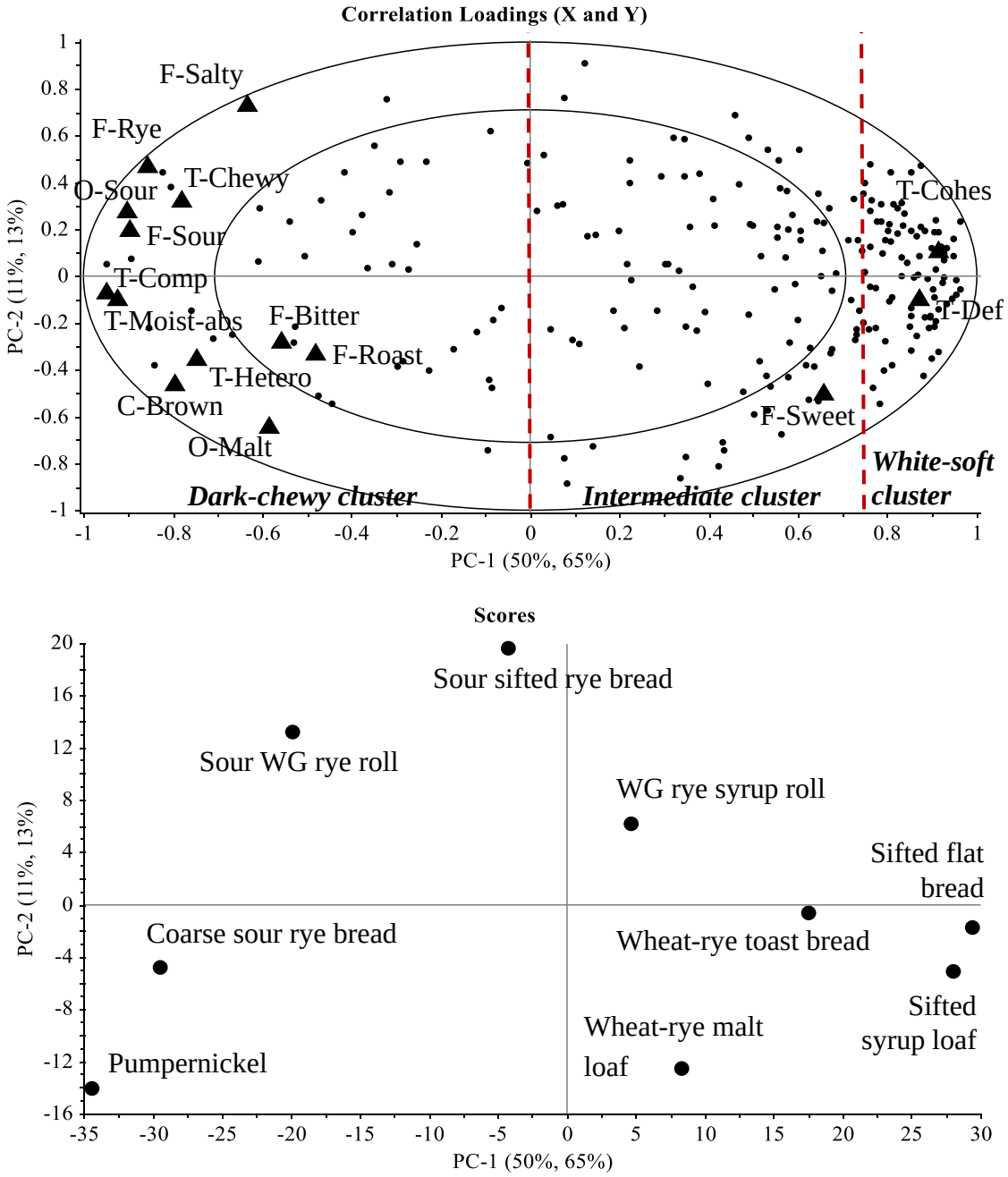

Figure 1a. Correlation loading and scores plot for younger group, 18-44 years, n=225 based on internal preference mapping by principal component regression of nine rye bread samples. Each dot represents a consumer. The two vertical dotted lines assign cluster limit based on visual inspection of the correlation loadings plot. C:Color, T:Texture, O:Odor, F:Flavor.

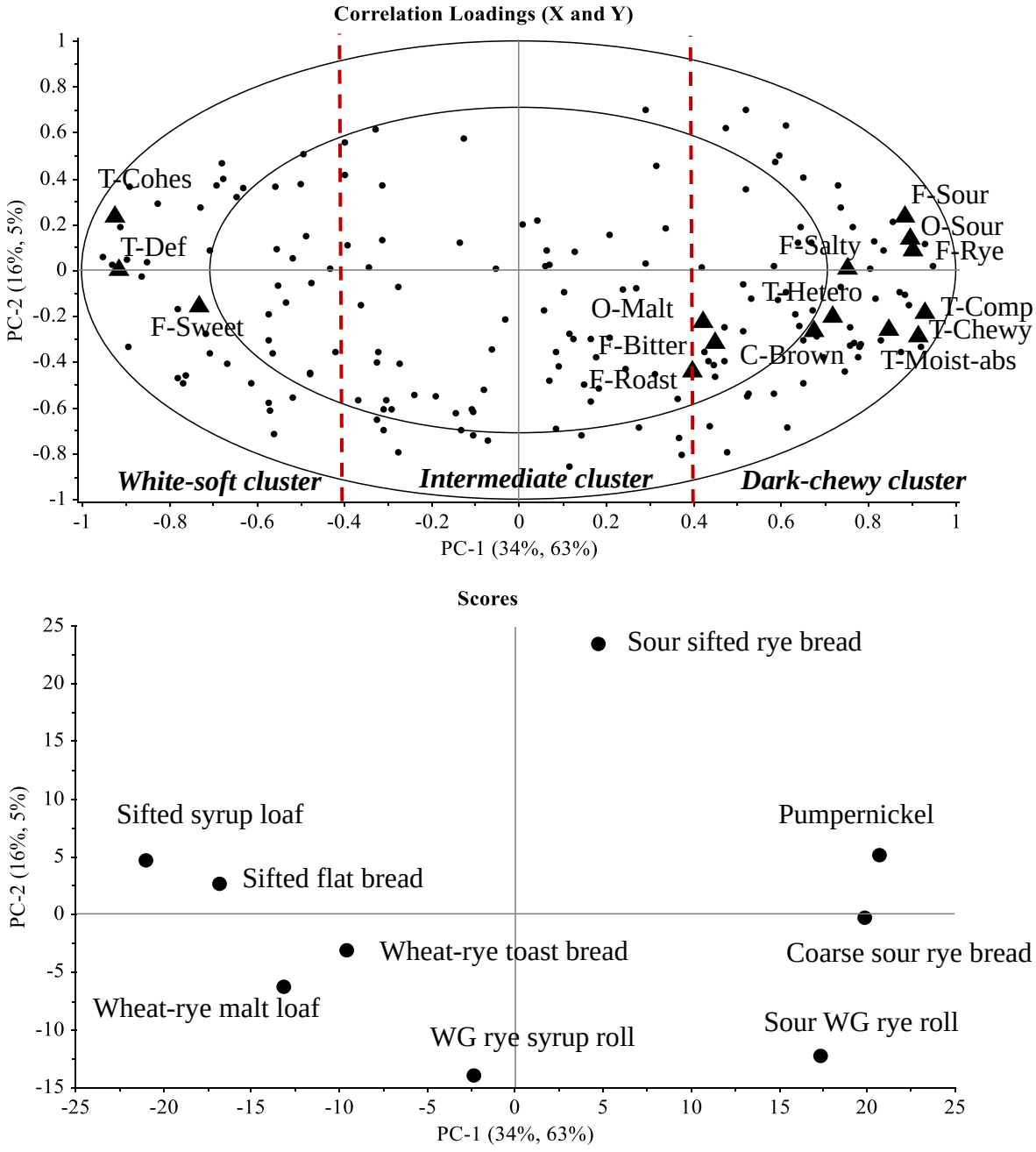

Figure 1b. Correlation loading and scores plot for older group, 45-80 years, n=172 based on internal preference mapping by principal component regression of nine commercial rye bread samples. Each dot represents a consumer. The two vertical dotted lines assign cluster limit based on visual inspection of the correlation loadings plot. C:Color, T:Texture, O:Odor, F:Flavor. One consumer in the older group was excluded due to displaying no variance in liking between samples.