Food Research International 66 (2014) 325–331

Contents lists available at ScienceDirect

Food Research International

journal homepage: www.elsevier.com/locate/foodres

Effect of social interaction and meal accompaniments on acceptability of sourdough prepared *croissants*: An exploratory study

Rossella Di Monaco [a,b,*], Davide Giacalone [c], Olimpia Pepe [a], Paolo Masi [a,b], Silvana Cavella [a,b]

[a] Food Science and Agricultural Department, University of Naples-Federico II, Italy
[b] Centre for Food Innovation and Development, University of Naples, Portici, Italy
[c] Department of Food Science, University of Copenhagen, Denmark

ARTICLE INFO

Article history:
Received 10 June 2014
Accepted 2 October 2014
Available online xxxx

Keywords:
Croissants
Meal accompaniments
Context
Social interaction
Consumer research

ABSTRACT

The objective of this study was to investigate the effect of two contextual variables on consumer acceptance of *sourdough*-prepared croissants: social interaction among participants during the test and accompanying beverages. Three groups of consumers evaluated five samples in three different conditions: in individual testing booths (control group) and in the meeting room with and without an accompanying beverage. Croissants were also submitted to descriptive analysis (DA), and the effect of the sourdough addition on the sensory properties of croissants was evaluated. The results of DA demonstrated that sensory differences among croissants were mainly due to the leavening procedure used in their production process. Generally, those sensory differences did not significantly affect hedonic judgments, since all the samples were highly acceptable by consumers. Social interaction among subjects negatively affected all the liking scores when compared to the control group, whereas no effect of adding a beverage was observed. The liking of croissants for the three experimental groups corresponded to different sensory profiles, indicating that particular context in which the croissants were evaluated affected the relative contribution of the sensory characteristics to the consumer liking of the croissants.

1. Introduction

Food, consumer and context are themselves bundles of various factors and phenomena. Food products have perceived sensory characteristics, which, of course, depend on the consumer, and extrinsic properties which affect consumer sensory perception and acceptability. Consumers have personalities, moods, physiological statuses, cultures, habits and memories which all affect their reactions to different foods. Finally, foods are not consumed in a vacuum, but within specific contexts which greatly affect their acceptability. Context can be considered as the time, the place, the situation, the way and who and what the food is consumed with (Gains, 1994).

Petit and Siefferman (2007) defined the context as all the circumstances that come with an event.

Meiselman, Johnson, Reeve, and Crouch (2000) emphasized that eating environment, serving conditions and association with other products could modify food acceptability and sensory attribute perception by consumers. Stroebele and De Castro (2004) pointed out that environmental factors such as where, when, and with whom food consumption takes place, presence of other people, time of consumption, smell, colors or physical setting influence food intake and food choice.

Meiselman (1996) separated the contextual variables into: internal context related to the product (preparation methods, association with other products), internal context related to the individual (actual experiences, expectations), and external context (social interaction, physical parameters, setting). Before, Cardello (1995) divided contextual factors into two categories: factors that are physically and concurrently present with the food (simultaneous) and factors that are antecedent to it (temporal). Each of these factors may also be sub-categorized as being food or non-food related. Food related simultaneous factors consist of other foods or beverages served and eaten together with the food of interest, whereas non-food simultaneous factors include social interaction, ambient conditions and other aspects of the food consumption. Food-related temporal factors include all foods and beverages recently consumed, whereas non-food temporal factors are variables as time of day or season of year.

Even though the importance of contextual factors was largely demonstrated, the most part of consumer tests is conducted in laboratory, while a little part is performed at central location, at home or in public places. A laboratory represents the most controlled environment for testing, because one can control environmental variables, stimulus variables and to a certain degree social interaction (Hersleth, Ueland, Allain, & Næs, 2005). That test situation allows that sensory characteristics are evaluated without being influenced by external variables (Cardello,

* Corresponding author at: Department of Agricultural and Food Science, University of Naples, Via Università 100, 80055 Portici, NA, Italy. Tel.: +39 081 2539456.
E-mail address: rossella.dimonaco@unina.it (R. Di Monaco).

http://dx.doi.org/10.1016/j.foodres.2014.10.001
0963-9969/

Schutz, Snow, & Lesher, 2000), however it is very different from a real eating environment and the realism of the test can be questioned. Meiselman et al. (2000) stated that laboratory consumer tests are not able to predict whether consumers will choose or consume the product in real life situation. Moreover, if a food is considered as a part of a context, other food and/or beverages are served and consumed with it, but natural and real meals are not usually served during laboratory test.

Miele, Di Monaco, Cavella, and Masi (2010) found a significant effect of meal accompaniments on mayonnaise acceptability evaluated in laboratory test; the effect was positive if the sample was consumed in association with the most appreciated food. The positive effect of meal accompaniment on spinach acceptability was also demonstrated by Bingham, Hurling, and Stocks (2005).

An alternative to the laboratory test is situational test developed to approach the context in which a product is really consumed (Petit & Siefferman, 2007). This test is organized in a mall, at a school, in a canteen or restaurant, where from a side one can partially control environmental variables and the degree of social interaction, and on the other side it is possible to increase the realism of the test (King, Weber, Meiselman, & Lv, 2004). Food testing by consumers in naturalistic conditions is considered to be more advantageous compared to laboratory tests with regard to realism of the evaluation, however situational tests are more expensive and time-consuming than laboratory ones (Petit & Siefferman, 2007). Experiments are carried out at a meal or a snack time in place where people naturally eat and social interaction is not limited (Meilgaard, Civille, & Carr, 2007). Hein, Hamid, Jaeger, and Delahunty (2010, 2012) studied the impact of evoking context by using a written scenario on hedonic ratings, as a tool to explore product acceptability under different contexts when real test is not feasible due to practical or financial constraints. Those researchers found that evoked context affected the relative importance of different sensory attributes for the consumers and the effect varied between product categories.

Many studies have clearly shown that the results of a hedonic test depend on the chosen methodology, but there is no consensus about the way in which it affects the results (Boutrolle, Delarue, Arranz, Rogeaux, & Köster, 2007). It is of great interest for food companies to obtain information about how preference ratings for a product may change from one situation to another. This knowledge may be of interest both for developing marketing strategies and in practical product development projects (Hersleth, Mevik, Næs, & Guinard, 2003). For the development of meat substitutes, the results of Elzerman, Hoek, Van Boekel, and Luning (2011) suggested that emphasis is needed on consumer evaluation of meal combinations instead of on the sensory properties of the individual product.

The objective of the present study was to investigate the effect of two contextual variables on consumer acceptance of croissants: social interaction among participants during the test and accompanying beverage. Croissants represent an interesting study case for our aim, since they are a food usually consumed with an accompanying beverage during breakfast time at home and moreover in a bar with other people. Three groups of consumers evaluated the same set of samples in three different conditions: in individual testing booths and in the meeting room with and without an accompanying beverage. In the experimental design definition, samples of croissants produced with different technologies were used. As sourdough, fermented by the original microflora of the flour or by selected lactobacilli (LAB), could influence the rheology of the dough and the quality of croissants, the samples were also submitted to descriptive analysis.

2. Materials and methods

The study consisted of two parts: 1) a sensory profiling of the croissants and 2) a consumer test, performed in three different experimental conditions.

2.1. Samples

Investigation was carried out over five samples of frozen croissants: four samples were provided by the same company (1) and were produced using different technologies; the fifth sample was provided by a competitor company (2). The analyzed samples were coded according to the main processing differences listed in Table 1.

The samples were stored at −19 °C. Before sensory and consumer tests, the samples were equilibrated at room temperature for 10 min and cooked in an electrical oven for 23 min at 180 °C. Samples were evaluated 30 min after baking.

2.2. Descriptive analysis

Seven trained assessors took part in the descriptive analysis (DA) of the croissants. The DA included developing a sensory vocabulary (two sessions), training of the panel (four sessions), and actual evaluation (three sessions). The sensory vocabulary was developed via panel discussion and included attributes related to the appearance, odor, flavor, taste and texture of the samples (Table 2). During the training phase, each assessor evaluated a subset of three samples in triplicates on all attributes. Once the panel was sufficiently calibrated, they carried out to the actual sensory profiling. Three replicates were performed during which the assessors evaluated the croissant samples using 10 cm unstructured line scales (anchors are given in Table 2). The samples were placed on a white plastic plate and blind labeled with a three-digit code, and were evaluated in a monadic way by the assessors. The sample presentation order was randomized and balanced per subject during each DA session.

2.3. Consumer test

2.3.1. Participants' selection

95 consumers (66 women and 29 men; aged 18–33, mean: 23) participated at the consumer test. Most of them were students at the Food Science and Agricultural Department, University of Naples, who were recruited on the basis of interest and availability.

Prior to the study, 120 subjects completed a questionnaire where they provided information on their gender, age, as well as their liking (on a 9 point hedonic scale) and frequency of consumption for croissants (on a 7 point scale ranging from 1 = less than once a month, to 7 = every day). Only the subjects which gave both a liking score equal to or higher than 5 (=neither like nor dislike) and a frequency score equal to or higher than 3 (=2 times a month) were selected to participate in the experiment. In the preliminary questionnaire the subjects were also asked to indicate their two preferred breakfast drink among ten different beverages (white milk, espresso coffee, *caffelatte*, *cappuccino*, tea, barley, orange juice, fruit juice, chocolate milk, other).

2.3.2. Procedure

Consumers were divided into three experimental groups that did not differ with regard to the following characteristics: gender ($\chi^2_{(2)} = 2.4$, $p = 0.4$); age ($F_{(2,92)} = 0.02$, $p = 0.9$); liking for croissant ($F_{(2,92)} = 0.003$, $p = 0.9$); and frequency of consumption ($F_{(2,92)} = 0.04$, $p = 0.9$). By establishing homogeneity between the groups, subsequent differences between conditions can be inferred to be a result of the experimental conditions.

The first group ("Control", $N = 32$) evaluated the samples individually in the sensory booths. The second group ("Social", $N = 33$) evaluated the samples in meeting sessions, during which consumers could freely interact and discuss, configuring a more realistic consumption situation. The evaluations occurred in a meeting room belonging to the Department of Agricultural and Food Science, with approximately six–eight consumers per session. The last group ("Social + Drink", $N = 30$) evaluated the sample in the same conditions as the previous one with the difference that they were served the croissant samples

Table 1
List of the evaluated croissants.

Sample code	Producer	Icing	Leavening procedure	Starter type
1-IC-so-LAB	Company 1	Yes	Sourdough	Selected LAB[a] + baker's yeast
1-IC-st	Company 1	Yes	Straight dough	Baker's yeast
1-IC-so	Company 1	Yes	Sourdough	Baker's yeast
1-so-LAB	Company 1	No	Sourdough	Selected LAB[a] + baker's yeast
2-st	Company 2	No	Straight dough	Baker's yeast

1, 2 = company; IC = icing; so = sourdough; st = straight dough; LAB = selected LAB strains.
[a] Selected Lactic Acid Bacteria (LAB) strains were used for sourdough fermentation. Baker's yeast was added to obtain the leavening of dough for croissants.

with one drink accompaniment chosen between espresso coffee, *caffelatte* and white milk, on the basis of their preference indicated in the preliminary questionnaire. As far as the quantities, for the espresso coffee the volume was about 25 ml and for both *caffelatte* and white milk it was about 200 ml, typical quantities used in Italy for those products. Each consumer was allowed to add the preferred quantity of sugar to the drink.

All groups evaluated half croissant samples blindly, labeled with a three digit code. Consumers in the Control group evaluated the samples monadically following a randomized and balanced presentation order. In the other two groups, during each session, consumers were served the half croissant samples in trays at the discussion tables, and evaluated them in the same order.

In each group, consumers freely decided the sufficient amount of sample to taste. Each session lasted approximately 40 min.

For each of the samples, consumers (all groups) were asked to score the overall liking (OL), as well as the attribute liking (AL) for the appearance, odor, flavor, taste and texture. Nine point hedonic scales were used with endpoints (1 = dislike extremely; 9 = like extremely). Moreover, consumers were asked to evaluate the holistic attribute *freshness* on a 9 point scale (1 = not fresh at all; 9 = very fresh).

2.4. Data analysis

2.4.1. Descriptive analysis

In order to uncover differences between samples, results from descriptive analysis were analyzed by two-way Analysis of Variance (ANOVA), considering sample, assessor and their interaction as fixed source of variation. Differences were considered significant when $p < 0.05$. Attributes that were significantly different were included in a sample by an attribute matrix and a Principal Component Analysis (PCA) was performed in order to visualize differences between samples and the underlying sensory differences. The data were mean-centered column-wise prior to PCA computation.

2.4.2. Consumer test

Differences in mean hedonic scores for OL and AL were analyzed by mixed-model ANOVA including experimental group, sample and their interaction as main effects, and including consumers (within experimental group) as random source of variation. Where significant main effects were found, Tukey HSD test was used to identify significantly different means considering a 95% confidence interval.

Table 2
List of attributes and definitions developed by the sensory panel and used for the descriptive profiling of the croissants.[a]

Attribute	Definition	Scale anchors
Appearance		
Crust color	Degree of brown color by visual evaluation	Light brown → dark brown
Crumb color	Degree of yellow color by visual evaluation	Light yellow → dark yellow
Bubbles density	Number of the most visible bubbles on the inside of the sample	Indicate their number
Bubbles structure	Homogeneity of bubbles in terms of size and shape by visual evaluation of the cut surface	Not much homogeneous → very homogeneous
Odor		
Roasted	Roasted odor by orthonasal evaluation	Absent → very intense
Fruity	Fruity odor by orthonasal evaluation	Absent → very intense
Yeasty	Yeasty odor by orthonasal evaluation	Absent → very intense
Vanilla	Vanilla odor by orthonasal evaluation	Absent → very intense
Taste		
Sweet	Sweetness intensity by taste evaluation	Not much sweet → very sweet
Bitter	Bitterness intensity by taste evaluation	Not much bitter → very bitter
Flavor		
Overall flavor	Overall flavor intensity after full sample assessment	Absent → very intense
Butter flavor	Butter flavor intensity of the internal part of the croissant	Absent → very intense
Uncooked dough	Uncooked dough flavor intensity of the internal part of the croissant	Absent → very intense
Yeast flavor	Yeast flavor intensity of the internal part of the croissant	Absent → very intense
Texture		
Springiness	Compress the sample partially with fingers and evaluate the degree and rapidity of recovery	Not much spring → very spring
Hardness	Break the sample with the fingers and evaluate the required force	Soft → hard
Crumbliness	Amount of crumbles on the surface after breaking the sample	Few → a lot
Oiliness	Touch the sample and evaluate the oiliness released to the fingers	Not much oily → very oily
Mouthfeel		
Chewiness	Place the sample in the mouth and evaluate the number of needed chewies to swallow it	Not much chewy → very chewy
Oily mouthcoating	After swallowing the sample evaluate the oiliness as residual mouthcoating	Not much oily → very oily

[a] Comendador et al. (2012) for more details on DA procedure.

2.4.3. Relationships between descriptive and hedonic data

Relationships between the sensory descriptive profiles of the croissants and consumers' hedonic scores were explored by Partial Least Squares Regression (PLSR). The predictor matrix contained ratings for the significant attributes averaged over samples, whereas the response matrix contained average OL ratings for the three experimental groups. PLSR fit a vector for each of the consumer groups to the sample space, thus allowing evaluation of drivers of liking for the three experimental groups.

PCA and PLSR analyses were done using non-standardized, mean-centered variables in the software SIMCA-P V. 10.0 (Umetrics, Sweden). All other analyses were carried out in the statistical environment R (R Development Core Team, 2010).

3. Results

3.1. Descriptive analysis

ANOVA results from DA data (Table 3) revealed significant differences among the samples for all but five of the evaluated attributes: *bubbles structure*, *overall flavor*, *springiness*, *crumbliness* and *oily mouthcoating*.

Significant attributes were retained for further analysis by PCA. A two-component solution was found to be optimal based on screen plot inspection (not shown here) and on the high proportion of variance (84%) explained by the first two principal components (PCs). Fig. 1 shows scores and loadings from the PCA, i.e., a representation of the sample differences and the attributes responsible for these differences. From the PCA scores plot (Fig. 1a), the first PC clearly opposes sample *1IC-st* to sample *2-st*. Attributes highly associated to the former were especially *sweetness*, *yeast flavor* and *yeast odor*, *dough* and *butter flavor*, whereas attributes associated to sample *2-st* were *crumb* and *crust color*, *bitterness*, *hardness*, and *fruity odor* (Fig. 1b). The remaining three samples (*1IC-so-LAB*; *1IC-so*; *1-so-LAB*) were clustered towards the center of the scores plot with respect to the PC_1 and appeared to have similar sensory profiles with respect to the sensory differences expressed by the first PC. This group of samples was found to be opposed to both samples *2-st* and *1IC-st* on the second PC, which described differences in terms of *crust* and *crumb color*, against *bubbles density* and *oiliness*.

3.2. Consumer test

Results of mixed effect ANOVA (Table 4) showed a significant main effect of sample for all attributes, indicating significant differences in OL, freshness, and AL ratings among the croissants. Importantly, the analysis also showed a significant main effect of group on all variables but two, indicating that the contextual manipulation altered consumers' perception of the croissants. The only two exceptions regarded liking for appearance where a significant sample by group interaction was observed instead of a main effect, and liking for taste where the main effect did not reach statistical significance ($p = 0.065$).

Concerning sample differences (Table 5), the main finding was that sample *1-so-LAB* (sourdough/selected LAB strains, no icing) was significantly less liked than the others. Sample *1IC-so* (sourdough from baker's yeast, with icing) was the most liked sample overall, though it did not differ significantly from other samples (except sample *1-so-LAB*) for some of the variables. It should be observed, however, that all samples received mean ratings above the neutral point of the hedonic scale, meaning that all samples were highly acceptable for the consumers.

With regard to differences between groups, the main finding was that lower acceptance ratings were observed in the two experimental groups compared to the control group. The direction of this effect was very consistent across all variables. However, post-hoc comparisons (Table 5) revealed that the differences from the control pertained primarily to the social group, for which significantly lower ratings were obtained for all rated variables. On the contrary, ratings for the

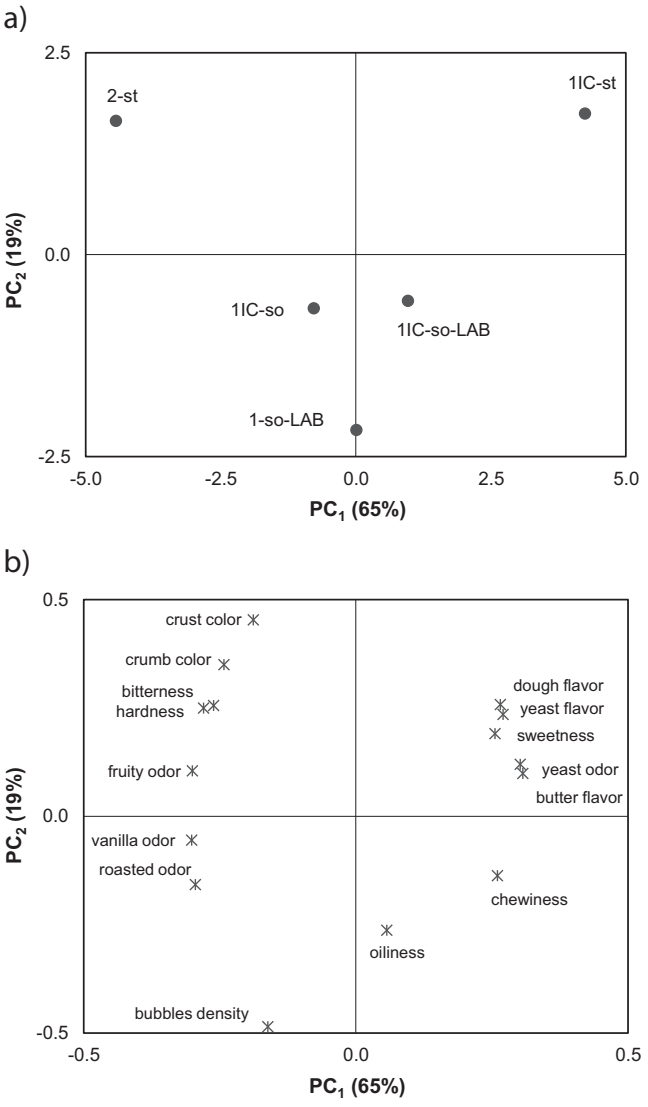

Fig. 1. PCA scores and loadings plots representing the correlations of samples (a) and (b) attributes with the first two principal components.

Table 3
ANOVA of DA results.

Attribute	DF	Sum. sq.	Mean sq.	*F* value	*p* value
Crust color	4	36.8	9.2	3.2	*0.017*
Crumb color	4	292.5	73.1	29.5	*≪0.001*
Bubbles density	4	41.6	10.4	3.6	*0.011*
Bubbles structure	4	24.6	6.2	1.0	0.413
Roasted	4	48.2	12.0	2.8	*0.043*
Fruity	4	163.5	40.9	6.6	*<0.001*
Yeasty	4	193.3	48.3	8.7	*≪0.001*
Vanilla	4	75.1	18.8	4.0	*0.005*
Sweet	4	57.5	14.4	3.3	*0.013*
Bitter	4	97.9	24.5	5.6	*<0.001*
Overall flavor	4	9.0	2.2	0.6	0.689
Butter flavor	4	52.8	13.2	3.0	*0.023*
Uncooked dough	4	50.4	12.6	2.8	*0.040*
Yeast flavor	4	46.4	11.6	2.9	*0.033*
Springiness	4	13.4	3.4	0.6	0.653
Hardness	4	107.0	26.7	10.9	*≪0.001*
Crumbliness	4	35.8	8.9	1.8	0.145
Oiliness	4	36.0	9.0	2.9	*0.030*
Chewiness	4	60.6	15.2	4.9	*0.001*
Oily mouthcoating	4	37.1	9.2	1.7	0.164

$p < 0.05$ means a significant effect.

Table 4
ANOVA results showing main and interaction effects for all attributes evaluated during the consumer test.

Overall liking	DF	Sum. sq.	Mean sq.	*F* value	*p* value
Sample	4	19.1	4.8	3.4	*0.009*
Group	2	41.5	20.8	6.0	*0.003*
Sample * group	8	20.9	2.6	1.8	0.07
Appearance liking					
Sample	4	29.7	7.4	4.1	*0.002*
Group	2	13.4	6.5	1.9	0.143
Sample * group	8	39.5	4.9	2.8	*0.005*
Odor liking					
Sample	4	56.2	14.1	8.1	*<0.001*
Group	2	41.5	20.7	5.4	*0.006*
Sample * group	8	12.0	1.5	0.9	0.549
Flavor liking					
Sample	4	73.8	18.4	9.4	*<0.001*
Group	2	36.0	18.0	4.4	*0.014*
Sample * group	8	37.6	4.7	2.4	*0.015*
Taste liking					
Sample	4	94.6	23.6	12.1	*<0.001*
Group	2	24.7	12.4	2.8	0.065
Sample * group	8	26.6	3.3	1.7	0.097
Texture liking					
Sample	4	13.7	3.4	2.1	0.075
Group	2	32.6	16.3	5.0	*0.008*
Sample * group	8	13.6	1.7	1.1	0.391
Fragranza (freshness)					
Sample	4	13.3	3.3	2.4	*0.049*
Group	2	39.3	19.7	5.7	*0.004*
Sample * group	8	10.6	1.3	1.0	0.467

$p < 0.05$ means a significant effect.

Social + Drink group tended to fall in between the two other groups, but no significant differences with the control could be established.

The last part of the analysis applied PLSR to model consumer liking in the three experimental conditions from the sensory profiles of the croissant. Scores and loadings plots from this analysis are shown in Fig. 2. Again, main fit statistics indicated that a two-component solution was optimal based on the large variance explained and the high predictive ability achieved by the first two components ($R^2 = 92\%, Q^2 = 53\%$).

As Fig. 2b shows, liking of consumers in the control group was positively affected by sensory attributes such as *chewiness*, *bubbles density*, *sweetness*, *butter flavor* and *yeast odor*, and negatively affected by *color* intensity of the crust. On the contrary, *crust color* was instead a strong positive determinant of liking for the other two groups, as was the *color of the crumb*.

In addition to color attributes, liking for the Social + Drink group was highly and positively related to *fruity* and *vanilla odors*, *hardness* and *bitterness*, whereas the Social group liking was also negatively related to *oiliness* and *bubbles density*.

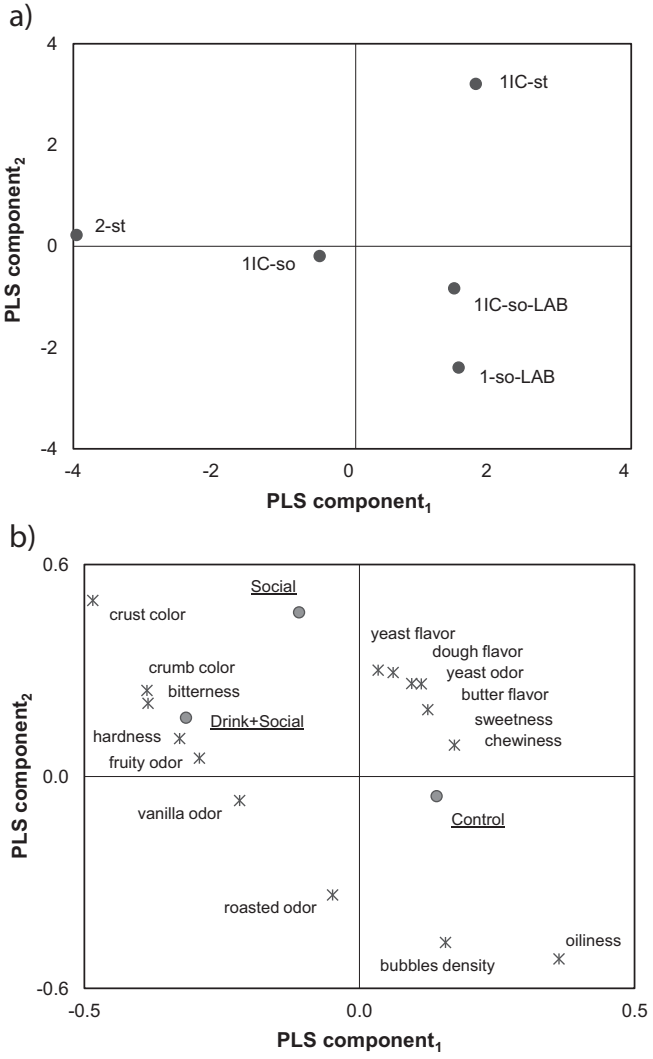

Fig. 2. PLSR scores and loadings plots showing the correlations of samples (a) and (b) attributes with the first two PLS components.

4. Discussion

The results of DA, as showed in the Fig. 1, demonstrated that sensory differences among croissants were mainly due to the leavening procedure used in their production process. In fact, samples *1IC-so-LAB*, *1IC-so* and *1-so-LAB* were all prepared by using the sourdough whereas sample *1IC-st* and sample *2-st* were prepared with a straight leavening

Table 5
Mean ratings (on a 9-pt. scale) for OL and all attribute liking across experimental groups. Samples which do not share superscript letters are significantly different according to Tukey's HSD ($p < 0.05$).

	Sample					Group		
	1IC-so-LAB	1IC-st	1IC-so	1-so-LAB	2-st	Control	Social	Social + Drink
Overall liking	6.0^{ab}	6.3^{ab}	6.4^{a}	5.8^{b}	6.2^{ab}	6.4^{a}	5.7^{b}	6.2^{a}
Appearance liking	6.3^{a}	6.1^{ab}	6.3^{a}	5.7^{b}	6.4^{a}	6.4^{a}	6.0^{b}	6.1^{ab}
Odor liking	5.7^{bc}	5.9^{abc}	6.5^{a}	5.6^{c}	6.3^{ab}	6.3^{a}	5.6^{b}	6.1^{a}
Flavor liking	5.7^{b}	5.8^{b}	6.6^{a}	5.5^{b}	5.6^{b}	6.1^{a}	5.5^{b}	5.9^{a}
Taste liking	5.9^{b}	5.9^{b}	6.9^{a}	5.7^{b}	5.8^{b}	6.3^{a}	5.7^{b}	6.1^{ab}
Texture liking	6.2^{a}	6.2^{a}	6.4^{a}	6.2^{a}	5.9^{a}	6.5^{a}	5.9^{b}	6.1^{ab}
Freshness	6.0^{a}	6.3^{a}	6.4^{a}	6.1^{a}	6.1^{a}	6.5^{a}	5.8^{b}	6.2^{a}

of dough. The results were in accordance with other works in literature demonstrating the significant effect of sourdough technology on sensory properties of baked food (Gocmen, Gurbuz, Kurmal, Dagdellen, & Sahin, 2007; Di Monaco, Torrieri, Pepe, Masi, & Cavella, in press). Lacaze, Wick, and Cappelle (2007) found that dextran sourdough improved the sensory properties of several baked samples, by increasing their volume and their crumb softness. In this study, all the sourdough prepared croissants were chewier, less hard and showed a larger number of big bubbles in the crumb than the straight dough prepared croissants. These results are consistent with Katina, Heinio, Autio, and Poutanen (2006), who also found a significant effect of sourdough on bread volume, crumb softness and flavors' intensity. Among the investigated samples, croissants produced using the sourdough procedure (*1IC-so-LAB*; *1IC-so* and *1-so-LAB*) were characterized by dough and yeast flavors less intense than the sample produced using the straight dough (*1IC-st*). The flavor is one of the first elements determining the consumer acceptance for new products (Rehman, Paterson, & Piggott, 2006). The sourdough technology determines changes in the concentrations of key aroma compounds that can improve flavor production in the crumb of baked goods (Hansen & Schieberle, 2005). Sourdough croissants showed also lighter brown crust and lighter yellow crumb colors than other croissants.

The samples prepared by the straight dough (*1IC-st* and *2-st*) were opposed on the first PC, showing significant sensory differences, which could be due to the different formulations and processes used by the two producers. The icing did not seem to affect the sensory properties of croissants, since samples *1IC-so-LAB* and *1-so-LAB*, identical for all the ingredients and procedures, but respectively prepared with and without icing, were not different on the PCA.

Generally, those sensory differences did not significantly affect hedonic judgments, since all the samples were highly acceptable by consumers, however sample *1IC-so* was the only one which received the most high liking scores for overall, odor, flavor and taste. As it is possible to observe from the PCA plots, sample *1IC-so* was characterized by strong fruity, vanilla and roasted odors, and less intense yeast odor and flavor, uncooked dough and butter flavors. Thus, for the investigated samples it is possible to state that, as sensory characteristics, the odors and flavors were definitely the most important drivers of liking.

Earlier research suggests that when consumers eat a food their response not only depends on both sensory characteristics of the product and their physiological status but they are also related to other factors (Costell, Tárrega, & Bayarri, 2010), such as the context in which the product is eaten (Meiselman et al., 2000).

In this study social interaction among participants in the test and accompanying beverage were studied as contextual variables. Importantly, the size of the effect produced by the context was found similar to the sample effect, and even larger for overall liking as shown in Table 4. This confirms that the context in which a product is consumed is an important factor affecting its acceptance level (Gains, 1994).

Contrary to what was hypothesized, social interaction among subjects participating in this research negatively affected all the liking scores (Table 5). This result was in disagreement with findings from other researchers. Hersleth et al. (2003) found that wine acceptability significantly improved when the sensory evaluation occurred in a reception room where a socializing among subjects occurred. Another study by the same authors (Hersleth et al., 2005), however, showed that changing the environments in laboratory, central location or home, and modifying the level of social interaction among the consumers did not affect the hedonic ratings for cheese. In the work of King, Meiselman, Hottenstein, Work, and Cronk (2007), social interaction and enhanced environment had no effects on acceptability scores for several food items, as well. Test situation and environment were proved to be significant on acceptability scores by other researchers (Edwards, Meiselman, Edwards, & Lesher, 2003; Meiselman et al., 2000). In particular, consumer tests performed in more realistic situations of consumption provided higher liking scores than consumer tests conducted in individual laboratory booths. It is even true that in several works where the context effect on hedonic evaluation was studied, the different locations such as restaurants, canteens, refectories, laboratory booths or participant's home, generated different expectations (Cardello, Bell, & Kramer, 1996) and, moreover were associated to different consumer profiles. Accordingly, consumer background variables could invalidate the results of a study aimed to explore the context effect on the acceptability (Petit & Siefferman, 2007), and could be one of the reason why previous studies did not always agree with each other. In this research, the homogeneity for several socio-demographic variables between the three groups of consumers was established, and as such we are reasonably confident that the results could be inferred from the experimental conditions. However, it cannot be ruled out that other factors such as hunger state, liking and familiarity for the other participants may have also influenced the results. It should be also noted that the heterogeneity of results in the literature may also be explained by the fact that context effect is also product-dependent, as previously observed by other authors (Meiselman, 2008), pointing at the difficulty of generalizing results to different product categories.

The finding that social interaction negatively affected all hedonic judgments for the croissant samples could be explained by the observation that social facilitation has a positive effect on food consumption of *naturally* created groups but not of *artificially* created ones (Pliner, Bell, Kinchla, & Hirsch, 2003), as in our case. This interpretation is consistent with King et al. (2004), who also reported that an artificial socialization among participants in the consumer test negatively affected pizza acceptability.

The effect of a drink accompaniment seems to have improved hedonic response, although the Social + Drink group did not differ from the Control. Unfortunately, a “drink group” was not created in this study, since our first hypothesis was that sample acceptability would increase with the addition of various context variables. Therefore, we cannot gather that the effect of accompanying drink on the croissant acceptability was definitely positive, even though it is possible to hypothesize that drink effect was canceled by the negative effect of the social interaction in the Social + Drink group. Consumer evaluation of a sample as part of a complex meal is not usually a concern in the laboratory setting, and in the few studies where this approach was used, standardized and artificial combinations of foods were served to consumers (Miele et al., 2010). Those combinations sometimes were not chosen and accepted by consumers participating in the test. In order to avoid any limitation due to different acceptability levels of subjects for the accompanying drink, in this work the drink was chosen as outcome of the individual questionnaire compiled by each consumer before the test. In the work of Hersleth et al. (2003), wines received higher liking score when they were served with food. In that case consumers were requested to eat some food by choosing among cheese, vegetables and chips, to accompany each wine sample. In the work of Miele et al. (2010) mayonnaise acceptability varied as function of the accompanying food. King et al. (2004) found different effects of the meal context for each investigated sample: the acceptability scores of salads and tea were higher if the samples were tested in a meal context, for pizza the presence of other foods in the meal was irrelevant on acceptability score.

One of the most interesting findings from this research was that liking of croissants for the three experimental groups corresponded to different sensory profiles, indicating that the context in which consumers evaluated the samples affected the importance of different characteristics. In particular, the importance of appearance attributes, such as color, changed when consumers evaluated the croissants individually in the sensory booths (Control group) versus a more natural situation (Social group and Social + Drink group). Some of the odors, such as vanilla and fruity, were more relevant for consumer liking when the samples were tested with an accompanying drink, as well. This result has important implications considering the common use of external preference mapping for product development or optimization,

as it indicates that consumer liking scores obtained in an artificial environment (e.g. the sensory booths) may give misleading information as to what sensory characteristics "really" drive consumer acceptance. In general, the results of this study support the recommendation that, in order to produce ecologically valid results, the test situation of consumer studies should be as close as possible to a natural consumption situation (Giacalone, Bredie, & Frøst, 2013; Köster, 1981; Meiselman, 1996; Schutz, 1988).

5. Conclusions

We can conclude that in this study sensory differences among croissants were mainly due to the use of sourdough, even though those differences did not significantly affect hedonic judgments.

The context in which the samples were consumed affected their acceptance levels: where a social interaction negatively affected all hedonic judgments, drink accompaniment seemed to have reduced the negative impact. Finally, this research suggested that context in which consumers consumed the samples also affected the relative importance of sensory characteristics in determining consumer hedonic response. So, knowing how the sensory attributes of croissants are affected by the technology of production, what are the most important drivers of liking and how the latter are affected by the context are important information both to improve the product and to answer to marketing needs. With regard to the consumer test results, it should be noted that this study had an exploratory nature, based on a specific product case. In particular, because of the relatively limited number of consumers involved and the fact that they all resided in the same Italian region, future research is warranted to evaluate the inference of the findings.

Acknowledgments

This research was supported by funds provided by grants "Borsa di Studio Annalisa Intermoia" from Adacta International S.p.a. and by a Regione Campania fund (grant number/CUP: B25B09000080007) within the program "POR CAMPANIA FSE 2007/2013" — project CARINA (safety sustainability and competitiveness of the agro-food production in Campania).

References

Bingham, A., Hurling, R., & Stocks, J. (2005). Acquisition of liking for spinach products. *Food Quality and Preference*, *16*, 461–469.

Boutrolle, I., Delarue, J., Arranz, D., Rogeaux, M., & Köster, E.P. (2007). Central location test vs. home use test: Contrasting results depending on product type. *Food Quality and Preference*, *18*, 490–499.

Cardello, A.V. (1995). Food quality: Relativity, context and consumer expectations. *Food Quality and Preference*, *6*, 163–170.

Cardello, A.V., Bell, R., & Kramer, F. M. (1996). Attitudes of consumers toward military and other institutional foods. *Food Quality and Preference*, *7*, 7–20.

Cardello, A.V., Schutz, H., Snow, C., & Lesher, L. (2000). Predictors of food acceptance, consumption and satisfaction in specific eat situation. *Food Quality and Preference*, *11*, 201–216.

Comendador, F.J., Cavella, S., Di Monaco, R., Dinnella, C., Moneta, E., Monteleone, E., et al. (2012). Il pane e altri prodotti da forno. In TecnicheNuove (Ed.), *Atlante Sensoriale dei prodotti alimentari* (pp. 156–176). Società Italiana di Scienze Sensoriali (SISS).

Costell, E., Tárrega, A., & Bayarri, S. (2010). Food acceptance: The role of consumer perception and attitudes. *Chemosensory Perception*, *3*, 42–50.

Di Monaco, R., Torrieri, E., Pepe, O., Masi, P., & Cavella, S. (2014). Effect of sourdough with exopolysaccharides (eps)-producing lactic acid bacteria (lab) on sensory quality of bread. *Food and Bioprocess Technology* (in press).

Edwards, J.S.A., Meiselman, H.L., Edwards, A., & Lesher, L. (2003). The influence of eating location on the acceptability of identically prepared foods. *Food Quality and Preference*, *14*, 647–652.

Elzerman, J.E., Hoek, A.C., Van Boekel, M.A.J.S., & Luning, P.A. (2011). Consumer acceptance and appropriateness of meat substitutes in a meal context. *Food Quality and Preference*, *22*, 233–240.

Gains, N. (1994). The repertory grid approach. In H.J.H. Macfie, & D.M.H. Thompson (Eds.), *Measurement of food preferences* (pp. 51–76). London: Elsevier Applied Science.

Giacalone, D., Bredie, W.L.P., & Frøst, M.B. (2013). "All-In-One Test" (AI1): A rapid and easily applicable method to consumer product testing. *Food Quality and Preference*, *27*, 108–119.

Gocmen, D., Gurbuz, O., Kurmal, A.Y., Dagdellen, A.F., & Sahin, I. (2007). The effects of wheat sourdough on glutenin patterns, dough rheology and bread properties. *European Food Technology*, *225*, 821–830.

Hansen, A., & Schieberle, P. (2005). Generation of aroma compounds during sourdough fermentation: Applied and fundamental aspects. *Trends in Food Science & Technology*, *16*, 85–94.

Hein, K.A., Hamid, N., Jaeger, S.R., & Delahunty, C.M. (2010). Application of a written scenario to evoke a consumption context in a laboratory setting: Effects on hedonic ratings. *Food Quality and Preference*, *21*, 410–416.

Hein, K.A., Hamid, N., Jaeger, S.R., & Delahunty, C.M. (2012). Effects of evoked consumption contexts on hedonic ratings: A case study with two fruit beverages. *Food Quality and Preference*, *26*, 35–44.

Hersleth, M., Mevik, B.H., Næs, T., & Guinard, J.X. (2003). Effect of contextual factors on liking for wine-use of robust design methodology. *Food Quality and Preference*, *14*, 615–622.

Hersleth, M., Ueland, Ø., Allain, H., & Næs, T. (2005). Consumer acceptance of cheese, influence of different testing conditions. *Food Quality and Preference*, *16*, 103–110.

Katina, K., Heinio, R.L., Autio, K., & Poutanen, K. (2006). Optimization of sourdough process for improved sensory profile and texture of wheat bread. *LWT — Food Science and Technology*, *39*, 1189–1202.

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*, 58–65.

King, S.C., Weber, A.N., Meiselman, H.L., & Lv, N. (2004). The effect of meal situation, social interaction, physical environment and choice on food acceptability. *Food Quality and Preference*, *15*, 645–653.

Köster, E.P. (1981). Sensory evaluation in a "natural environment". In P. Schreier (Ed.), *Flavour 81* (pp. 93–100). Berlin, Germany: Walter de Gruyter.

Lacaze, G., Wick, M., & Cappelle, S. (2007). Emerging fermentation technologies: Development of novel sourdoughs. *Food Microbiology*, *24*, 155–160.

Meilgaard, M.C., Civille, G.V., & Carr, T. B. (2007). *Sensory evaluation techniques* (4th ed). Boca Raton, FL: CRC Press.

Meiselman, H.L. (1996). The contextual basis for food acceptance, food choice and food intake: The food, the situation and the individual. In H.L. Meiselman, & H.J.H. Macfie (Eds.), *Food choice acceptance and consumption* (pp. 139–263). Glasgow: Blackie Academic and Professional.

Meiselman, H.L. (2008). Experiencing food products within a physical and social context. In P. Hekkert, & H. Leder (Eds.), *Product experience* (pp. 559–580). Amsterdam: Elsevier.

Meiselman, H.L., Johnson, J.L., Reeve, W., & Crouch, J. E. (2000). Demonstrations of the influence of the eating environment on food acceptance. *Appetite*, *35*, 231–237.

Miele, N.A., Di Monaco, R., Cavella, S., & Masi, P. (2010). Effect of meal accompaniments on the acceptability of a walnut oil-enriched mayonnaise with and without a health claim. *Food Quality and Preference*, *21*, 470–477.

Petit, C., & Siefferman, J.M. (2007). Testing consumer preferences for iced-coffee: Does the drinking environment have any influence? *Food Quality and Preference*, *18*, 161–172.

Pliner, P., Bell, R., Kinchla, M., & Hirsch, E. (2003). Time to eat? The impact of time facilitation and social facilitation on food intake. *Pangborn Sensory Science Symposium Abstract Book, O72*.

R Development Core Team (2010). *R: A language and environment for statistical computing.* Vienna, Austria: R Foundation for Statistical Computing http://www.R-project.org/.

Rehman, S., Paterson, A., & Piggott, J.R. (2006). Flavour in sourdough breads: A review. *Trends in Food Science & Technology*, *17*, 557–566.

Schutz, H.G. (1988). Beyond preference: Appropriateness as a measure of contextual acceptance of food. In D.M.H. Thomson (Ed.), *Food Acceptability*. New York: Elsevier.

Stroebele, N., & De Castro, J.M. (2004). Effect of ambience on food intake and food choice. *Nutrition*, *20*, 821–838.