FULL TITLE: Effect of fiber information on consumer's expectation and liking of wheat bran enriched pasta

RUNNING TITLE: Expectation and liking of bran enriched pasta

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Abstract

The need to promote a diet rich in wholegrain has been recognized as an important task in nutrition education. Despite this, the intake of fiber in Western countries is below the recommended 25 g per day. The aim of the study was to evaluate the impact of wheat bran addition on the sensory quality of durum wheat spaghetti and to evaluate the effect of fiber information on consumer's acceptability and expectation. Information about fiber content had a positive impact on consumer's expected product quality but only for bran addition equal or higher than 20%. Consumers completely assimilated their liking in the direction of expectations for spaghetti with 20% and 25% of bran addition. Assimilation was incomplete for the 30% added sample indicating that the health benefit of eating fiber did not compensate the decrease in liking. The effect of information varied according to consumers' frequency consumption of bran-enriched pasta. Non-users showed a negative disconfirmation starting with a 20% bran addition, whereas for low- and high-users disconfirmation occurred at a higher bran addition. A complete assimilation effect was seen only for non-users, indicating that fiber information had an impact only for those consumers who actually do not consume wholegrain pasta.

Practical Applications

Consumer-led product development requires having a detailed understanding of what the consumer expects from a product. The findings of the present study provide information about the hedonic expectation and liking of pasta with high wheat bran content. Establishing the right balance between the expected health benefit of eating fiber and perceived product liking might be useful to food developers to increase fiber content in pasta formulations without sacrificing sensory attributes and pleasure.

Keywords: Information, Health, Fiber, Wholegrain, Assimilation, Acceptability

1. Introduction

Consumers worldwide are becoming increasingly interested in healthy eating and have consequently reconsidered wholegrain-based products value. As a result, the interest towards food with high fiber content has increased, leading to the development of a large market of fiber-rich ingredients and products (Baixauli et al., 2008). Wholegrain products consumption is also growing, but dietary fiber intake remains below the recommended 25 g per day (EFSA, 2010).

Reasons for lack of compliance with recommendation are manifold. One factor may be consumers' inability to correctly identifying wholegrain and high fiber foods (Van der Kamp et al., 2014), as well as consumers' poor knowledge of the effect of wholegrain consumption on specific chronic diseases risk reduction (Marquart et al., 2006; Dammann, Hauge, Rosen, Schroeder and Marquart, 2013). Moreover, consumers often perceive fiber as having dark color, bitter flavor and a course texture, which can make food unpalatable (Baixauli et al., 2008). Unfortunately, healthy food choices are often in conflict with pleasure in eating. Therefore, one of the major challenges of food industry is to increase food fiber content without sacrificing sensory attributes.

Changing consumer's dietary patterns is not an easy task since food choice is mainly dominated by sensory preferences. Product information has been reported to be highly influential in affecting consumer's expectation and choice (Laureati et al., 2013). Consumer's expectation is often measured in terms of disparity degree between expected and perceived product performance. Different theoretical models have been proposed to explain the effect of discrepancies between expected and actual product liking (Anderson, 1973): 1) the *dissonance or assimilation theory* assumes that any shift between expectations and product performance will be minimized by the consumer, who adjusts his/her product perception in order to be less dissonant with his/her expectations; 2) according to the *contrast theory*, the consumer amplifies the difference between

68 the expectation and the actual performance of the product; 3) the *generalized negativity theory*
69 states that any discrepancy between expectations and reality produces a generalized negative
70 hedonic perception; 4) the *assimilation-contrast theory* asserts that there would be a limit beyond
71 which the subject no longer accepts the disconfirmation, thus an assimilation model takes place in
72 case of small disconfirmation, while a contrast model takes place in case of strong disconfirmation;
73 5) finally, on the basis of the prospect theory (Kahneman & Tversky, 1979), which takes the sign of
74 disconfirmation into account, lower assimilation occurs when the product is worse than expected.
75 The assimilation model has been observed to occur in most of the studies conducted to investigate
76 how information about food influences expectation (Siret & Issanchou, 2000).
77 The effect of health and nutrition information on consumer's preferences has been investigated
78 mainly in the context of fat content in a variety of foods. For instance, Aaron, Mela, and Evans (1994)
79 found a positive effect of information on consumer's liking of full-fat and reduced-fat versions of a
80 spread. Westcombe and Wardle (1997) found a negative effect of fat content information on cheese
81 pleasantness, whereas no effects were found on yogurt pleasantness (Kähkönen et al., 1997). Fat
82 information was found to affect expected pleasantness for sausages (Kähkönen & Tuorila, 1998),
83 cakes and crackers (Tuorila et al., 1994) but did not affect actual pleasantness. The inconsistency of
84 these results may be ascribed to the fact that the effect of information is strongly product-
85 dependent and it is determined by consumer's background and information/background
86 interactions.
87 Although fiber information is increasingly used on food packaging, not many studies of the effect of
88 fiber-related information on consumer's perception have been reported in the literature (Baixauli
89 et al., 2008). The effect of fiber information on consumers' acceptance and/or willingness to pay
90 has been investigated in bread (Ginon et al., 2009; Mialon et al., 2002; Saba et al., 2010), muffins

(Baixauli et al., 2008; Mialon et al., 2002), and yogurt and cakes (Saba et al., 2010). These studies showed an effect of fiber-related information on consumers' acceptance and willingness to pay but with great inter-individual differences. For instance, Ginon et al. (2009) found a significant effect of age on willingness to pay for high-fiber bread, with younger consumers more influenced than the older ones by the hedonic value of the product rather than health related concerns. Baixauli et al. (2008) found that fiber information was more effective in increasing acceptance of muffins for health conscious consumers. Mialon et al. (2002) and Saba et al. (2010) found culture-related differences in the impact of fiber information on liking and/or sensory properties of food.

It should be underlined that, in some cases, the above-mentioned studies were designed to provide information about the product fiber content without providing information about the benefit of eating fiber (Baixauli et al., 2008; Mialon et al., 2002). Therefore, the effect of nutritional information might have been underestimated. Moreover, no studies have examined the effect of fiber information according to frequency consumption. This issue is important to consider since consumers may perceive fiber-enriched/wholegrain products as novel foods, thus familiarity with the product is a crucial factor in appreciation and expectation (Laureati et al., 2006).

The objective of the present study was to evaluate the impact of bran wheat addition on the sensory quality of durum wheat spaghetti and to evaluate the effect of fiber information on consumer's acceptability and expectation. The simple nature of pasta ingredients (water and durum wheat) and being a commonly consumed food product worldwide, make pasta an excellent vehicle for the inclusion of wholegrain and dietary fiber materials (Brennan, 2013). Although Italy is one of the major producers and consumers of pasta (Di Monaco et al., 2004), bran-rich pasta consumption is rather low (UNAFPA, 2013), probably due its distinct taste and softer texture (Edwards et al., 1995; Manthey & Schorno, 2002; Manthey, 2002) that can make it less acceptable to consumers. Thus,

both product sensory optimization and conveying appropriate information to consumers are needed to increase fiber-enriched pasta consumption. To this purpose, spaghetti with different bran wheat addition (up to 30% addition) were evaluated for liking before and after having received an information about the fiber content and the benefit of including fiber in the diet in order to see to what extend consumers are willing to compromise the taste in return of possible long-term health benefits. Effect of fiber information on the acceptability was also analyzed according to bran-enriched pasta frequency of consumption in order to highlight different patterns of answer.

2. Materials and methods

2.1 Samples production

Spaghetti were produced in a pilot plant of the University of Foggia with durum wheat semolina by using the following operating conditions: semolina was mixed with water with a rotary shaft mixer (Namad, Rome, Italy) at 25°C for 20 min so as to obtain a dough with 30% moisture content. Wheat bran was added at various concentrations: 10%, 20%, 25% and 30%. The dough was extruded with a 60VR extruder (Namad). The extrusion pressure was about 4 MPa, whereas the temperature of the spaghetti after the extrusion was about 27–28°C. The extruder was equipped with a screw (30 cm in length, 5.5 cm in diameter), which ended with a bronze die (diameter hole of 1.70 mm). The screw speed was 50 rpm. Subsequently, pasta was dried in a dryer (SG600; Namad). The process conditions applied were the following: 1st step, time 20 min at 60°C and 65% moisture (named as external drying); 2nd step, time 130 min at 90°C and 79% moisture (named as wrapping); 3rd step, time 150 min at 75°C and 78% moisture (named as drying); 4th step, time 160 min at 45°C and 63% moisture; 5th step, time 1040 min at 50°C and 50% moisture. The 4th and 5th steps are used for spaghetti cooling.

137

138 2.2 *Physico-chemical characterization*

139 The optimal cooking time (OCT), the cooking loss and the amount of solid substance lost into the
140 cooking water were determined according to the AACC approved method 66-50. The swelling
141 index and the water absorption of cooked pasta (grams of water per gram of dry pasta) were
142 determined according to the procedure described by Padalino et al. (2013). Cooked spaghetti
143 samples were also submitted to hardness and adhesiveness analysis by means of a Zwick/Roell
144 model Z010 Texture Analyzer (Zwick Roell Italia S.r.l., Genova, Italia) equipped with a stainless
145 steel cylinder probe (2 cm diameter). Hardness (mean maximum force, N) and adhesiveness (mean
146 negative area, Nmm) were measured according to the procedure described by Padalino et al.
147 (2013), after six measurements for each sample.
148 To determine pasta composition, dry spaghetti were ground to fine flour on a Tecator Cyclotec
149 1093 (International PBI, Milano, Italy) laboratory mill (1mm screen – 60 mesh). Moisture and ash
150 content (%) were measured according to AACC methods 44-19 and 08-03 (2000). Protein content
151 (%N x 5.7) was analyzed with the micro Kjieldahl method according to AACC method 46-13 (2000).
152 Total dietary fiber (TDF), soluble–water fiber (SDF) and insoluble-water fiber (IDF) contents were
153 determined by the Total Dietary Fiber Kit (Megazyme), based on the method of Lee et al. (1992).
154 The available carbohydrates (ACH) were determined according to McCleary et al. (2006), as
155 described in the available carbohydrates kit assay (Megazyme). All nutritional analyses were made
156 in triplicate.

157 *2.2 Consumer test*

158 *2.2.1 Subjects*

One hundred (50 females and 50 males) regular pasta consumers aged between 19 and 72 years (M=31.5; ds=12.4) were recruited among students and staff of the Faculty of Agronomical and Food Sciences of the University of Milan. They had seen or received an invitation to participate in the study and volunteered based on their interest and availability. Participants had no history of disorders in oral perception and ate traditional pasta regularly (at least 1-2 times a week). Written informed consent was obtained from each subject after the description of the experiment.

2.2.2 Preparation of spaghetti and serving conditions

For each pasta formulation, 160 g (an amount appropriate for 8 consumers) were cooked in 1.6 L of water in which 13 g of salt were added. Samples formulation with relevant cooking time is reported in **Table 1**. After cooking, spaghetti were drained and seasoned with 16 g of extra-virgin olive oil (Bertolli Gentile, Deoleo S.A., Inveruno, Italy). For each formulation, approximately 20 g of spaghetti were served in white plastic plates coded with a three-digit number. Mineral water was provided for rinsing between each sample tasting. To avoid any changing in sensory properties of spaghetti during the session, samples were cooked one at a time, so that each of them experienced the same time–temperature history prior to consumer assessment (Di Monaco et al., 2004).

2.2.3 Procedure

Consumer testing took place in the sensory laboratory of the Department of Food, Environmental and Nutritional Sciences (DeFENS) of the University of Milan, designed according to ISO guidelines (ISO 8589, 2007). Participants were involved into two tasting sessions performed in two different days one week apart. Consumer groups of maximum 8 subjects were created according to the

number of individual booths available (eight in total) and asked to come to the sensory lab at 60 min time intervals from 11.30 am to 1.30 pm. Three consumer groups performed the test per day, the whole study was performed in ten days over a period of 2 months. According to Deliza and MacFie (1996), samples were evaluated under three different tasting conditions: non-informed, expected and informed conditions. During the first session (day 1), participants performed the non-informed and the expectation test. For the non-informed test, subjects received the five samples of spaghetti monadically and asked to rate their liking degree without any information about the product and its nutritional value. The only information provided to the participants was that they were about tasting spaghetti at different fiber content. Thus, for each product, participants received about 20 g of spaghetti and judged them in individual booths under white light at room temperature. Participants rated the samples liking degree using a 100-mm unstructured, linear scale anchored at the extremes with the terms ‘‘extremely disliked’’ (left of the scale) and ‘‘extremely liked’’ (right of the scale). After tasting each sample, participants were instructed to rinse their mouth with mineral water.

After a short break, they performed the expectation test. All participants were shown on a screen the following information: “*The consumption of food high in fiber reduces the risk of several diseases such as type 2 diabetes, cardiovascular diseases and gastrointestinal disorders. Whole-wheat pasta is among the foods recommended to increase dietary fibers. Usually, commercially available whole-wheat pasta contains approximately 6-8% of fiber*”. Then, the image of each spaghetti sample with information about the relevant wheat-bran addition (i.e., no addition, 10%, 20%, 25%, 30%) was shown to participants. For each sample, subjects rated the expected liking induced by its image and the relevant information without tasting the sample using the hedonic scale described above.

After one-week interval, the same participants were invited again to the tasting center (day 2) and performed the informed test. As for the non-informed test, subjects received the five spaghetti samples monadically in plastic plate coded with 3-digit numbers and asked to rate their liking degree with the hedonic scale described above. The experimental conditions were the same as for the non-informed test, with the exception that for each sample of spaghetti, subjects received the information about bran addition and the benefit of consuming fiber in the diet.

For practical constraints, samples presentation order was kept identical within each session of maximum 8 consumers but varied across sessions in order to minimize serving order and carry-over effects (MacFie, Bratchell, Greenhoff, & Vallis, 1989).

At the end of the informed test, subjects were asked to complete a short questionnaire about their frequency consumption of traditional and wholegrain pasta, the most important aspects related to pasta consumption (e.g., size/format, nutritional aspect, price, color, texture, taste, cooking properties), the reasons for consuming (if user) or not (if non-user) wholegrain pasta and their willingness to pay an extra for wholegrain pasta.

2.3 Data analysis

Data from physico-chemical analyses were compared by a one-way variance analysis (ANOVA). A Duncan's multiple range test, with the option of homogeneous groups ($p<0.05$), was carried out to determine significant differences between samples.

In order to verify the effect of information on liking, consumer data were subjected to analysis of variance (ANOVA) considering subjects (nested within wholegrain pasta consumption), the 2-way interaction pasta samples*conditions and the 3-way interaction pasta samples*conditions* wholegrain pasta consumption, as factors and hedonic scores as dependent variable. The 2-way

228 interaction is useful to get insights on the effect of information on liking of the whole group of
229 consumers, whereas the 3-way interaction indicates whether a different effect of information on
230 liking can be observed depending on consumers' frequency of consumption. Subjects were
231 considered as random effects in the model, whereas the other factors were considered as fixed
232 effects. When the ANOVA showed a significant effect ($p < 0.05$), t-tests were applied as multiple
233 comparison analysis (Laureati et al., 2013).
234 T-tests on the differences between non-informed and expected mean hedonic ratings for each
235 pasta formulation enabled establishing whether a hedonic disconfirmation took place. A
236 disconfirmation occurs when this difference is significantly different from zero. In the same way, t-
237 tests on the differences between the informed and non-informed mean hedonic ratings allowed
238 verifying whether the disconfirmation was associated with an assimilation or a contrast effect.
239 When this difference is significantly different from zero, it means that there was a significant
240 effect of the nutritional information on hedonic scores. More specifically, if this difference is
241 higher than zero, an assimilation effect occurs; if the difference is lower than zero, a contrast
242 effect occurs. In the assimilation case, when the difference between expected and informed liking
243 is significantly different from zero, the consumers do not completely assimilate towards their
244 expectation and assimilation is not total (Siret & Issanchou, 2000).
245 All statistical analyses were performed using SAS/STAT statistical software package version 9.3
246 (SAS Institute Inc., Cary, USA).
247
248
249 **3. Results and discussion**
250 *3.1. Pasta physico-chemical properties*

The chemical composition of samples is shown in Table 2. Anova results show a significant effect ($p<0.001$) of the main factor samples on all parameters. From **Table 2** it can be seen that the addition of wheat bran increased proteins, fibers and ash content and reduced available carbohydrates, in agreement with findings of other authors (Padalino et al., 2015). The ash in wheat is not evenly distributed throughout the kernel, being more concentrated in the bran (6%) than in the endosperm portion (0.4%) of the grain (Pomeranz, 1988). As regard fibers, in spaghetti with wheat bran there was a significant increase of the insoluble fiber content (IDF) ($F_{3.47}$=3122.2; $p< 0.0001$), that accounted about for 18% because the IDF are more concentrated in the bran fraction. As a consequence of the high dietary fiber content, the samples enriched with bran recorded lower available carbohydrate content (ACH) ($F_{3.47}$=2583.2; $p< 0.0001$) than the CTRL sample (Sp_0) (Mongeau, 2003). It should be underlined that, for this study, pasta samples were produced with semolina obtained from a particular durum wheat cultivar that it is very rich in dietary fiber, as confirmed by the CTRL sample showing a 7% total dietary fiber content, which is comparable with the amount of fiber present in commercial pasta sold on the market as "wholegrain" (Sgrulletta et al., 2005). Indeed, with a minimal enrichment of bran (10%) the total fiber content reached more than 15%.

Cooking performance of spaghetti (optimum cooking time, cooking loss, water absorption, swelling index, hardness and adhesiveness) is shown in **Table 3**. Data demonstrate that pasta fortification with wheat bran had a noticeable impact on cooking quality. In fact, ANOVA results showed a significant effect of the main factor samples on all parameters ($p<0.05$). In particular, for samples with wheat bran, optimal cooking time (OCT) values were lower than the control pasta. This is due to the physical disruption of gluten matrix by bran particles, which provided a path of water absorption into the whole-wheat spaghetti strand that reduced cooking time. Similar results

were also observed by Kaur et al. (2012). **Table 3** also highlights a cooking loss increase for spaghetti enriched with fibers, because the disruption of protein matrix by bran particles generally facilitates starch granule swelling and rupture ($F_{3.47}$=18.55; p< 0.0001) (Manthey et al. 2004). Spaghetti samples enriched with wheat bran also showed a significant decline in swelling index ($F_{3.47}$=851.93; p< 0.0001). One possible explanation of the observed results is that the fortified spaghetti had high dietary fiber content (mainly insoluble fiber) as compared to the free-fiber sample. Aravind et al. (2012) also found that in durum wheat pasta containing bran there is typically a less absorption of water because bran competes for water with starch. Cooking quality is also related to the ability of spaghetti to maintain textural properties during cooking (Del Nobile et al., 2005). In fact, the textural characteristics of pasta play an essential role in determining the final acceptance by consumers (Tudorica et al., 2002). Mean values for hardness ($F_{3.47}$=4.37; p< 0.05) and adhesiveness ($F_{3.47}$=5.54; p< 0.05) showed significant differences between the samples studied. Specifically, pasta with 30% bran addition showed lower firmness and adhesiveness respect to the other samples investigated. Again, this result may be associated with the role of the insoluble fiber present in the bran of fortified spaghetti, which might interfere with the continuity of the gluten matrix (Tudorica et al., 2002; Aravind et al., 2012). The adhesiveness did not increase because bran contains insoluble fiber, which is known to have a positive effect on stickiness (Cleary et al., 2006). Hence, a combination of reduced hardness and adhesiveness characteristics in the cooked spaghetti indicates that the inclusion of the insoluble fiber makes the pasta softer, more malleable but less sticky. Softness and adhesiveness are known to reduce consumer's acceptability (Edwards et al., 1995; Manthey & Schorno, 2002; Manthey, 2002).

3.2. Questionnaire: consumption of and attitude toward pasta products

296 The questionnaire was provided in order to have an overview of consumer's frequency
297 consumption of pasta and, in particular, of wholegrain pasta and consumer's attitude towards
298 pasta products. The answer to the question related to the frequency consumption of wholegrain
299 pasta was used to categorize the subjects in no (never), low (less than once a week) and high users
300 (at least once a week) in order to highlight different pattern of responses. Results emerged from
301 the questionnaire are reported in **Table 4**.
302 As expected, overall pasta frequency consumption was high, with 38% of respondents consuming
303 pasta daily, 60% weekly and only 2% monthly. This result is in line with pasta consumption
304 frequency in Italy (UNAFPA, 2013).
305 The most important characteristics at purchase are taste (41%) and cooking quality (37%),
306 reflecting the importance of sensory properties at the moment of choice. Only 13% and 9% of
307 respondents were interested in the nutritional properties and shape of pasta, respectively. For
308 high users, the importance of the nutritional aspect increased, while decreasing the relative
309 importance of taste.
310 When asked about the frequency consumption of wholegrain pasta, 31% of respondents declared
311 to be non-consumers. The remaining 69% of subjects reported to consume wholegrain pasta, 44%
312 of which consumed it monthly, 24% weekly and only 1% daily. The percentage of wholegrain pasta
313 consumers observed in the present study is surprising and exceed by a large amount national data
314 about wholegrain pasta consumption (O'Neil et al., 2010). An explanation of this high proportion
315 might be that participants recruited were mainly students and employees of the Faculty of
316 Agronomy and Food Sciences (University of Milan), thus highly educated and probably more
317 conscious of the health benefit of consuming dietary fiber. Literature data indicate that
318 consumption of wholegrain products increase according to the level of education (Bellisle et al.,

2014). Moreover, participants were recruited via advertisements asking for pasta and wholegrain pasta consumers. This might have attracted a higher number of regular users of bran-enriched pasta consumers. Another plausible explanation is that respondents may sometimes have the bias to answer what they think is the correct answer, and not what they actually do (Köster, 2003). In this regard, the fact that the questionnaire was filled out after they had received information and tasted a number of samples, may indeed support the assumption that subjects felt they had to admit to consuming wholegrain, or even expressed a wish to consume.

Approximately 40% of the non-consumers indicated sensory properties as main reasons for not eating wholegrain pasta (taste 23%, texture 16%), supporting the important role played by sensory factors in the acceptance and choice of wholegrain products (Aravind et al., 2012; Bauxali et al., 2008). Despite the higher cost of wholegrain foods has been reported to be an obstacle for consumption of these products (McMackin et al., 2014), price as well as nutritional concerns had little impact (respectively 16% and 13%) for our sample of consumers. It is noteworthy that more than one third of respondents reported other reasons for not consuming wholegrain pasta (32%). Analysis of these answers revealed that consumers reported to have never thought about eating wholegrain pasta, supporting the reported lack of consumers' awareness about wholegrain products (Marquart et al., 2006).

On the contrary, wholegrain pasta consumers declared to eat this specific type of pasta mainly for its healthy aspects (59%), whereas a reduced percentage of respondents answered for its taste (22%) and because they were advised to do so (10%). Finally, 38% of subjects declared to be unwilling to pay any premium price for wholegrain pasta. Unwillingness to pay for wholegrain pasta decreased according to its frequency consumption. A relatively high percentage of respondents (62%) was willing to pay a premium price for wholegrain pasta, of which 48% would

342 pay between 10-20% more and only 14% (mainly high users) between 20-30% more. Some limits
343 of the questionnaire should be pointed out. First, a reduced number of respondents have been
344 involved, thus results cannot be generalized. In addition, willingness to pay was investigated by
345 direct questioning, which might be prone to bias such as overstatement of willingness to pay or
346 the choice of more socially desirable options (Ginon et al., 2014). Future studies should consider
347 approaches such as auctions that places consumers in a decision-making situation closer to a real
348 shopping situation.
349
350 *3.3. Influence of nutritional information on consumer's expectation*
351 Mean hedonic ratings of spaghetti samples in the three different experimental conditions (non-
352 informed, expected and informed) are reported in **Table 5**. Anova results showed a significant
353 effect of the interaction Samples*Condition ($F_{(4,1358)}$=5.12, p<0.0001). Considering the non-
354 informed condition, except the ones with 25% and 30% bran wheat addition, all samples were
355 generally liked. The traditional pasta sample (Sp_0, M=69.6) and the sample with 10% addition
356 (M=69.7) were significantly more liked than the other spaghetti. The addition of bran wheat
357 produced a systematic and significant decrease in acceptability ratings. A similar pattern was
358 observed in both the expected and informed conditions.
359 Increasing concentration of bran is known to produce a higher perception of a series of sensory
360 properties that might be considered unpleasant by consumers (Aravind et al., 2012). In this
361 context, the reduced rating for pasta with 25% and 30% bran addition is likely attributable to its
362 texture properties, as also evidenced by physical data showing lower firmness values for this
363 sample respect to the others. As a fact, bran by interfering with the continuity of the gluten matrix
364 causes weakening of the dough and reduces mechanical strength and cooking quality of bran-

supplemented spaghetti (Padalino et al. 2015). Therefore, proper technological options should be adopted to improve acceptability of pasta rich in high amount of bran.

The effect of information about the nutritional benefit of consuming fiber on consumer's acceptability was analyzed comparing the mean hedonic scores in the non-informed and expected conditions for all samples (**Table 5**). T-test comparison indicated a confirmation of expectation for the traditional sample (Sp_0) and the 10% added sample, whereas for the spaghetti with 20, 25 and 30% addition a negative disconfirmation of expectation occurred (i.e., the samples were worse than expected). This means that information about bran addition had an impact on consumer expected product quality but only for an addition equal or higher than 20%.

The disconfirmation was associated with an assimilation effect as the difference between liking scores under non-informed and informed conditions was significant for the two samples with the highest addition of bran (25 and 30%) and marginally significant for the sample with 20% of addition. Therefore, the information given about the nutritional benefit of consuming fiber was able to affect the actual liking (informed condition) of spaghetti, since informed liking moves in the direction of the expectations. In particular, the information concerning the benefit of consuming fiber in the diet had a positive impact on actual liking.

The assimilation was complete for the 20% and 25% added spaghetti since the difference between informed and expected liking for those samples was not significant. This result is particularly relevant because if consumers do not completely assimilate towards expectations, repeated disconfirmations may lead to a decrease in expectations and liking, whereas in case of complete assimilation repeated disconfirmations did not induce a decrease in expectation nor a decrease in the assimilation effect (Lange et al., 1999; Napolitano et al., 2010).

A marginally significant difference ($p<0.10$) between liking in the informed and expected conditions was observed for the 30% added sample, indicating that assimilation was not complete. In previous studies, assimilation effects were observed for products which information created the highest level of expectation (Cardello, 2007). The incomplete assimilation observed for Sp_30 might be because expected liking created by the external information was low and sensory properties had a major impact on ratings in the informed condition, thus the health benefit of eating fiber does not compensate the decrease in liking. This assumption is in line with literature data indicating that many consumers feel that sensory pleasure may have to be sacrificed in order to achieve the goal of a healthy diet, but this effect is dependent upon the specific nature of the expected health benefit (Tuorila & Cardello, 2002).

The effect of fiber information on consumer's judgements has not received much attention in the literature. In a study by Baixauli et al. (2008) a positive effect of the information on hedonic scores was found for wholegrain muffins but not for enriched-fiber muffins. Mialon et al. (2002) noticed a slight increase in liking for a fiber-enriched white bread presented with a 'high in fiber' label, and a slight decrease in liking for white bread presented with a 'low in fiber' label. Ginon et al. (2009) found that a "source of fiber" label had a positive effect on willingness to pay for bread, whereas consumers did not perceive the absence of the label negatively. Unfortunately, these studies adopted a methodology that is not exactly the same as the one used in the present study, thus our results are not easily comparable. Nevertheless, a common finding is that providing the information about fiber had a positive effect on consumer's product perception. Therefore, it seems that information on the benefit of wholegrain food in the diet might be a suitable way for ensuring that the population receives adequate amounts of fiber. Likewise, literature data indicate that the presence of a health claim had positive influence on respondents' perception of the

products (Saba et al., 2010; van Kleef et al., 2005). More specifically, the information about the presence of wholegrain influenced positively the perception of healthiness and had a small influence on likelihood to buy foods such as yoghurt, cake and bread (Saba et al., 2010). It is interesting to note that in their cross-cultural study, Saba and colleagues found that health claims referred to wholegrain had little impact on Italian consumers compared with consumers from other European countries. On the contrary, we found that Italian consumers are positively influenced by nutritional information. This discrepancy might be explained in at least two ways. First, by the different products tested, in fact, yoghurt, bread and cake, despite being highly consumed in Italy, may not have the same connotation of traditional Italian food as pasta (Laureati et al., 2006). Second, in Saba et al. (2010) study the influence of information was tested through a questionnaire without presenting an actual product. Contextualizing the information about healthiness of wholegrain by associating it to a real eating situation, as in the present study, might indeed be more effective than providing the same information on a questionnaire.

3.4. Influence of nutritional information on hedonic expectation: consumer's segmentation according to frequency consumption of wholegrain pasta

Mean hedonic ratings provided by consumers, grouped according to their wholegrain pasta consumption under the three conditions, are reported in **Table 6**. Consumers are increasingly segmented on the basis of their attitudes towards food, particularly towards health and hedonic characteristics of food (Roininen, Lähteenmäki, & Tuorila, 1999). Identifying segments of consumers with different attitudes towards food and nutrition might allow targeting different types of products for each segment (Laureati, Giussani, Pagliarini, 2012; Ares et al., 2010).

Anova results showed a non-significant effect of the 3-way interaction samples*condition*wholegrain pasta consumption. Looking at hedonic ratings in each condition, a systematic decrease in liking with increasing bran addition is observed whatever the consumer group is, as already highlighted analyzing the data of the overall sample of consumers. However, considering the difference between the ratings in the different conditions for the three groups, it can be observed that information had a different impact on consumers depending on their wholegrain pasta frequency use. A negative disconfirmation of expectation was seen for high-users starting from spaghetti samples with 25%, whereas for low-users negative disconfirmation occurred at the highest bran addition. For non-users disconfirmation occurred already with 20% addition. What is especially remarkable is that an assimilation effect occurred for non-users but not for high and low users, indicating that the nutritional information about the benefit of fiber on health had an impact only for those consumers who actually do not consume wholegrain pasta. Moreover, the assimilation was complete, showing that the information elicited an increase of liking in the informed condition that equals the expectation, even for the spaghetti sample with the highest addition (30%). T-test comparison showed that the difference between the groups of consumers is mainly due to differences in liking in the non-informed condition, especially for the spaghetti with highest addition of bran (20, 25 and 30%), which were more liked by low- and high-users than non-users (**Figure 1)**.

INSERT FIGURE 1 ABOUT HERE

Thus, it seems that low- and high-users, who also showed a higher interest in health, are more willing to compromise liking for healthiness (Ares et al., 2010) than non-users but information had a smaller impact on their liking compared with non-users. This result might be explained by the fact that bran enriched pasta is more familiar to high- and low-users. Familiarity is known to be

455 one of the most powerful drivers of liking (Laureati et al., 2006; Borgogno et al., 2015). In this
456 context, high- and low-users might have recognized in the non-informed condition the presence of
457 bran in the spaghetti samples - and thus fiber - from the darker appearance (Aravind et al., 2012).
458 This association might have led the high- and low- users to provide higher hedonic ratings than
459 non-users to the spaghetti with the highest bran addition. Actually, it should be underlined that
460 the visual differences, mainly dark color, of the spaghetti samples were considerably reduced by
461 cooking. Therefore, although an effect of the visual appearance on liking and expectation may
462 have occurred, it is likely that it was negligible. Moreover, it might be hypothesized that users are
463 already aware of the health benefit of incorporating fiber into the diet, thus the information
464 provided in the expected and informed conditions might have had a reduced effect on their liking
465 ratings. This assumption is supported by questionnaire data, indicating that 72% of high users of
466 wholegrain pasta declare to consume it for its health benefits. Contradicting results were found by
467 Baixauli et al. (2008) who reported a positive correlation between health consciousness and liking
468 of wholegrain muffins when the information about fiber was provided. The discrepancy in the
469 outcome might be explained with differences in the experimental design used, and type of
470 product and information provided.
471
472 **4. Conclusions**
473 The need to promote a diet rich in wholegrain has been recognized as an important task in
474 nutrition education. This study revealed that higher amount of wheat bran reduced product
475 acceptability; in particular, pasta with 30% addition of wheat bran should be implemented from a
476 technological point of view in order to have pasta samples that besides having a nutritional benefit
477 show good sensory properties.

478 However, a positive effect of nutritional information on consumer's acceptability of pasta
479 produced with the addition of high levels (up to 30%) of wheat bran was seen. The effect of
480 information varied according to frequency consumption of bran-enriched pasta in our sample of
481 consumer, with non-users being more sensitive to information about fiber health benefit than
482 regular ones. The development of persuasive communication of health messages might be an
483 effective way for promoting awareness and knowledge of high fiber products.
484
485 CONFLICT OF INTEREST: the authors have no conflict of interest to declare
486

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622

623 Table 1. Spaghetti formulations used in the consumer test with relevant cooking time.

Samples code	Bran addition (%)	Cooking time (min)	Samples picture
Sp_0	0	11.30	
Sp_10	10	11.00	
Sp_20	20	10.40	
Sp_25	25	10.30	
Sp_30	30	10.20	

624

Table 2 - Chemical composition of dry spaghetti samples.

	Protein (%)	Ash	IDF (%)	SDF (%)	TDF (%)	ACH (g/100g)
Sp_0	15.18±0.04^{e}	2.17±0.02^{e}	3.82±0.16e	3.50±0.23d	7.32±0.17^{e}	68±0.16^{a}
Sp_10	15.46±0.10^{d}	4.08±0.01^{d}	11.45±0.10^{d}	3.77±0.20^{c,d}	15.22±0.15^{d}	65±0.16^{b}
Sp_20	15.67±0.08^{c}	4.96±0.00^{c}	14.46±0.16^{c}	4.04±0.28^{b,c}	18.52±0.10^{c}	60±0.20^{c}
Sp_25	15.95±0.02^{b}	5.15±0.08^{b}	15.81±0.24^{b}	4.37±0.15^{b}	20.18±0.24^{b}	57±0.24^{d}
Sp_30	16.09±0.02^{a}	5.28±0.10^{a}	17.90±0.16^{a}	4.77±0.10^{a}	22.67±0.08^{a}	55±0.15^{e}

TDF, total dietary fiber; SDF, water-soluble dietary fiber; IDF, water-insoluble dietary fiber; ACH, available carbohydrates.
Mean in the same column followed by different superscript letters differ significantly ($p < 0.05$)

Table 3 - Cooking quality of dry spaghetti samples (OCT: Optimal Cooking Time).

	OCT (min)	Cooking Loss (%)	Swelling Index (g water per g dry spaghetti	Water Absorption (%)	Adhesiveness (Nmm)	Hardness (N)
Sp_0	11.30	5.00 ± 0.16^{d}	2.10 ± 0.02^{a}	183 ± 0.24^{a}	0.78 ± 0.05^{a}	7.07 ± 0.15^{a}
Sp_10	11.00	5.60 ± 0.14^{c}	1.98 ± 0.02^{a}	180 ± 0.24^{b}	0.75 ± 0.02^{ab}	6.78 ± 0.25^{ab}
Sp_20	10.40	5.91 ± 0.30^{bc}	1.87 ± 0.15^{a}	174± 0.55^{c}	0.73 ± 0.05^{abc}	6.46 ± 0.30^{bc}
Sp_25	10.30	6.18 ± 0.12^{ab}	1.85 ± 0.18^{a}	173 ± 0.21^{d}	0.68 ± 0.04^{bc}	6.35 ± 0.30^{bc}
Sp_30	10.20	6.34 ± 0.28^{a}	1.83 ± 0.25^{a}	170 ± 0.20^{e}	0.65 ± 0.05^{c}	6.21 ± 0.25^{c}

1 Table 4. Percentage of answers to the items of the questionnaire provided by the overall sample of

2 consumers and by consumers grouped according to wholegrain pasta frequency consumption.

Questions/Items	**Subjects**			
	Overall (n=100)	Non users (n=31)	Low users (n=37)	High users (n=32)
Pasta frequency consumption (%)				
Daily	38	48	43	25
Weekly	60	45	57	75
Monthly	2	7	0	0
Never	0	0	0	0
Most important aspect for consuming pasta (%)				
Nutritional aspect	13	3	11	26
Price	0	0	0	0
Taste	41	52	38	34
Cooking quality	37	35	46	28
Shape	9	10	5	12
Color	0	0	0	0
Wholegrain pasta frequency consumption (%)				
Daily	1	0	0	3
Weekly	24	0	0	97
Monthly	44	0	100	0
Never	31	100	0	0
Reasons for consuming wholegrain pasta (if consumer) (%)				
For its taste	22	0	27	16
For nutritional concerns	59	0	49	72
Because I've been advised to	10	0	13	6
Other	9	0	11	6
Reasons for not consuming wholegrain pasta (if non consumer) (%)				
For its taste	23	23	0	0
For its texture	16	16	0	0
For its appearance	0	0	0	0
For its price	16	16	0	0
Not interested in its nutritional aspect	13	13	0	0
Other	32	32	0	0
Willingness to pay a premium price for wholegrain pasta (%)				
No	38	52	41	22
10-20% more	48	45	51	47
20-30% more	14	3	8	31
> 50% more	0	0	0	0

3

Table 5. Mean hedonic ratings provided by consumers (n=100) for spaghetti samples under the three experimental conditions (NI= Non-informed, E=Expected, I=Informed) and expectation effect on spaghetti acceptability.

Samples	Ratings			E – NI		I - NI		I-E	
	NI	E	I	Mean	p-value	Mean	p-value	Mean	p-value
Sp_0	69.6^{a}(¥)	72.4^{a}	70.5^{a}	2.8	n.s. confirmation	0.9	n.s.	1.9	n.s.
Sp_10	69.7^{a}	70.2^{ab}	71.1^{a}	0.5	n.s. confirmation	1.4	n.s.	0.9	n.s.
Sp_20	60.7^{b}	69.4^{ab}	65.7^{b}	8.6	** disconfirmation	5.0	(*) assimilation	3.7	n.s. complete
Sp_25	53.8^{c}	65.0^{bc}	60.8^{c}	11.2	*** disconfirmation	7.0	** assimilation	4.2	n.s. complete
Sp_30	48.1^{d}	60.7^{c}	55.9^{d}	12.6	*** disconfirmation	7.9	** assimilation	4.7	(*) incomplete

(¥) Superscripts indicate significant differences by column (t-test, $p<0.05$).
n.s. not significant
(*) significant $p<0.10$
** significant $p<0.01$
*** significant $p<0.001$

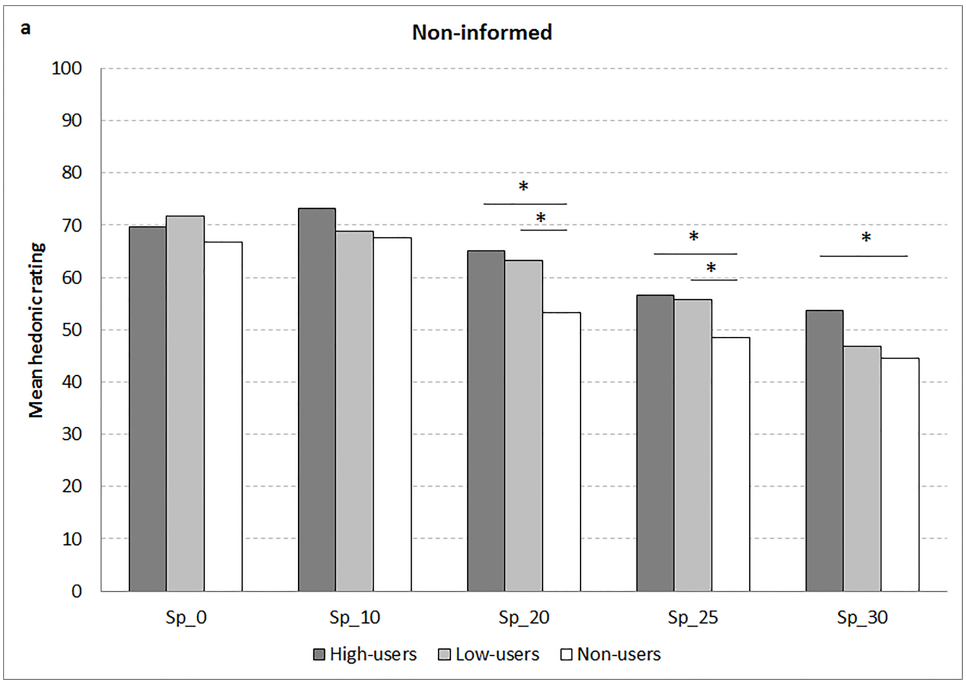
Table 6. Means hedonic ratings provided by high, low and no users of wholegrain pasta for spaghetti samples under the three experimental conditions (NI=Non-informed, E=Expected, I=Informed) and expectation effect on spaghetti acceptability.

Wholegrain pasta consumption	Samples	Ratings			E – NI		I - NI		I - E	
		NI	E	I	M	p-value	M	p-value	M	p-value
High-users (n=32)	Sp_0	69.7	71.2	68.8	1.5	n.s.	-0.9	n.s.	-2.4	n.s.
	Sp_10	73.1	71.7	74.4	-1.4	n.s.	1.3	n.s.	2.7	n.s.
	Sp_20	65.2	70.8	66.3	5.6	n.s.	1.1	n.s.	-4.5	n.s.
	Sp_25	56.5	69.4	62.7	12.9	** disconfirmation	6.2	n.s.	-6.7	n.s.
	Sp_30	53.7	65.3	62.4	11.6	** disconfirmation	8.7	n.s.	-2.9	n.s.
Low-users (n=37)	Sp_0	71.7	72.0	72.2	0.3	n.s.	0.5	n.s.	0.2	n.s.
	Sp_10	68.9	67.2	69.4	-1.7	n.s.	0.5	n.s.	2.2	n.s.
	Sp_20	63.2	68.6	67.7	5.4	n.s.	4.5	n.s.	-0.9	n.s.
	Sp_25	55.8	61.9	59.0	6.1	n.s.	3.2	n.s.	-2.9	n.s.
	Sp_30	46.8	61.5	54.6	14.7	** disconfirmation	7.8	n.s.	-6.9	n.s.
Non-users (n=31)	Sp_0	66.8	74.1	70.0	7.3	n.s.	3.2	n.s.	-4.1	n.s.
	Sp_10	67.5	72.5	70.0	5.0	n.s.	2.5	n.s.	-2.5	n.s.
	Sp_20	53.3	68.9	62.7	15.6	*** disconfirmation	9.4	* assimilation	-6.2	n.s. complete
	Sp_25	48.6	64.2	61.1	15.6	*** disconfirmation	12.5	** assimilation	-3.1	n.s. complete
	Sp_30	44.5	56.2	54.7	11.7	** disconfirmation	10.2	* assimilation	-1.5	n.s. complete

n.s. not significant

(*) significant p<0.10
* significant p<0.05
** significant p<0.01
*** significant p<0.001

24 FIGURE CAPTIONS



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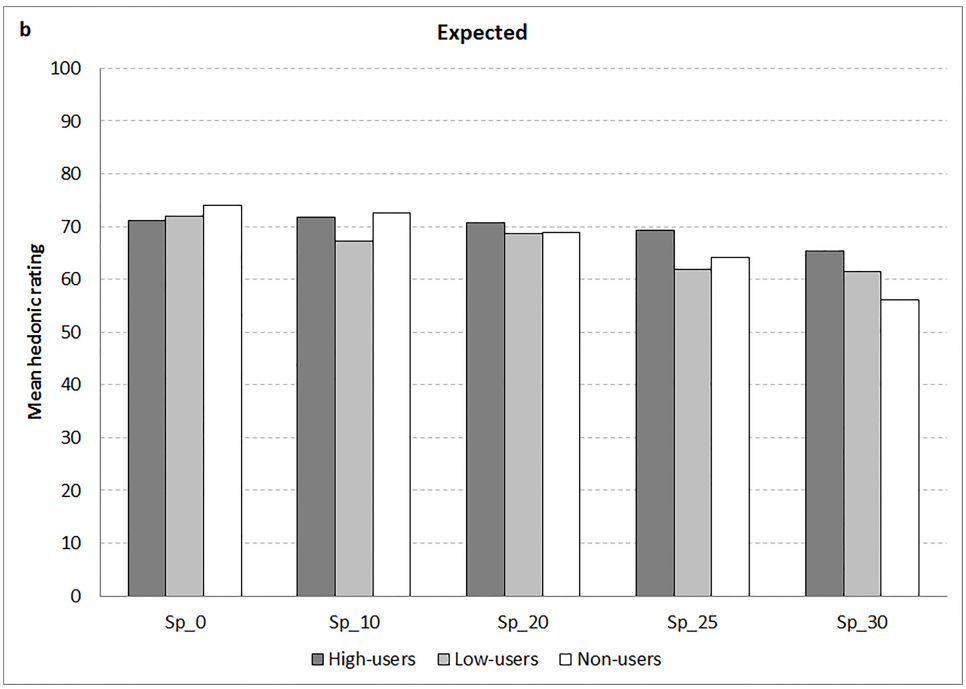

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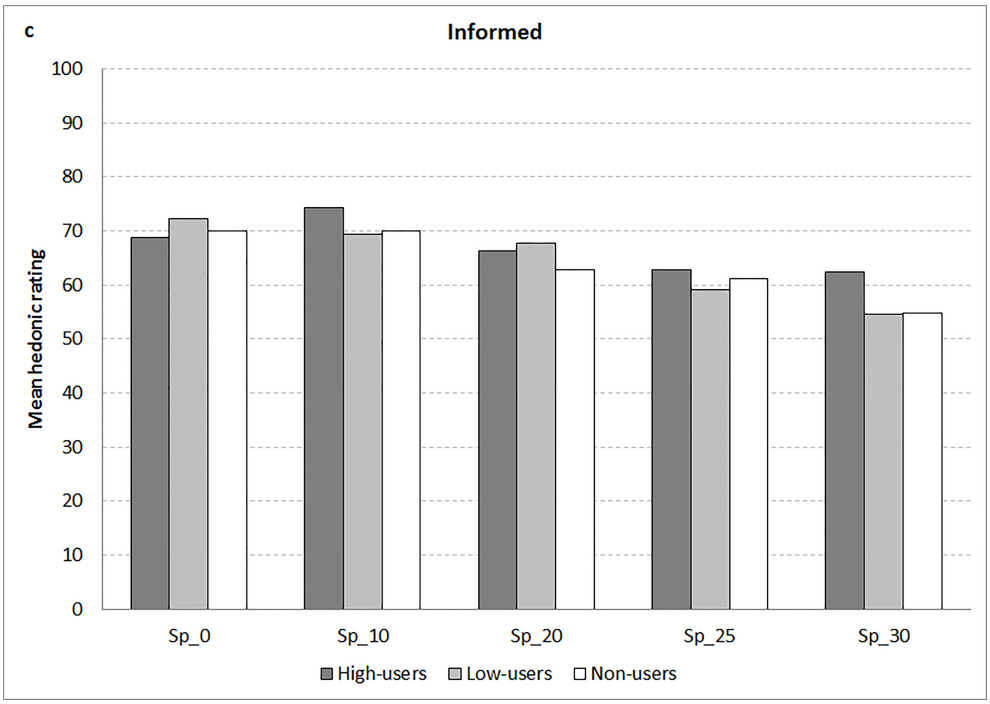

Figure 1. Mean liking ratings for the 5 spaghetti formulations expressed by high, low and no users of bran enriched pasta in the Non-informed (a), expected (b) and informed condition (c). Significant differences detected according to t-test are indicated by * ($p<0.05$).