Suitability of home milling of wheat grains as a means to produce high quality sourdough breads

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Production of leavened wheat bread using a sourdough starter is a long established biochemical process. The addition of sourdough starter to breads has a substantial effect on the volume, texture and flavour of the resulting loaf. The objective of this study was to investigate the effect of the differences in bread starter on selected physical characteristics and eating quality of wheat sourdough. The experimental design consisted of a comparison of two types of wholegrain wheat. One treatment (THE-NAT) used wholegrain wheat, milled in house to yield wholegrain flour. A second treatment used addition of lactic acid bacteria and yeast to the wheat grain milled in house (THE-INO). The purpose was to establish the characteristics of wheat sourdough made from the native microbial population present. The two remaining treatments used commercially milled wholegrain flour, either relying exclusively on the presence of native microorganisms (COM-NAT), or added with lactic acid bacteria (LAB) and yeast (COM-INO). Sourdough bread was prepared and cooked according to a common protocol and recipe. The preparation of the starter consists in a 6-day process that involved the use of an initial batch of 50 g of flour and non-chlorinated water. The 4 day period following the initial preparation of the starter consist of an addition of 50 ml of water and 50 g of flour to the mix, which is kept for the entire duration at a controlled temperature of 25ºC (ambient temperature). The differences in the microbial composition of the sourdough starter culture were assessed by conventional microbiological methods. The overall quality of the dough and of the cooked bread was assessed by means of texture analyser. A second part of the experiment aims at comparing two of the sourdough breads used in the Experiment 1 (THE-NAT) and (COM-NAT) and combined them with a 50%-50% mix of wholegrain and conventional strong flour for the recipe optimisation of a sourdough bread. In experiment 1 there were significant differences between the THE-NAT and the other types of bread in terms of texture. In addition the eating quality (texture, colour, taste and aroma) of the bread was assessed by an untrained sensory panel composed of the trained and trainee chefs, as well as the food and beverage professionals. The results of this study showed a preference from the panel for sourdough bread produced with additional inoculum, but showed no significant differences between breads made with home milled flour (THE-NAT and THE-INO) and sourdough bread made with commercial flour (COM-NAT) as a base for potential optimisation of the production method for the starter and the

cooking process with the view of manufacturing high quality sourdough bread. The eating quality of the four sourdough breads will be assessed by sensory methods, to determine the suitability of home milling of grains as means to obtain a high quality starter for the production of sourdough bread.

Introduction

The popularity of sourdough breads is on the increase due to the consumer increasingly seeking food products that rely less on the addition of chemicals for the purpose of preservation. (Plessas et al., 2011). The production of sourdough bread is the result of a complex mechanism that involves the interaction of different microorganisms, their metabolism, the fermentation conditions (temperature, time, oxygen availability, etc.) and the raw ingredients used (Carnevali et al., 2007). One of the main characteristic in the use of sourdough starter is the concurrent presence of yeasts and lactic acid bacteria. According to Arendt et al. (2007) there are over 50 types of lactobacilli naturally occurring in sourdough, with L. sanfranciscensis being one of the dominant strains (Brandt et al., 2004), and over 25 types of yeasts, predominantly Saccharomyces and Candida (Brandt, 2007; Ottogalli et al., 1996)

While yeasts are required for the leavening effect, by production of CO_2, the presence of lactic acid bacteria in sourdough starter and their activity strongly influences the textural, flavour and nutritional properties of the resulting bread (Gobbetti and Ganzle, 2007). The differences in the microbial population in the starter can have an effect in the process of acidification of the bread. Normally the pH of a wheat sourdough ranges between 3.5 and 4.3 (Thiele et al., 2002) and the pH can in turn impact on structural components of the bread, like the gluten and the starch (Arendt et al., 2007).

One drawback of the production of wheat sourdough bread is that only moderate acidity of a wheat bread is accepted by consumers, unlike in the case of other cereals (e.g. rye) (Katina et al., 2006). This has led in turn to a limited use of sourdough fermentation for wheat breads, as the advantage of such process has been shown to be somewhat limited, with contrasting results in terms of flavour enhancement, extension of shelf life and volume (Armero et al., 1996, Thiele et al., 2002)

The effect of the addition of different proportion of sourdough started to wheat bread has been shown to impact on the overall aroma volatile profile (Hansen, A and Hansen, B., 1996). In this study differences in the taste and aroma were also observed following use of different strains of lactobacilli (*Sanfranciscensis* vs. *plantarum*). The generation of aroma volatiles by the metabolism of lactobacilli is characterised by a large production of butyric and acetic acid (Kam et al., 2011), although the metabolism of other bacteria of the clostridium genus and yeasts are also considered to have an impact. In general, the addition of baker’s yeast has been shown to improve the overall taste and aroma of sourdough bread (Hansen, A. and Hansen, B., 1996).

Mixed starter cultures may result in an improvement of sensory attributes of the bread (Plessas et al., 2011), though the mechanisms of evolution of the different microbial strains are not fully understood and depend on a number of factors, such as nutrients, stress, metabolites, this in turn will ultimately affect the organoleptic properties of the final product (Guerzoni et al., 2007). In addition, the overall effect of the flour may have significant impact on the quality of the bread due to technological aspects, other than the microbial population present. Studies from Katina et al., (2005), and Poutanen et al. (2009) also reported the potential of sourdough breads for not just improved flavour and structural quality of the bread, but also improved nutritional attributes, digestibility and glycaemic responses.

The main objective of this study was to assess the feasibility to use home milling of Irish native wheat as a method to enhance the quality of sourdough bread by increasing the diversity of the microorganisms in the starter. A second objective was to compare the eating quality of breads obtained with native or with a starter added with lactobacilli and yeasts.

Materials and Methods

Ingredients used

In the present experiment the only two main ingredients used were flour and bottled water (Deep RiverRock, Coca-Cola HBC, Dublin, Ireland). Two types of flour were used, a commercially available wholegrain flour (Coarse wholemeal, Odlums, Dublin, Ireland) and a home milled wholegrain flour. The home milling process was performed with a commercial thermo blender (TM31 Thermomix, Vorwerk, Wuppertal, Germany). Commercially sourced wheat grain was milled in batches of 750 g in the thermo blender bowl in 3 intervals, to prevent overheating of the flour. The grains were milled for 30 s twice, with a 1-min pause to prevent overheating. A total of 2 kg of grains were used for the manufacturing of each batch of home milled flour.

Preparation of the starter

In experiment 1 for the preparation of the starters four 2L kilner jars with hermetic closure were used. A total of 50g of flour and 50 g of water were added to each of the four jars. The same type of flour (commercial, COM; or Thermomix, THE) was added to two jars. Within each pair of jars with the same flour, one jar was added with 1g of baker’s yeast and 1 g of commercially sourced natural yoghurt to add both *Saccharomyces cerevisiae* and Lactic Acid Bacteria (LAB). Therefore four different starters were generated, one with commercial flour and no additional microorganism (COM-NAT), one with commercial flour and additional inoculum (COM-INO), one with home milled flour and no additional microorganisms (THE-

NAT) and a final starter with home milled flour and additional inoculum (THE-INO). All starters were mixed and the sealed jars were kept for 24h at 25ºC in an incubator.

After the preparation of the starter and the 24h storage, the following morning each jar was added with 50 g of the respective flour for the treatment (COM or THE) and with 50 ml of water (maintained at 25ºC to prevent any thermal shock). Each mix was stirred and the sealed jars were placed for another 24 h in the incubator. The same procedure was repeated for three additional days. On the morning of day 6 after 24h in the incubator, the four jars with the starters were moved to a refrigerator.

For Experiment 2 the protocol followed was identical to experiment 1 with the only exception that only two types of starter were prepared: one from commercial wholegrain flour (COMM) and one from whole wheat home milled with the Thermomix (THERMO).

Preparation of the bread and cooking conditions

Experiment 1

After 48 h at refrigeration temperature each of the starters was transferred to a stainless steel bowl and 225 ml of water at 25ºC and 225 g of the flour corresponding to the treatment were added. The stainless steel bowls were covered with cling film and incubated overnight. The process was repeated on the following day and, after mixing, the bowls containing the dough were covered with cling film and incubated for 5 h. They were then moved to a refrigerator and refrigerated overnight. The four bowls were removed from the refrigerator in the morning, allowed to reach ambient temperature in the incubator for 1h. To the dough present in the bowl 700 g of the appropriate flour were added, 7.5 g of salt and 550 ml of water. The dough was mixed using four KitchenAid stand mixers concurrently, at maximum speed for 6 min. The doughs were removed from the mixing bowls, placed in the stainless steel bowls and left to rise for 6h. The doughs were then deflated and refrigerated overnight.

After refrigeration the bowls were moved to an incubator to reach ambient temperature, 800 g of each dough were placed into baking tins, ready for cooking. Two tins of each of the breads were cooked concurrently in two identical combi ovens with a randomisation of the oven placement. The loaves were baked in pre-heated ovens at 230ºC for 55 min. After cooking the loaves were allowed to cool and were sliced to prepare the samples for sensory and textural analysis.

Experiment 2

Starters were prepared according to the protocol described in Experiment 1. After 48 h at refrigeration temperature the starters were transferred to an incubator set at 25ºC for reconditioning. After 8 h reconditioning time 200 ml of each starter were used to make a sponge. The two sponges were prepared from each starter (THERMO and COMM) by adding 1200 ml of water and 1000 g of the corresponding flour, and stirring the loose dough that was obtained. The two sponges were left in the incubator at 25ºC overnight. The following day the bread was prepared by using 1200 g of the sponge, and 600g one of the following flours: whole wheat milled with Thermomix (THERMO), commercial wholegrain flour (COMM) or white strong flour. As THERMO flour was added to the THERMO sponge the bread dough was labelled as 100%THERMO, while as COMM flour was added to the COMM sponge, the resulting bread dough was labelled as 100%COMM. When white strong flour was added to either THERMO or COMM sponge, the resulting bread doughs were labelled as 50-50%THERMO or 50-50%COMM, respectively. The four doughs were kneaded by hand and left in the incubator for 2h. They were moved to refrigeration overnight. On the following day the doughs were re-conditioned for 1 h in the incubator, they were then shaped and proved. At the end of the 4h proving period, the doughs were cooked in a pre-heated stone oven at 250ºC for 55 min. Once cooked the breads were left to rest on a metal rack, prior to sample preparation on the following day.

Sensory analysis

For the purpose of sensory analysis, the cakes were prepared in by cutting two samples of 1.25 cm (L) × 2.5 cm (W) × 4.5 cm (H). Each pair of samples was placed on plates that were randomly numbered. This was repeated for all the four treatments. Forty untrained panellists were asked to assess different attributes of the cheesecake samples. The test consisted in assessing on a 9-point hedonic scale the colour of the bread crust, the colour of the bread crumb, the aroma, the texture and the taste of the four bread types. A 15-cm structured scale with anchor points in the middle (7.5 cm) and at each end was used for evaluating the different attributes. The point 1 of the scale corresponded to dislike extremely point 9 to like extremely. The colour of the crust and the crumb was assessed on a similar scale where point 1 corresponded to ‘too dark’, point 9 corresponded to ‘too light’ and point 5 was ‘just right’.

Textural analysis (Experiment 1)

Textural analysis was carried out by using a TA TX2 Texture Analyser. The bread samples were tested using a Warner Bratzler test and Texture Profile Analysis (TPA). The sample size was 2.5 cm (L) × 2.5 cm (W) × 4.5 cm (H) and two samples were analysed per test per batch. A first test (Warner Bratzler) was used to assess the peak force necessary to cut through the bread sample. The blade speed was 2.0 mm/s and it was set to travel for a total of 60 mm, to ensure that the bread sample was completely cut in two by the blade. The TPA double compression test was used to simulate the chewing action. The head speed was 2.0 mm/s and the total distance travelled was set to be equal to 50% of the original sample height (22.5 mm), the timing between the first and the second 'bite' was set to be 2 s to allow relaxation of the bread texture.

Statistical analysis

Data were structured using a factorial design with flour type and type of inoculum as main effects in experiment 1, while flour type and percentage of inclusion were the factors tested in experiment 2. All data were subjected to statistical analysis using SPSS. Experimental treatments were compared using a one-way analysis of variance (ANOVA). Significant differences ($p<0.05$) between treatment means were determined by the Student's t test.

Results and Discussion

Experiment 1

Results of sensory analysis

The results of sensory analysis are illustrated in Figure 1(a-e). On average the panellists assessed the colour of the crust to be different depending on the type of flour used, but not on the type of starter used. The scores ranged from 4.4 for COM-INO to 4.7 for COM-NAT, while THE-NAT and THE-INO were scored 7.0 and 6.9, respectively ($P>0.05$). This result was to be expected as there were substantial differences in colour between the home milled and the commercial flour. A similar trend was observed in the crumb colour, as the COM-INO and COM-NAT were scored just below the ideal score of 5 (4.5 and 4.6 respectively), while THE-INO and THE-NAT obtained scores of 6.8 and 6.7 respectively, significantly higher than the other two treatments ($P>0.05$). One of the characteristics of sourdough bread is the evenness of baking and colour (Chavan, 2011). While the differences in the starter culture may have accounted for some of the colour differences observed by the panel, the initial colour and compositon of the two flours used was the determining factor. In general it is to be expected that the characteristics of the crumb and the crust in a sourdough bread will widely differ, to the extent that they can be evaluated separately not just in terms of colour, but also in terms of flavour. Lotong et al. (2000) found the two parts of the bread to be described by a different number of attributes when investigating the lexicon for sourdough bread flavour description.

The aroma of the breads however, was not affected by either factor (type of flour and type of starter) as scores range from 4.5 for THE-INO to 5.5 for COM-INO. There was no significant difference statistically across all treatments for the aroma.

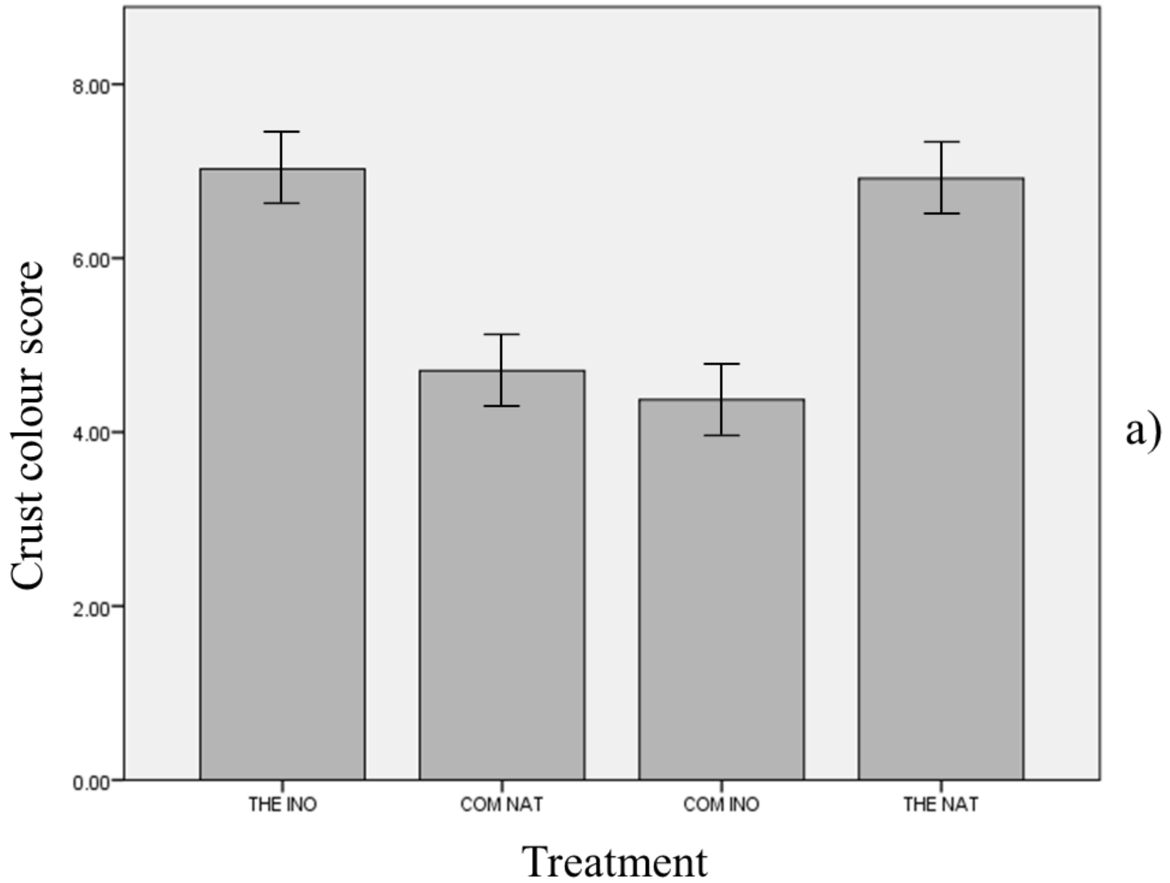


Figure 1-a. Sensory panel score for crust colour of the four types of bread

Differences in the flour composition have been shown to induce changes in the aroma profile (Czerny and Schieberle, 2002), as the composition of commercial wholemeal flour may present a lower fat concentration than in home milled flour, as the entire grain was used for milling. Hansen and Schieberle (2005) reported on how the flour and each step in the process for the production of sourdough rye bread has a substantial influence in the final concentrations of odorants in the bread. Such result would suggest that a similar impact can occur in the production of sourdough bread regardless of the cereal used for flour manufacturing.

Inducing different conditions during the fermentation process can be used as a tool to determine the aroma development of bread, as shown by Guerzoni et al. (2007), as yeasts and lactobacilli respond by generating different volatile compounds depending on factors such as acid and oxidative stress. Katina et al. (2006) studied the optimisation of flavour and texture of sourdough bread, acting on factors such as the temperature of fermentation of the starter and the fermentation time.

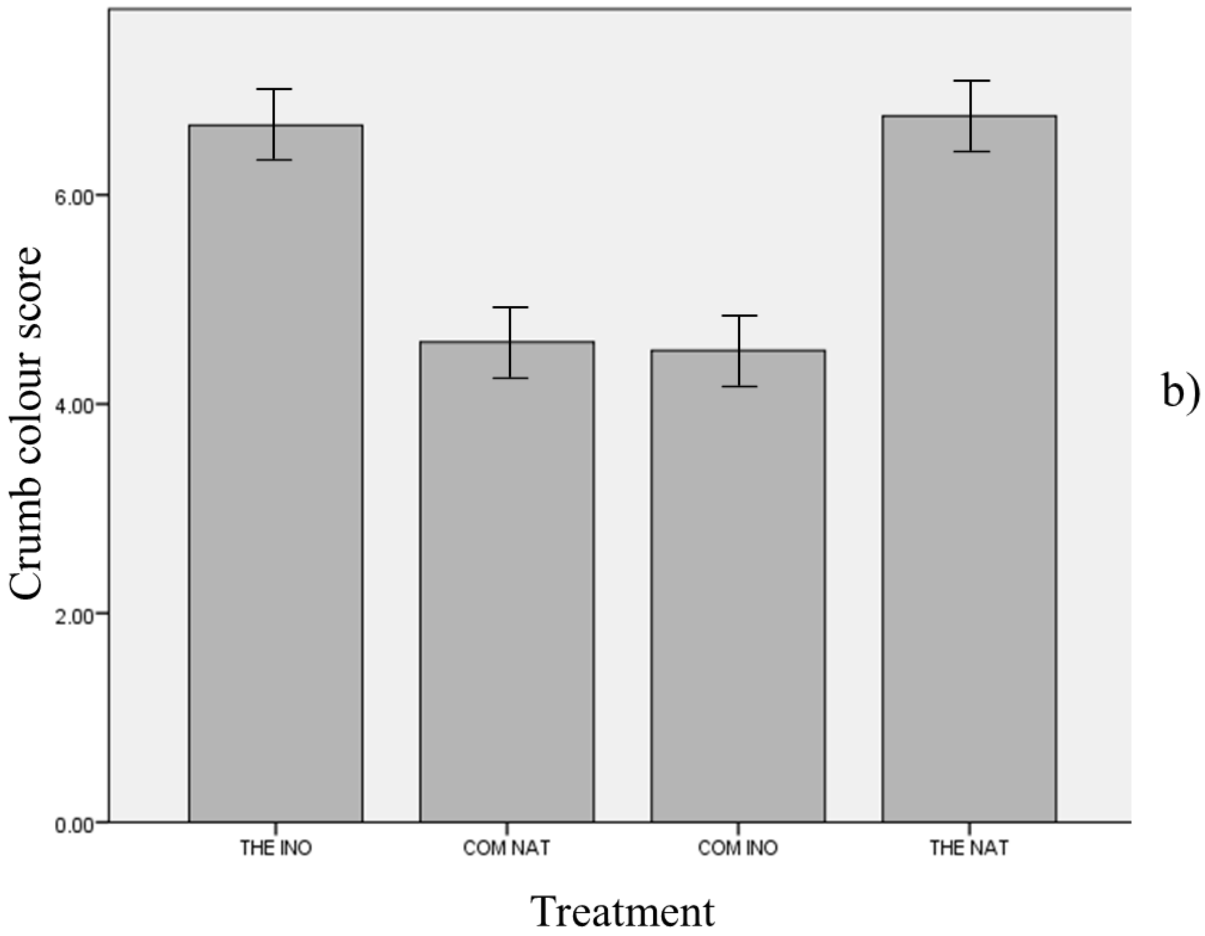


Figure 1-b. Sensory panel score for the crust colour of the four types of bread

The results for the texture showed that the panellists favoured the COM-INO bread (5.6), as the texture was possibly similar to what they might have experienced in the past. The commercial bread with native starter scored 4.5, which was not different from either the THE-NAT (3.8) or the THE-INO bread (4.0). Katina et al. (2006) showed an effect of both the fermentation time and the fermentation temperature on the overall texture of sourdough wheat bread. Depending on the type of microorganism there was a different response in terms of hardness of the bread.

The average panel score for taste was below average (4.1), and the COM-INO bread scored the highest (5.2). The other three breads were similar to one another but lower than COM-INO, with values ranging from 3.4 to 4.1. A possible explanation for these results, similar to the results for texture, is the large availability and consumption of commercial breads that are obtained with commercial yeasts and made with wholemeal flour. The home milled flour was characterised by an unusual degree of refinement, but more homogeneous than the commercial flour, which instead is made with fine white flour and large elements of bran.

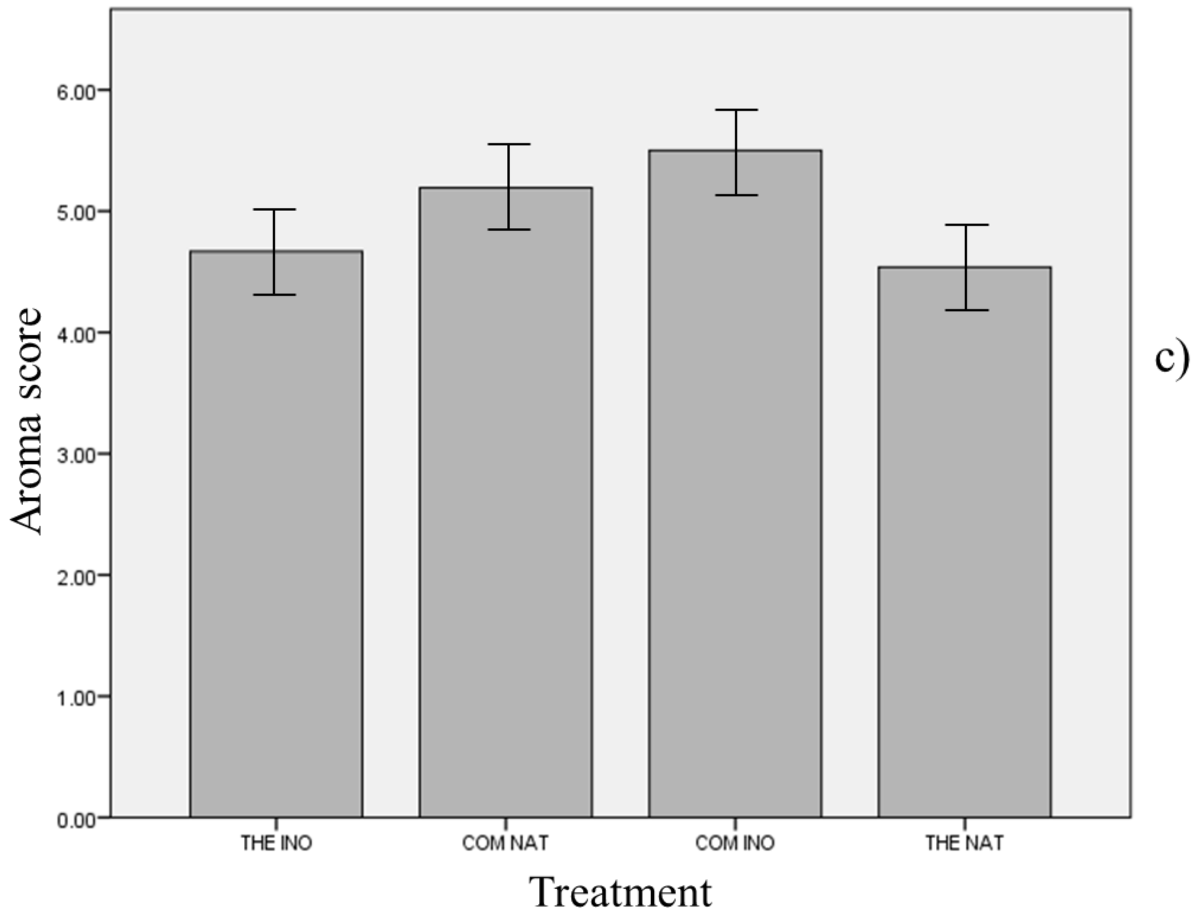


Figure 1-c. Sensory panel score for the aroma of the four types of bread

Results of Texture analysis

The results of the texture analysis are summarised in Figure 2(a-c). Overall there was no significant difference in the average force necessary to cut through the bread between the breads made with commercial flour and those made with the home milled flour. In addition, the peak force used to cut through the THE-INO sample was similar to that showed for COM-NAT, COM-INO, and THE-NAT. Even though the results were numerically different, the variability of hardness among the samples tested within each treatment resulted in differences which were not statistically significant. The TPA test showed similar result for peak force bot h during the first and the second bite, with THE-NAT samples showing lower peak force 4935 g_f versus 5857, 6252 and 7046 g_f respectively for COM-NAT, COM-INO and THE-INO. The average force during the two bites was similar across all treatments during both bites, though THE-NAT showed a value of 282, while the average of all other treatments was 421 $g_{f..}$

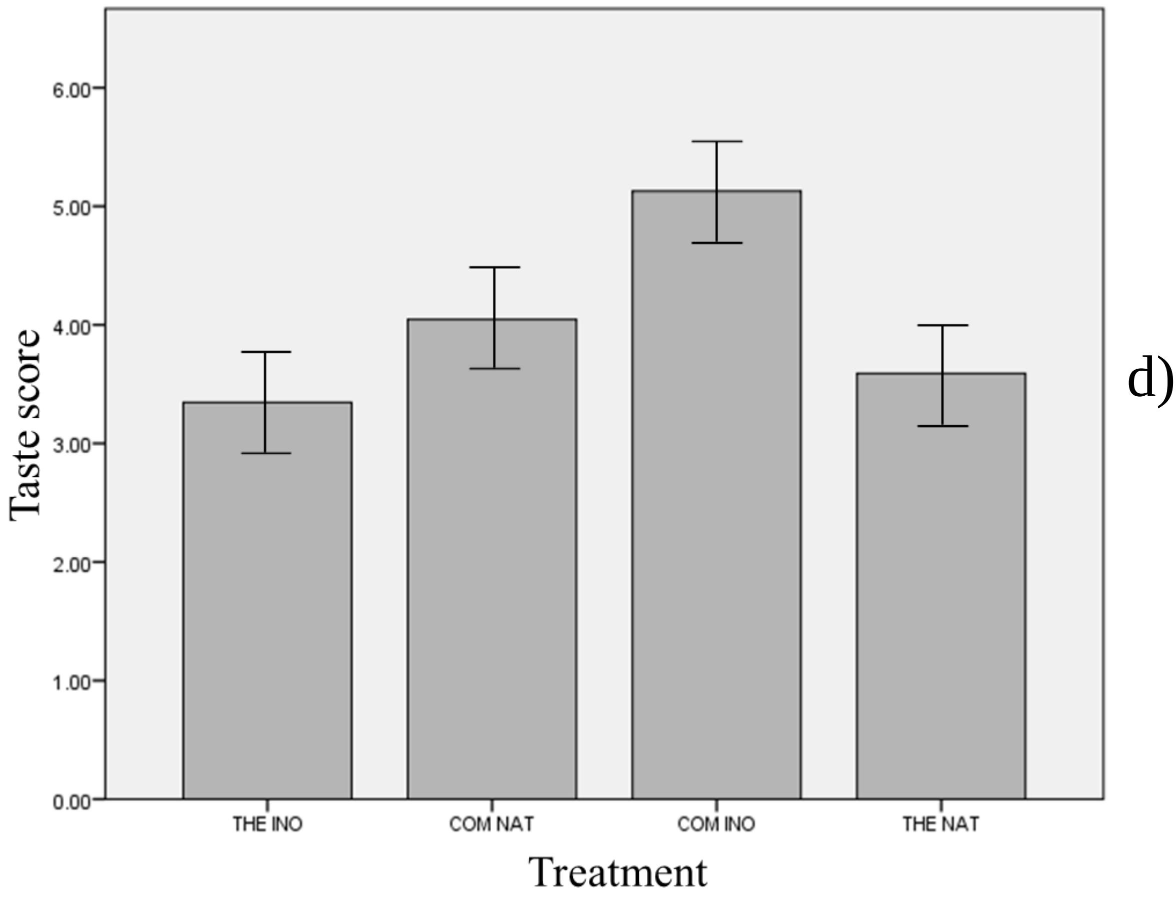


Figure 1-d. Sensory panel score of the texture for the four different breads

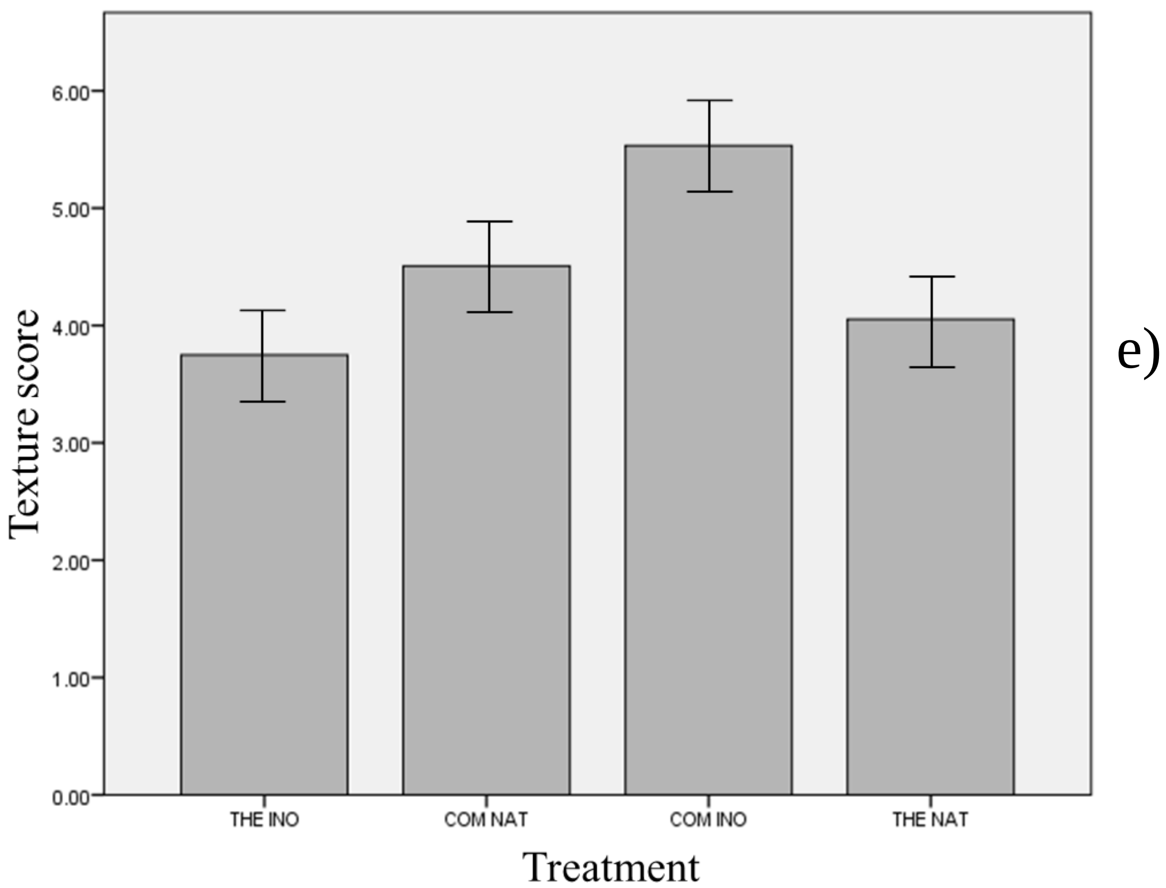


Figure 1-e. Sensory panel score of the taste for the four different breads

Arendt et al. (2007) stated that the use of sourdough in bread making increases the activity of proteases and amylases, therefore causing a delay in the staling of the bread. In the current study the time elapsed between the cooling of the bread and the analysis of instrumental texture was not sufficient to start observing any significant staling process. However the similar degree of water migration from the crumb to the crust has to be assumed as no significant differences were observed in the overall hardness of the crust.

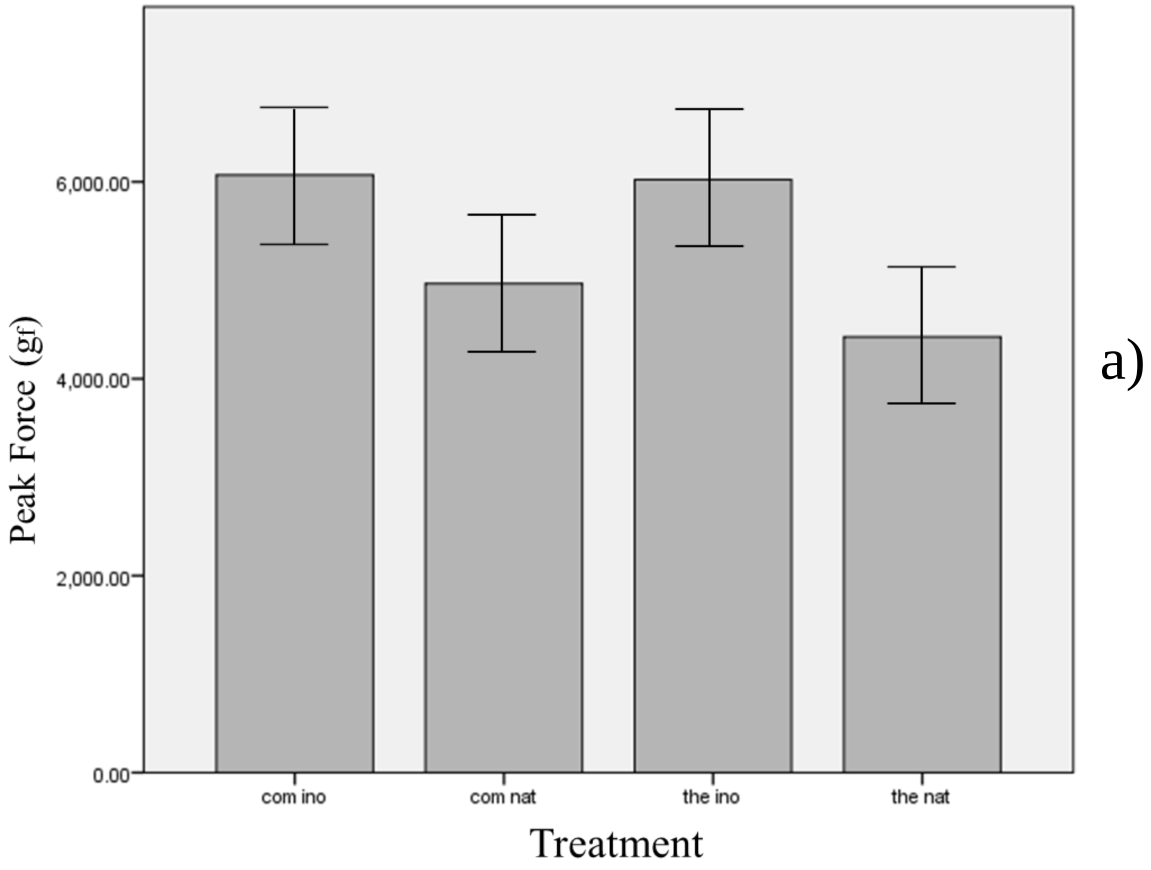


Figure 2-a. Warner-Bratzler peak force for the four types of bread

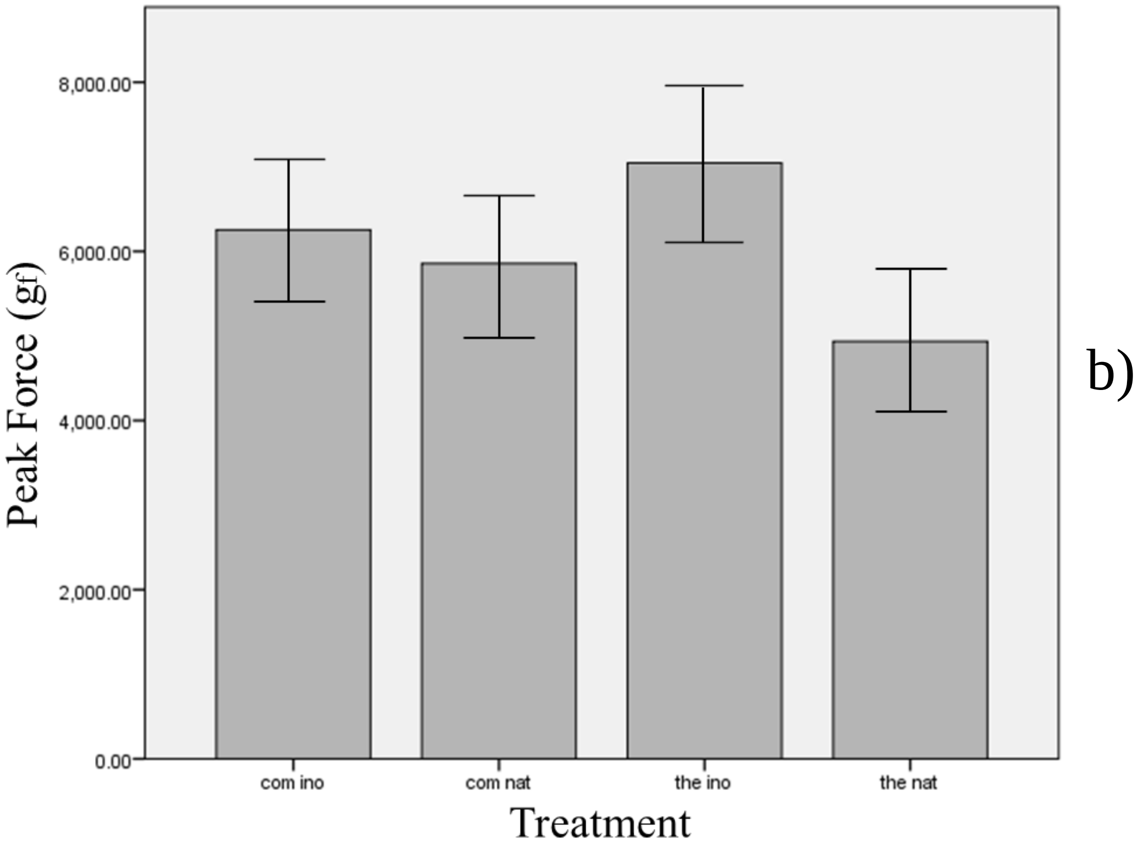


Figure 2-b. Texture profile analysis peak force for the four types of bread, first bite

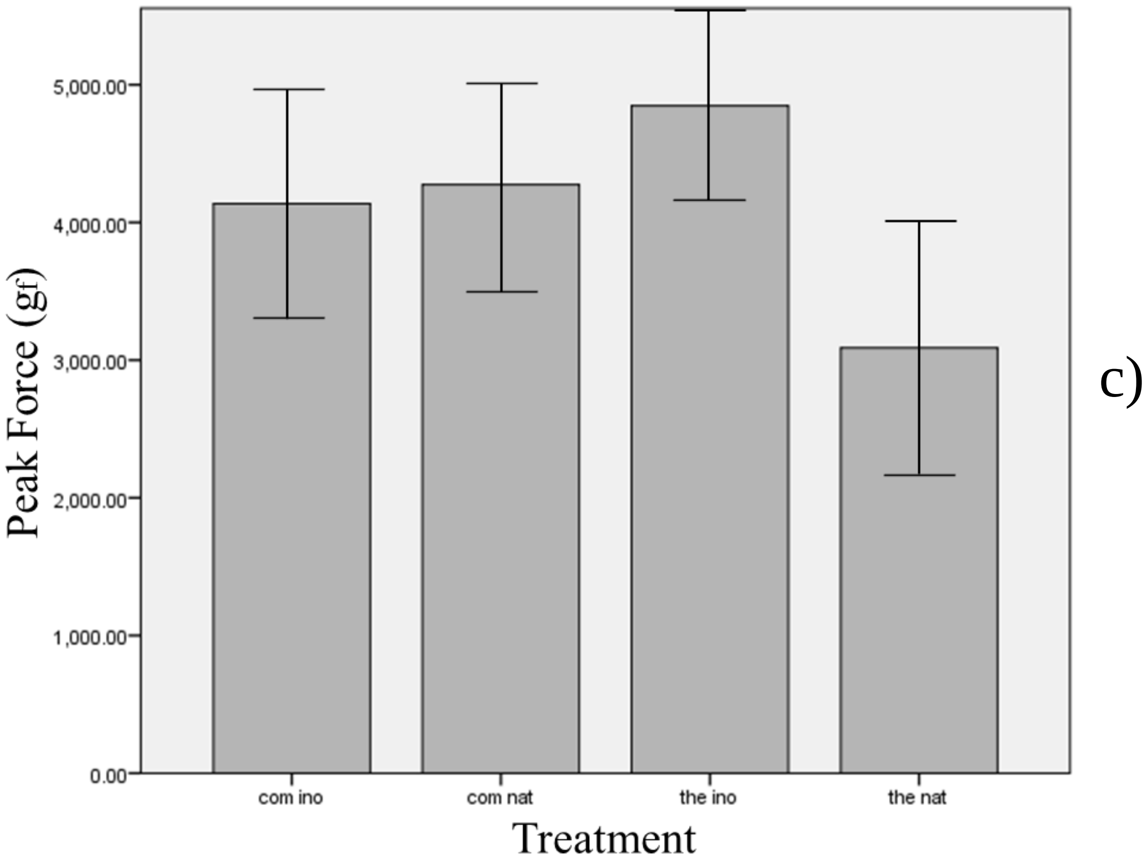


Figure 2-c. Texture profile analysis peak force for the four types of bread, second bite

Experiment 2

Results of sensory analysis

The results of the sensory analysis in Experiment 2 are illustrated in Figure 3 (a-e). Overall there were significant differences ($P<0.05$) across the four treatments, as the bread 50-50%THERMO was found to be the closest to the ideal crust colour (score = 5) by the panellists. All other breads were considered to be too dark, though 50-50%COMM and 100%COMM were not significantly higher than 50-50%THERMO. Overall the crust colour was perceived to be closer to the ideal value in breads produced with 50-50% mix of wholegrain flour and strong flour, compared to the 100% wholegrain. There was no significant difference in the crust colour according to the panel due to the type of flour used. ($p>0.05$). The trends were similar when the panellists assessed the crumb colour, as the 50-50%THERMO was the bread considered to be the closest to the optimum value (4.46). The 50-50%COMM was considered to be lighter (4.00), though it was not significantly lower than 50-50%THERMO. The breads made with 100% wholegrain (THERMO and COMM) were deemed to be darker (6.55 and 5.84, respectively). There was a significant effect of the flour percentage (4.23 vs. 6.00) for 50-50% and 100%, while the type of wholegrain flour was not significant.

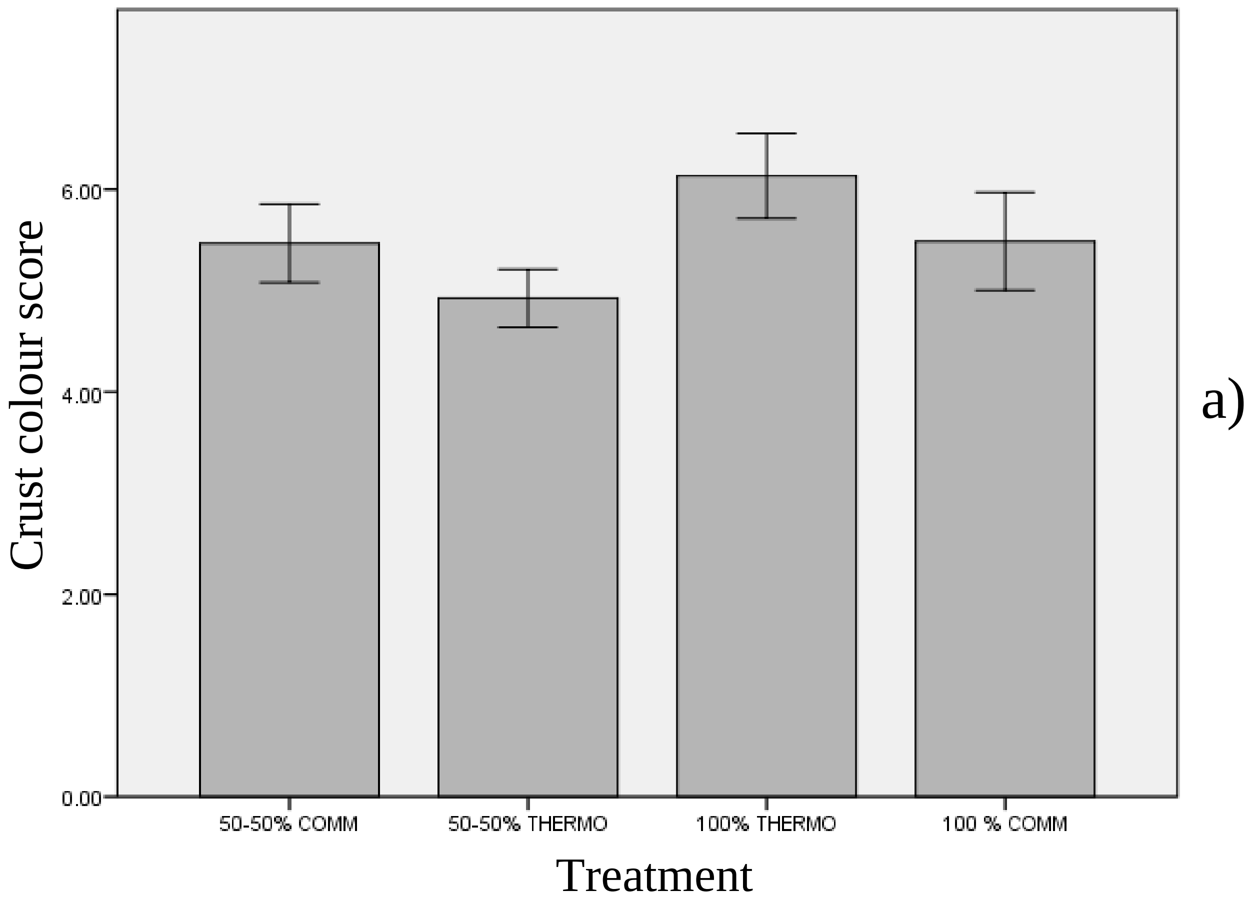


Figure 3-a. Crust colour assessment (5 – optimum)

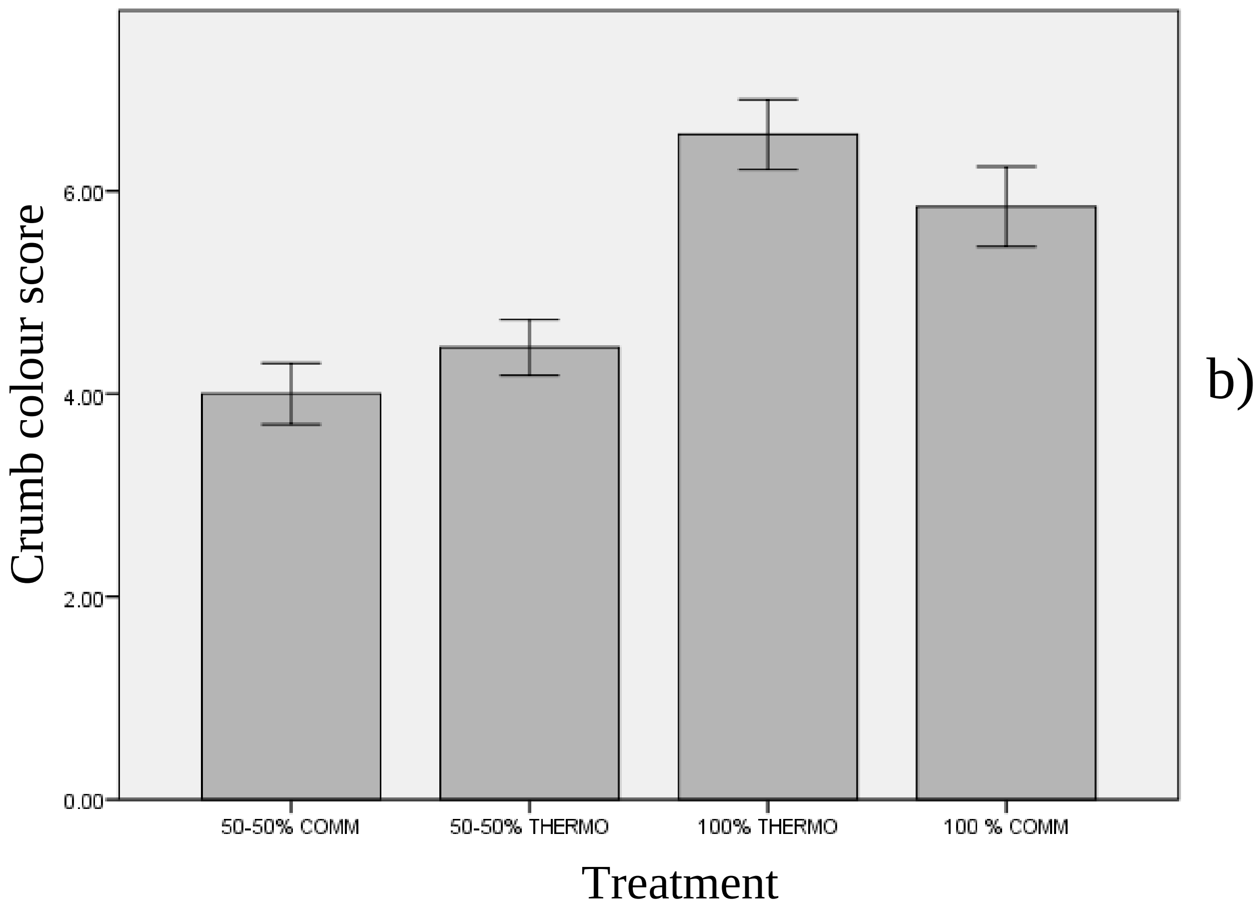


Figure 3-b. Crumb colour assessment (5 – optimum)

The 50-50% COMM and 50-50% THERMO breads scored the highest in terms of aroma, though there was no significant difference across the four treatments. Overall the differences between 50-50% and 100% wholegrain bread were small (4.68 vs. 4.35, respectively) while the differences between THERMO and COMM were not significant ($p>0.05$). It has been reported that the level of proteolysis and acidification during fermentation has a considerable impact on the flavour formation (Czerny and Schieberle, 2002). However, the lower scores of breads produced with 100% wholemeal flour may be attributable to the greater presence of bran, which is rich in polyphenols and normally imparting a more bitter flavour (Heiniö et al., 2003).

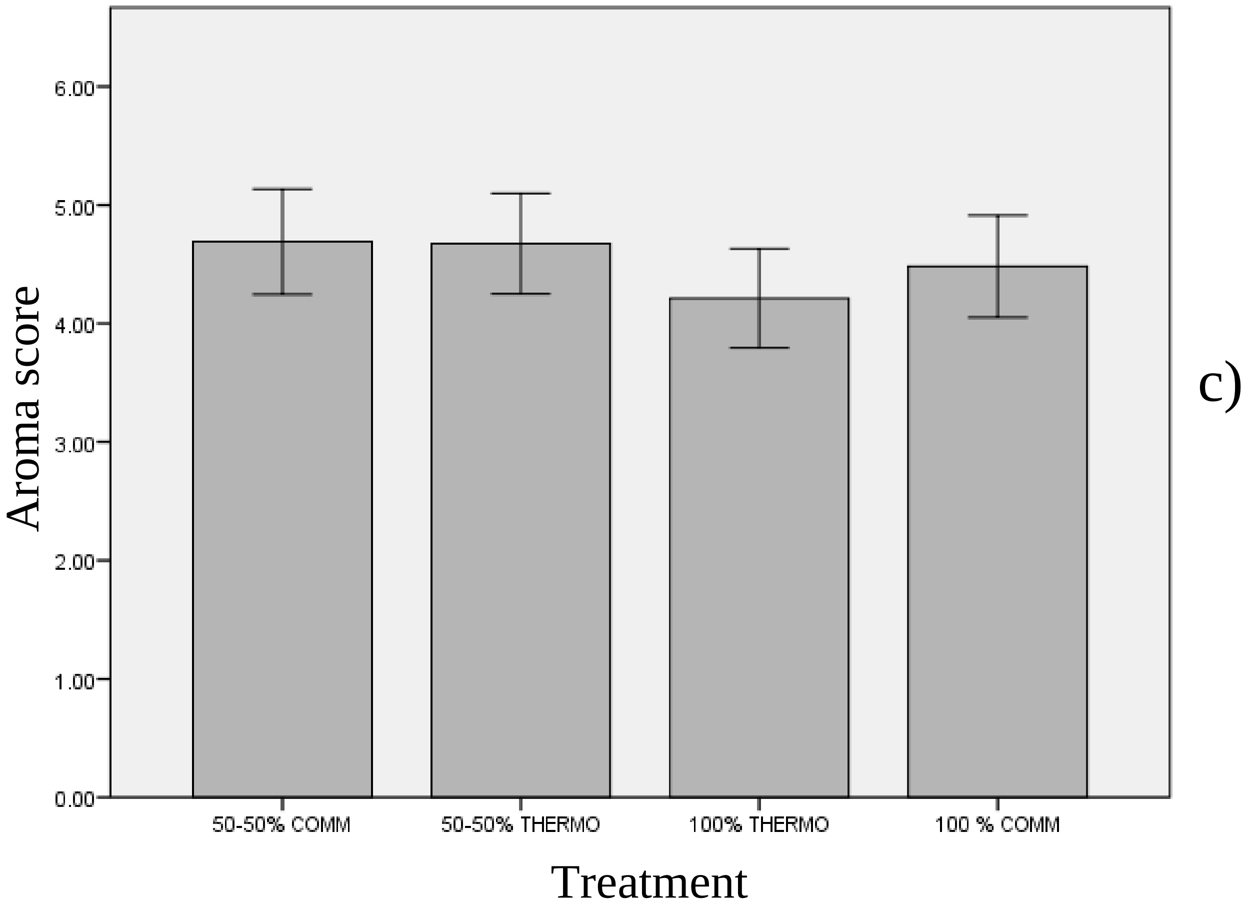
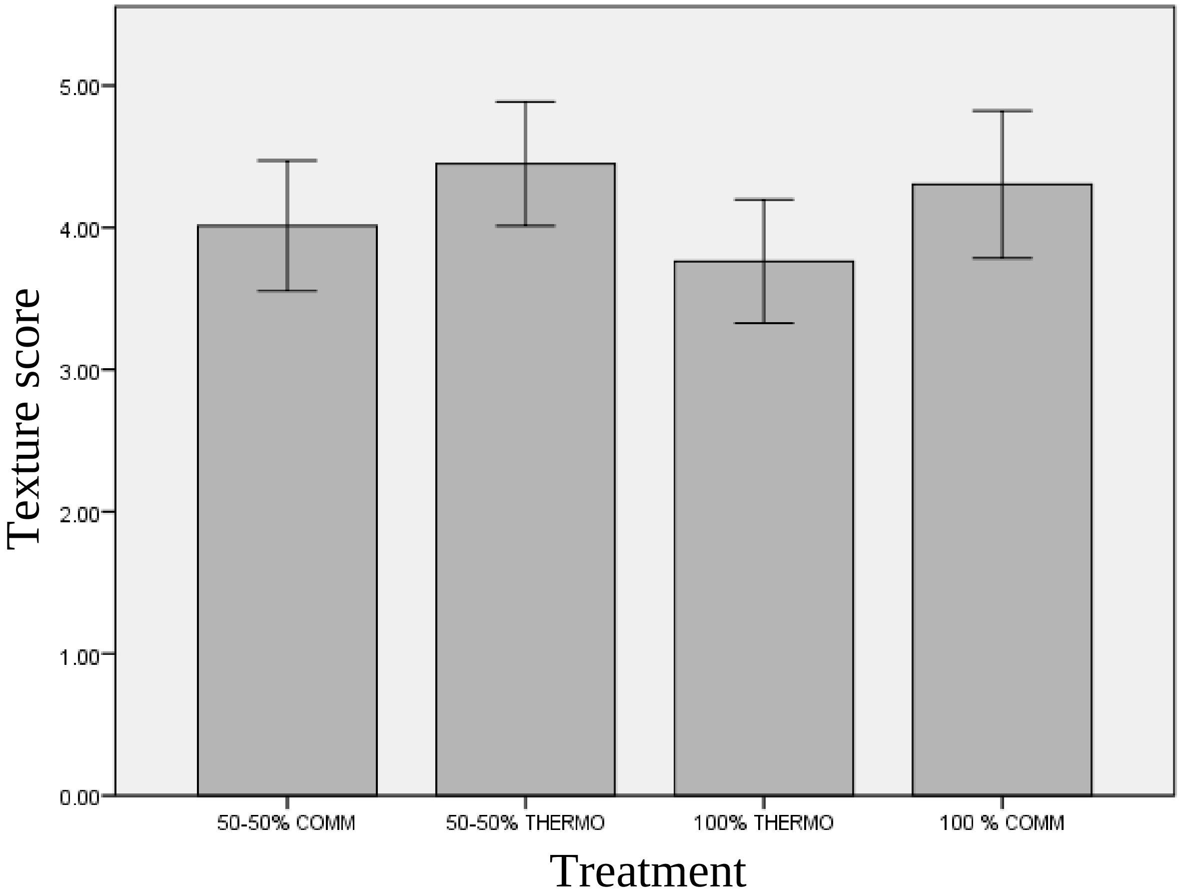


Figure 3-c. Aroma assessment (1 Dislike extremely– 9 Like extremely)

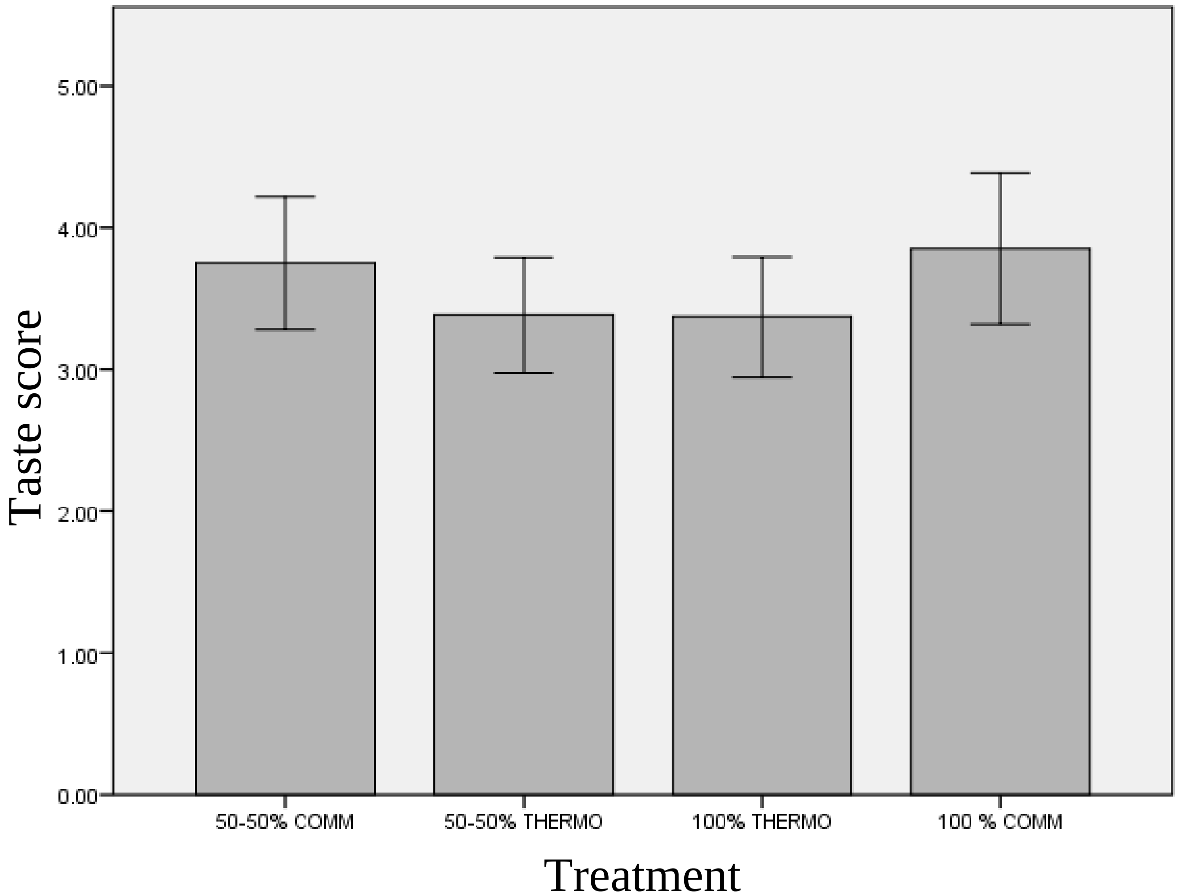
In terms of texture the 50-50%THERMO was scored the highest by the panellists, above the 100%THERMO and 50-50%COMM breads, and marginally above the 100%COMM bread. However, differences across all breads were not found to be significant ($p>0.05$). There were also no differences between COMM and THERMO breads, while when averaging across the percentage of wholegrain flour, the 50-50% breads were only marginally better than the 100% breads (4.24 vs. 4.05).

The panellists favoured the bread that was made from COMM flour, in terms of taste score, regardless of the percentage of wholegrain flour (3.86 and 3.76 for the 100% and 50-50%, respectively). Similar to what was observed for aroma and texture, these results were found not to be significant statistically ($p>0.05$). Overall there was no significant difference due to the type of flour. The level of inclusion of wholegrain flour in the breads also did not have a significant effect. A possible explanation for the results could be found in the different composition of the two flours used, with the home milled flour was richer in fat and protein, due to the complete inclusion of the entire grain. This may have led to the formation of products of lipid oxidation and lipid breakdown, as well as favoured the proteolytic process and acidification of the bread (Salovaara and Valijakka, 1987).



d)

Figure 3-d. Texture assessment (1 Dislike extremely– 9 Like extremely)



e)

Figure 3-e. Taste assessment (1 Dislike extremely– 9 Like extremely)

Overall Experiment 2 suggests a general positive response of the panellists towards bread made with wholegrain flour that was home milled. There were no elements to identify the percentage of inclusion of wholegrain flour in the breads as a factor that affected the sensory perception by the panellists; as such factor was only significant in the colour assessment. Other studies (Katina et al., 2006) highlighted the difficulty in finding a sourdough starter that would improve all characteristics of sourdough bread in terms of softness, volume and flavour. This is in agreement with the current study, where the positive characteristics observed in the 50-50%THERMO bread in terms of colour and flavour were not mirrored in the taste. The different pattern of fermentation in the starter could have been induced by the use of home milled flour, due to the different composition that may lead to increased proteolysis and acidification. This would suggest that the home milling could represent a potential for product diversification in bakeries, restaurants and households, provided that appropriate optimisation of the product is performed.

Conclusions

Overall the eating quality of sourdough bread obtained using commercial flour and with added yeast and LAB from yoghurt was found to be the best by the untrained panel. There was however no difference between sourdoughs breads that relied uniquely on the native culture, and altogether the home milled flour with no additional inoculation yielded bread that showed to be softer. In general, the panellists found the colour of the breads to be quite dark, and that reflected the nature of the flours used. Traditionally the flour used in sourdough bread is white flour and the brown texture is predominantly associated with sourdough rye bread. The optimisation of the cooking protocol and the proportion of strong white flour to wholegrain flour that characterised experiment 2 suggest that the perception of the colour was more favourable in breads that were 50-50% wholegrain and strong flour. While there was not a distinct effect of the home milling compared to the commercial flour, the 50-50% bread with home milled flour was considered to be the favourite by the panellists on many attributes. The very active starter produced bread that had an intense acidic note and this may be the reason for a lower score in the taste attribute. Further optimisation will be required to maximise the leavening effect of breads that rely on native bacteria only, while a use of mixed flours during the two phases of preparation of the starter and preparation of the loaves would be recommended to obtain a product that is more in line with the expectations of the public.

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