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ORIGINAL PAPER

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Quality evaluation of re-milled durum wheat semolinas used for bread-making in Southern Italy

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Abstract Re-milled durum wheat semolinas from Altamura, Laterza and Matera (Southern Italy), currently used in the production of traditional breads, were tested for quality. The re-milled semolinas exhibited variable technological quality, and different bread-making techniques were observed. Alveograph P/L ranged from 0.34 to 2.50 with W values from 71×10^{-4} to 176×10^{-4} J. The higher values were found in samples from Laterza, which gave breads with the lowest specific volumes, due to its excessive gluten tenacity. The P/L values were correlated to SDS sedimentation height; dry gluten was correlated to both wet gluten content and protein content, and was negatively correlated to P/L. Bread protein content was correlated to the protein content of the starting material and bread specific volumes were negatively correlated to alveographic P/L values. Significant differences were found between breads from different points of origin (attributable to differences in the bread-making processes), in terms of the level of total titratable acidity and the yellow pigment content of the crumb.

Keywords Re-milled semolina · Bread · Durum wheat · Chopin alveograph · Specific volume

Introduction

Various types of bread are produced from durum wheat in Italy, mainly in the southern regions and in the major islands. Some of these breads are very popular with consumers due to their desirable sensory properties and good resistance to staling [1, 2]. Since these breads are not produced at industrial levels, their production processes still exhibit artisanal characteristics, and they are therefore more expensive to produce. To ensure the survival of these products, the bakers have asked for either protected denomination of origin (PDO) or protected geographical indication (PGI) status [3, 4].

In particular, in the area between the regions of Apulia and Basilicata, there are three towns (Altamura, Laterza and Matera) that are characterised by a well-known bread-making tradition based mainly on the use of durum wheat as starting material and sourdough in the leavening process.

The use of sourdough in these bread-making processes gives them a long shelf-life [5], which is also aided by the high water-binding capacity of the durum wheat flour used [6, 7]. In general, in fact, the addition of durum wheat prolongs soft wheat bread's resistance to staling [8, 9].

However, the benefits from the use of durum wheat, such as the prolongation of bread shelf-life mentioned above, and enhanced amounts of carotenoid pigments, are offset by some negative technological features, such as excessive gluten tenacity.

Therefore, the aim of this research was to evaluate the technological quality of re-milled starting semolinas used to produce various types of bread from southern Italy, and to assess the effects of their use on bread quality. For this purpose, re-milled durum wheat semolinas from Altamura, Laterza and Matera, as well as their corresponding breads, were collected and examined.

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Materials and methods

Samples

Three towns with a strong bread-making tradition were considered: Altamura (Bari, Italy), Laterza (Taranto, Italy) and Matera (Italy). A total number of twelve 1-kg loaves of bread, four per town, were collected at local bread-makers, together with the re-milled semolinas used in their production. All the breads examined were produced by a traditional baking method, which involved a prolonged sponge-dough procedure and the use of sourdough starter for leavening. The composition of the mix was 20% leaven (20 kg for 100 kg flour), 2% sea salt and approximately 60% water (60 litres for 100 kg flour). The leaven was made by adding ingredients (water and durum wheat meal) at least three times to increase the fermenting dough. The three types of bread differed mainly in the ways that they were kneaded, and cooked shaped.

Analyses of re-milled semolina

Protein content (N×5.7) and ash content were determined according to the AACC approved methods 46–11A and 08–01, respectively [10]. Acidity was determined as in Acquistucci et al [11]. Gluten content and gluten index were determined by means of a Glutomatic (Perten Instruments, Hamburg, Germany) as in the AACC method 38–11 [10]. Sedimentation height in sodium dodecyl sulphate was analysed following the indications reported by Dick and Quick [12]. Alveographic analysis was adapted to durum wheat as reported by D'Egidio et al [13], and performed by Chopin alveograph (Chopin, Villeneuve La Garenne, France). Yellow index was determined by a Chromameter CR300 (Minolta, Osaka, Japan) tristimulus colorimeter, considering the b^* value. The yellow pigment content was determined as described in Fares et al [14]. The detection of soft wheat was carried out using a Durotest S kit (R-Biopharm Rhône Ltd., Glasgow, UK). Fat extraction was performed using Soxhlet apparatus. The gas chromatographic analysis of fatty acid methyl esters, prepared following the AOCS method Ch. 1–91 [15], was performed using a Fisons HRGC Mega 2 series gas chromatograph (Milan, Italy) with a flame-ionisation detector equipped with a WCOT fused silica capillary column, FFAP-CB coating (film thickness 0.30 μm, 25 m in length by 0.32 mm internal diameter) from Chrompack (Middleburg, The Netherlands). The oven temperature was isothermal at 180 °C, while the temperature of the split-splitless injector was 270 °C with a splitting ratio of 1:17 and a detector temperature of 300 °C. All of the analyses were carried out in duplicate.

Analyses of bread

Humidity and protein (N×5.7) contents were determined according to the AACC methods 44–15A and 46–11A [10], respectively. Loaf volume was determined by rapeseed displacement, as in the method AACC 10–10 [10]. Total titratable acidity (TTA) of bread was determined as in Boskov Hansen et al [16]. TTA was expressed as % acetic acid. The yellow pigment content was determined by applying the method described in Fares et al [14] to the lyophilised crumbs of the bread examined, after grinding in a mortar. Analysis of fatty acid composition was carried out as described for semolina. All of the analyses were carried out in duplicate.

Statistical analysis

One-way analysis of variance was used to compare breads from different environments.

Results and discussion

Table 1 reports the results from the routine analyses performed on the re-milled semolinas from Altamura, Laterza and Matera. As far as the colour of the starting material is concerned, the yellow index ranged from 18.35 to 22.65, and the yellow pigment content was between 3.99 and 5.20 ppm β-carotene, with a significant correlation between these two parameters (r=0.59, P<0.05).

Since yellow colour is a distinctive characteristic of durum wheat products with respect to soft wheat products, it represents an important factor in influencing the acceptance by the consumer. In many cases the values found were relatively low if we consider that, for example, the official production process of Altamura bread [3] requires a yellow index higher than 20 and that of the Matera bread requires a value higher than 21 [4]. For the re-milled semolinas collected in Altamura, the required value was reached in just one sample out of the four examined, and none of the semolinas from Matera reached the required value. Indeed, at the time of sampling, the protection marks (PDO and PGI) had not yet been presented to the examined breads. Also, the presence of soft wheat was found in some of the breads, indicating the addition of soft wheat flour, a practice that should be

Table 1 Basic analytical characteristics of the re-milled semolinas used to prepare the traditional breads examined

Sample	Yellow pigments (ppm β-carotene)	Yellow index	Acidity (°)[a]	Ash (% d.m.)	Soft wheat addition (%)
Matera 1	4.03	19.00	2.5	0.92	10
Matera 2	4.26	19.68	2.6	0.87	20
Matera 3	4.62	19.51	2.1	0.90	10
Matera 4	4.53	18.77	2.8	0.89	5
Mean	4.35	19.24	2.5	0.90	11
Standard deviation	0.27	0.43	0.3	0.02	6
Altamura 1	4.39	18.35	2.3	0.85	25
Altamura 2	4.46	19.90	2.5	0.87	25
Altamura 3	5.07	22.65	3.2	0.90	0
Altamura 4	4.62	19.52	2.9	0.86	15
Mean	4.63	20.11	2.7	0.87	16
Standard deviation	0.31	1.82	0.4	0.02	12
Laterza 1	4.53	19.28	2.3	0.90	0
Laterza 2	4.87	19.07	3.3	0.84	0
Laterza 3	4.48	18.54	2.5	0.92	0
Laterza 4	4.20	19.24	3.2	0.87	20
Mean	4.52	19.03	2.8	0.88	5
Standard deviation	0.27	0.34	0.5	0.03	10

[a] ml of NaOH 0.1 N used to neutralise 100 g dry matter

Table 2 Qualitative characteristics of the re-milled semolinas used to prepare the traditional breads examined

Sample	Proteins (% d.m.)	P/L	W (10^{-4} J)	SDS test (mm)	Gluten index	Dry gluten (% d.m.)	Wet gluten (% d.m.)
Matera 1	12.4	1.11	133	36	86	11.6	34.4
Matera 2	12.9	0.98	153	40	82	12.2	36.4
Matera 3	12.6	1.03	138	41	92	12.2	36.4
Matera 4	11.5	1.00	147	51	87	11.4	34.4
Mean	12.4	1.03	143	42	87	11.9	35.4
Standard deviation	0.6	0.06	9	6	4	0.4	1.2
Altamura 1	11.7	0.34	71	35	76	11.0	34.4
Altamura 2	11.3	0.50	89	36	80	10.2	34.5
Altamura 3	12.5	1.03	120	49	83	11.6	35.2
Altamura 4	12.3	1.05	135	54	80	11.3	34.8
Mean	12.0	0.73	104	44	80	11.0	34.7
Standard deviation	0.6	0.36	29	9	3	0.6	0.4
Laterza 1	11.9	1.35	104	49	86	11.4	35.0
Laterza 2	12.1	2.50	176	52	94	10.8	33.2
Laterza 3	11.3	0.83	101	45	83	10.9	32.6
Laterza 4	11.0	1.90	166	47	94	10.1	30.1
Mean	11.6	1.65	137	48	89	10.8	32.7
Standard deviation	0.5	0.72	40	3	6	0.5	2.0

avoided according to the official recipes of these breads if the PDO or PGI mark is to be applied.

The ash contents of all of the flours examined fell within the limits of the current rules, and the level of free acidity (determined to check the storage conditions of the raw materials), was found to be 2.1–3.3°, as expected from well stored semolinas.

Table 2 reports the qualitative characteristics of the re-milled semolinas examined, with particular reference to the main quali-quantitative indices related to the protein and gluten fractions. The overall protein content of the re-milled semolinas examined showed values of 11.0–11.9% d.m., with the highest values in the semolinas from Matera (12.4% d.m. as a mean).

In order to evaluate the bread-making attitudes of the re-milled semolinas examined, sedimentation heights in sodium dodecyl sulphate, alveographic indices and gluten indices were considered. The SDS sedimentation height varied from 35 to 54 mm, with the highest values in the semolinas used for Laterza bread (mean value 48 mm). The alveograph data showed a wide variability, with P/L values ranging from 0.34 to 2.50 and with *W* values from 71×10^{-4} to 176×10^{-4} J. The P/L values were correlated to SDS sedimentation height (r=0.58, P<0.05), so that, once again, the highest P/L values were found in semolinas from Laterza (mean value 1.65), indicating the presence of gluten characterised by tenacity more than by extensibility. On the other hand, the lowest P/L values were observed in re-milled semolina from Altamura, with a mean value of 0.73, reflecting a greater addition of soft wheat. Figure 1 shows three alveographic diagrams: that of sample Laterza 2 (very tenacious), Altamura 1 (very extensible), and that of Matera 4, with an moderate P/L ratio. Finally, the highest *W* values were found in semolinas from Laterza and from Matera (mean values of 137×10^{-4} J and 143×10^{-4} J, respectively).

For bread-making purposes, the P/L ratio should not to be higher than 2, with an optimum ranging from 0.4 to 0.8 [8, 17, 18]. Indeed, in previous studies conducted by the authors regarding bread made from re-milled durum wheat semolinas, P/L values much higher than 0.4–0.8 were observed. In particular, re-milled semolinas currently used for the production of Altamura bread showed, in the harvest of 1998/99, P/L values ranging from 1.90 and 2.50, with *W* values ranging from 147×10^{-4} to 250×10^{-4} J [19]. The P/L value is also influenced by environmental factors, which vary from one year to the next [18], but nevertheless bread-making from durum wheat typically leads to a more compact product than that obtained from soft wheat.

As far as gluten content is concerned, the highest values were found in re-milled semolinas from the Matera region, with mean values of 12.9% d.m. and 35.4% d.m. for dry gluten and wet gluten, respectively. The dry gluten value was much higher than that required by the official recipe of Matera bread (11% d.m.) [4]. Dry gluten was significantly correlated to wet gluten content (r=0.92, P<0.001) and to protein content (r=0.72, P<0.01), and was negatively correlated to P/L value (r=–0.58, P<0.05), as has already been found by other authors [20]. The overall gluten index was very high for bread-making; its values ranged from 76 to 94, with the lowest values observed in Altamura re-milled semolinas (mean value 80). The official requirements [3] for Altamura bread production stipulate a gluten index lower than 80.

Figure 2 reports the mean fatty acid compositions of the starting semolinas and of the corresponding breads. The analytical results indicate that although all of the breads roughly reflected the characteristics of their raw materials, some small differences were found that were mainly caused by oxidative modifications that occur during the baking process [21, 22]. On the whole, all of the semolinas and breads contained a high proportion of

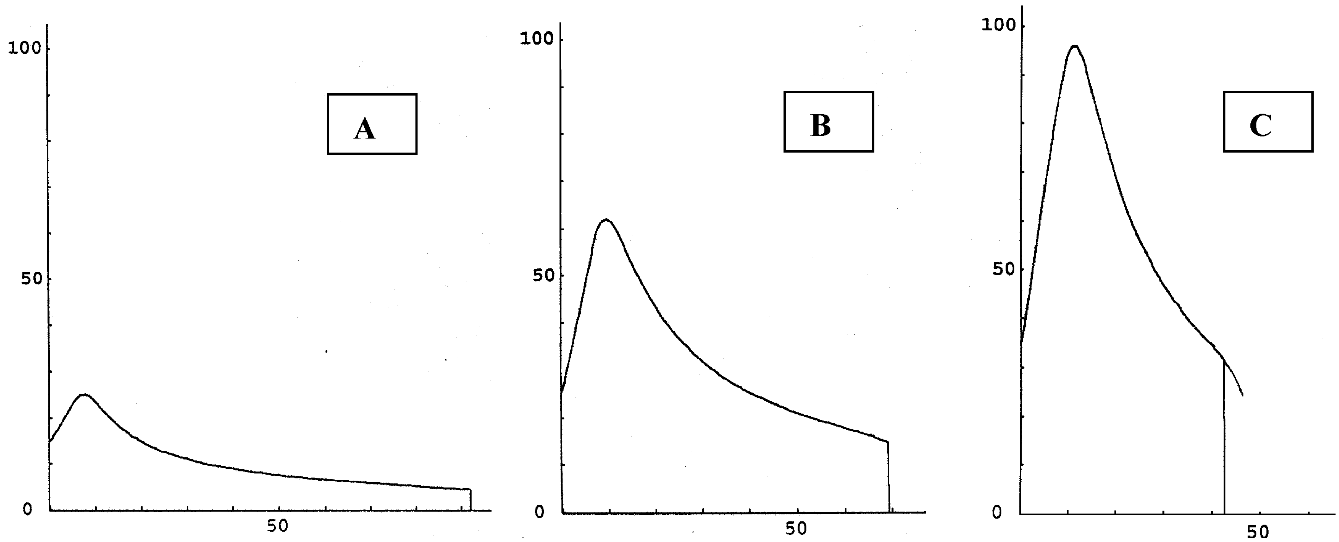

Fig. 1 Alveographic diagrams for the re-milled semolinas from Altamura 1 (A), Matera 4 (B) and Laterza 2 (C) used to make the sample breads

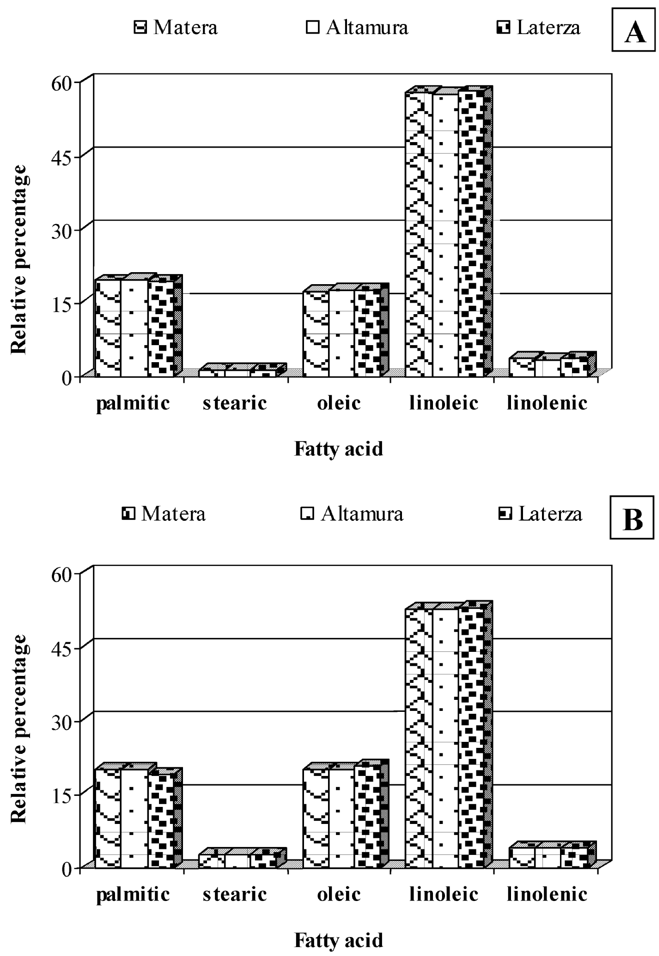

Fig. 2 Relative amounts of the main fatty acids in the re-milled semolinas examined (A) and their corresponding breads (B)

unsaturated fatty acids (70–80%), which is also observed in seed oils. In all cases the main fatty acid was linoleic acid, representing (on average) about 58% of the total in the flours and about 53% in the breads. No significant regional differences were found.

Table 3 reports the main characteristics of the traditional breads examined. The bread protein content was correlated to the protein content of the starting flour (r=0.59, P<0.05). The yellow pigments found in the crumb were much lower than those present in the corresponding re-milled semolinas, due to degradation processes connected to the bread-making procedure. The extent of the degradation was different from one case to another (from about 20%, in the Altamura 4 sample, up to 75%, in the Laterza 1 sample) due to differences in kneading and leavening times, and in baking time-temperature combinations. In fact, significant differences (P<0.05) were found between the mean yellow pigment contents of breads from the Altamura region to those found in the breads collected at Laterza and Matera.

Bread specific volumes where somewhat low, ranging from 3.10 to 3.83 ml/g. The lower values were found in breads from Laterza (mean 3.41 ml/g), reflecting the lowest additions of soft wheat. Bread volumes were negatively correlated to alveographic P/L values (r=–0.84, P<0.001), as already found by other authors [20, 23], indicating the negative effect of flour tenacity for bread-making purposes. No significant differences were found in the specific volume due to the great variability of this parameter within the same area.

The high values found for the total titratable acidity (TTA), ranging from mean values of 0.34% acetic acid (breads from Matera) to 0.55% acetic acid (breads from Laterza), confirmed the use of sourdough in the production process, with consequent lactic-acetic fermentation [24] and lowering of pH. Significant differences (P<0.05) were found comparing the mean TTA values of breads

Table 3 Analytical characteristics of the breads examined

Sample	Humidity (%)	Protein content (% s.s.)	Yellow pigments (ppm β-carotene)	TTA (% acetic acid)	Specific volume (ml/g)
Matera 1	35.8	11.1	1.71	0.40	3.54
Matera 2	35.3	11.4	1.69	0.33	3.39
Matera 3	34.3	11.3	2.33	0.30	3.63
Matera 4	34.4	11.0	2.76	0.34	3.49
Mean	34.9^{a}	11.2^{a}	2.16^{a}	0.34^{a}	3.51^{a}
Standard deviation	0.7	0.2	0.52	0.04	0.10
Altamura 1	34.2	11.0	3.38	0.33	3.83
Altamura 2	35.4	11.0	2.75	0.37	3.70
Altamura 3	33.5	12.1	2.60	0.56	3.51
Altamura 4	32.1	11.2	3.74	0.54	3.41
Mean	33.8^{a}	11.4^{a}	3.12^{b}	0.45^{ab}	3.61^{a}
Standard deviation	1.4	0.6	0.54	0.12	0.19
Laterza 1	31.4	11.6	1.13	0.72	3.61
Laterza 2	32.3	11.6	2.54	0.44	3.10
Laterza 3	32.8	11.2	1.83	0.51	3.51
Laterza 4	35.5	10.8	1.19	0.54	3.40
Mean	33.0^{a}	11.3^{a}	1.67^{a}	0.55^{b}	3.41^{a}
Standard deviation	1.8	0.4	0.66	0.12	0.22

Different superscript letters in the columns indicate significant differences ($P<0.05$)

from the Matera environment to those found in the breads from Laterza. In general, the breads with the more acidic character did not present evidence of the addition of soft wheat and probably better fitted the traditional recipes, which advocate the exclusive use of durum wheat flour and of sourdough without compress yeast.

In conclusion, the technological quality of the examined re-milled semolinas was generally variable, and different bread-making attitudes were observed. Moderate additions of soft wheat, to correct poor bread-making techniques, were detected in some cases. The characteristics of the flours examined influenced those of the corresponding breads, so that, on the whole, the examined breads showed a yellow crumb, an acid character and a modest specific volume, all of which are characteristics that are very different to breads exclusively made of soft wheat. Significant differences, in terms of levels of total titratable acidity and yellow pigment contents in the crumb, between breads from different regions are ascribable to different bread-making processes.

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