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Composition of whole and refined meals of Kamut under southern Italian conditions

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Due to the need for crop diversification and sustainable agriculture, and the increasing demand of healthy foods, a renewed interest in the so-called 'ancient wheats' took place in the last decades. In this study, whole and refined meals of Oriental wheat accession QK-77, registered as Kamut®, were compared with four cultivars, one each for common wheat, cv. Rio, durum wheat, cv. Norba, emmer, cv. Farvento, and spelt, cv. Forenza. Fifteen parameters related to meal composition were investigated. Kamut®, emmer and spelt cultivars showed the higher protein and ash contents. Distinctive traits of Kamut were higher amounts of selenium and pigments. To better perceive the differences among the cultivars, data were submitted to the Principal Component Analysis (PCA). Two sub-groups, corresponding to whole and refined meals, were distinguishable in the three-dimensional plot. Overall compositional traits of Kamut meals were comparable with those of cv. Norba.

1. Introduction

The need for crop diversification and the increasing demand of nutritional, healthy and innovative foods have led to a renewed interest in the so-called 'ancient wheats': emmer (*T. dicoccon* Schrank.), spelt (*T. spelta* L.) and Oriental wheat or Khorasan (*T. turgidum* L. subsp. *turanicum* (Jakubz.) A. Löve & D. Löve). Oriental wheat has the relatively most recent origin being a free-threshing species as the modern wheats (Abdel-Aal et al., 1998). This wheat species is survived until today in subsistence farming systems of the Near and Central Asia and Northern Africa (Gökgöl, 1961). Kamut® is a registered trademark used in marketing products of the Oriental wheat variety QK-77 registered by the USDA under Plant Variety Protection Certificate 8900108 (Quinn, 1999). Today it is mainly cultivated in North America to the border between USA and Canada. In the last years, European farmers have been attracted by Kamut® cultivation because the market request is increasing. The references in the scientific literature on the agronomic,

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nutritional and technological traits of Kamut® cultivated in European environments are still rare and elusive (Grausgruber et al. 2005; Stagnari et al. 2008).
The aim of this study was to compare the meal composition and some parameters related to the technological quality of Kamut® with four cultivars one each for common wheat, durum wheat, emmer and spelt. The field trials were carried out in Southern Italy, a geographical area traditionally devoted to durum wheat cultivation.

2. Materials And Methods

The cultivars (cvs.) Rio (*Triticum aestivum* L. Thell. ssp. *vulgare* Vill. Mk.), Norba (*T. turgidum* L. Thell. ssp. *turgidum* L. conv. *durum* Desf.), Farvento (*T. dicoccon* Schrank.), Forenza (*T. spelta* L.) and Kamut® (*T. turgidum* L. subsp. *turanicum* (Jakubz.) A. Löve & D. Löve) were investigated. The entries were grown in an experimental field in Southern Italy (Gaudiano di Lavello, 140 m elevation, soil medium-textured) in 10 m^2 plots distributed in a completely randomised block design with three replications. Farvento and Forenza kernels were dehulled with a wheat thresher before milling. Equal portions of kernels from each replication, were conditioned for humidity (16 %) and finely ground with a Cyclotec mill 1093 (Tecator). A MLU202 (Bühler) was used to obtain refined meals. Moisture and ash contents were determined according to AOAC methods (AOAC, 1995). Protein content (N x 5.7) was measured by the micro-Kjeldhal method. After ashing the samples, Ca, Fe and Mg were determined by atomic absorption spectrophotometry (AA); K and Na by flame emission spectrophotometry (EA) using an Atomic Absorption Spectrophotometer 3110 (Perkin-Elmer). Total P was measured by the colorimetric method of Fiske and Subbarow (1925). Se was determined with 2,3-diamino-naphthalene (AOAC, 1995) using fluorescence detection after the matrix dissolution obtained according to Cook (1996). Pigments (expressed as ppm of β-carotene) were extracted with water saturated 1-butanol and measured spectrophotometrically (AACC, 1995). Yellow and brown indices were determined by Chromameter CR300 (Minolta). Gluten content was determined by Glutomatic (Perten Instruments) (AACC, 1995). Data were normalised and submitted to the Principal Component Analysis (PCA) by using the Statistica 6.0 software package (1996).

3. Results And Discussion

The obtained results indicated that the 1000 seeds weight of Kamut® grains was the highest one, while the highest protein contents were recorded for the hulled wheat cvs. Farvento and Forenza (Table 1). Research has demonstrated that a trait common to 'ancient wheats' is the capacity to store high protein levels in grains (Abdel-Aal et al. 1998; Piergiovanni, 1999; Oliveira, 2001). In this study Kamut® showed a protein content intermediate between those of hulled and unhulled wheat cvs. The dry gluten content, the ratio dry gluten/protein content, as well as the ash content relative to Forenza, Kamut® and Farvento, were higher than those recorded for Rio and Norba as expected in materials not subjected to breeding.
As concerns macro- and micro-elements, K achieved the highest concentrations for all the cultivars. The cv. Forenza, characterised by the highest ash content, showed also the

Table 1. Grain size and compositional traits of tested whole meals. Values are referred to dry matter

	Kamut®	**Norba**	**Farvento**	**Rio**	**Forenza**
1000 seeds weight (g)	71.0	54.8	45.2	30.1	44.4
Protein (%)	16.4	14.3	17.7	16.6	18.4
Dry gluten (%)	15.5	12.5	14.0	13.4	17.1
Dry gluten/protein	94.5	87.5	79.0	80.6	93.0
Ash (%)	2.13	1.86	2.07	1.95	2.62
K (mg/100 g)	490.8	471.8	429.1	472.2	646.2
Mg (mg/100 g)	111.81	83.26	114.21	96.30	129.24
Na (mg/100 g)	5.98	9.88	9.82	8.00	7.74
Ca (mg/100 g)	16.57	22.04	22.61	22.48	23.26
Fe (mg/100 g)	2.88	3.64	3.83	2.86	3.86
P (mg/100 g)	445.0	382.1	421.7	379.2	531.9
Se (mg/100 g)	0.0070	0.0022	0.0053	0.0022	0.0023
β-carotene (ppm)	5.97	5.40	3.03	4.07	4.95
Yellow index	19.16	16.85	13.76	10.58	10.10
Brown index	18.96	19.28	21.47	13.13	15.74

highest amounts for all elements with the exception of Na and Se. Abdel-Aal et al. (1998) observed comparable amounts in spelt and common wheat cvs. for several elements, while superior aptitude of spelt to store minerals was described by Piergiovanni et al. (1997). The present study confirms the spelt aptitude to store higher amount of minerals also respect to Kamut®.

Periodically, claims are made that 'ancient wheats' are rich of antioxidants such as Se (Piergiovanni et al. 1997). In this study the Se amount of Kamut® was about three times greater than those of Norba, Rio and Forenza. This suggests that a high aptitude to uptake Se from soil could be associated to Kamut®.

It is known that diets rich in carotenoids were associated with a reduced incidence of cancer (Handelman, 2001; Hughes, 2001). In this study, the pigment content, expressed as β-carotene, of Kamut® whole meal was about two times greater than that detected for Farvento and Norba, that also are tetraploid wheats. This agreed with Abdel-Aal et al. (2002) that reported β-carotene content of Oriental wheat accessions lower than those of einkorn but higher than in emmer.

It is known that the wheat processing industry mainly utilises refined meal for the preparation of wheat-based products. As shown in Table 2, the composition of refined meals appreciably differed from the correspondent whole ones. Although a reduction of protein content was common to all cvs., the 'ancient wheats' values remained the higher ones. Protein content is one of the most important parameter to improve the cooking quality and colour of pasta when a high-temperature drying technology is used (Novaro et al. 1993). Semolina protein content above 10% is generally required by industry to obtain good pasta quality. The tetraploid cvs. Norba, Farvento and Kamut®, satisfied this requirement (Table 2). As concerns the gluten content, the highest reduction was observed for Kamut® (-21.2 %). As a consequence, Kamut® showed the highest ratio dry gluten/protein content among the tested whole meals but the lowest one by comparing the refined meals (94.5 and 81.0, respectively).

Table 2. Compositional traits of the refined meals of tested cultivars. All the values are referred to dry matter

	Kamut®	**Norba**	**Farvento**	**Rio**	**Forenza**
Protein (%)	15.1	12.6	16.6	14.0	17.3
Dry gluten (%)	12.2	11.1	14.4	12.3	15.7
Dry gluten/protein	81.0	87.8	86.5	88.0	90.7
Ash (%)	1.16	1.04	1.48	0.60	0.88
K (mg/100 g)	256.0	258.4	254.6	124.2	216.8
Mg (mg/100 g)	46.56	33.55	52.70	24.84	27.68
Na (mg/100 g)	4.31	5.11	5.00	3.13	5.26
Ca (mg/100 g)	12.86	23.74	20.50	16.04	18.21
Fe (mg/100 g)	1.27	1.20	2.30	Traces	0.82
P (mg/100 g)	232.8	196.7	299.9	118.9	169.2
β-carotene (ppm)	5.87	5.03	2.16	3.48	4.35
Yellow index	21.23	19.37	13.42	8.84	10.12
Brown index	12.93	13.61	15.00	7.05	8.52

The lowest ash contents were recorded for the hexaploid Forenza (0.88 %) and Rio (0.60 %) cvs. In several European countries the ash content of wheat meal for human consumption is regulated by law. In Italy this parameter must not exceed 0.9 % (dry matter basis) for the first-grade commercial semolina. As shown in Table 2, the ash amount of Kamut® and Farvento overcomes this threshold. This suggests that a different setting of milling conditions should be used to reduce the ash value increasing the commercial quality of these refined meals.

Also the data relative to macro and micro element levels evidenced a significant difference between whole and refined meals. As expected, the absence in the refined meal of the high-ash outer-endosperm particles produced a significant loss of the tested elements. On the average the K, Mg, Na, Fe and P reduction in refined meals was - 47.7 % for the tetraploid cvs. but –77.0% for the hexaploid ones, while the Ca amount appeared little affected by the type of meal.

Bright yellow colour of semolina, being appreciated by consumers, is an important factor in the use of refined meal to make good-quality pasta. The pigments, expressed as β-carotene, were less abundant in the refined meals as compared to the whole ones (Table 2 vs Table 1). This is attributable to the different positioning of yellow pigments in wheat grains with embrio, bran and endosperm containing decreasing levels (Quaglia, 1988). However, it should be noticed that whole and refined Kamut® meals showed similar values (5.97 and 5.87 ppm, respectively). If this result will be confirmed by further studies, Oriental wheat germplasm could significantly aid to increase the dietary intake of carotenoids.

The experimental data were submitted to PCA to better perceive the differences among the cvs. The first three components accounted for the 84.7 % of the observed variance. On the first principal component (PC1) β-carotene, yellow index and Fe content showed the highest absolute values of loading (1.385, 1.350 and 1.311, respectively). The second principal component (PC2) was mainly influenced by Ca amount, yellow index and protein content (absolute values of loading: 1.736, 1.523 and 1.454, respectively),

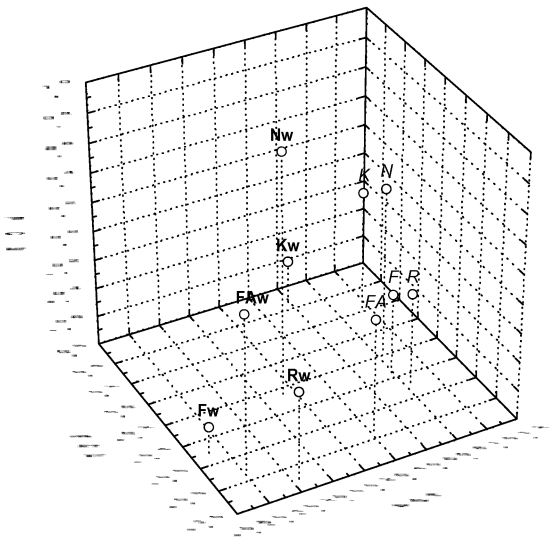

Figure 1. Three-dimensional scatterplot of the first three principal components. The cultivar codes are: R - Rio; N - Norba, Fa - Farvento; F - Forenza; K - Kamut; w indicates the whole meal samples

while the third principal component (PC3) was characterised by high absolute loading of Na, gluten and Mg contents (1.721, 1.242 and 1.059, respectively). Two main groups, mainly discriminated by PC1 and PC2 accounting for 39.5 % and 28.4 % of observed variance respectively, were detectable in the three-dimensional scatter plot (Fig. 1). Whole meals fell on the left of the diagram, while the refined ones on the right. A higher dispersion was associated to the whole meal samples and, within this group, Kamut® resulted the most isolate. Two sub-groups could be identified within the refined meal samples. The first one composed by Rio and Forenza, while the tetraploid cvs. Norba, Kamut® and Farvento, constituted a heterogeneous sub-group. Farvento appeared the most dissimilar.

In conclusion, overall compositional traits relative to Kamut® were found close to those of durum cv. Norba. This is a very interesting result because it is known that Oriental wheat has little adaptation (Vavilov, 1951). The results of this study encourage to evaluate the Oriental wheat germplasm in Southern Italian environments to identify the most promising accessions. Moreover, the high pigment and Se contents observed for Kamut®, if confirmed by further studies, could suggest important applications in the production of innovative nutritious food products.

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