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PHYSICOCHEMICAL CHARACTERISTICS AND PROXIMATE COMPOSITION OF WHEAT LANDRACES FROM THE CANARY ISLANDS

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Abstract:	Proximate composition (moisture, protein, fat, ash and carbohydrate components such as total carbohydrates, starch, amylose, dietary fibre, sucrose and fructose), pH and acidity were determined in eighteen wheat landraces cultivars from the Canary Islands in order to establish differences between them and contribute to their characterization. All the parameters analyzed showed significant differences between the analyzed cultivars; and also many parameters were affected by the specie and subspecie of wheat considered. The samples of Triticum aestivum had higher mean moisture, protein and fibre and lower mean starch, sucrose, and amylose concentrations than those samples belonging to Triticum turgidum. Low starch content and high fibre content could be due to the transformation of starch in resistant starch in the desiccation process of wheat grains. An important contribution to the daily intake of complex carbohydrates including fibre, as well as of protein and phenolic compounds was observed for the consumption of wheat.
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PHYSICOCHEMICAL CHARACTERISTICS AND PROXIMATE COMPOSITION OF WHEAT LANDRACES FROM THE CANARY ISLANDS

Short running title: Wheat landraces from Canary Islands

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Abstract

Proximate composition was determined in 19 wheat landraces cultivars from the Canary Islands in order to establish differences between them and contribute to their characterization. All the parameters analyzed showed significant differences between cultivars; and also many parameters were affected by the specie and subspecie of wheat. *Triticum aestivum* had higher mean moisture, protein and fibre and lower mean starch, sucrose, and amylose concentrations than *Triticum turgidum*. Low starch content and high fibre content could be due to the transformation of starch in resistant starch in the desiccation process. An important contribution of complex carbohydrates including fibre, as well as of protein and phenolic compounds was observed for the consumption of wheat.

Keywords: wheat landraces (*Triticum sp.*); proximate composition and physicochemical parameters; nutrient intake

Wheat has been widely recognized as a symbol of the Mediterranean diet due to its nutritional relevance for the human diet. This cereal is an important source of proteins although with a relatively low biological value; complex carbohydrates, including dietary fibre; vitamins and minerals; and bioactive secondary metabolites as phenolic acids. Epidemiological studies suggest that consumption of whole grain and bran may help to prevent cardiovascular diseases, diabetes and certain forms of cancer (SLAVIN et al., 1997).

Modifications of the nutritional value can be of interest because of their high consumption in the population. Diets including enriched cereal products are encouraged by nutritionists in Western Europe in order to improve its nutritional contribution. Obviously, the selection of cultivars cereals, more rich from nutritional point of view, is also a good alternative to contribute in the improvement of the status nutritional of the population.

The project “Germobanco Agrícola de la Macaronesia” included in the Interreg III-B European program aims to characterize traditional cultivars to conserve the biodiversity of the agricultural cultivations in the Macaronesic region. Several papers have been published to chemically characterize traditional wheat cultivars (HERNÁNDEZ et al., 2011; HERNÁNDEZ RODRÍGUEZ et al., 2011). In this paper we determined proximate composition in different wheat landraces from Tenerife in order to establish differences between them and contribute to their characterization. Furthermore, this will help to select cultivars with best nutritional characteristics.

1. Material and methods

1.1. Wheat sampling

A total of 35 accessions corresponding to 19 cultivars belonged to *Triticum aestivum* (n=27) and *Triticum turgidum* (n=8), were provided for analysis by the Centro de Conservación de la Biodiversidad Agrícola de Tenerife (CCBAT, Spain). The description of the wheat samples, including mean weight per grain and number of accessions for each cultivar is shown in Table 1. All the wheat cultivars used in the present study were traditional cultivars from Canary Islands, except Vitrón cultivar which is a commercial cultivar.

All the wheat cultivars were experimentally cultivated in the same breeding ground using the same cultivation methods and agronomic conditions on a collaborating farm of the CCBAT (La Laguna). The wheat was sown in December 2004 and the harvest took place in July 2005, when the wheat grains were in the same stage of maturation.

1.2. Analytical methods

The wheat samples (≈100 g) were separated in 5 sub-samples which were analyzed independently, and each sub-sample was homogenized till formation of a fine and homogeneous flour (Ika-Werke, Staufen, Germany).

All these analysis were carried out in duplicate, and the results expressed as fresh weight (FW). Moisture (oven drying method), protein (Kjeldahl method, factor of 5.7), fat (Soxhlet method), fiber (enzymatic-gravimetric method), pH, acidity (titration with NaOH 0.1N until pH 8.1, results were expressed as g citric acid per 100 g), ash (heated at 900 ºC for 24 h), starch (enzymatic method) (A.O.A.C., 2006). Total phenolic contents were determined by spectrophotometry at 750 nm after the colorimetric reaction with the Folin-Ciocalteu reagent (Sigma, St. Louis, MO) (KUJALA et al., 2000). Gallic acid (Sigma, St. Louis, MO) was used for the external standard calibration curve. Amylose was determined according to the method of HOVENKAMP-HERMELINK et al. (1988), and the results were expressed as g amylose per 100 g starch. Sugar determination was performed by HPLC following the method described by RODRÍGUEZ GALDÓN et al. (2009).

1.3. Statistics

All the statistics were performed by means of the SPSS version 17.0 software for Windows (SPSS Inc. Chicago, IL). Mean values obtained for the variables studied in the different groups were compared by One-Way ANOVA (Dunkan's multiple range) assuming significant differences when P<0.05. Correlation analysis was carried out to see relationships between variables.

2. Results and discussion

Proximate composition, pH and acidity obtained in all the samples and differentiating them according to the cultivar are shown in Table 1. There were important (P<0.001) differences between the wheat cultivars. Some differences in the chemical composition of wheat grains in the data reported in the literature were observed, which might be associated with the genotype and an environmental effect.

Moisture content was relatively constant in all the analyzed landraces (11.4-13.0%). Moisture was inversely correlated with starch (r=-0.459, P<0.01), fructose (r=-0.430, P<0.01), amylose (r=-0.594, P<0.01) and pH (r=0.423); and positively with fat (r=0.494). All the cultivars considered showed a mean pH inside a narrow interval between 6.33 and 6.65. The lowest acidity was found in Raspinegro Canario landrace (0.116 mg/100 g), in contrast with Marrueco and Español landraces, which had an acidity of 0.188 mg/100 g. Carbohydrates represent the more abundant nutrient in wheat grain, ranging between 70.4% and 75.5% for Colorado and Isla de Fuerteventura landraces respectively. The mean protein concentration in all the landraces was 12.5%, which agrees with most of data published in the literature (ANDERSON et al., 2013; DI SILVESTRO et al., 2012; KANDLAKUNTA et al., 2009; RAGAEE et al., 2006, 2012; RANDHAWA et al., 2002; RANHOTRA et al., 1996; SIKA et al., 1995). Colorado landrace had the highest protein content (14.2%), in contrast with Vitrón landrace (10.3%), which presented the lowest protein percentage. All the wheat landraces analyzed showed an ash content inside the interval 1.23% and 1.67%, whose values were obtained for Vitrón and Español landraces, respectively. Ash mean content obtained in this paper is in agreement with data reported in the literature (ANDERSON et al., 2013; HAGER et al., 2012; KANDLAKUNTA et al., 2009; RANDHAWA et al., 2002; SERENA & KNUDSEN, 2007). The fat concentration varied between 0.64% and 1.24% obtained in De la tierra and Vitrón landraces, respectively. The fat content found by us was lower than the data published by most of authors (ANDERSON et al., 2013; DI SILVESTRO et al., 2012; HAGER et al., 2012; KANDLAKUNTA et al., 2009; RANHOTRA et al., 1996; SIKA et al., 1995), although similar to those reported by RAGAEE et al. (2006). Total phenolic concentrations were fairly constant among the landraces considered. Isla de Fuerteventura landrace had the highest value (75.8 mg/100 g), and Arisnegro velloso de grano blanco the lowest concentration (52.0 mg/100 g). Some investigators found higher concentrations than those obtained in this paper (DI SILVESTRO et al., 2012; DINELLI et al., 2011), while other obtained similar amounts of these compounds (ANDERSON et al., 2013; RAGAEE et al., 2006).

Table 2 shows the results obtained in parameters related with the carbohydrates. Sum of the all the carbohydrates determined was lower than the calculated total carbohydrate (Table 1), which could be due to the calculation of total carbohydrate is overestimated and/or to some carbohydrate components were not adequately quantified. Starch percentage was between 42.6% and 58.7% found in Colorado and Raspinegro Canario landraces, respectively. The mean concentration of starch (49.9%) was clearly lower than the values obtained by other authors (ANDERSON et al., 2013; DI SILVESTRO et al., 2012; HAGER et al., 2012; RAGAEE et al., 2006). Also, high amylose content was observed with a mean value of 37.5% of starch and a range between 34.1% and 44.3% of starch found in Colorado and Español landraces, respectively. These data are similar that those reported by BLAZEK and COPELAND (2008) but are higher than indicated by HAGER et al. (2012). Positive correlations ($P<0.001$) were observed between starch, amylose and sucrose. Sucrose concentration increased when the starch content increased which could be due to the sucrose is mostly produced for the hydrolysis of starch. In contrast, inverse correlations were observed between starch with protein (r=-0.534, P<0.01) and moisture (r=-0.459, P<0.01). These correlations could be explained for the dilution effect of the starch on the concentrations of water and protein. Dietary fibre concentration varied between 13.4% obtained in Arisnegro velloso de grano blanco and above 18% in the Raposo, De la tierra, Español and Jallado landraces. The content of fibre was similar to data showed by DI SILVESTRO et al. (2012), slightly higher than those reported by RAGAEE et al. (2012) and ANDERSSON et al. (2013) and considerably higher than other values found in the literature (KANDLAKUNTA et al., 2009; RANHOTRA et al., 1996). It is a well known that during the storage of starchy foods resistant starch is produced (ANDERSON et al., 2013; RAGAEE et al., 2006). There two relevant factors influencing the formation of resistant starch, temperature applied and proportion of amylose. Our samples were desiccated at 105 ºC and they contained high amounts of amylose, which favour the formation of resistant starch (ÅKERBERG et al., 1998; LEEMAN et al., 2006; VAN HUNG et al., 2008). Like soluble fibre, resistant starch has interest in the maintenance of colonic health (ÅKERBERG et al., 1998). Also, food products rich in resistant starch frequently result in low glycaemic and insulinaemic responses (GRANFELDT et al., 1995). Insulin resistance syndrome is increasingly considered as a potential risk factor for the development of a number of diseases such as obesity, diabetes and atherosclerosis (ÅKERBERG et al., 1998). So, the consumption of wheat landraces with trend to produce resistant starch could be of interest in the prevention of these diseases (ÅKERBERG et al.; LEEMAN et al., 2006).

The fructose content detected in all the analyzed landraces varying between 0.53% and 0.84% for Colorado and Isla de Fuerteventura landraces, respectively. The sucrose was the predominant sugar in the samples of wheat grain. Plaganudo landrace had the highest content of sucrose (1.86%), while Colorado landrace presented the lowest sucrose concentration (0.84%). The sum of the sugars is in agreement with other data reported in the literature (ANDERSSON et al., 2013; SERENA and KNUDSEN, 2007).

The consumption of 100 g of whole-wheat flour represents 22.3% and 27.1 % of the recommended dietary intake (RDA) of proteins for male (56 g/day) and female (46 g/day) adults, respectively. Wheat grains are a very good source of complex carbohydrates; so, the consumption of 100 g de wheat represents a 38% of the RDA (130 g/day) for total digestible carbohydrates. The fibre intake for the 100 g of wheat accounts for 64.8% and 42.6% of the RDA intake (FOOD AND NUTRITION BOARD, 2005) for female and male adults, respectively, while the fat intake is very low. There is no recommended dietary intake for phenolic compounds. However, the American Cancer Society (KREBS-SMITH et al., 1995) has established 100 mg/day of flavonoids as an adequate amount for the prevention of cancer and other degenerative illnesses. The consumption of 100 g of the wheat landraces studied represents a 63.1% of the adequate intake for total phenolic compounds.

Many significant differences were found in the mean concentrations physicochemical parameters between the two species of wheat considered (*Fig*. 1.A and B). The samples of *T. aestivum* specie had higher ($P<0.05$) mean moisture, protein and fibre and lower ($P<0.05$) mean starch, sucrose, and amylose concentrations than those samples belonging to *T. turgidum*. Also, mean total phenolic compounds, ash, fructose and acidity (with a lower pH mean value) were higher in the samples belonging to *T. aestivum*, although without significant differences ($P>0.05$). Mean concentrations of the physicochemical parameters analyzed were determined in the two subspecies included in *T. aestivum* (*spp. vulgare* and *spp. compactum*) and in *T. turgidum (spp. durum* and *spp. turgidum)*, respectively (data no shown). The *spp. compactum* belonging to *T. aestivum* showed higher ($P<0.05$) mean fibre, amylose and acidity concentrations and lower ($P<0.05$) mean moisture and fat concentrations than the *spp. vulgare* Similar physicochemical characteristics were observed in both subspecies of *T. turgidum*. Only the mean fibre content of the *spp. turgidum* was higher than that mean content in the *spp. durum*.

3. Conclusions

There are differences in the proximate composition and pH and acidity between the cultivars, species and subspecies of wheat analyzed. Low contents of starch and fibre suggest the transformation of starch in resistant starch in the storage and desiccation process. The high proportion of amylose could favour this transformation. An important contribution of complex carbohydrates including fibre, protein and phenolic compounds was observed for the consumption of wheat.

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Table 1. Description and physicochemical parameters (expressed in wet basis) of the landraces considered and in all the wheat samples

Specie and subspecie	Cultivar	Nº Accession	Weight per grain (g)	Moisture (%)	Protein (%)	Ash (%)	Fat (%)	Carbohydrate[a] (%)	TC[b] (mg/100 g)	pH	Acidity (mg/100 g)
T. aestivum L. ssp. aestivum	Colorado	1	0.043	12.8	14.2	1.49	1.09	70.4	72.1	6.43	0.128
T. aestivum L. ssp. aestivum	Isla de Fuerteventura	1	0.044	11.9	10.4	1.37	0.79	75.5	75.8	6.48	0.150
T. aestivum L. ssp. aestivum	Del País	4	0.035	12.9	12.3	1.33	1.07	72.4	59.2	6.35	0.138
T. aestivum L. ssp. aestivum	Morisco	3	0.038	12.3	11.7	1.34	0.91	73.7	65.9	6.39	0.152
T. aestivum L. ssp. aestivum	Alto	2	0.040	12.8	11.8	1.41	0.71	73.4	59.8	6.38	0.131
T. aestivum L. ssp. aestivum	Marsello	1	0.046	12.7	13.8	1.57	0.81	71.2	73.3	6.50	0.146
T. aestivum L. ssp. aestivum	Barbilla	9	0.036	13.0	12.8	1.61	1.13	71.4	66.2	6.35	0.153
T. aestivum L. ssp. aestivum	Marrueco	3	0.038	12.2	13.6	1.62	0.91	71.7	54.2	6.38	0.188
T. aestivum L. ssp. aestivum	Jallado	1	0.034	11.9	13.4	1.47	0.82	72.4	64.7	6.42	0.152
T. aestivum L. ssp. aestivum	De alto	1	0.044	12.0	12.1	1.53	0.99	73.4	62.8	6.39	0.180
T. aestivum L. ssp. compactum	Raposo	1	0.033	11.9	12.9	1.55	0.78	72.8	56.3	6.33	0.182
T. turgidum L. ssp. turgidum	De la tierra	1	0.034	11.6	11.8	1.59	0.64	74.4	56.0	6.48	0.126
T. turgidum L. ssp. turgidum	Pelón	1	0.037	12.5	12.2	1.41	1.22	72.7	64.2	6.41	0.172
T. turgidum L. ssp. durum	Español	1	0.040	11.4	13.2	1.67	0.74	73.0	67.7	6.51	0.188
T. turgidum L. ssp. durum	Raspinegro canario	1	0.049	13.0	11.1	1.40	1.08	73.5	52.5	6.35	0.116
T. turgidum L. ssp. durum	Plaganudo	1	0.038	12.6	13.7	1.36	1.07	71.2	71.2	6.65	0.140
T. turgidum L. ssp. durum	Arisnegro de Tenerife	1	0.052	12.5	11.8	1.59	1.11	73.0	54.9	6.49	0.152
T. turgidum L. ssp. durum	Arisnegro velloso de grano blanco	1	0.059	12.1	10.7	1.41	0.99	74.8	52.0	6.52	0.126
T. turgidum L. ssp. durum	Vitrón[c]	1	0.046	12.3	10.3	1.23	1.24	75.0	74.5	6.50	0.140
Overall		35	0.039	12.5	12.5	1.49	0.99	72.5	63.1	6.40	0.152

[a] The value of carbohydrate was calculated for difference between 100 and the percentages of major components; [b] Total phenolics; [c] Commercial cultivar.

Table 2. Content of carbohydrates (expressed in g/100 g wb) in the landraces considered and in all the wheat samples

Cultivar	Starch	Amylose	Fibre	Sucrose	Fructose
Colorado	42.6	34.1	16.3	0.84	0.53
Isla de Fuerteventura	50.6	40.3	14.3	1.05	0.84
Del País	50.0	37.2	16.5	1.05	0.65
Morisco	49.8	35.9	15.9	1.14	0.72
Alto	47.8	36.7	15.3	0.95	0.58
Marsello	46.6	35.3	16.5	1.01	0.59
Barbilla	47.3	35.3	16.8	1.02	0.65
Marrueco	52.2	37.1	16.2	1.21	0.69
Jallado	49.8	38.2	18.7	0.93	0.81
De Alto	52.3	41.3	16.7	1.07	0.75
Raposo	51.9	39.5	18.1	1.21	0.81
De la Tierra	53.8	42.4	18.4	0.97	0.59
Pelón	52.2	40.2	16.2	1.40	0.55
Español	51.2	44.3	18.2	0.98	0.81
Raspinegro Canario	58.7	37.4	14.1	1.61	0.69
Plaganudo	46.8	38.0	15.7	1.86	0.82
Arisnegro de Tenerife	53.7	42.1	14.6	1.52	0.54
Arisnegro velloso de grano blanco	55.3	40.7	13.4	1.66	0.59
Vitrón	54.7	41.9	13.6	1.46	0.66
Overall	49.9	37.5	16.2	1.14	0.67

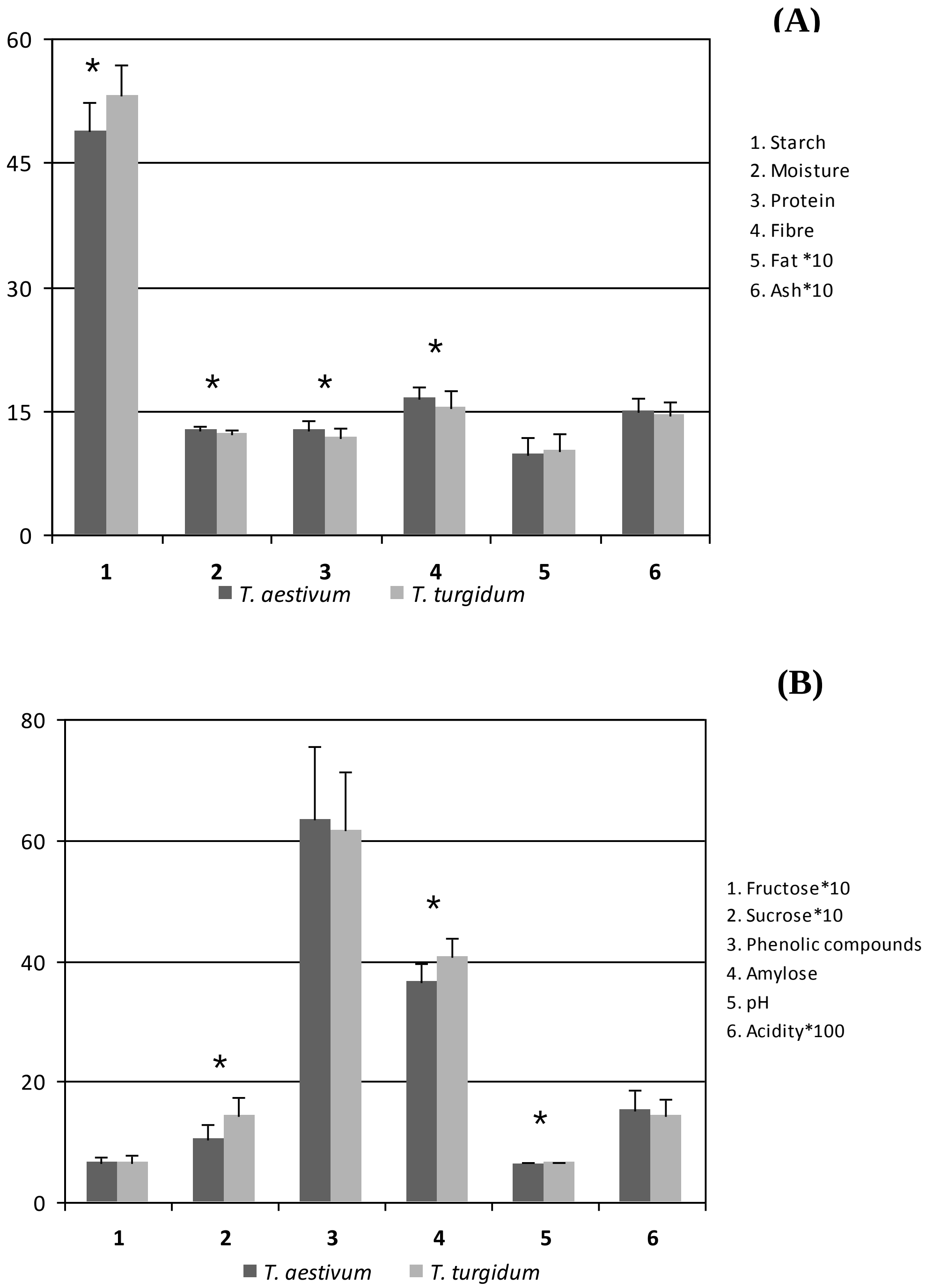

Fig. 1. Comparison of the physicochemical parameters according to the species. Significant differences ($P<0.05$) between mean concentrations are indicated by *.