Use of Triticale Flours in Cookies: Quality Factors

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ABSTRACT

The quality of flours obtained from 10 triticale cultivars and its usefulness in the manufacture of cookies were studied. Factors affecting cookie quality were also analyzed. The results obtained show that triticale flours are suitable for cookie manufacture. Best quality is related with flours exhibiting low protein content, high prolamine percentage with a high proportion of species with a molecular mass ≈34 kDa, low glutenin content with a low proportion of species with a molecular mass <30 kDa, and low content of free sulfhydryl groups.

Triticale (× *Triticosecale* Wittmack) is a hybrid resulting from the crossing between wheat (*Triticum* sp.) and rye (*Secale* sp.). In areas of the world where diseases or untoward soil conditions restrict wheat production, triticale has proved to be an alternative crop for human consumption. The main disadvantages for its cultivation are susceptibility to certain diseases, sensitivity to light period, germination in spike, and presence of wrinkled grains (Bushuk and Larter 1980, CIMMYT 1985, Varughese 1991). Triticale flours have been found to be more suitable for the manufacture of products that may be prepared with a gluten of lower tenacity than that needed in bread manufacture. Thus, these flours have been used in the experimental preparation of waffles and pancakes (Rodgers 1973), crackers (Tsen 1974), cakes (Peña and Amaya 1980), and cookies and tortillas (CIMMYT 1980).

Spring triticales are cultivated in Argentina. These cultivars usually have the rusticity and tolerance to weather conditions that are harmful to rye. However, good industrial quality grains have not been obtained as yet. Several programs aimed at improving grain quality are being conducted at present. Features to be improved include soft endosperm, shriveling of grain, low test weight, and scarce gluten content (Amaya and Peña 1991). Cultivation of soft wheats is not permitted in Argentina. Consequently, cookies are manufactured with flours of poor baking quality from *Triticum aureus*, which are inappropriate for producing bread. Use of triticale in the manufacture of these products appears to be an interesting alternative.

The objective of this study was to determine the quality of flours obtained from 10 advanced experimental lines and cultivars of triticale, and to analyze both their usefulness in the manufacture of cookies and the factors that are more likely to affect the quality of the manufactured cookies.

MATERIALS AND METHODS

Plant Materials

Triticale cultivars and advanced experimental lines of different regions were used (Table I). Cananea, Eronga, Currency, and Tatu were the parental material of the breeding program. They were provided by CIMMYT and have been selected by successive sawing and harvesting at the experimental field of the Facultad de Ciencias Agropecuarias of the Universidad Nacional de Córdoba, Argentina. They could be introduced to the local market as regional selections of the original cultivars. La 24 Bve, La 20 FCA, and LA 83 FCA are advanced lines of our breeding program. Tehuelche, and Yagan and Quiñe are currently cultivated varieties. Crops were grown in mid-level fertility soils at Campo Experimental of the Facultad de Ciencias Agropecuarias of the Universidad Nacional de Córdoba, Argentina.

Lines and cultivars under study were sowed by hand at the end of May in 3-m^2 parcels. No watering or fertilizing was used. Harvest was performed by hand during December as each line and cultivar reached the optimal level of harvesting, i.e., the plants were totally yellow and the grains obtained were hard and dry. Material harvested from each line and cultivar was threshed with a Forti Trituradora Estatica de Gavillas (Argentina).

Preparation of Flours

Kernels were milled to 54–64% flour yield on a Brabender Quadrumat Jr. mill (Duisburg, Germany). Each of the fractions divided at threshing was ground separately, providing three samples that were used as replicates.

Chemical Analysis of Flours

Moisture, ash, and protein contents were determined by the standard methods (AACC 1995). Lipid content was determined by extraction in hexane and further elimination of the solvent by heating (IRAM 1980). Starch content was calculated by subtraction. The results were expressed of wet weight basis.

Determination of Flour Quality

Alkaline water retention capacity (AWRC) was determined according to Yamazaki et al (1968). White flour (1 g) was suspended in 5 ml of 0.1*N* $NaHCO_3$, hydrated for 20 min and centrifuged at 700 × *g* for 15 min at room temperature. The precipitate obtained was weighed and AWRC was calculated as weight of the precipitate × 100.

Sodium dodecyl sulfate sedimentation index (SDS-SI) values were determined using 1 g of flour moistened in a 25-ml cylinder with 8 ml of Coomassie Blue solution. The sample was let to stand for 3 min, 40 sec; vortexed for 5 sec; let to stand for 1 min, 55 sec; and vortexed again. SDS and lactic acid (12 ml) were added immediately and agitated for 1 min in a horizontal agitator. The resulting suspension was let to stand, and the volume of moistened flour was measured. Results were expressed in milliliters (Dick and Quick 1983).

Wet and dry gluten content was determined according to the standard methods (AACC 1995). A Glutomatic 2200 and a Glutork 2020 (Huddinge, Sweden) heating surface were used.

Extraction and Solubility of Flour Proteins

Protein fractionation was performed according to a modification of the sequence used by Lupano and Añón (1985). Extraction was performed from 1 g of flour using three solvents: 1) 10 ml of 5%

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NaCl, for 2 hr with permanent agitation at 4°C (albumin and globulin fraction); 2) 10 ml of 70% isopropanol for 2 hr with constant agitation at 4°C (prolamin fraction); 3) 10 ml of tris-HCl-SDS (2%) (pH 8) for 2 hr with constant agitation at 4°C (glutelin fraction). Protein concentration of each fraction was determined by acid digestion of the dehydrated samples in a Technicon BD-40 mineralizer. The resulting ammonium was evaluated by the phenol-hypochlorite reaction using $(NH_4)_2SO_4$ as the nitrogen standard (Leon et al 1992).

Electrophoresis

Layer electrophoresis under dissociating conditions was performed in polyacrylamide SDS gels, according to the Laemmli discontinuous buffer system (Laemmli 1970): 0.125*M* tris-HCl (pH 6.8) 1% (w/v) SDS for the stacking gel; 0.375*M* tris-HCl (pH 8.8) 1% (w/v) SDS for the separating gel; and 0.025*M* tris-HCl, 0.192*M* glycine and 1% (w/v, SDS) (pH 8.3) for the running buffer. The separating gels were prepared with 10% (w/v) acrylamide. Protein samples (prolamin and glutelin fractions) were dissolved in 0.125*M* tris-HCl (pH 6.8), 20% (v/v) glycerol, 1% (w/v) SDS, and 0.05% (w/v) bromophenol blue. The electrophoresis were conducted for 1 hr at a constant voltage of 200V. A Mini Protean II Slab Cell (Bio-Rad laboratories, Richmond, CA) was used. Molecular mass standards were: bovine serum albumin (67 kDa), egg albumin (43 kDa), and carbonic anhydrase (30 kDa).

Gels stained with Coomassie Brilliant Blue R-250 were scanned in a Shimadzu dual wavelength TLC Scanner CS-910 (wavelength for sample was 570 nm; wavelength for reference was 395 nm) joined to a C-RIA Chromatopac Shimadzu integrator (Kyoto, Japan).

Determination of free sulfhydryl groups (SH) was performed as described by Ellmans (1959) and adjusted for cereals by Chan and Wasserman (1993). Results were expressed as micromoles of SH/g.

TABLE I
Advanced Lines and Cultivars of Triticale Samples

Sample	Name	Origin[a]
1	Cananea	CIMMYT México
2	Currency	CIMMYT Australia
3	Eronga	CIMMYT México
4	LA 24 Bve	INTA Argentina
5	LA 20 FCA	FCA-UNC Argentina
6	LA 83 FCA	FCA-UNC Argentina
7	Tatú	CIMMYT México
8	Tehuelche	INTA Argentina
9	Quiñe	FAV-UNRC Argentina
10	Yagán	INTA Argentina

[a] CIMMYT = Centro Internacional de Mejoramiento de Maíz y Trigo, México. INTA = Instituto Nacional de Tecnología Agropecuaria, Argentina. FCA-UNC = Facultad de Ciencias Agropecuarias. Universidad Nacional de Córdoba, Argentina. FAV-UNRC = Facultad de Agronomía y Veterinaria. Universidad Nacional de Río Cuarto, Argentina.

TABLE II
Chemical Composition (%) of Triticale Flours[a]

Flours	Proteins	Starch	Lipids	Ash	Humidity
Cananea	12.7 ± 0.1	70.7 ± 1.1	1.5 ± 0.0	1.9 ± 0.2	13.9 ± 0.0
Currency	12.6 ± 0.1	71.2 ± 1.0	1.1 ± 0.0	1.3 ± 0.1	13.9 ± 0.0
Eronga	13.2 ± 0.1	70.7 ± 0.9	1.0 ± 0.1	1.3 ± 0.1	13.4 ± 0.0
LA 24 Bve	11.9 ± 0.2	71.1 ± 1.4	1.0 ± 0.0	1.6 ± 0.1	13.9 ± 0.0
LA 20 FCA	13.5 ± 0.1	70.3 ± 0.8	1.3 ± 0.0	1.3 ± 0.2	13.6 ± 0.0
LA 83 FCA	12.3 ± 0.1	72.0 ± 0.9	1.3 ± 0.1	0.7 ± 0.1	13.7 ± 0.1
Tatu	12.1 ± 0.0	72.0 ± 0.7	1.2 ± 0.1	0.7 ± 0.1	13.9 ± 0.1
Tehuelche	13.2 ± 0.1	69.9 ± 0.9	1.3 ± 0.0	1.8 ± 0.1	13.8 ± 0.0
Quiñe	14.0 ± 0.1	69.6 ± 1.0	1.4 ± 0.0	0.9 ± 0.1	14.0 ± 0.0
Yagan	13.5 ± 0.1	68.2 ± 1.1	1.4 ± 0.0	3.0 ± 0.2	14.0 ± 0.0

[a] Mean ± standard error. (n = 3).

Preparation of Cookies

Cookies were prepared according to micromethod III described by Finney et al (1950) and modified at CIMMYT. Ingredients used were: flour (45 g); caster sugar (27 g); 20:20 vegetable fat and powdered milk (2.25 g); $NaHCO_3$ (0.50 g); NaCl (0.42 g); water (8.5 ml). Cookies were baked at 200°C for 10 min.

The term "cookie factor" was introduced to determine cookie quality as the ratio between the width and height of four cookies taken at random. This ratio was expressed as percentage related to a standard provided by the Estación Experimental Marcos Juarez del INTA, Argentina, which was considered 100%. The standard used was composed by a mix of soft wheats provided originally by CIMMYT.

Statistical Analysis

Each value represents a mean of three determinations ± standard error. Data were subjected to statistical analysis by the MGLH SYSTAT package. Correlation coefficients and significance level at $P \leq 0.05$ were determined.

RESULTS AND DISCUSSION

Characterization of Flours

Table II shows the chemical composition of flours obtained from the triticale lines and cultivars studied. Their protein values were somewhat higher in comparison with those from cereals in general. The triticales studied showed shriveled kernels with partial filling, which implies incomplete storage of starch. Therefore, the starch and protein ratio decreases, resulting in grains with increased protein content. This assumption is supported by the significant correlation at $P \leq 0.05$ between the test weight and its starch content ($r = 0.787$) (Fig. 1).

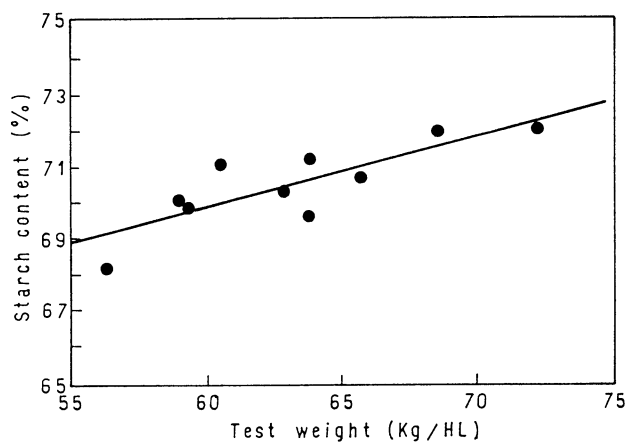

Fig. 1. Relationship between test weight and starch content for 10 triticale cultivars and advanced experimental lines ($r = 0.787$, $P \leq 0.05$).

TABLE III
Quality of Triticale Flours[a]

Flour	FN (sec)	AWRC (%)	SDS-SI (cm^3)
Cananea	69 ± 2	63.8 ± 1.2	8.4 ± 0.1
Currency	62 ± 0	60.7 ± 0.6	7.6 ± 0.2
Eronga	62 ± 0	64.4 ± 1.3	7.7 ± 0.1
LA 24 Bve	62 ± 0	62.8 ± 0.9	7.8 ± 0.1
LA 20 FCA	93 ± 3	69.7 ± 0.8	8.0 ± 0.1
LA 83 FCA	72 ± 2	68.4 ± 1.1	5.8 ± 0.1
Tatu	89 ± 6	63.1 ± 0.4	6.1 ± 0.1
Tehuelche	134 ± 2	71.9 ± 1.0	8.0 ± 0.1
Quiñe	62 ± 0	66.4 ± 0.9	8.2 ± 0.1
Yagan	62 ± 0	65.4 ± 1.3	5.4 ± 0.3

[a] Mean ± standard error. (n = 3). FN = falling number; AWRC = alkaline water retention capacity; SDS-SI = sodium dodecyl sulfate sedimentation index.

Ash percentages, with the exception of LA 83 FCA, Tatú, and Quiñé cultivars, were higher than those reported for einkorn (n = 12), durum (n = 2), and common (n = 2) wheats (D'Egidio et al 1993). Note the ash content of the Yagán cultivar. With regard to the lipid content, the average content was higher than those reported previously for four hexaploids triticales (Peña and Ballance 1987).

Quality of Obtained Flours

Values of falling numbers obtained (with the exception of Tehuelche) (Table III) were lower than usual values corresponding to the semiarid cultivation region (Cananea, 62 sec; Currency, 148 sec; Eronga, 73 sec; LA 24 Bve, 79 sec; LA 20 FCA, 132 sec; LA 83 FCA ,104 sec; Tatú 92, sec; Tehuelche 193, sec; Quiñé, 62 sec; Yagan, 87 sec). These results could have been affected by the high rainfall (mainly through the period from anthesis to harvest) recorded during cultivation of the triticales in this study; such behavior is similar to that described by Aguirre et al (1993).

Low values of falling number in triticales compare with rye characteristics and imply a high α-amylase activity and an increase of the susceptibility to spike germination. High α-amylase activity and low test weights are the two most important drawbacks of the triticale kernel. It has been postulated that these two problems are related (Klassen et al 1971). However, Dedio et al (1975) claim that this statement cannot be generalized since there are factors independent of kernel shriveling which determine germination in spikes. No correlation was found in this study between values of falling number and test weight

Values obtained for the SDS-SI (Table III) were within the 5.4–8.4 cm^3 range and are in agreement with those previously reported for lines and cultivars of triticales by Amaya et al (1986) and Vargas and Baier (1991) (six lines and 12 cultivars). These values are considerably lower than those of wheat and similar to those of rye (Oliveira and Baier 1991).

After hydration and mixing, only five of the flours obtained from the triticales lines and cultivars were able to form a strongly cohesive and viscoelastic paste. The wet and dry gluten content, respectively, obtained for these samples were: Cananea, 26.3 and 9.9%; Currency, 24.4 and 8.8%; LA 20 FCA, 29.3 and 10.2%; Quiñe, 28.2 and 10.1%; Yagan, 17.8 and 6.7%.

AWRC in the different cultivars ranged between 60.7 and 71.9% (Table III). These values are in the upper limit of the range usually found in hard (n = 11), club (n = 11) (Abboud et al 1985), and soft wheats ([n = 22] Abboud et al 1985 and [n = 4] Gaines et al 1992a,b). They are also in agreement with values previously reported for triticale cultivars (Kinsell and Lorenz 1976).

Preparation of Cookies

Cookies were prepared with flours obtained from the different triticale lines and cultivars studied. Features were assessed by means of the cookie factor defined earlier. Results obtained are listed in Table IV. According to the categories used by CIMMYT: two of the cookies were of very good quality (Tatú and LA 24 Bve); two were of acceptable quality (Cananea and Currency); four were of fair quality (Eronga, LA 83 FCA, Tehuelche, and Yagan); and two were of poor quality (LA 20 FCA and Quiñe). Tatu, LA 24 Bve, and standard triticale flours yielded cookies with finer crumb grain and excellent top grain characteristics. LA 20 FCA and Quiñe flours yielded smaller cookies with unacceptable external and internal appearance.

TABLE IV
Cookie Factor Values[a] and Quality Ranking[b]

Flour	L4C (cm)	H4C (cm)	CF (%)	Ranking
Cananea	25.2 ± 0.1	4.2 ± 0.1	90 ± 1	3
Currency	25.5 ± 0.1	4.3 ± 0.1	88 ± 0	4
Eronga	25.1 ± 0.1	4.4 ± 0.0	85 ± 1	5
LA 24 Bve	26.7 ± 0.1	4.1 ± 0.0	97 ± 0	1
LA 20 FCA	24.4 ± 0.1	4.6 ± 0.1	79 ± 0	9
LA 83 FCA	24.1 ± 0.3	4.4 ± 0.0	83 ± 1	7
Tatu	24.5 ± 0.1	3.9 ± 0.1	94 ± 1	2
Tehuelche	25.2 ± 0.0	4.4 ± 0.0	85 ± 0	5
Quiñe	23.5 ± 0.2	4.5 ± 0.1	78 ± 2	10
Yagan	24.0 ± 0.1	4.4 ± 0.1	82 ± 1	8
Standard	26.8 ± 0.1	4.4 ± 0.0	100 ± 0[c]	...

[a] L4C = width of 4 cookies; H4C = height of 4 cookies; CF = cookie factor.
[b] Mean ± standard error. (n = 4).
[c] Triticale standard (100% CF) provided by the Estación Experimental Marcos Juarez, INTA, Argentina.

Analysis of Factors Affecting Cookie Quality

Wheat has been reported to exhibit a positive relationship between protein content in flours and the volume of breads obtained from them. The role that flour proteins play in cookie preparation remains unknown, although a good gluten development has been shown to be unfavorable. Several correlations were found in wheat between cookie diameter and protein content of flours. In most cases, such correlations are negative (Yamazaki et al 1977; Abboud et al 1985; Gaines 1990, 1991; Bettge et al 1989; Kaldy et al 1993).

Figure 2 shows the correlation obtained between the cookie factor and the protein concentration in flours from the 10 triticale lines and cultivar obtained. It was clear that the lower the flour protein content, the better the quality of the cookies obtained. The inverse correlation obtained (r = –0.865) was significant at $P \leq 0.05$. There was also a significant correlation (r = 0.792, $P \leq 0.05$) between cookie heights and protein content in flours. The inverse correlation between cookie width and protein concentration was not significant at $P \leq 0.05$ (r = –0.610).

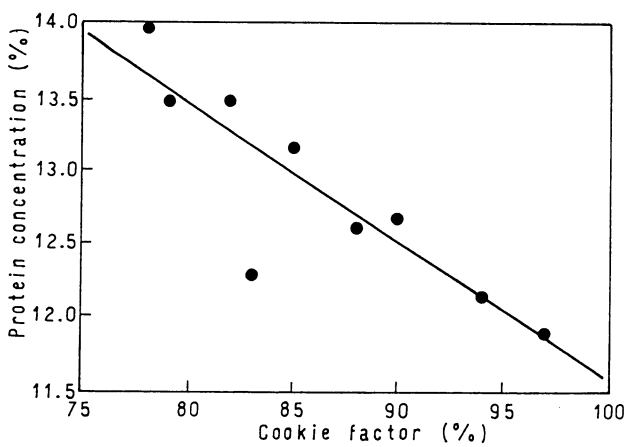

Fig. 2. Cookie factor versus protein concentration in flours for 10 triticale cultivars and advanced experimental lines (r = -0.865, $P \leq 0.05$).

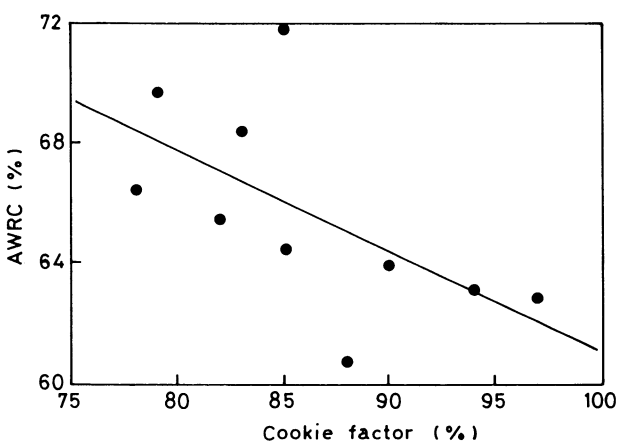

Fig. 3. Relationship between alkaline water retention capacity (AWRC) and the cookie factor for 10 triticale cultivars and advanced experimental lines(r = -0.555, $P \leq 0.05$).

AWRC is a drawback for cookie development. Yamazaki (1953) devised an AWRC test to select flours of good cookie quality. This test is used trials seeking to improve cookie quality. The fraction consisting of pentosans, proteins, glycoproteins, and protein-polysaccharide complexes is thought to be the factor responsible for retention of alkaline water. Several authors have found a negative correlation between AWRC and cookie quality in wheat (Yamazaki 1953, Kissell and Lorenz 1976, Abboud et al 1985). Figure 3 shows the relationship between AWRC and the cookie factor for the triticale lines and cultivars under study. The negative correlation obtained was not significant at $P \leq 0.05$ and the correlation coefficient ($r = -0.555$) was noticeably lower than those reported for soft wheats (n = 22) ($r = -0.63$ and -0.78 Abboud et al 1985) ($r = -0.99$ Kinsell y Lorenz 1976). No significant correlations between cookie width and AWRC ($r = 0.061$, $P \leq 0.05$) and cookie height and AWRC ($r = 0.390$, $P \leq 0.05$) were observed. The results obtained suggest that AWRC of triticale flours would not indicate the resulting cookie quality. This fact could be probably attributed to the pentosan fraction of the triticale flour. Moreover, more research should be needed to elucidate the role of these components on the quality of the manufactured cookies.

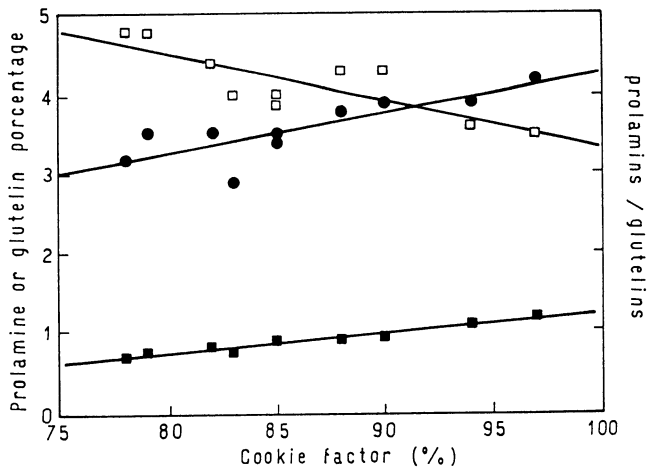

Fig. 4. Relationship between the cookie factor and prolamin (●) ($r = 0.819$, $P \leq 0.05$) and glutelin percentages ($r = -0.869$, $p \leq 0.05$) (□) and the prolamin-glutelin ratio ($r = 0.963$, $P \leq 0.05$) (■) for 10 triticale cultivars and advanced experimental lines.

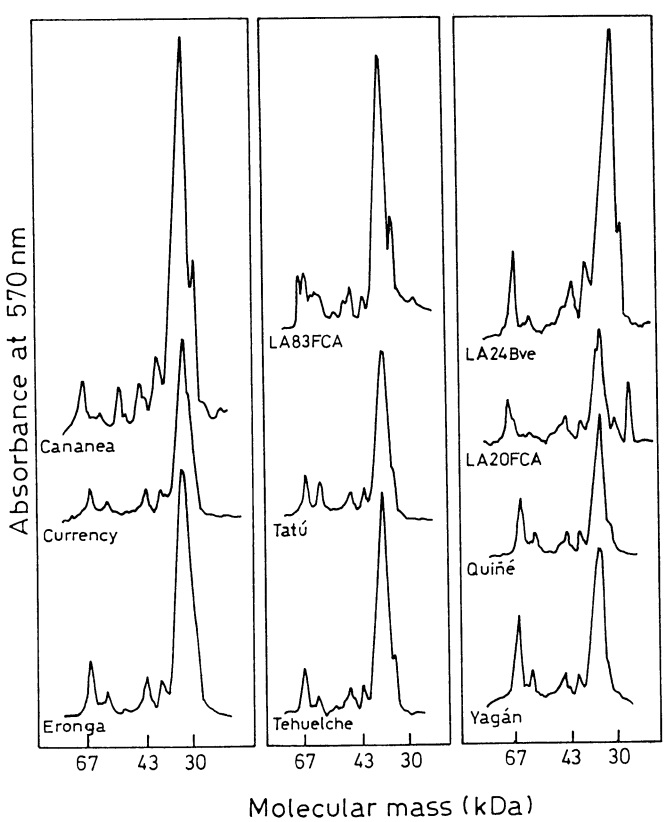

Fig. 5. Sodium dodecyl sulfate polyacrylamide gel electrophoresis densitometry scans for prolamines of 10 triticale cultivars and advanced experimental lines in 10% acrylamide.

Protein Fractions

To a large extent, wheat proteins determine the behavior of dough prepared for bread preparation. It has been shown that higher glutenin content and higher ratios of high molecular weight proteins to low molecular weight proteins produce doughs with rheologic properties more acceptable for bread production (Singh et al 1991). Knowing the different protein fractions in flour ,we decided to fractionate the proteins of the triticale flours, looking for the relationship between the content of each protein and the cookie factor. Results obtained are shown in Figure 4. Significant correlations at $P \leq 0.05$ were found between the cookie factor and the percentage of prolamins ($r = -0.819$), the percentage of glutenins ($r = -0.829$), and the prolamin-to-glutenin ratio ($r = 0.963$). Significant correlations at $P \leq 0.05$ were also obtained between the cookie widths and heights and the prolamins and glutelins percentages ($r = 0.740$, $r = -0.700$, $r = -0,710$, $r = 0.770$). These results can be understood by bearing in mind the important role of prolamins with regard to dough stretchability, a desirable feature for cookie manufacture; whereas glutelins supply strength, a feature affecting negatively the suitability of flours for cookie preparation. It seems likely then that when the prolamins-to-glutelins ratio (the ratio with a good correlation to the cookie factor) is used, the correlation would become even better.

The prolamin and glutelin fractions obtained were further analyzed by dissociating electrophoresis. Analysis of densitograms obtained (Figs. 5 and 6) shows that the largest difference among the triticale cultivars occurs in the band corresponding to a protein at 34 kDa.

For glutelins, the largest differences are detected both in the intensity and amount of proteins at <30 kDa. Taking these differences into account, the probable influence of these proteins on the quality of the prepared cookies was analyzed. To this end

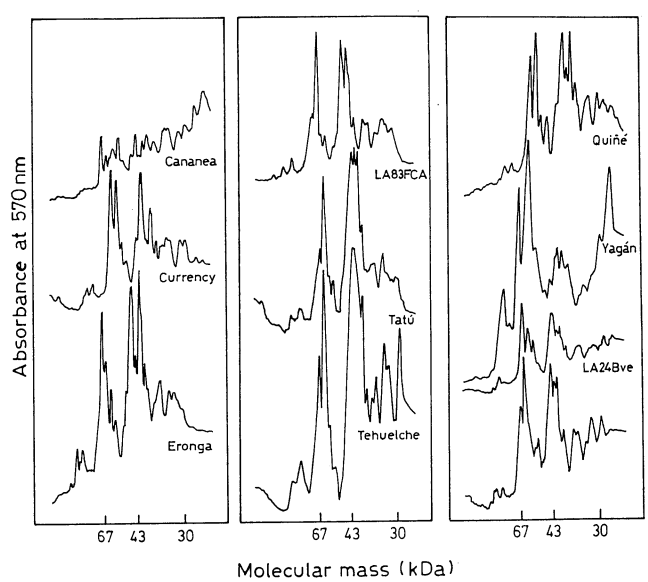

Fig. 6. Sodium dodecyl sulfate polyacrylamide gel electrophoresis densitometry scans for glutenins of 10 triticale cultivars and advanced experimental lines in 10% acrylamide.

TABLE V
Content of Free Sulfhydrl (SH) Groups

Flour	SH (μmoles/g)[a]
Cananea	1.80 ± 0.11
Currency	1.83 ± 0.10
Eronga	2.08 ± 0.03
LA 24 Bve	0.87 ± 0.05
LA 20 FCA	1.92 ± 0.17
LA 83 FCA	2.11 ± 0.10
Tatu	1.46 ± 0.06
Tehuelche	1.84 ± 0.05
Quiñe	2.04 ± 0.04
Yagan	2.16 ± 0.08

[a] Mean ± standard error. (n = 3).

areas of peaks of 34 kDa and total prolamines from Figure 5 ([area peak 34 kDa/total area prolamines] × 100) and areas of peaks <30 kDa and total glutenins from Figure 6 ([area peaks <30 kDa/total area of glutelins] × 100) were measured. Results are shown in Figure 7. Flours with the best quality to manufacture cookies (higher cookie factor) have a lower amount of glutelins at <30 kDa (r = –0.907, $P \leq 0.05$).

A significantly good correlation, though somewhat lower (r = 0.799, $P \leq 0.05$) was also found between the content of the prolamins at 34 kDa and the cookie factor.

Content of Free SH groups

Triticale flours had a varying content of free SH, the minimum (0.87 μmoles/g) for LA 24 Bve and the maximum (2.16 μmoles/g) for Yagan (Table V). These values are similar to those reported in wheat by Tsen and Bushuk (1968) and Beveridge et al (1974). Rye content of free SH groups is unknown. It might be thought to be slightly lower than that of wheat, as is the case with the sulfur-containing amino acids (Sikka et al 1978, Mosse et al 1988).

Examination of the relationship between the content of free SH groups in flours from the 10 triticale cultivars studied and the quality of the prepared cookies is obtained suggests a significantly negative correlation exists between these traits (r = –0.848, $P \leq 0.05$) (Figure 8). It seems likely that the short mixing period is enough to produce SH-SS exchange reactions that would confer a greater strength to the dough obtained from flours with high levels of free SH. This would lead to a lower cookie quality, as expressed by the cookie factor.

CONCLUSIONS

Comparison of the triticale flours of the 10 advanced lines and cultivars studied and wheat flour exhibited: similar chemical composition; lower falling number and SDS-SI, and higher AWRC values. It has been shown that four of the 10 triticales (Tatú, LA 24 Bve, Cananea, and Currency) are suitable for cookie manufacture. Moreover, flours giving the best quality cookies exhibit low protein content, high prolamine percentage, low glutelin content, high proportion of prolamines at 34 kDa, low proportion of glutenins at low molecular mass, and low content of free SH groups. The relationship between prolamine and glutelin content in triticale flours and the relative content of 34kDa prolamins and glutelins < 30 kDa could become selection criteria to assess the ability for cookie manufacture.

On the other hand, it was shown that the AWRC is not as efficient in forecasting flour quality for cookie manufacture as it is in wheat. The results obtained indicate that triticale could constitute a good alternative for cookie manufacture. Nevertheless, these results, obtained using 10 triticales of advanced lines and cultivars could not be representative of general triticale germplasm. Moreover, more research should be done to completely establish that triticale can be used commercially for cookie manufacture.

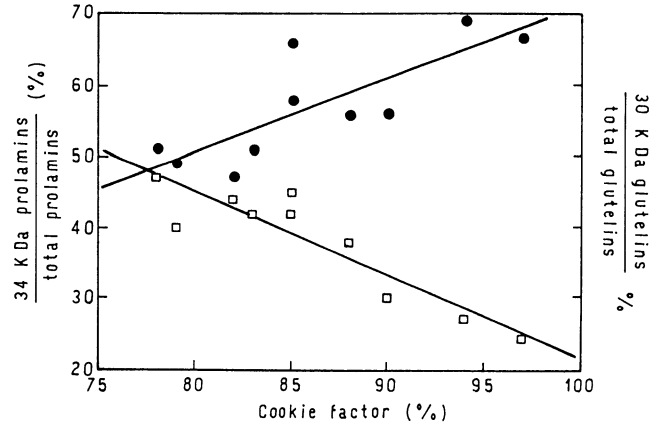

Fig. 7. Relationship between cookie factor and the percentage of prolamines at 34 kDa from total prolamines (r = 0.799, $P \leq 0.05$) (●) and the percentage of glutenins at <30 kDa from total glutelins (r = -0.907, $P \leq 0.05$) (□). Calculated from the active area of sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE) densitometry scans.

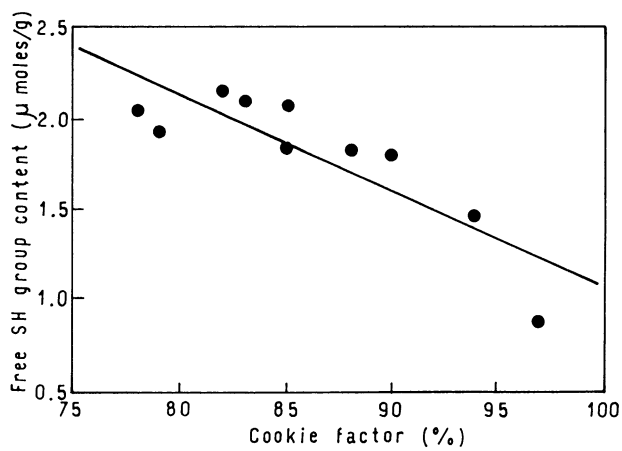

Fig. 8. Cookie factor vs. content of sulfhydryl groups for 10 triticale cultivars and advanced experimental lines (r = –0.848, $P \leq 0.05$).

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