

Findings on the Making of Triticale and Wheat-Based Low Calorie Flour

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Abstract

By means of this triticale experiment we determined the chemical composition (protein, wet gluten, gluten index, Zeleny number, Hagberg number, fiber, ash, fat, carbohydrate, mineral content) and rheological properties (alveograph, amylograph, extensograph, compression of bread) of triticale flour. The approximately 20% gluten content justified the addition of wheat flour to triticale flour in proportion of 10% - 50%, thus increasing the volume of the produced bread. The 50% - 50% ratio produced a bread that was 10% bigger in volume than the loaf made of only triticale flour. Our other aim was to produce a bread characterized by the ratio 1/3, 1/3, 1/3, mixed with a premix (?) that had a low carbohydrate content. As a result, the calorie content of the obtained bakery products were significantly reduced. Their glycemic indices were lower and the sugar absorption dynamics were more favourable than those of traditional products.

Keywords: *Triticale; Wheat; Flour; Bread; Composition*

Abbreviations

TB: Triticale Bran; TF: Triticale Flour; TG: Triticale Grain; WF: Wheat Flour; WG: Wheat Grain; WT: Whole Meal Triticale Flour; WF: Wheat Flour; BU: Brabender Unit

Introduction

With the increasing consumption of the so-called pseudo-cereals characterised by unique compositions and regional significance (amaranth, quinoa) [1,2], new issues have to be addressed following the discovery and breeding of new cereals (Triticosecale Withmack, Tritordeum) [3,4]. An important question is what role they play in tackling the problem of gluten intolerance. Another one is whether, and to what extent, they are suitable to produce low calorie products either alone or mixed with other cereal flours [5,6]. In this process, triticale - as the crossbred of wheat and rye - has a unique position. Its significance increased in the past decades since, beside its favourable agronomic responses [7-11], it can have beneficial foddering properties as well [12,13]. Via extensive research, many effects of both macro- and micro element fertilization experiments were clarified. It was found that triticale is superior to wheat in terms of protein content and amino acid composition [14,15]. In the last decades, new varieties were developed while both previously mentioned utilization demands (food and feed) increased simultaneously [5,6]. New means of utilization have also been investigated such as the production of biodegradable food packaging materials for cereals [16,17]. It is well-known that there are varieties in general production in the Baltic countries with gluten contents that make them suitable to produce yeast-bread [18]. The data of Tayyar [19] on Turkish varieties indicated a level of 22 - 26% gluten contents.

From nutrition point of view, triticale varieties differ from wheat not only in terms of their protein contents but also in terms of their dietary fibres and mineral contents [12,20], since they are higher in fibres. This property is especially important for the production of flakes having significant nutritional effects [21]. These varieties differ from wheat regarding their milling properties and thus their flour outputs can vary, even under the same milling conditions [22].

The mineral content of this cereal is highly dependent on the properties of the production site as well as on the dilution applied [23].

In the main, it can be concluded that, despite the less favourable bread making properties of triticale flour, blending it with wheat flour (up to 50 - 70%) can result in products similar to the ones made from wheat flour [5,24,25]. To this end the alpha amylase activities of flour blends were also tested [26].

Apart from the reasons described above, difficulties may be caused by the fact that, in Europe, in the eyes of the general public, this plant is predominantly associated with animal feed. It is only possible to change this conception through continued information campaigns and by introducing new products. This was partly the reason why we set out to produce various bakery and pastry products from triticale and wheat flour, based on our detailed research data, since other techniques to improve the rheological qualities of triticale flour are already known [27]. Regarding wheat flour, the various products, gums, modified cellulose and the flours from different cereals added to triticale have been examined. According to the results, carob and pea fibres decrease the loaf volume but increase the daily fibre intake [28]. In their experiments, Peressini and Sensidoni found that the most favourable rate of inulin addition was 5%, based on probes of adding of 2.5 - 7.5% inulin doses [29]. The blending of white wheat flour with sorghum flour resulted in an acceptable bread quality [30].

One of the aims of this research was to decide if triticale itself is suitable for making bread and what properties that would have. The other aim was how to improve these properties by blending triticale with wheat flour and see if this can improve the organoleptic properties of the bread. As certain consumer groups show significant interest in low/reduced calorie bread [31,32] we aimed at creating a product with considerably lower calorie content than pan bread made from the mixture of wheat and triticale flour.

Materials and Methods

Materials

Triticale grain samples were obtained directly from the breeder of Hungaro, the first triticale variety whose flour is expected to produce good quality bread on its own in Hungary [33]. The production location was at Kisvárdá (48.23609; 22.112638). In the study, samples from 2007 were used. Milling, bread making and analyses were carried out at the Institute of Food Science, University of Debrecen Hungary. Based on the test data, it was determined that the gluten content of this variety is 20%. Protein contents vary between 9 - 15% depending on the production location, growing year and agricultural management. In the experiment, from the commercially available wheat flour stocks, the WF-55 type (ash content: 0.55%) was used as it is one of the most common ingredients of bread making.

For the purposes of investigating the quality of flour properties before grinding, the wheat samples were wetted at 15.5% moisture. The original moisture contents of the samples ranged between 11.5 and 12.5%. Conditioning was carried out at 25°C for 18 hours. Flour samples were left to rest at room temperature for a week before the experiments. The production of the samples was performed with LABOR MIM FQC 109 (Budapest) laboratory mill with a 250 mm sieve, to determine the gluten and protein contents, Zeleny sedimentation values, Hagberg falling numbers and amylograph, farinographic and extensographic research. This mill is suitable for grinding in the range of 65 and 67%. The flour required for the alveographic analysis was produced by a CHOPIN LABORATORY MILL CD 1 (Tripette & Renaud, Villeneuve-la-Granne, France) with a 160 mm sieve.

The triticale flour was substituted for wheat flour at the rates of 0%, 10%, 20%, 30%, 40% and 50%. We also performed experiments, in which the objective was to reduce the carbohydrate level in bread. In this experiment, triticale and wheat flour and a special premix with 1/3-1/3-1/3 proportions were used. The premix had 17 components; its composition is (has been) patented. The main components of the premix were vital wheat gluten, pea protein and partially hydrolysed wheat starch (all the three are from Roquette Freres, France) and polydextrose (AmylumEurope BV Belgium). The aim was to reduce the calorie content of the bread while maintaining its organoleptic properties. Ultra-pure water was used throughout the experiments (MilliQ system, Millipore, Bedford, MA, USA).

Methods

The moisture contents of flour samples were determined by drying them in a drying cabin at 105°C constant mass. The protein contents of the flours were tested with Kjeldahl method in a Vapodest 50s instrument (C. Gerhardt GmbH and Co. KG, Königswinter, Germany) and presented for N x 5.7. All chemical data were presented for 100 g dry matter. The gluten contents and indices of the flour samples were determined with a Perten Glutomatic instrument (ICC No. 155, 137, 158) [34]. The Hagberg falling numbers were determined by the Perten falling number method (ICC No. 107) [34]. The Zeleny sedimentation index was determined by means of the Zeleny test (ICC no. 116) [34]. The total dietary fibre was established based on the AOAC 985.29 methods [35].

Following the detailed chemical analysis of the end product, we determined the mineral contents [36] using an ICP OPTIMA 3300DV (Perkin Elmer) instrument. The amino acid content was determined by the Stein and Moore method (Eppendorf- Biotronic, Hamburg, Germany, 1963) [37], using a BIOTRONIC LC3000 Instrument, the results of which were presented in the unit of g/100g protein. The ash (ICC No. 104) [34] and fibre contents of the samples were analysed by a FIBERTECH instrument (ICC No. 113,156) [34]. The different carbohydrates were determined on the basis of the ICC 123/1 and Codex Alimentarius Hungaricus [38] methods while the fat contents by a Tecator Soxtec instrument (ICC No. 136.) [34]. In order to determine the nutritive values and the different carbohydrate components, the following methods were used: EU Regulations No. 1169/2011 [39].

For determining the mineral contents, BCR CRM 189 wheat flour was used as the certified reference material and, for measuring the rheological properties, BCR CRM 563 flour was applied.

Dough test

When determining rheological properties of the dough, the water absorption capacity of the dough and the farinographic properties were analysed by a Brabender Farinograph (Brabender GmbH and Co. KG, Duisburg, Germany) (ISO/WD 5530-1) [40] and the extensographic properties of the dough by a Brabender Extensograph (Brabender GmbH and Co. KG, Duisburg, Germany), based on the AACC Standard No. 54-10 method [41-48] after 45, 90 and 135 minutes of resting time. The alveographic indicators tested were extensibility (mm), the resistance to 5 cm extending, Brabender unit (BU), resistance to the highest degree of extension (BU), the area under the curve (cm²). The analysis of the alveographic properties was performed using an Alveograph (Tripette and Renaud, Villeneuve La Garevne, France), based on the AACC Standard No. 54-30A method [41-48]. The alveographic indices tested were P (tenacity) (mm), L (mm), G (swelling index) (ml), P/L value and W (deformation energy) (10⁻⁴ Joule).

Baking test

The experimental bread was made according to the recommendations of Codex Alimentarius Hungaricus [49]. The baking formula was based on 300g (14%) flour mass, 6g salt, 5g fresh compressed yeast and 4.5g salt. The dough was leavened (Stephan Machinery GmbH, Hameln, Germany). The flour blends were stirred in a Stephan UM 12 mixer bowl for 1 minute, then the other ingredients (salt and yeast), previously dissolved separately in water, and additional water were added. The amount of water to be used was determined according to the farinograph absorption value. The dough was then mixed for 5 minutes in the whole amounts of flour or flour blends and placed in baking pans to get leavened at 30°C at a relative moisture content of 80 - 90%. Then the dough was re-mixed and placed in the pan for leavening again. The above two leavening periods were 45 minutes in either case. Each 300g piece of dough was baked at 230°C for 45 minutes. While baking, some water was vaporized in the oven (micro oven 2001LMS, Metefém, Budapest, Hungary) to avoid any extreme dryness of the crust. The specific loaf volume was weighted by rapeseed displacement after cooling. Loaf volume is reported on a 100-gram flour basis.

Bread evaluation

The height of the round loaf and the consistency of the crumb were determined three hours after baking by the time the bread had cooled completely. The bread was cut into 25 mm slices, the highest slice was drawn around and its height was measured with a ruler.

Bread crumb structure was evaluated with a plus texture analyser by the AACC Method 74-09 [41-48] using TA-XT2 (Stable Micro Systems Ltd., Godalming, Surrey, UK). The loaves were sliced into 2.5 mm slices 3 hours after baking. We used a cylinder probe with 36 mm diameter and the deformation was 10 mm compression. We measured the force required to bring about the deformation.

We examined the mass, volume and width/depth ratio of the round loaves and their sensory properties.

The determination of glycaemic index was carried out by the method of Brouns., *et al.* (2005) [50].

The statistical analysis was done with SPSS 22.0.0.0 statistics software.

Results and Discussion

Our studies covered both nutritional indicators and the rheological properties of the dough. The triticale used in the experiment was the first triticale variety in Hungary that had been recognized as food (year of recognition: 2006). Since then, new varieties have been bred for this purpose [51] just as in other countries.

Evaluation of ingredients

The gluten content varied between 15 and 24% depending on the production location and plant growing technology. On average, the change was 20% with a standard deviation of 2.4 (See table 1). These values are considerably lower than that of the control wheat flour (WF-55) and the average of wheat flour calculated from the data of 6 varieties, since these results represent half of the value measured for the wheat flours. At the same time the gluten index that indicates the strength of gluten is hardly different from the values of the control wheat flours. It can be determined that the amino acid composition of the variety studied has a higher lysine and methionine + cysteine level than wheat (data not provided). The falling number of the flour characteristic of alpha-amylase exceeds one hundred seconds making up only one third of the wheat flour value. As a result, it can be concluded that this flour is low in enzymes. According to the amylographic results there is a great difference in the peak viscosity of the maximum gelatinization value (AU) because the value for TF is 90, while the value for wheat is 640. The temperature of maximum viscosity also shows a considerable difference because wheat develops later. The Zeleny sedimentation volume and the low value, characteristic of triticale is significantly lower than the values for wheat flour. The protein content in dry matter of the latter does not reach 10%, while the protein content of flours exceed it significantly.

Sample	Wet gluten %	Gluten index %	Hagberg falling number (s)	Zeleny number (ml)	Protein content for dry matter %	BU	Water absorption %	Development time (min.)	Stability (min.)	Degree of softening (VE)
TF	15.48	94.61	117	18	9.95	28.6	58.2	0.50	0.30	206
WF-55	28.65	98.74	387	42	12.63	82.4	67.6	6.6	1.1	32.4
Wheat*	31.0	94.0	395	43	13.3	75	62.2	4.5	9.4	40

Table 1: Properties of different flours.

*average of 6 varieties (n = 144) [52].

In terms of the rheological properties of the flours applied in the experiments and studies, we found in the farinographic values that the water absorption capacity of triticale was 10% lower than those of the applied wheat flours. The dough leavens very quickly with low stability and high degree of softening. As a consequence of these indicators the Brabender unit of the triticale flour is very low.

The alveographic tests support the results of farinographic analyses (See table 2) since the value of extensibility energy is only 45×10^{-4} J while it is 5 times higher with the flours used and the extensibility length (L) is considerably low.

Sample	P (mm)	L (mm)	P/L	G (ml)	W (10-4J)
TF	35.0	49.0	0.73	15.5	45.0
WF-55	83.0	70.0	1.18	18.6	195
wheat*	73	103	0.87	22.1	244

Table 2: Alveogram* characteristics of flours.

*average of 6 varieties (n = 144) [52].

The extensographic data after 45 minutes of resting cannot be evaluated while, in the case of the data after the resting of 90 and 135 minutes, respectively, they reflect the values of the other two rheological research regarding extensibility and the resistance to extending (See table 3). During the production of bread and bakery products the question of what sort of nutritional quality the applied ingredients have often arises.

Sample	Temperature the beginning of gelatinization	Temperature of max. viscosity (C)	Starting time of gelatinization (min)	Development time of max. viscosity (min.)	Peak viscosity AU
TF	55	62.5	20	25	90
BF-55	56.5	80.5	21	37	640

Sample	Area (cm ²)		Resistance to extension (BU)		Extensibility (mm)	
	90	135	90	135	90	135
TF	1	4	22	85	22	39
WF-55	65	62	290	298	131	127
Wheat*	84	79	237	242	168	160

Table 3: Amilograph characteristics of flours.

*average of 6 varieties (n = 144) [52].

We present these values for three triticale products, wheat, bran and the so-called whole-meal products by comparing them to the industrial and commercial flour (WF-55) that were used in the study (See table 4). Based on the data we can establish that triticale flour contains more fibre than wheat flour does. The value of 15% dietary fibre coincides with the value found by Rakha., *et al.* (2005) but the total carbohydrate content in triticale is 6% lower. Accordingly, its energy content is 10% lower than the energy content of the wheat flour of the same category. Triticale bran contains 4% more crude fibre, due to the dominance of crust materials, and 21% more digestible fibre and 50% less total carbohydrate. Based on the 10% difference in the carbohydrate contents of the two flours, it can be concluded that bakery products made of triticale cannot meet the requirements of low calorie products.

	TF	TB	WTF	WF-55
Crude Protein %	9.95	13.60	12.22	12.46
Crude Fibre %	0.41	4.14	2.68	0.11
Crude Ash %	0.66	2.83	2.18	0.64
Crude Fat %	1.86	2.26	2.08	0.44
Dietary Fibre %	15.18	21.74	18.91	8.72
Total Carbohydrate %	70.31	48.70	60.91	76.12
Energy Kcal	345	300	350	375
Energy KJ	1452	1256	1467	1570

Table 4: Nutritional components of different grains products in 100% dry matter.

The available analytical capacity allowed us to have an insight into the mineral compositions of the four products mentioned previously: 3 triticale and 1 wheat products (See table 5). According to them, triticale flour contains more potassium and all other components than wheat flour does. Regarding other elements, the mineral content of triticale is lower than that found in wheat flour. As expected, triticale bran contains macro- and micro components of high nutritional importance. If we perform the comparison with, for example, the Presto variety, it can be concluded - based on the total of triticale flours - that the Hungaro variety contained higher levels of calcium, strontium and zinc, while its values are lower in the cases of the other elements. In the grain the manganese, iron and zinc contents - these elements are especially important in terms of nutritive value- are 31, 36.8 and 35.7 mg/kg, respectively.

Elements (mg/kg)	TF	TB	WTF	WF
Ca	273	759	559	387
Cu	1.93	7.95	5.72	3.74
Fe	18.4	57.3	33.8	25.7
K	2936	9467	5290	1412
Mg	187	2020	1255	452
Mn	6.78	48.9	31.7	11.2
Na	9.93	37.4	30.0	13.4
P	1333	6473	3380	2014
S	1215	1726	1359	3105
Sr	1.03	3.87	2.69	1.39
Zn	11.71	59.8	33.8	17.1

Table 5: Mineral content of triticale and wheat products.

We carried out the baking test of triticale flour and wheat bread flour. The resulting data showed 304 cm³/100g specific bread volume for triticale flour and 379 cm³/100g for wheat flour. This means that the use of wheat flour results in a better leavened test bread and of higher volume. The ratio of the diameter of the basic disk divided by the bread height represents the shape of the two kinds of bread since the triticale test loaf was flatter than was the wheat test loaf. Regarding the nutritional values, the triticale test bread was about 5% lower in protein. There is no significant difference between their ash and crude fat contents. The total carbohydrate content indicates the differences between the ingredients.

Triticale and wheat flour blends

Considering the bread volume and its properties recorded previously, we performed tests with flour mixtures, too (See table 7). Triticale flour and wheat flour were used at the ratio of 10% (WF) and 90% (TF), which then changed to 50% - 50%. During this process the specific bread volume (for 100 g/cm³) increased from 309 cm³ to 345 cm³, the latter one measured with the 50% - 50% mixture. Meanwhile the diameter of the basic disk divided by the height of the loaf decreased, which means that the test bread was better leavened with more favourable crumb.

Flour and flour in blends	Bread volume*	Basic disk divided by bread height	Basic disk divided by bread height std deviation	Std deviation of volume
100 % TF	309	2.69	0.06	6.56
100 % WF	391	1.47	0.11	8.92
10 % WF + 90 % TF	310	2.44	0.12	3.46
20 % WF + 80 % TF	318	2.31	0.19	14.42
30 % WF + 70 % TF	329	2.22	0.25	20.00
40 % WF + 60 % TF	338	2.12	0.26	17.32
50 % WF + 50 % TF	345	1.98	0.28	25.17

Table 7: Physical properties of mix-flour test breads.

WF: Wheat Flour

*specific volume (cm³/100g)

*average of triplicate baking experiment

The study with the TA.XT2 texture analyser indicates that the crumb of triticale bread is denser than that of wheat bread crumb, as the data of table 8 indicate. Thus we propose the use of the mixture of triticale and wheat flour for making bread. This does not exclude the possibility that through the change in bread making technology (composition of ingredients, leavening and baking time) we could find parameters that would enable us to produce good quality bread from triticale only.

	Compression force. g		
	TF	WTF	WF
Average*	1923.7	2546.7	646
Std. Deviation	96	166.6	42.4

Table 8: Data for bread crumb.

**average of 6 data*

Based on the results presented above we decided to perform further experiments. The aim was to reduce the energy level of the products in order to achieve the best possible properties. In addition to changing the nutritional values, we had to achieve better results in terms of other indicators as well such as loaf volume. In order to meet the demands, we developed a special premix composition (protected by patent, the major components are defatted soy flour, wheat gluten, polydextrose and pea protein), some components of which (wheat gluten) result in a favourable low calorie content product besides providing the suitable condition of the crumb. The results of the 1/3 TF + 1/3 premix + 1/3 WF-55 are shown in table 9. The produced loaves were of significantly higher volumes than the previously shown values in table 6, due to the higher protein- gluten content of the input mixture with the specific volume being 470 cm³/100g in the average of 6 measurements.

Blend of 1/3 TF + 1/3 premix + 1/3 WF-55	Average	Std deviation
Crude protein g/100g bread	19.7	0.50
Crude fat g/100g bread	3.6	0.28
carbohydrate g/100g bread	53.5	2.25
Non-digestible carbohydrate g/100g bread	5.0	0.18
Digestible carbohydrate g/100g bread	48.5	2.29
Dietary fiber g/100g bread	20.1	1.03
Bread specific volume (cm ³ /100g)	470	18.00

Table 9: Chemical properties of MFP bread (mixed-flour plus premix).

Figures 1 - 4 demonstrate different bread crusts.



Figure 1: Control wheat bread.



Figure 2: Bread crumb structure made from 30% Premix + 70% Triticale flour.



Figure 3: Bread crumb structure made from 1/3 + 1/3 + 1/3 blend.



Figure 4: Triticale and BL-55 bread.

Glycemic index: We performed a stress test to study the new product (See figure 5). During the process we carried out the experiment with groups of 40 individuals and tested their glycemic indices. The data presented show averages of 20 individuals. Based on the data, it can be established that the individuals, who consumed the newly developed products (bread) exhibited no change in their glycemic indices, which can be observed after glucose consumption. The glycemic profile was identical to the results for spelt and wheat bread by Marques., *et al.* [53].

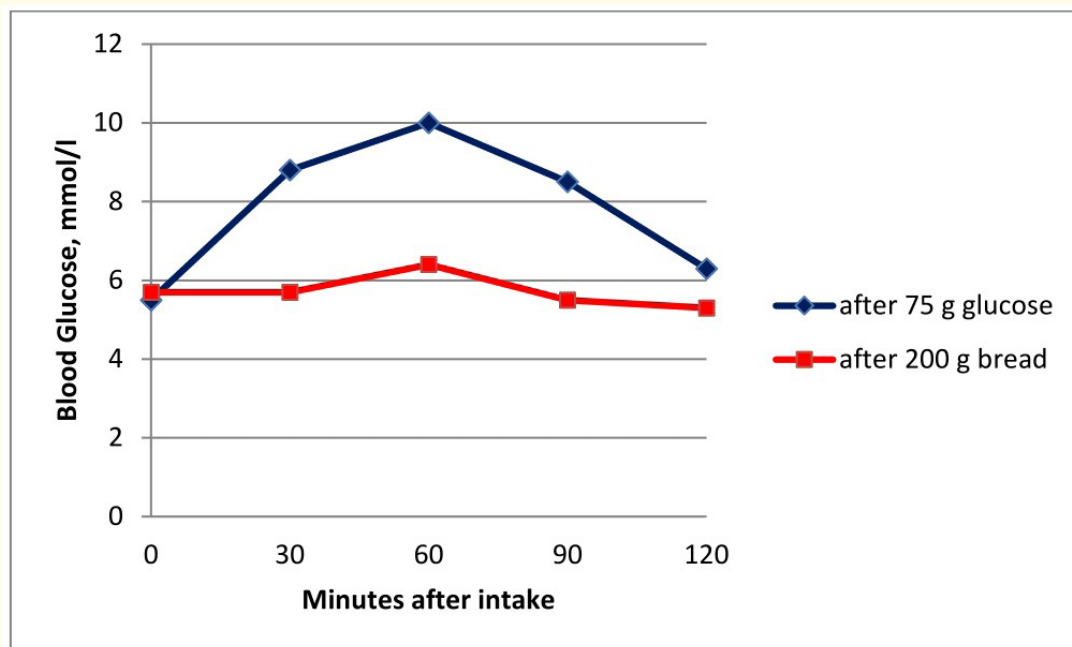


Figure 5: Glycemic load of mixed low calorie bread.

In Summary, the results so far indicate that, with this new low calorie product, we can satisfy the demand of a cohort of consumers; while admitting that the marketing of these low calorie bakery products have to be investigated with other scientific methods as well.

Conclusion

Triticale, due to its gluten content - with the right technology - can be suitable for the production of bread both on its own and blended with wheat flour. The bread made of triticale has higher density and smaller volume. As the result of blending triticale with wheat flour, the bread volume and the loaf was higher because the dough leavened better. If consumer demands for low calorie bakery products have to be met, the rate of the basic flour material needs to be changed through the development and use of a premix that reduces the amount of carbohydrate and increases the protein and fibre contents of the product. As a result we can get a product that meets the above mentioned demand. In our experiments we achieved this in the case of using the 1/3 triticale, 1/3 wheat flour and 1/3 premix blend.

In further studies flour output should be increased since triticale grains requires the grinding system to be refined due to the specific shape of the grains thus the new, resulting flour can be the subject of further research.

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