

Nutritional Quality and Technological Value of Triticale

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Abstract

The nutritional quality of triticale in comparison with other cereals and its technological value with wheat were measured. The protein content (14.1%) in triticale was higher than wheat, maize, rice, millet and sorghum. The fat, crude fibre, ash, calcium, phosphorus and tannin contents were higher whereas available carbohydrates and iron levels were lower than wheat. The concentration of lysine (2.9 g/16g N) was higher than wheat, maize, millet and sorghum. The values for true protein digestibility (TD) biological value (BV) and net protein utilization (NPU) of triticale were 93, 66 and 61% respectively. The NPU of triticale was 15, 6, 9 and 22% higher than wheat, maize, millet and sorghum respectively. Brabender Farinograph and Chopin Alveograph tests indicated that triticale flour had higher water absorption but lower stability, extensibility and strength as compared to wheat flour. The triticale chapati was darker in colour and tougher in texture than wheat chapati. The chapati baking qualities of triticale were improved by partial replacement with medium strong wheat.

Introduction

Cereal grains comprise the most important source of energy and protein constituting about 80 percent of the diet of a large majority of the people in the developing countries such as Pakistan. It has been suggested that if the people in the developing countries had enough to eat in the form of their traditional diet of food grains, the protein and energy requirements could be met to a large extent (Khan and Eggum, 1978).

Cereal protein is known to be poor quality because of its low content of certain essential amino acids. According to Khan and Eggum (1978) the order of limiting amino acids in triticale protein is lysine, threonine and valine. Since there is little information available on the quality characteristics of triticale, the present studies were undertaken to investigate the nutritive value of triticale in comparison with other cereal grains and to evaluate the technological value of some triticale lines.

Materials and Methods

Experiment I

Seven cereal grains viz: triticale, wheat, rice, maize barley, millet and sorghum grown in Pakistan were used in this study. The chemical composition was determined according to standard methods (AOAC, 1970). The energy value was estimated in an IKA calorimeter. The methods for the determination of tannin and amino acids were as described by Khan and Eggum (1979). The biological utilization of protein of cereals was determined in nitrogen balance experiments with growing rats according to Eggum (1973). Groups of five Wistar male rats each weighing approximately 75g were used. The preliminary period lasted for 4 days and the balance period for 5 days. The rats were weighed at the beginning of the experiments and divided into groups of five such that the average weights of groups

differed by no more than $\pm 0.5g$. Weighing was repeated at the end of the preliminary and balance periods: access to feed and water was prevented 3h before weighing. Each animal received 150mgN and 10g dry matter daily throughout the preliminary and balance periods. The N content of the diet was adjusted using a basal diet consisting of a N free mixture.

Experiment II

Flour from three advanced lines of triticale (Armadillo 70 HN458, 133, 135 obtained from Manitoba, Canada) and a commercial wheat flour/atta were tested for their physical, rheological and bread (flat bread chapati) baking characteristics. All grains were milled to 90 percent extraction rate. The physical dough studies were made by using standard methods on the Brabender Farinograph (AACC, 1962) and the Chopin Alveograph (Kent Jones and Amos, 1967). Chapatis were baked on an electric hot plate at 205°C for 3.5 minutes according to Rashid (1974). The colour of chapatis was determined by using the method of Kannur *et al* (1973). The texture was measured objectively by Instron Universal Testing Machine. The measurements were made by compressing of a 30mm pile of 9-11 discs of chapati (each cut by 30mm diameter die). They were transferred to the compression cell and compressed by a moving compression head. The height of resultant peak was taken as hardness in kg. The sensory evaluation of chapatis was performed by presenting freshly baked chapatis to eight trained panel members. A hedonic scale (0-10) arranged in terms of colour, texture, smell and taste of quality characteristics was used for scoring. The highest number represented the better quality in terms of acceptance of the product.

Results and Discussion

Chemical Composition

The chemical composition and biological utilization of protein of triticale in comparison with other cereals are presented in Table 1. The protein content of triticale (14.1%) was higher than wheat, maize, rice, millet and sorghum. The fat content was highest in maize (5.7%) and ranged from 2.2 – 5.5% in the rest of grains. The available carbohydrates and fibre content varied from 64.9–90.1% and 0.7–4.8% respectively. The ash and calcium contents in triticale were higher than wheat, maize, rice and millet, while the phosphorus content was the highest (399.6mg/100g). The concentration of iron varied considerably with the highest value of 10.1mg/100g in sorghum and the lowest of 2.9mg/100g in triticale and rice. The tannin content was highest in sorghum. The lysine content in triticale was higher (2.9g/16g N) than wheat, maize, millet and sorghum. The protein digestibility ranged from 85–100%. The biological value of triticale was higher (66%) than wheat, maize, millet and sorghum due to higher content of lysine in triticale. The low digestibility of sorghum may be due to higher content of tannin present in the grain. According to Eggum and Christensen (1975) tannin has a negative effect on protein digestibility. However, the net dietary protein calories percent of triticale bread has been reported to be 8.6% and could meet the protein requirement of all the groups except lactating mothers if consumed in adequate amounts (Khan and Eggum, 1978).

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Table 1.
Chemical Composition (dry basis) and Biological Data of Cereal Grains

| | Triticale | Wheat | Maize | Rice | Barley | Millet | Sorghum |
|---------------------------|-----------|-------|-------|-------|--------|--------|---------|
| Protein (Nx5.7)% | 14.1 | 11.2 | 10.4 | 8.1 | 14.4 | 12.2 | 6.9 |
| Fat % | 2.6 | 2.2 | 5.7 | 1.4 | 3.9 | 5.5 | 4.5 |
| Available CHO % | 67.4 | 18.1 | 74.0 | 90.1 | 64.9 | 73.7 | 69.4 |
| Crude Fibre % | 2.7 | 1.2 | 2.3 | 0.7 | 4.3 | 1.8 | 4.8 |
| Ash % | 2.0 | 1.6 | 1.6 | 0.6 | 2.2 | 1.8 | 3.0 |
| Calories/100g | 442 | 436 | 461 | 432 | 454 | 459 | 447 |
| Calcium mg/100g | 44.4 | 31.4 | 16.8 | 12.5 | 62.4 | 22.5 | 44.8 |
| Phosphorus mg/100g | 399.6 | 395.4 | 330.3 | 125.5 | 374.3 | 338.2 | 314 |
| Iron mg/100g | 2.9 | 5.1 | 4.2 | 2.9 | 7.0 | 8.1 | 10.1 |
| Tannin % | 0.70 | 0.50 | 0.48 | 0.11 | 0.81 | 0.72 | 1.90 |
| Lysine g/16g N | 2.9 | 2.3 | 2.5 | 3.4 | 3.2 | 2.7 | 2.7 |
| True protein | | | | | | | |
| Digestibility % | 93.0 | 96.0 | 95.0 | 100.0 | 88.0 | 93.0 | 85.0 |
| Biological Value % | 66.0 | 55.0 | 61.0 | 71.0 | 70.0 | 60.0 | 59.0 |
| Net Protein Utilization % | 61.0 | 53.0 | 58.0 | 71.0 | 62.0 | 56.0 | 50.0 |

Rheological Studies

The data obtained from various measurements of the farinograph and alveograph curves of wheat and triticale flours are shown in Table 2. Triticale flours had on average a shorter dough development time than wheat flour. Wheat flour had more than twice longer stability at 600 B.U. line with much lower tolerance to mixing values as compared to triticale flour.

Triticale flour II and triticale flour III were very weak as shown by their MTI values. Their farinograms had tolerance index figures exceeding 300 B.U. There was a significant difference between the breakdown time of wheat and triticale doughs as measured by Farinograph. The triticale doughs had distinct farinograph curves of very weak gluten quality with short stability and low tolerance to mixing.

comparison of rheological data, it was evident that wheat flour was much stronger than triticale flours, but reasonably satisfactory chapatis could be made from all samples of triticale flours. Although the strength of the flour may not be critical in terms of the quality of the finished product, the weaker flours are more difficult to handle and give very sticky doughs. This of course is a matter of considerable importance. Dough structure consists of two phases, a continuous phase mainly of swollen proteins, lipids and pentosans and dispersed phase mainly of starch granules and gas cells. The rheological properties of dough are mostly attributable to its gluten content. Addition of more water to dough makes the continuous phase of gluten softer and in addition increases the average distance between starch granules, thus reducing the number of contacts

Table 2.
Brabender Farinograph and Chopin Alveograph Data for Wheat and Triticale Flours

| Flours | Farinograms | | | MTI B.U. | Alveograms | | |
|---------------|----------------|--------------------------|---------------------------|-------------|-----------------|---------------------|-----------------------------|
| | Water abs.% | Do. Dev. time min. | Stability time min. | | Stability mm | Extensibility mm | Strength cm ² |
| Wheat | 58.5 | 4.0 | 8.5 | 21 | 28.2 | 13.5 | 3.52 |
| Triticale I | 65.5 | 3.5 | 3.5 | 60 | 18.0 | 7.1 | 1.30 |
| Triticale II | 72.0 | 2.7 | 2.5 | 300 | — | — | — |
| Triticale III | 72.0 | 2.5 | 1.8 | 400 | — | — | — |

Do. Dev.: Dough Development

MTI: Mixing Tolerance Index (in Brabender Units)

Data not available for triticale II and III in alveograph test due to their extremely weak nature.

Alveograms of the triticale flour showed that dough had lower values for stability, extensibility and strength than those of wheat flour (Table 2). The results of alveograms, shown in the table are only for triticale flour I, because doughs mixed from triticale flour II and III were so weak that it was not possible to obtain alveograms by using the standard procedures. Doughs of those samples were extremely weak and sticky and even when mixed with 2.5% sodium chloride solution, no significant improvements were observed. However, it was possible to obtain alveograms by reducing the water level to considerably below that indicated by standard farinograph procedure. The abnormal stickiness was presumably due to the high level of water soluble protein in these two triticale flours. The alveogram results obtained at lower water absorption are not recorded here since the data are of no value for comparison. From a

comparison of rheological data, it was evident that wheat flour was much stronger than triticale flours, but reasonably satisfactory chapatis could be made from all samples of triticale flours. Although the strength of the flour may not be critical in terms of the quality of the finished product, the weaker flours are more difficult to handle and give very sticky doughs. This of course is a matter of considerable importance. Dough structure consists of two phases, a continuous phase mainly of swollen proteins, lipids and pentosans and dispersed phase mainly of starch granules and gas cells. The rheological properties of dough are mostly attributable to its gluten content. Addition of more water to dough makes the continuous phase of gluten softer and in addition increases the average distance between starch granules, thus reducing the number of contacts

Baking Quality

It was noticed that triticale chapati sample discs of dough tended to cook faster than those of wheat flour. It has been shown that gelatinization temperature of triticale starch is lower than that of wheat (Hawthorn, 1974), and this accounts at least in part for difference in cooking rate of the dough disc of chapati.

Table 3 presents the colour, texture and panel score of chapaties made from wheat and triticale. The results of colour determination showed that wheat flour chapaties had an optical density of 0.30 as compared to 0.56, 0.58, 0.64 for triticale I, II and III respectively. The colour of the flour is affected by both the quantity and the colour of bran. The intensity of colour in the baked product depends upon the flour as well as on the browning reaction which take place during baking process. Since the rate of extraction of the experimental flours was similar and the baking conditions were standardized, the error or the change in colour intensity due to bran percentage or baking variables was minimized. Triticale flour chapaties were darker in colour as compared to those made from wheat flour. Perhaps one of the reasons for the dark colour of triticale chapaties was that brown coloured triticale grains were milled without conditioning. Hence it is possible that a fairly high proportion of the brittle bran particles were reduced to a fine powder and sifted along with the flour. Wheat was also milled without tempering but its light bran did not cause any appreciable change in the colour of chapaties. As shown in Table 3, triticale flour chapaties had comparatively higher hardness values, representing tougher texture than wheat chapaties. The sensory evaluation data are summarised in Table 3. Each figure in the table represents the mean score of each taster examining the same product (chapati) on each of at least two occasions.

The wheat chapaties had better colour, smell and taste scores than those of triticale chapaties. Among triticale samples, triticale I produced reasonably good scores because of slightly better colour, smell and taste than triticale II and III.

All triticale samples produced chapaties of less sweet and supplemented wheaty flavour than those prepared from wheat flour. Although all triticale chapaties did not receive high scores, yet the overall impression of triticale I was of fair acceptability. It was decided to examine the qualities of flour and chapati baking of triticale I by blending its flour with light coloured wheat atta. The reason for the selection of this triticale is also evident from its rheological data. A medium strong wheat

sample was milled to obtain a flour of approximately 87% extraction. The triticale I and wheat flour were blended in 50:50 and 75:25 proportions (wheat:triticale). All physical dough tests on the farinograph and the alveograph were carried out and the data is presented in Table 4. Wheat flour had higher values for stability, extensibility and strength. There was a little improvement in the physical or rheological characteristics of triticale wheat blends in 50:50 ratio. An increase was observed in mixing tolerance by increasing the amount of wheat flour in blends. The handling qualities of dough were also improved with a marked decrease in stickiness in 75:25 wheat and triticale blend. Interestingly, while baking on a hot plate, chapaties of blended flours puffed much better than those of wheat flour chapaties.

The objective and subjective of blended chapaties indicated a marked improvement in the quality of samples with an increase in the percentage of wheat flour in blends (Table 5). The acceptability scores, obtained by adding the individual scores of colour, texture, and flavour (smell + taste) of wheat and blended chapaties (75:25 blend) were similar and the taste panel was unable to recognize the presence of triticale flour in samples.

Conclusion

The quality and quantity of the triticale protein is superior to many cereals and can partly replace wheat flour without impairing the baking quality of the chapati.

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Table 3.
Objective and Subjective Evaluation Data of Wheat and Triticale Chapaties

| Chapati | Colour* | | Texture** | | Panel Score | | |
|---------------|-----------------|-------------|-----------|-------------|-------------|-------|---------|
| | Optical density | Panel Score | Hardness | Panel Score | Smell | Taste | Overall |
| Wheat | 0.30 | 4.6 | 3.6 | 6.3 | 8.1 | 8.0 | 27.0 |
| Triticale I | 0.56 | 2.5 | 4.8 | 3.7 | 6.3 | 6.6 | 19.1 |
| Triticale II | 0.58 | 2.2 | 4.5 | 4.6 | 4.8 | 6.0 | 17.8 |
| Triticale III | 0.64 | 2.2 | 3.8 | 4.1 | 5.0 | 5.9 | 17.2 |

* At 375 mm of 3.5g food item (moisture and fat basis) in 50ml of 66 percent alcoholic extraction.

** Hardness in kg., as determined by Instron Universal Testing Machine.

Table 4.
Brabender Farinograph and Chopin Alveograph Data for Wheat and Triticale Flours and their Blends.

| Flours | Farinograms | | | | Alveograms | | |
|-------------|--------------|--------------------|---------------------|-----|--------------|------------------|--------------------------|
| | Water abs. % | Do. Dev. time min. | Stability time min. | MTI | Stability mm | Extensibility mm | Strength cm ² |
| Wheat | 54.5 | 4.0 | 8.0 | 40 | 39.6 | 12.75 | 6.34 |
| Triticale I | 65.5 | 3.5 | 3.5 | 60 | 18.0 | 7.10 | 1.34 |
| 50:50 blend | 65.5 | 4.0 | 4.0 | 50 | 19.2 | 6.00 | 0.95 |
| 75:25 blend | 67.0 | 4.0 | 5.3 | 45 | 25.2 | 6.75 | 1.96 |

Do. Dev.: Dough Development

MTI: Mixing Tolerance Index (in Brabender Units)

Table 5.
Objective and Subjective Evaluation Data of Chapaties of Wheat, Triticale and their Blends

| Chapati | Colour* | | Texture** | | Panel Score | | |
|-------------|-----------------|-------------|-----------|-------------|-------------|-------|---------|
| | Optical density | Panel Score | Hardness | Panel Score | Smell | Taste | Overall |
| Wheat | 0.33 | 7.5 | 4.4 | 8.0 | 7.0 | 7.3 | 29.8 |
| Triticale | 0.56 | 2.5 | 4.8 | 3.7 | 6.3 | 6.6 | 19.1 |
| 50:50 blend | 0.40 | 5.0 | 4.78 | 4.0 | 7.5 | 6.7 | 23.2 |
| 75:25 blend | 0.36 | 7.1 | 4.64 | 8.3 | 7.5 | 6.9 | 29.8 |

* At 375 mm of 3.5g food item (moisture and fat basis) in 50ml of 66 percent alcoholic extraction.

** Hardness in kg., as determined by Instron Universal Testing Machine.

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