Nutritional Evaluation and Sensory Characteristics of Biscuits Flour Supplemented with Difference Levels of Whey Protein Concentrates

Mohammed AA¹, Babiker EM², Khalid AG³, Mohammed NA⁴*, Khadir EK² and Eldirani⁵

¹Department of Quality Control, Seina Milles, Khartoum North, Sudan
²Department of Food Science and Technology, Faculty of Agriculture, University of Khartoum, Khartoum North, Shambat, Sudan
³Department of Nutrition and Food Technology, Faculty of Science and Technology, Omdurman Islamic University, Omdurman, Sudan
⁴Faculty of Applied Medical Science, Department of Community Health, Albahta University, Albahta City, Kingdom of Saudi Arabia
⁵Department of Food Science and Technology, Faculty of Agriculture, Omdurman Islamic University, Omdurman, Sudan

Abstract

Proximate analysis and amino acid profile were carried for biscuit flour and whey protein. The gluten quantity and quality was tested for biscuit flour and biscuit flour-whey mixture with different concentration 0, 5, 10 and 15% whey. The results of the proximate analysis showed that there was no difference between protein 11.3% and carbohydrate (74.87%) for biscuit flour and protein (11.7%), carbohydrate (74.47%) for whey. The moisture content of biscuit flour was 10.97% which was higher than whey (5.47%) with highly significant difference at level of (p>0.05). The fat and ash contents of Biscuit flour were significantly (p>0.05) lower than the other one. The biscuit flour had lower content in essential amino acids especially limiting amino acid (Lysine) compared to whey protein. The gluten quantity and quality was affected by supplementation with whey and decreased with increased the concentration of whey. The overall quality of biscuits made from mixture showed high acceptability, Biscuit flour blended with 10% spray-dried whey showed best biscuit.

Keywords: Whey; Proximate analysis; Amino acid; Wheat flour; Biscuits; Gluten

Introduction

Wheat is a type of grass grown all over the world for its highly nutritive and useful grain. It is one of the top three most produced crops in the world, along with corn and rice. Wheat has been cultivated for over 10,000 years and probably originates in the Fertile Crescent, along with other staple crops. A wide range of wheat products are made by humans, including most famously flour, which is made from the grain itself. There are six different classes of wheat: Hard Red Winter, Hard Red Spring, Soft Red Winter, Hard White, Soft White and Durum. The end products are determined by the wheat's characteristics, especially protein and gluten content. The harder the wheat, the higher the protein content in the flour. Soft, low protein wheat is used in cakes, pastries, cookies, crackers and oriental noodles. Hard, high protein wheat is used in breads and quick breads. Durum is used in pasta and egg noodles [1]. Whey protein is a mixture of some of the proteins naturally found in milk. The major proteins found in whey include beta-lactoglobulin and alpha-lactalbumin. Whey protein has one of the highest protein digestibility-corrected amino acid scores (PDCAAS; a measure of protein bioavailability) and is more rapidly digested than other proteins, such as casein (another milk protein), [2]. Increasing knowledge of the nutritional and health benefits of dairy proteins (casein and whey and their bioactive peptides and amino acids) is leading to recognition of their potential as value-added ingredients in many functional foods and beverages, not only for weight management, but also for other health benefits [3]. Dairy proteins, specifically casein and whey, are high quality protein sources that provide all the essential amino acids, and in particular the branched chain amino acid leucine, which has been shown to specifically stimulate the synthesis of new muscle protein [4]. Whey proteins is of high biological value compared to most other protein; has high content of sulfur amino acid important for the biosynthesis is of glutatienne, atripeptide with antioxidant, anti-carcinogenic and immune simulating properties and the highest natural source of branched chain amino acid which may stimulate muscle protein synthesis [5]. Biscuits are widely accepted and consumed in many developing countries, so its need supplementation with another sources of proteins such as legumes and milk proteins to improve their nutritional values, the objective of this work was to determine the proximate composition and amino acids profiles of biscuit wheat flour and spray-dried whey (whey powder), to investigate the effect of whey protein supplementation on quantity and quality of biscuit wheat flour gluten and to show the effect of supplementation with different levels of whey protein on sensory characteristics of Biscuits quality.

Materials

Biscuit wheat flour (Australian wheat, 72% extraction rate) samples were collected from the local market (Omdurman market). Liquid whey was collected from cheese makers in Khartoum north (helat koko). Alaseel (hydrogenated vegetable oils), skimmed milk and sugar which were used in process of biscuit were purchased from local market. All chemicals and reagents used in this study were of analytical grade.

Methods

Spray drying of whey

Whey protein, which is drained off the coagulated cheese cured during the cheese making process, was collected from cheese making...
in Khartoum north. The liquid was evaporated to make 30% whey concentration. Because whey contains 93% water and only 0.6 proteins, it must be concentrated to produce the various whey ingredients [6]. The concentrated whey was then spray dried into whey powder with 67% yield. It can be observed that the dried whey ingredients are manufactured after pasteurized and clarified of liquid whey. The main advantages of spray drying are rapid drying, large scale continuous production, low labor costs and simple operation and maintenance [7].

Whey protein preparation

The whey protein, a bye product of cheese making, was collected, concentrated to 30% by the evaporator (70-75°C), and dried by spray drier [6]. The powder yield was calculated by the following equation:

\[
\text{Yield}\% = \frac{\text{Actual weight}}{\text{Theoretical weight}} \times 100
\]

Where:

- Actual weight = weight obtained from spray drier
- Theoretical weight = Concentration of whey (30%) / Volume used in spray drier

The resultant powder was divided into two portions; one portion was kept in plastic container and stored in a deep freezer at -18°C for further analysis. The other portion was mixed with wheat flour to make concentrations of 5, 10 and 15%, kept in plastic containers and stored in a deep freezer at -18°C until required.

Determination proximate analysis

The proximate chemical composition of each of the biscuit wheat flour and the whey powder was performed according to AOAC [8] method. Carbohydrates were determined by difference.

Determination of amino acids

Amino acid composition of samples was measured on hydrolysates using amino acids analyzer (Sykam-S7130/Germany) based on high performance liquid chromatography technique. Sample hydrolysates were prepared following the method of Moore and Stein. Two hundred milligrams of sample were taken in hydrolysate tube. Then 5 ml 6N HCl was added to sample into tube tightly closed and incubated at 110°C for 24 hours. After incubation period, the solution was filtered (Whatman No. 1) and 200 ml of the filtrate were evaporated to dryness at 140°C for further analysis. Afterward, the filtered solution was acidified with 2% HCl in order to maintain the concentration of the hydrolysate of amino acids. Ninhydrin solution (reaction reagent) and an eluent buffer (The buffer system contained solvent A = 14 ml biobiglycol + 12 ml 32% HCl + 2.0 g phenolinone liter), the same as the amino acids standards (amino acid standards H, Pierce, Inc., Bockford). An amount of 150 µl of sample hydrolysate was injected in the cation separation column at 130°C. Ninhydrin solution (reaction reagent) and an eluent buffer (eluent system containing solvent A, pH 4.5, and solvent B, pH 10.85) were delivered simultaneously into a high temperature reactor coil (16 m length) with a flow rate of 0.7 ml/min. The buffer/ninhydrin mixture was heated in the reactor at 130°C for two minutes to accelerate chemical reaction of amino acid with ninhydrin. The products of the reaction mixture were detected at wavelength of 570 nm and 440 nm on a dual channel photometer. The amino acid composition was calculated from the areas of standards obtained from the integrator and expressed as percentages.

Gluten quantity and quality attributes of base and substituted flours

Gluten quantity and quality were carried on the base wheat flour and wheat flour- spray-dried whey mixture by the Glutomatic system (Perten instrument) according to ICC standard method No. 155 (2000). The wet gluten content, gluten index and dry gluten content were determined as follows: Ten gram of samples was mixed with 4.8 ml of 2% sodium chloride solution for 20 seconds in test chamber. The dough was washed with 2% NaCl for 10 min. When the glutomatic was stopped, the gluten ball was carefully centrifuged through special sieve. The percentage of wet gluten remaining on the sieve after centrifugation was defined as gluten index. The part of the gluten remaining on the sieve and the part, which passes through it, were collected and weighed and were defined as wet gluten content.

\[
\text{Wet gluten content}\% = \frac{\text{Weight of wet gluten} \times 100}{\text{Weight of sample}}
\]

Then the total wet gluten was dried in Glutork heater to give the dry gluten.

\[
\text{Dry gluten content}\% = \frac{\text{Weight of dry gluten} \times 100}{\text{Weight of sample}}
\]

\[
\text{Gluten index}\% = \frac{\text{Total wet gluten wt} – \text{passed gluten wt}}{\text{Total wet gluten wt}}
\]

Statistical analysis

The statistical analysis of the sample was done according to the method described by Mead and Gurnow [9], data generated was subjected to Statistical Package for Social Sciences (SPSS). Means (± SD) were tested using one-factor analysis of variance, and then separated using Duncan’s Multiple Range Test (DMRT).

Results and Discussion

Proximate chemical composition

The proximate chemical composition of each of the biscuit wheat flour and the whey powder was determined. The results expressed on dry weight basis, are presented in table 1.

Moisture content: Wheat flour gave relatively higher moisture content (10.97%), compared to whey powder which gave (5.47%) with high significant difference (p ≤ 0.05). The moisture content of the wheat flour was lower than the range of 13.0-15.5% [10]. The result obtained was in an agreement with the value of 10.5% for wheat flour (all purpose) and 10.1% for special flour [11]. The moisture content of the whey powder was found to be higher than the value of 3.8% moisture reported.

Ash content: Wheat flour gave lower ash content (0.87%) compared

<table>
<thead>
<tr>
<th>Samples</th>
<th>Moisture</th>
<th>Ash</th>
<th>Protein</th>
<th>Fat</th>
<th>Fiber</th>
<th>Carbohydrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biscuit wheat flour</td>
<td>10.97 ± 0.09 a</td>
<td>0.87 ± 0.09 a</td>
<td>11.30 ± 0.06 a</td>
<td>1.10 ± 0.12 a</td>
<td>0.87 ± 0.15 a</td>
<td>74.87 ± 0.09 a</td>
</tr>
<tr>
<td>Whey powder</td>
<td>5.47 ± 0.18 b</td>
<td>5.60 ± 0.12 a</td>
<td>11.73 ± 0.18 a</td>
<td>2.63 ± 0.15 a</td>
<td>0.00 ± 0.00 b</td>
<td>74.47 ± 0.29 a</td>
</tr>
</tbody>
</table>

*Values are means of three triplicates.
**Mean values (± SD) having different superscript letters in columns differ significantly (p ≤ 0.05)

Table 1: Proximate chemical composition of biscuit wheat flour and whey powder.

The amino acid profile of the biscuit flour was completely absent in the whey powder. Furthermore, the base wheat flour contain crude fiber which was found to possess lower levels of fat and ash and higher moisture indicated that the biscuit wheat flour and the whey powder contained carbohydrate level (75.3%). The proximate chemical composition carbohydrate of the whey powder was slightly lower than the range of 65-70% and lower than the value of 75.9% [13]. The value of fat content of biscuit flour was 1.67% fat. The level of fat in the biscuit flour, under study, was lower than the range of 2.1-2.35% fat in four Sudanese wheat cultivars (Deberia, Elnelaini, Condor and Sasaraib). The fat content of the whey powder was higher than the value of 0.9% fat.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Dry Gluten</th>
<th>Wet Gluten</th>
<th>Gluten index</th>
</tr>
</thead>
<tbody>
<tr>
<td>control</td>
<td>27.50 ± 0.06a</td>
<td>9.20 ± 0.06a</td>
<td>91.13 ± 2.32a</td>
</tr>
<tr>
<td>A</td>
<td>26.53 ± 0.03b</td>
<td>9.30 ± 0.30b</td>
<td>96.27 ± 1.40bc</td>
</tr>
<tr>
<td>B</td>
<td>22.10 ± 1.20b</td>
<td>6.83 ± 0.07b</td>
<td>93.07 ± 0.12bc</td>
</tr>
<tr>
<td>C</td>
<td>14.30 ± 0.15c</td>
<td>5.23 ± 0.19b</td>
<td>99.13 ± 0.09bc</td>
</tr>
</tbody>
</table>

*Each value in mean of three measurements.
**Mean values (± SD) having different superscript letters in columns differ significantly (p ≤ 0.05)

Where:
- Control: Biscuit wheat flour (base).
- A: 95% biscuit wheat flour + 5% whey powder
- B: 90% biscuit wheat flour + 10% whey powder
- C: 85% biscuit wheat flour + 15% whey powder

Table 3: Effect of whey protein substitution on quantity and quality of biscuit wheat flour gluten.

Table 2 shows the biscuit wheat flour and whey powder composition.

Table 2: Amino acid profile for biscuit wheat flour and whey powder.
pea were found to be 31.2, 30.2, 30.5, 28.7, 27.3 and 23.1% respectively [17].

Dry gluten content: The biscuit wheat flour (control) gave 9.20% dry gluten; while biscuit wheat flour substituted by 5%, 10% and 15% whey powder gave 9.30%, 6.83% and 5.23% dry gluten respectively. The highest dry gluten level was found in the control biscuit flour and the flour substituted by the 5% whey powder. Which were none significantly different (P<0.05) in their dry gluten level. The lowest dry gluten level was seen in the biscuit wheat flour and substituted by 15% whey powder.

Gluten index: The biscuit wheat flour (control) gave 91.13 gluten index, while wheat flour with 5, 10, 15% whey powder gave 96.27, 93.07 and 99.13% gluten indices respectively. The highest gluten index was obtained by the addition of 15% whey powder, while the lowest value was found in the control base flour. All flour mixtures were significantly different with respect to their gluten index. A lower value of gluten index (80.29) for biscuit wheat flour [17]. The results indicated that substitution by the varying levels of whey powder reduced the gluten quantity, the lowest being in the flour substitution by 15% whey. On the other hand, substitution has resulted in increased gluten quantity; the highest was noticed in the biscuit wheat flour substituted by 15% whey. The increased gluten index lowered the quality of the biscuit flour (Table 3).

Sensory evaluation of biscuits

Table 4 shows the score of sensory evaluation of biscuit made from 100% biscuit wheat flour (control) and biscuits made from wheat flour replaced by three different levels of whey powder. Biscuits were evaluated for color, aroma, texture, taste and overall acceptability. Increasing levels of whey powder resulted in increased scores of color. The reaction of amino acids with carbohydrate (millered reaction) could be responsible for the color formation in the final product [18-21].

Conclusion

The values obtained increased from 3.7 (control) to the highest score of 7.46 (15% replacement). A significant difference (p ≤ 0.05) was observed in score of color between biscuits made from the control and those from whey powder-supplemented flours. Increasing the levels of supplementation with whey powder also resulted in a significant increase in the score of aroma of biscuits. The values obtained were 4.01 (control), 5.31 (5% substitution), 6.53 (10% substitution) and 6.53 (15% substitution). The score of taste was increased with increasing whey powder levels in the substituted flours with significant difference at a level of (p ≤ 0.05). The values obtained were increased from 4.09 (control) to the higher value of 6.53 (10% replacement). The sensory evaluation of biscuits showed that there was a significant difference in the overall acceptability of biscuits made by different levels of whey powder supplementation. Biscuits made from wheat flour supplemented by 10% whey powder showed the best panelist’s scores for overall acceptability of the biscuits produced. The panelists scores indicated that all sensory attributes evaluated were improved by inclusion of increasing levels whey powder in the base flour (100% biscuit wheat flour) used for the production of biscuits. Earlier reports found that milk and milk derivatives were used for color improvement, water absorbing, and spread control properties and flavor in baked goods. Adding of milk was reported to help the product to brown during baking and add to its nutritive value. Whey protein is widely used in various food applications due to their interesting functional properties such as thickening and fat and flavor binding capacity.

References


<table>
<thead>
<tr>
<th>Treatment</th>
<th>Color</th>
<th>Aroma</th>
<th>Texture</th>
<th>Taste</th>
<th>Overall Acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>3.70 ± 0.79</td>
<td>4.01 ± 0.67</td>
<td>1.99 ± 0.35</td>
<td>4.09 ± 0.77w</td>
<td>4.09 ± 0.77w</td>
</tr>
<tr>
<td>A</td>
<td>5.78 ± 0.63</td>
<td>5.31 ± 0.53w</td>
<td>4.97 ± 0.39</td>
<td>5.02 ± 0.58</td>
<td>5.21 ± 0.45</td>
</tr>
<tr>
<td>B</td>
<td>7.07 ± 0.59</td>
<td>6.54 ± 0.47</td>
<td>6.16 ± 0.77</td>
<td>6.93 ± 0.46</td>
<td>6.87 ± 0.43</td>
</tr>
<tr>
<td>C</td>
<td>7.46 ± 0.47</td>
<td>6.53 ± 0.59</td>
<td>6.35 ± 0.62</td>
<td>6.65 ± 0.46w</td>
<td>6.49 ± 0.80</td>
</tr>
</tbody>
</table>

*Each value is a measure of three determinations.

**Mean values (± SD) having different superscript letters in columns differ significantly (p ≤ 0.05).

Control: Biscuit wheat flour (base).
A: 95% biscuit wheat flour ± 5% whey powder.
B: 90% biscuit wheat flour ± 10% whey powder.
C: 85% biscuit wheat flour ± 15% whey powder.

Table 4: Sensory attributes of biscuits.
