Summary & Conclusion
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The present investigation was carried out to study the effect of incorporation of makhana flour on physicochemical properties of blends and the biscuits made of these blends. The effect of blending of makhana flour and optimization of other ingredients such as sugar, fat and baking powder on physical, chemical and sensory characteristics of biscuits were studied. The extensive studies were made in respect to the changes in colour, appearance, flavour, taste, texture and overall acceptability of biscuits during storage. The results are summarized as below.

1. The white flour contained 10.15, 0.69, 0.63, 0.28 and 88.25 per cent protein, fat, ash, crude fiber and carbohydrates respectively.

2. The makhana flour showed 12.04, 0.53, 0.46, 0.42 and 86.55 per cent protein, fat, ash, crude fiber and carbohydrates respectively.

3. The white flour showed 0.06, 28.16, 10.28, 0.41, 2.78 and 3.19 per cent acid insoluble ash, wet gluten, dry gluten, reducing sugar, non reducing sugar, and total sugars, respectively. The pigment content in white flour was 2.99ppm. Calcium, phosphorus and iron content in white flour were 33.86, 155.74, and 2.80 mg/100 g, respectively.

4. Makhana flour contained 0.06 per cent acid insoluble ash and 3.71 ppm pigment. It also contained 0.26, 0.57, 0.83 per cent reducing, non reducing and total sugars. Calcium, phosphorus and iron content in makhana was 40.67, 79.79 and 4.46 mg / 100 g, respectively.
5. The 1000 kernel weight, bulk density, true density and porosity of popped kernels of makhana were 321.04 g, 0.062 g/cc, 0.343 g/cc, and 81.92 per cent, respectively.

6. The values of bulk density, true density, porosity, peleshenke value, and water absorption of wheat flour was 0.670 g/cc, 1.43 g/cc, 53.14 per cent, 64 minutes, and 45.60 per cent, respectively.

7. The values of bulk density, true density, and porosity of makhana flour were 0.270 g/cc, 1.00 g/cc, and 73 per cent, respectively.

8. The incorporation of makhana flour in wheat flour at 5, 7.5, 10, 12.5, 15, 17.5, and 20 per cent resulted decrease in the values of bulk density, true density, porosity, and peleshenke value. There was a significant (\( p \leq 0.05 \)) decrease in bulk density of blended flours with incorporation of makhana flour at all levels. There was a significant (\( p \leq 0.05 \)) decrease in true density of blended flour with incorporation of makhana flour in wheat flour from 7.5 to 20 per cent level. Inclusion of makhana flour in the blend above 10 per cent produced significant (\( p \leq 0.05 \)) decrease in porosity of blends. A significant (\( p \leq 0.05 \)) decrease in peleshenke values was observed with incorporation of makhana flour at all levels. The increase in values of water absorption was significant (\( p \leq 0.05 \)) with incorporation of makhana flour in wheat flour.

9. Makhana flour was incorporated at 5, 7.5, 10, 12.5, 15, 17.5, and 20 per cent level in white flour to prepare biscuits. The effect of blending showed a significant (\( p \leq 0.05 \)) increase in protein and crude fibre content at 7.5 and above level of makhana flour incorporation while a significant (\( p \leq 0.05 \)) decline in fat, ash and carbohydrate content was observed at 10 per cent and above level of makhana flour incorporation. A significant (\( p \leq 0.05 \)) increase in calcium and iron content while a significant (\( p \leq 0.05 \)) decrease in phosphorus
content was observed on incorporation of makhana flour with white flour.

10. The incorporation of makhana flour showed a significant \( (p \leq 0.05) \) increase in water requirement for proper dough consistency.

11. The incorporation of makhana flour showed a significant \( (p \leq 0.05) \) increase in weight, thickness, hardness, and cutting strength and a significant \( (p \leq 0.05) \) decrease in diameter, spread ratio, and spread factor of biscuits.

12. The increase in level of sugar showed a significant \( (p \leq 0.05) \) increase in weight, diameter, spread ratio, and spread factor and a significant \( (p \leq 0.05) \) decrease in thickness, hardness, and cutting strength of biscuits.

13. The increase in fat level showed a significant \( (p \leq 0.05) \) decrease in weight, hardness, and cutting strength of biscuits. No significant effect of fat level was observed on diameter and thickness of biscuits. A significant \( (p \leq 0.05) \) increase in spread ratio and spread factor of biscuits was observed with increase in fat level of biscuits.

14. The weight of biscuits showed a non significant variation with increase in baking powder up to 0.3 per cent. However a significant \( (p \leq 0.05) \) decrease in weight was noted with increase in baking powder level from 0.4 to 0.6 per cent. The increase in baking powder produced a non significant variation in thickness of biscuits. The increase in baking powder level showed a significant \( (p \leq 0.05) \) decrease in hardness and cutting strength of biscuits and a significant \( (p \leq 0.05) \) increase in diameter, spread ratio and spread factor of biscuits was observed.

15. The incorporation of makhana flour showed a significant \( (p \leq 0.05) \) increase in moisture, protein, and crude fibre content and a significant \( (p \leq 0.05) \) decrease in ash and carbohydrate content of biscuits. No significant effect on fat content of biscuits was
observed with makhana flour incorporation. A significant (p ≤ 0.05) increase in calcium and iron content, however, a significant (p ≤ 0.05) decrease in phosphorus content was noted with increase in makhana flour incorporation in biscuits.

16. On the basis of amino acid analysis, the wheat flour was deficient in lysine and complete absence of glutamic acid and glycine was noted in it. However, makhana flour was rich in lysine, and also contained glutamic acid and glycine but alanine was absent in it. Makhana flour incorporation in biscuits enriched them with lysine, glutamic acid and glycine. Thus, the number and quantity of amino acids increased in the biscuit, making it nutritionally rich.

17. On the basis of sensory evaluation, the biscuits prepared with 10 per cent incorporation of makhana flour showed a non significant variation in the colour, appearance, taste, and overall acceptability scores with the control biscuits. The texture and flavour scores differed significantly (p ≤ 0.05) with the control, but the scores were in the acceptable range.

18. The sugar level 22.5 per cent was optimized, as the biscuits were found significantly (p ≤ 0.05) superior on the basis of sensory evaluation in colour, appearance, flavour, taste, texture, and overall acceptability.

19. On the basis of sensory evaluation, the biscuits prepared with 16 per cent fat level were found most suitable as it improved significantly (p ≤ 0.05) the colour, appearance, flavour, taste, texture, and overall acceptability of biscuits.

20. Similarly, 0.3 per cent of baking powder improved significantly (p ≤ 0.05) the sensory characteristics of biscuits such as colour, appearance, flavour, taste, texture, and overall acceptability. Hence, 0.3 per cent level of baking powder was optimized for further
studies.

21. On the basis of physical, chemical, nutritional, and sensory evaluation the biscuits prepared with 10 per cent incorporation of makhana flour, 22.5 per cent sugar, 16 per cent fat, and 0.3 per cent baking powder were found most acceptable. Hence these levels were taken as optimized level for further studies.

22. On the basis of storage studies, the biscuits may be stored successfully for 90 days at room temperature without adversely effecting moisture level, free fatty acid content and peroxide value as, all these parameters were in the range as per BIS specifications of biscuits (1992).

23. Similarly, on the basis of organoleptic evaluation no significant variation was observed in colour and appearance after 90 days of storage. No significant (p ≤ 0.05) change was observed in the flavour and taste on 60 days of storage. However, a significant (p ≤ 0.05) variation in texture score was found at 30 days of storage. No significant (p ≤ 0.05) variation in overall acceptability was noted up to 30 days of storage. On the basis of sensory evaluation it was observed that the biscuits were found in the highly acceptable range on 90 days of storage.