CHAPTER VI

SUMMARY

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CONCLUSION
SUMMARY

Chapati is the main traditional staple food consumed by majority of the population in the Indian subcontinent and is also widely consumed in UK, and other countries, particularly by the Asian ethnic community. In India, different wheat varieties are produced, however, not all varieties are suitable for chapati preparation. The chapati quality is influenced by the contents of protein, protein characteristics, damaged starch and pentosans. The use of unsuitable whole wheat flour for chapati preparation affects quality of the product resulting in a tough or fragile, non-pliable and undesirable chapati.

Chapatis are generally consumed fresh, however, due to urbanization there is a need for ready to eat foods. Just like bread, chapatis are also known to stale on storage, and due to their larger surface area, chapatis stale faster than bread. Incorporation of additives like chemicals and enzymes may improve quality of chapatis and prevent their staling. However, enzymes are preferred over chemicals as dough improvers, as they are generally regarded as safe. Chapati preparation involves various processing steps like mixing the flour into dough, sheeting and baking. During these processing steps, flour components are likely to undergo changes with respect to their nutrients and polyphenol composition, and their antioxidant properties due to phenol mediated cross-linking of proteins and carbohydrates.
In the present study ten wheat varieties were evaluated for their physico–chemical and chapati making quality. Further, effect of enzymes like amylases, xylanase, peroxidase and pentosans on the improvement of chapati quality and its nutritional and nutraceutical properties were systematically investigated.

The results of this study are summarized below.

1. The damaged starch, total protein and total sugar contents in whole wheat flour in ten wheat varieties ranged from 12.3 to 17.6%, 11.6 to 14.6% and 0.84 to 1.41%, respectively.

2. Water absorption of whole wheat flour as measured in Brabender Farinograph, varied from 69.9% to 77.8%.

3. Gelatinization temperature ranged from 63.6ºC to 76.5ºC in the amylograph studies. The wheat variety GW-322 had the highest paste viscosity of 567 BU and cold paste viscosity of 809 BU.

4. Objective measurement of chapatis, like puffed height varied from 4.7 to 5.5 cm and shear force ranged from 4.2 to 8.5 N.

5. Sensory properties of chapatis prepared from wheat varieties DWR-162, DWR-39, GW-322, and NI-5439 had very appealing wheatish brown color with uniform dark spots. On the other hand, color of chapatis made from wheat varieties MACS-2496 and K-9644 was relatively darker. Evaluating the overall quality of chapatis, the varieties DWR-162, DWR-39 and GW-322 produced highly
acceptable chapatis. This was closely followed by those prepared from NI-5439, NIAW-34, HD-2501 and HD-2781.

6. Moisture contents of control chapatis prepared from GW-322, NI-5439, MACS-2496 and HD-2781 varieties decreased by 4.6 – 6.0% on storage for 96 h. However, in chapatis prepared with enzyme treated dough the decrease in moisture contents was low. The moisture content of chapatis prepared from fungal α-amylase, bacterial α-amylase and combination of bacterial α-amylase and xylanase treated doughs decreased by 2.4 – 2.7%, 1.4 – 1.8% and 0.4 – 2.0%, respectively on storage for 96 h in all the varieties.

7. Chapatis prepared from the dough treated with bacterial α-amylase, xylanase, fungal α-amylase and combination of bacterial α-amylase and xylanase had shear force of 2.4 to 2.8 N, 2.3 to 2.8 N, 3.2 to 3.8 N and 2.2 to 2.5 N, respectively, which were less than the control chapatis. This indicated that chapatis prepared from dough treated with enzymes yielded softer chapatis.

8. The overall sensory quality scores of control chapatis prepared from GW-322 and NI-5439 were 7.1 and 7.2, respectively, while the overall quality scores of chapatis prepared from enzyme treated doughs of these varieties increased significantly and their values ranged from 7.6 to 8.0. Thus, the results indicated that chapatis prepared from enzyme treated dough had better pliability and higher overall quality compared to control.
9. The microstructure of chapatis prepared from enzyme treated dough were uniform with distorted starch granules surrounded with protein matrix, while in control chapatis, the starch granules were spherical with protein matrix overlapping on one another to form aggregation.

10. Soluble starch, soluble amylose and amylopectin contents of chapatis prepared from dough treated with bacterial $\alpha$-amylase were higher than the control chapatis. Amylograph paste viscosity was low in chapatis prepared from bacterial $\alpha$-amylase treated dough. This may be due to higher residual enzyme activity in chapatis prepared from dough treated with bacterial $\alpha$-amylase compared to other variations.

11. There was no change in the carbohydrate, protein and fat contents of chapatis on treatment with enzymes, however, the insoluble dietary fibre content was more in chapatis compared to their respective whole wheat flours.

12. Soluble polyphenol content of chapatis (control) prepared from different wheat varieties varied from 820 to 905 $\mu$g g$^{-1}$ and was found to be lower than their corresponding whole wheat flours (940 - 1132 $\mu$g g$^{-1}$).

13. In chapatis prepared from fungal $\alpha$-amylase, bacterial $\alpha$-amylase and xylanase treated doughs, the soluble polyphenol contents ranged from 956 to 1135 $\mu$g g$^{-1}$, 1208 to 1501 $\mu$g g$^{-1}$, and 892 to
1007 µg g⁻¹, respectively. Of these enzyme treatments, amylases increased soluble polyphenol content significantly compared to control chapatis.

14. The free radical scavenging activity of chapati extracts were compared with BHA, which is a synthetic antioxidant. It was observed that only the extracts of chapatis prepared from bacterial α-amylase treated doughs possessed higher scavenging activity than that of BHA.

15. The chapatis prepared from dough treated with enzymes had higher amount of total free phenolic acid contents compared to control chapatis, especially chapatis prepared from bacterial α-amylase treated doughs (176–189 µg g⁻¹).

16. The estimated total pentosan contents in whole wheat flours of DWR-162, DWR-39 and GW-322 varieties were 4.7%, 4.1% and 4.1%, respectively, which were higher than the other wheat varieties (3-3.9%). The arabinose-xylose ratios were high in DWR-162, DWR-39 and GW-322 varieties (1.24-1.28%) whereas, the arabinose-xylose ratios of HD-2189 and MACS-2496 wheat varieties were low indicating that it might be due to lower degree of branching in these pentosans.

17. The yields of water soluble pentosans isolated from DWR-162, DWR-39, GW-322, NI-5439 and NIAW-34 wheat varieties were higher (3.0 – 3.1%) compared to other wheat varieties. However, the arabinose-
xylose ratios of water soluble pentosans from DWR-162 and DWR-39 wheat varieties which are known to have good chapati making property were high.

18. Farinograph water absorption increased from 2.0 to 5% for good chapati making variety whole wheat flours, whereas only 0.3 to 0.6% for poor chapati making quality whole wheat flours upon addition of 0.25 – 0.5% water soluble pentosans to flours.

19. The increase in Amylograph paste viscosity was high for good chapati making quality flours and it was low for poor chapati making quality flours upon addition of 0.5% water soluble pentosans. Similarly increase in cold paste viscosity was high for good chapati making quality flours and it was low for poor chapati making quality flours upon addition of 0.5% water soluble pentosans.

20. An increase in puffed height and decrease in shear force of chapatis was observed on addition of water soluble pentosans to the whole wheat flours. Sensory scores of chapatis prepared from wheat varieties having poor chapati making quality increased significantly on adding water soluble pentosans of wheat varieties having good chapati making quality.

21. The gluten protein extractability decreased by about 20% upon treatment of dough with peroxidase compared to control. The -SH content decreased from 16.8 to 10.9 µmole/g gluten, while –S-S-
content significantly increased from 7.3 to 10.5 µmole/g gluten. Thus, the decrease in solubility of gluten proteins in SDS solution may be due to protein cross-linking through disulfide bonds in protein.

22. Upon treatment with peroxidase, the molecular weight of salt soluble wheat proteins increased. The yield of high molecular weight fraction (peak I) also increased upon treatment with peroxidase. In case of control, it was 25%, while in peroxidase treated dough the peak I yield was 32%. It is to be noted that there is a decrease in yield of peak III which is around 30 kDa. This increase may be due to peroxidase mediated cross-linking of proteins, in addition to increase in molecular weight of proteins.

23. Farinograph characteristics like water absorption of whole wheat flour treated with peroxidase, increased from 76.0 (control) to 81.4%, dough development time decreased from 5.0 to 4.6 min and dough stability increased from 1.3 to 2.5 min.

24. The puffed height of chapatis prepared from dough treated with 2,500 U and 10,000 U peroxidase increased by 0.2 and 0.6 cm, respectively.

25. Protein digestibility of chapatis prepared from dough treated with peroxidase was not significantly different from control chapati. GI of chapatis prepared from peroxidase treated dough was significantly lower than control chapatis (without treatment).
CONCLUSIONS

Ten wheat varieties were evaluated for their physico-chemical properties and chapati making properties. Of these, DWR-162, DWR-39 and GW-322 varieties yielded highly acceptable chapatis. This was closely followed by those prepared from NI-5439, NIAW-34, K-9644, HD-2501 and HD-2781. Varieties MACS-2496 and HD-2189 had low overall quality scores. The total protein content in these varieties ranged from 11.6 to 14.6%. The total protein content did not show any correlation to the tearing strength, puffed height or overall scores of the chapatis. Few studies indicate that wheat varieties having protein content of 9.5 to 10.5% were found to be more suitable for chapati preparation. However, no such relation was observed in the present study. The present study indicate that total protein content of wheat alone may not govern the chapati quality of a particular wheat variety, rather characteristics of protein and other major constituents of wheat may also contribute to the quality of chapati.

Chapatis are generally consumed fresh, However, due to urbanization there is a need for ready to eat foods. Just like bread, chapatis are also known to stale on storage. Carbohydrates are the major constituents of wheat and starch constitutes about 80% and pentosans (arabinoxylans) constitute about 5-8% of the whole wheat flour. Changes in structural properties of these constituents may improve the quality characteristics of chapatis. Chapatis prepared from dough treated with
amylases and xylanase yielded soft textured chapati with improvement in overall quality and retained the same quality on storage for 96 h. The improvements in chapati quality observed upon addition of amylases and xylanase may be due to changes in starch and pentosan properties, respectively. There is an increase in the soluble starch contents and also alterations in structures of starch granules in chapatis incorporated with amylases. Thus, the addition of amylases and xylanase had improved the texture and shelf-life of chapatis.

In addition to improving the sensory and shelf-life of chapatis, treatment of amylases and xylanase had enhanced the nutraceutical and antioxidant properties of chapatis. Treatment of dough with amylases had increased the contents of soluble dietary fibre and polyphenols as well as antioxidant properties significantly, while treatment of dough with xylanase has increased antioxidant properties compared to control chapatis. Therefore, similar treatment with these enzymes may increase the content of nutraceuticals in other wheat based products also. Enzymes are preferred over chemicals as food additives to improve the quality of food products as they are natural and safe. As reported in the present study, additional benefit of improvement in nutraceutical properties will encourage the use of enzymes in food products.

Pentosans play an important role in water balance of wheat dough, rheological properties of dough, retrogradation of starch and bread making quality. Addition of water soluble pentosans to whole wheat
flours had improved the overall quality of chapatis. However, the water soluble pentosans from good chapati making wheat varieties resulted in soft textured chapatis with improvement in overall quality compared to that of water soluble pentosans of poor chapati making wheat varieties. These improvements are attributed to differences in their arabinose to xylose ratio. Thus, the studies showed that the quality of chapatis can also be improved by the addition of water soluble pentosans from good chapati making wheat varieties.

Treating the dough with peroxidase had altered the properties of proteins, Farinograph characteristics of dough, chapati quality characteristics, and glycemic index of dough and chapati. Peroxidase treatment of dough had increased the molecular weight of proteins and decreased their solubility due to their cross-linking through disulfide bonds. This change in protein properties does not result in decrease in digestibility of proteins. However, peroxidase treatment of dough had decreased the glycemic index of dough and chapatis, which were prepared from it. Peroxidase treatment also increased the overall quality of chapati of poor chapati quality variety. Decrease in glycemic index is a health beneficial effect. Thus, peroxidase treatment has not only improved the quality of chapatis but also improves the health benefits.