SUMMARY

Wheat is one of the major staple foods consumed all over the world. Major varieties of wheat include *T. aestivum*, *T. durum* and *T. dicoccum*. These three varieties are grown abundantly and extensively used in food production. *T. aestivum* is used in bakery products especially in bread production and in noodle production. *T. durum* is used in pasta products. *T. dicoccum* is used in Indian tradition food preparation chapti. Noodles are becoming more popular among all the regions and age groups, due to its palatability and ease of preparation. As the noodles are prepared with *T. aestivum* it is not recommended for the diabetic population as the release of glucose to the blood is rapid during digestion and absorption. Present study investigated the utilization of different modification techniques to formulate a low glycemic index noodles, beneficial for the diabetic population.

Diabetes mellitus is a group of metabolic disorders identified by high blood glucose levels. Majorly there are three types of diabetes namely, Type 1-due to non-functioning of pancreas to produce insulin. This condition is also referred to as insulin dependent diabetes mellitus (IDDM). Type 2-due to insufficient insulin in the body and/or non-responsive cells in the body to insulin. This condition is also referred to as non-insulin dependent diabetes mellitus (NIDDM). Gestational diabetes occurs in pregnant women with no previous history of high blood glucose levels and may/may not disappears during lactating period. Type 2 and gestational diabetes can be controlled by changing the life style and food habits of an individual. Diabetes can be controlled not only by medication, but also by adapting healthy life style. Modification of ingredients is an upcoming trend in food industries. By modifying starches, its physical and chemical properties can be altered. Chemically and enzymatically modified starches shows a unique characteristics by increase in the resistant starch, slowly digestible starch content and decrease in the rapidly digestible starch content. These factors are important in formulating low glycemic index products. Food products, which are prepared from these modified ingredients, may help the consumers who are in the risk of Diabetes, Cardio vascular disease and other health related consequences in the case of healthy individuals. Also it helps to reduce the severity of the disease condition in case of affected population. Low GI ingredients alone and with modification of its constituents may help humans in improving the health. By adapting to this type of diet in the day to day life, the affected individuals can get rid of external source of insulin and medicines, which they will consume to lower the blood glucose level. Different ingredients were chosen for the study and blends were prepared from the selected ingredients in different proportions. The rheological studies indicated the suitability of blends for the preparation of noodles. All the prepared
noodles were analysed for its physico-chemical characteristics. Analysis indicated the improved protein content in the noodles. From the study it can be concluded that pulses have positive effect lowering starch digestibility and simultaneously the blood glucose levels. Different chemicals were used for the modification of the ingredients. Chemicals such as sodium bicarbonate, succinic anhydride, octenyl-succinic anhydride and potassium permanganate were used. With modification process there was an increase in Farinograph water absorption, Amylograph pasting property and Alveograph maximum overpressure. This is due to the modification process, which changed the internal structural properties, justified by the scanning electron microscopic studies and infrared spectroscopy analysis. The most effective modification processes were taken for GI analysis. Samples indicated that modified T. durum sample with succinic anhydride reduced GI up to 27% compared to unmodified samples. Same trend was followed in T. dicoccum samples with reduction of 24%. So, with modification product quality characteristics were improved in terms of its physical, chemical and nutritional aspects.

An enzyme and an enzyme inhibitor were used to modify the samples. Basic ingredients were chosen for the study such as T. aestivum, T. durum and T. dicoccum. With α-amylase inhibitor the peak viscosity and maximum viscosity increased in samples. Samples modified with branching enzyme showed increase in the gelatinization temperature due to the formation of polymer structure. Modification with branching enzyme increased water absorption, dough development time and stability significantly. Colour and texture of the noodles confirmed the improved quality characteristics of the noodles after modification, with improved firmness after modification. Noodles were acceptable sensorily after modification of the ingredients with overall quality score of above 8 on 15 cm quantitative descriptive analysis scale indicating the retention and improvement of the quality parameters after the modification. In vitro starch digestibility of the sample reduced significantly after modification with the inhibitory action of the α-amylase inhibitor and formation of amylopectin due to branching enzyme action. Samples given for the glycemic index analysis indicated positive reduction in postprandial blood glucose levels in the healthy subjects. High Performance Size Exclusion Chromatography analysis indicated the formation of amylopectin with increase in the area of the peak obtained with the branching enzyme modification. Therefore, the effective enzymatic modification method to improve the nutritional quality can be with the use of branching enzyme.

Shelf-life study of the noodles indicated that samples stored at ambient condition can be stored for long time than in accelerated condition. Samples such as succinic anhydride
modified oat flour incorporated noodles (OF-SUC) and octenyl-succinic anhydride modified guar powder incorporated noodles (GP-OCT) can be stored for 180 days with the GI value not exceeding 60. Samples indicated good textural properties and sensory characteristics till 120 days, later the quality drastically declined. After 180 days the samples indicated reduced quality characteristics, so the analysis was terminated after 180 days for chemically modified samples. Samples modified with enzyme can be stored for 60 days at ambient condition and 30 days at accelerated condition with reduction in the product quality. During the storage period quality deteriorated slowly in all the samples.

In a nut shell it can be stated that the modification processes improved the noodle quality in terms of its physico-chemical and nutritional factors. These changes in the noodle quality parameters are beneficial for the population in need. The overview of the study with the percentage reduction in the glycemic index is depicted graphically in Fig.6. Glycemic index of the samples was reduced up to 27% compared to control. In case of enzymatically modified samples with branching enzyme showed improved product quality in terms of increased firmness and chewiness. Reduction of glycemic index was observed up to 20% compared to control. The output in terms of different products and its quality characteristics are represented in Fig.7.
Fig. 6 OVERVIEW OF THE RESULTS ACHIEVED FROM THE STUDY - Percentage reduction of the glycemic index of the noodles prepared with modified ingredients compared to control noodles

A - Noodles with low GI ingredients; B - Noodles with chemically modified ingredients; C - Noodles with enzymatically modified ingredients
OUTPUTS FROM THE STUDY

Noodles with pea flour
- High protein (15%)
- Low glycemic index (54)

Noodles with rajma flour (9.0)
- High dietary fiber (14%)
- Low glycemic index (45), stable up to 120 days

Noodles with oats flour (SUC)
- High soluble dietary fiber (5%)
- Low glycemic index (54), stable up to 180 days

Noodles with guar powder (OCT)
- Low glycemic index (46)
- Increased firmness, stable up to 180 days

Noodles with T. aestivum (Branching enzyme)
- Good palatability
- Reduced glycemic index (60), stable up to 60 days

Fig.7 Outputs in terms of products from the study
CONCLUSION

Modifying starch is an upcoming and innovative trend in the food industries. Modification of starches will be done to improve the different physical, chemical and nutritional factors. This is the first study where different wheat varieties and low GI ingredients were modified using different methods of modification. Modification was carried out using the chemicals such as sodium bicarbonate, succinic anhydride, octenyl-succinic anhydride and potassium permanganate, an enzyme (branching enzyme) and an enzyme inhibitor (α-amylase inhibitor) were also used for the modification. Among the different modification techniques, the best modification obtained from succinic anhydride and octenyl-succinic anhydride in case of chemical modification. Branching enzyme showed positive results by reducing the GI of the noodles in case of enzymatically modified samples. The samples such as succinic anhydride modified oat flour incorporated noodles (OF-SUC) and octenyl-succinic anhydride modified guar powder incorporated noodles (GP-OCT) were the best among all the chemically modified samples, with the reduction in IVSD, RDS and increase in SDS, RS (3 folds). Samples modified using branching enzyme also showed improved product quality and reduced RDS, IVSD. Improvement of product quality in terms of reduced cooking loss and textural properties were observed with both the chemical and enzymatic modification. From the study it can be concluded that different modification techniques can be used to modify the ingredients so that there will be noticeable changes in the physical, chemical and nutritional aspects of the final products. These prepared products can be beneficial for the people in need with different health related consequences such as diabetes mellitus. People with diabetes and also healthy individuals will be benefited with the prepared noodles with modified ingredients in maintaining their normal blood glucose level. Changing the life style with the adoption of these types of foods in their day to day life may be advantageous for maintaining the normal health.