Summary and Conclusion
Chapter : 4

SUMMARY AND CONCLUSION

Maintenance of health calls for a diet containing a mixture of foods sufficient in quantity and quality to provide all the required nutrients. However, in under or over nutrition or in chronic diseases it is necessary to modify the diet by including or avoiding some substances which may be beneficial or harmful in these circumstances. Available evidence indicates that hypercholesteremia is increasing in certain segments of the population, particularly in urban areas of our country. The main causes are hypertension and a sedentary life style, both of which are the anti-benefits of the globalisation scenario in the 21st century. The same factors also cause diabetes, which is the most prevalent chronic disease in the world. Both these diseases are caused due to over nutrition. However, among various diseases caused due to undernutrition, protein energy malnutrition is the major nutritional deficiency disease especially among children. This is true for all the third world countries of the world including India. It is caused due to a deficiency of protein or energy or both.

The World Food Summit (WFS 1996) reaffirmed the right of everyone to have access to safe and nutritious food. With the advancement in the field of nutrition, it is becoming increasingly clear that there is a strong relationship between the food we eat and our health. Due to the globalisation scenario in the new millennium, there is an increased demand for processed foods. Changes in the socio-economic conditions have also increased the domestic demand and consumption of processed food in India.

At present, bakery industry is one of the leading industries among other food based industries in India, with a growth rate of 8% per annum. However, per capita consumption of bakery products is very low, at present.

Normally bakery products are prepared with refined wheat flour (maida), hydrogenated fat (vanaspati) / shortening and sugar as the principle ingredients. These are calorie dense, bearing negligible fiber and contain low quantity and quality of protein. Therefore, continuous consumption of these may lead to certain nutritional disorders and major chronic diseases. Thus, it
is high time for the development of various healthy and therapeutic bakery products by modifying the existing commercial products. Modification in bakery products may be done by replacing the refined wheat flour, shortening and sugar or all of these with such ingredients which will enhance the nutritional or therapeutic value of the existing commercial products.

Fiber plays an important role in reducing the risk of cardiovascular diseases. It is also useful for easy bowel movement and in overcoming constipation. It is also beneficial in the management of chronic diseases such as obesity, hypertension, diabetes, etc. Refined cereals are the basis for all baked products but they are low in fiber content. Research has indicated that various brans and cereals could be incorporated as sources of dietary fiber into a formulated product for contribution towards nutritious and dietetic product development. Recent claims of therapeutic uses have evoked interest in psyllium husk. Hence, if acceptable products could be developed using psyllium husk, modifying the type of fat and minimising its level along with a concomitant decrease in the sugar content, it would be beneficial in hypercholesteremic conditions. Such products could be recommended as replacements for commercial bakery products in hypercholesteremia. Increases in fiber from a variety of dietary sources have shown to improve glycemic control in type II diabetics. Wheat bran is a rich source of fiber and other nutrients as well. Wheat bran also improves gastrointestinal health, prevents constipation and lowers the risk of tumor development and cancer. Wheat bran can be used to increase the fiber content in bakery products. Such products could replace commercial bakery products in the diabetic diet. Use of soya flour in bakery products could achieve nutritional improvement, along with other physical properties without disturbing the physical and sensory qualities. Such high protein products can be recommended as replacements for commercial bakery products which are generally low in protein in order to promote the growth of children.

The literature reviewed suggests that some work has been carried out on the development of therapeutic bakery products but very limited work has been carried out on aspects such as the evaluation of their nutritional/therapeutic effect, in India. On the other hand health consciousness and domestic consumption of bakery products is increasing due to the

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globalisation scenario. Therefore, this is the time to enrich commercially available bakery products.

In this background, the present study was planned to develop nutritionally modified and therapeutic bakery products. Products selected based on their commercial acceptability were: biscuits and bread. The modifications focused on three highly prevalent conditions of imbalanced nutritional status namely hypercholesteremia and maturity onset diabetes mellitus as well as protein energy malnutrition. The food ingredients selected were psyllium husk, wheat bran and defatted soya flour based on their nutritional merit for the above conditions.

Three different products were developed and then evaluated. These were psyllium husk fortified biscuit, wheat bran fortified bread and soya fortified biscuits. Thus the study was divided into three experiments. Each experiment was further divided into three parts namely product development, food property analysis and nutritional assessment.

The first experiment deals with the development of psyllium husk biscuits, analysis of various food properties and their evaluation through rat experiment. For product development, two commercial recipes namely vanilla as well as sweet and salty biscuit were selected and prepared successfully under laboratory conditions. Thereafter multipurpose white flour was replaced with whole wheat flour, followed by reduction in sugar levels, along with this salt and ajwain were added to the basic formula, further vanaspati levels were reduced. This was now considered as the control formula. Biscuits fortified with psyllium husk at various levels to whole wheat flour along with modification in fat sources (replacing vanaspati with groundnut oil or palm oil) at different levels were developed followed by sensory evaluation. Finally, 5 types of biscuits were analysed and the biscuit showing the highest sensory score was selected as the ‘experimental biscuit’. To assess nutrient levels and physico chemical properties whole wheat flour and psyllium husk used for product preparation were analysed for moisture, protein, fat, carbohydrate, fiber (total, soluble and insoluble), ash and mineral (calcium, phosphorus and iron) content. Raw ingredients and their composite flours based on the 2 raw ingredients (i.e. psyllium and whole wheat flour) were analysed for physico chemical characteristics such as water absorption power, wet and dry gluten.
content, sedimentation value, alkaline water retention capacity etc. The 5 biscuits finally developed were also analysed for physical properties namely weight, width, thickness, spread ratio, per cent spread factor and hardness along with the control biscuit.

The control formula was based totally on whole wheat flour in place of multipurpose white flour, with 30% sugar along with 2.5% salt and 3% ajwain containing 20% vanaspati. Initially whole wheat flour was replaced with psyllium husk on a wider range from 2 to 16%, where 14% psyllium husk supplementation showed best results based on sensory evaluation. Further on a narrow range of 13 to 15% psyllium husk supplementation, biscuits were subjected to further sensory evaluation. During this product optimization. 13.5% psyllium husk replacement scored the highest. Fat sources finalised for incorporation was vanaspati : groundnut oil in the ratio of 1:1 with a view to decreasing the level of hydrogenated fat. This experimental product was subjected to food property analysis.

Nutrient analysis of control biscuit and 13.5% psyllium husk biscuit showed 7.21 and 6.60 g% protein, 15.82 and 17.03 g% fat, 67.70 and 58.36 g% carbohydrate, 479.48 and 445.59 kcal %, 0.76 and 8.13 g% total fiber, non traceable and 6.87 g% soluble fiber, non traceable and 1.25 g% insoluble fiber content.

Physio-chemical properties of the bread indicated an increase in sedimentation value and alkaline water retention capacity as the level of psyllium husk increased. Weight, width, spread ratio, spread factor were reduced in biscuits upon replacing vanaspati with palm oil or ground nut oil. Hardness was increase upon addition of any of the vegetable oils. The cost price of experimental biscuit was increased by Rs. 12.45/kg due to the high cost of psyllium husk. This experimental product was now selected for evaluation of it’s hypocholesteremic properties through animal experimentation.

To assess the hypocholesteremic effect initially (before the beginning of experimental feeding) 6 animals (one group) were sacrificed to assess the initial lipid profile. Now 36 adult albino rats were fed a hypercholesteremic diet consisting of raw wheat : bengal gram dhal (80 : 20) providing 10% protein supplemented with 0.5% cholesterol and 0.5% taurocholic acid along with...
3.5% salt mixture, 1% vitamin mixture and 7% vitaminized oil for 7 weeks. After 7 weeks of feeding, one group of animals (6 rats) was sacrificed to confirm hypercholesteremia. The remaining 30 animals were divided into five groups and fed the following diets: Group I was continued on the same hypercholesteremic diet, the second group was fed control diet containing 7.5% psyllium husk (similar to the level of psyllium husk in the experimental biscuit) whereas group III was fed control diet containing 15.48% fat (similar to the level of fat in the experimental biscuit). The fourth group was fed the experimental biscuit (7.5% psyllium husk and 15.48% fat) and the last group was fed the commercial biscuit, for 4 weeks. Body weight was recorded weekly while diet intake and fecal output were recorded for the last one week. Animals were sacrificed and analysed for various parameters namely haemoglobin, plasma total protein, total, free, HDL, VLDL, LDL, cholesterol, triglyceride etc., while liver was analysed for moisture, total protein, total lipid and various cholesterol fractions. Similar estimations were carried out from the kidney.

The diet intake of the experimental groups fed psyllium husk either in the form of biscuit or psyllium husk added to the control diet was the highest among all the groups. Food intake was least in the groups fed commercial biscuit and therefore this group showed abnormal changes in all the parameters. The protein and cholesterol intake were found to be highest in groups containing added psyllium husk.

The fat/oil intake was the highest in the commercial biscuit group as it contained the highest fat. Fiber intake was about 10 times more in the groups with added PH compared to the other groups.

Commercial biscuit showed maximum weight loss. They weighed 15-20 g less compared to all the other groups, although weight loss was observed in all the groups.

A positive result of the study was found in the case of experimental biscuit which showed the second lowest LDL cholesterol level. The plasma lipoprotein profile of the developed biscuit showed positive results compared to the control diets.

All the groups showed nearly similar values for free : total cholesterol ratio x 100 and no significant differences were found. Plasma triglyceride...
levels of the control group showed the highest value and was found to be significantly different from the rest of the groups.

The liver weight of the experimental animals ranged from 6.32 to 7.54 g. Animals fed the control diet containing high fat (15.48%) and commercial biscuit (containing 29.73% fat) ranked highest and second highest, respectively.

The liver total lipid content of animals fed control diet containing high fat was found to be higher compared to the animals fed the control diet. Liver protein levels of the group fed experimental biscuit was found to be lower compared to the control diet, may this could be because the cereal pulse combination (i.e. wheat : bengal gram) was used in the control diet and only cereal was used as a source of protein in the case of experimental biscuit.

Liver total cholesterol decreased when psyllium husk was added to the diet, either as such or in the form of experimental biscuit. Animals fed the control diet along with high fat showed the second highest total cholesterol level per liver.

Experimental groups fed control diet along with high fat and commercial biscuit showed slightly higher values for kidney weight compared to the animals fed control diet. Kidney total lipid levels increased when more fat was included in the diet.

Overall, the biscuit with psyllium husk having hypocholesteremic properties showed the potential to be developed successfully. The animal feeding of the same showed a positive result.

The second experiment deals with the development of wheat bran enriched bread, analysis of various food properties of the developed bread and it's evaluation through a human experiment.

For product development, simple (straight dough method) bread preparation formula was selected and prepared successfully under laboratory conditions. Minor modification in ingredients and processing conditions led to the control formula. Further vanaspati was totally replaced with groundnut oil in the formula. Now wheat bran was supplemented at various levels, initially from 3-15%, from this 9% was selected as the most acceptable wheat bran bread. Therefore, wheat bran was than supplemented at levels between 7.5 to 10.5%. Finally, these 3 types of bread were analysed using composite

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scoring test and the bread showing the highest sensory score was selected as the 'experimental bread'.

Ideal fermentation (FI) time and temperature combination for experimental bread preparation was found to be 37°C for 18 minutes in place of 26.6°C for 120 minutes used generally. For the second fermentation (FII) ideal fermentation time and temperature, combination was found to be 37°C for 40 minutes in place of 26.6°C for 60 minutes. Final proofing gave best results at 50°C for 55 minutes in place of 37°C for 65 minutes. Ideal baking conditions were 230°C at 15 minutes in place of 220°C for 17 minutes.

Multipurpose white flour and wheat bran used for product preparation were analysed for moisture, protein, fat, carbohydrate, fiber (total, soluble and insoluble), ash and mineral (calcium, iron and phosphorus) content. Raw ingredients (wheat bran and multipurpose white flour) and their composite flours were analysed for physico chemical characteristics such as water absorption power, wet and dry gluten content, alkaline water retention capacity, sedimentation value etc. Control and the 3 types of bread (7.5, 9.0 and 10.5% wheat bran) were also analysed for physical properties namely volume, weight, specific volume, firmness and firmness index. Results obtained are described below.

Bread prepared by replacing upto 9% wheat bran in place of multipurpose white flour showed more or less similar acceptability compared to control bread when judged using a 9-point hedonic rating scale (Larmond 1977). When wheat bran replacement exceeded 9%, a drastic decrease in acceptability was found. Bread prepared using 7.5% replacement of wheat bran ranked highest (p ≤ 0.05) in all the sensory characteristics with an overall acceptability of 6.94/10 and 6.20/10 for both the days (i.e. on the day of preparation and the next day). Therefore this was considered as the experimental bread and selected for subsequent study.

Control bread and experimental bread showed the following values for protein 11.37 and 11.47 g%, fat 3.81 and 4.48 g%, carbohydrate 18.13 and 17.90 g%, energy 494.86 and 438.91 Kcal%, total fiber 1.05 and 4.92 g%, insoluble fiber NA (not analysed) and 3.73 g%.

Physico-chemical properties indicated that dry gluten content and sedimentation value were decreased upon the addition of wheat bran to
multipurpose white flour. Addition of wheat bran increased the water absorption power, bread firmness as well as firmness index while loaf volume and specific volume were decreased. However, loaf weight did not show any changes. The cost price of both control and experimental bread worked out to be the same.

To assess the effect of wheat bran enriched bread on glycemic control in diabetics, glycemic index of experimental bread was measured on purposively selected 20 adult human volunteers (15 M, 5 F) suffering from type II diabetes and 5 normals (3 M, 2 F), 35 to 70 years of age, belonging to a similar socio-economic background. Fasting blood samples (finger prick) were collected from all the subjects and then subjects were fed approximately 5 slices of control bread (providing 50 g carbohydrate and containing no wheat bran) weighing 97.84 g. Postprandial blood samples were collected exactly at 1 hr (PP$_{60}$BG), 2 hr (PP$_{120}$BG) and 3 hr (PP$_{180}$BG) after feeding. After a gap of one week (sometimes upto 2 weeks) approximately 5 1/2 slices of experimental bread (providing 50 g carbohydrate and containing 7.5% wheat bran) weighing 104.40 g were also fed and blood collected similarly. Glycemic index (GI) as well as glycemic load (GL) of experimental bread were determined after plotting glucose levels and finding the area under the curve (AUC) (separately for experimental bread and control bread).

The average FBG, PP$_{60}$BG, PP$_{120}$BG and PP$_{180}$BG for experimental bread were 168.67, 263.15, 229.00 and 199.04 mg% vs. 162.68, 306.09, 263.97 and 193.18 mg% for control bread in diabetics. Glycemic index for non diabetics was found to be significantly higher (P ≤ 0.05) i.e. 81.93% compared to the diabetics (77.04%). A similar trend was observed in females [n=5] i.e. 75.05% when compared to males [n=15] i.e. 77.70%, within the diabetic group.

It may be concluded that the bread prepared by replacing 7.5% wheat bran was acceptable and would be useful in the dietary management of diabetics as well as healthy subjects. The product developed needs to be tested for commercial marketing.

The third experiment deals with the development of soya fortified biscuit, analysis of various food properties and evaluation of it's growth promoting ability.

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For product development, two recipes namely vanilla biscuit and glucose biscuit were selected and prepared successfully under laboratory conditions. On a combined formula of both recipes, vanaspati was replaced with margarine, which was then replaced with groundnut oil or cotton seed oil or 'Dalda activa' brand vanaspati. Further sugar levels were replaced and the formula obtained was termed as the control formula. Initially defatted soya flour was supplemented on a wide range from 5 to 40%. From this 30% defatted soya flour biscuit was selected and therefore on a narrow range of 25 to 35% defatted soya flour supplemented biscuits were prepared again. These biscuits supplemented with defatted soya flour at various levels (25, 30, 35%) to multipurpose white flour were evaluated and the biscuit showing the highest sensory score was selected as the 'experimental biscuit'. Multipurpose white flour and defatted soya flour used for product preparation were analysed for the moisture, protein, fat, carbohydrate, fiber (total, soluble and insoluble), ash and mineral (calcium, iron and phosphorus) content. The raw ingredients and their composite flours (i.e. multipurpose white flour and defatted soya flour) were analysed for physico chemical characteristics such as water absorption power, wet and dry gluten content, alkaline water retention capacity, sedimentation value etc. Experimental biscuit was analysed for physical properties viz., weight, width, thickness, spread ratio, per cent spread factor and hardness along with the control biscuit.

Biscuit prepared using 25% replacement of defatted soya flour ranked the highest (p < 0.05) in all sensory characteristics among the varied combinations and procedural changes followed. But for the feeding programme, biscuits with 30% defatted soya flour was selected since 7 biscuits of these could supply 1/3rd the recommended dietary allowances for protein, since the nutritional evaluation was to be conducted on pre school children aged 3-5 years.

Control biscuit (containing no defatted soya flour) and experimental biscuit (supplemented with 30% defatted soya flour) showed 5.96 and 13.58 g% protein, 29.42 and 29.33 g% fat, 70.64 and 60.38 g% carbohydrate, 609.50 and 596.80 Kcal% energy, 0.56 and 1.12 g% total fiber, 3.56 and 66.20 mg% calcium, 30.19 and 198.00 mg% phosphorus 0.25 and 2.82 mg% iron content.
Physico-chemical properties indicated that gluten and sedimentation value decreased while alkaline water retention capacity increased upon the addition of defatted soya flour in the flour blends.

Weight, thickness and hardness were increased while width, spread ratio and percent spread factor were decreased in the experimental biscuit (30% defatted soya flour) compared to the control. Production cost was increased by Rs. 2.50 per kg for defatted soya flour biscuit compared to control biscuit.

To assess the growth promoting effect of soya fortified biscuits, 149 pre-school children from two local pre-schools (balwadies) were selected using purposive random sampling technique as the experimental model. The group consisted of both boys (n=88) and girls (n=61), 3 to 5 years of age, belonging to a similar socio-economic background. The children were divided into 3 groups depending on sex and weight. Group I (n=43, 25 boys and 18 girls) and II (n=44, 25 boys and 19 girls) were fed 70 g soya fortified biscuit or control biscuit, respectively, for 60 days in place of their regular breakfast provided at the balwadi. However, group III (n=41, 23 boys and 18 girls) were continued on their regular snack. The enrolled subjects were weighed and their standing and sitting heights were measured and recorded at the beginning of the feeding trial, the same parameters were repeated after every 15 days until the end of the experiment.

Feeding of control and experimental biscuits was carried out for a period of 60 days and compared with the regular snack supplied at the balwadi. Data for only 128 subjects were analysed for experimental purpose as some subjects dropped out of the study. Subjects fed soya fortified biscuits or control biscuits showed an average weight gain of 0.376 or 0.339 kg, respectively. The group which continued on the routine snack of the balwadi showed the lowest average weight gain (0.268 kg). Percent weight gain in the group fed soya fortified biscuit fed was 37.80% and in the group fed control biscuit was 13.40% as compared to the group fed regular snack. The beneficial effect of the soya fortified biscuits indicates that it can be successfully incorporated in mid day meal programmes.

All the three products recorded beneficial effects. They also showed the potential for scaling up to commercial levels after minor procedural
modification. The study observed up possibilities of developing modified bakery products which can replace existing commercial bakery products, thus providing long term health benefits to the community at large.