

**DEVELOPMENT AND EVALUATION OF ISABGOL
(*Plantago sp.*) AND WHEAT BRAN SUPPLEMENTED
BAKED PRODUCTS**

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**DEPARTMENT OF RURAL HOME SCIENCE
UNIVERSITY OF AGRICULTURAL SCIENCES
BANGALORE**

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BAKED PRODUCTS**

C. J. SHUBHA

Thesis submitted to the
University of Agricultural Sciences, Bangalore
in partial fulfilment of the requirements
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in
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BANGALORE

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*Dedicated to
My Beloved Parents
and Brother
and My Loving Guide*

DEPARTMENT OF RURAL HOME SCIENCE
UNIVERSITY OF AGRICULTURAL SCIENCES
BANGALORE

C E R T I F I C A T E

This is to certify that the thesis entitled "DEVELOPMENT AND EVALUATION OF ISABGOL (Plantago sp.) AND WHEAT BRAN SUPPLEMENTED BAKED PRODUCTS" Submitted by C.J.SHUBHA, for the degree of MASTER OF SCIENCE in FOODS AND NUTRITION of the University of Agricultural Sciences, Bangalore, is a record of research work done by her during the period of her study in this University under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

Bangalore
October , 1994

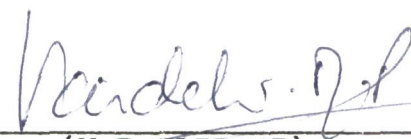


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INTRODUCTION

I. INTRODUCTION

Urbanisation and employment of women in the industrialized and public sectors have increased the demand for processed foods with better shelf-life, satisfying taste, ease of portability and high nutritional quality throughout the world (Booth, 1990). Bakery products being the most suitable item to satisfy these requirements, have gained a strong foot-hold in India, as evidenced by the two-fold increase in their production in the last five years (Srivastava and Rao, 1993). Even so, over the last decade or more, scientists and technologists in India have been conceptualizing the idea of special types of processed foods for special and dietary requirements.

The subject of plant fibres have raked up a lot of interest, since research on the subject has begun to indicate that if fibre could be incorporated into a formulated product which would fulfill the basic criterion of contributing to an acceptable final product, then it would also carry the added benefit of health promotion.

Dietary fibre enjoys a positive connotation as a food ingredient with consumers, nutrition professionals

and health food manufacturers. Although as yet unproven, it has been speculated that dietary fibre plays a role in the reduction or prevention of diseases of the colon such as constipation, appendicitis, cancer, haemorrhoids and ulcers and probably also be responsible for preventing or delaying the onset of metabolic diseases such as various vascular diseases heart disease, hypertension, obesity and diabetes; and may ameliorate the effects of endocrine diseases, hiatus hernia and dental caries (Spallholz, 1989).

Wheat bran is one of the major fractions of wheat, and a rich source of dietary fibre, obtained as a by-product of the milling process. It is known to comprise approximately 14.5 per cent of the total grain and amounts to millions of tonnes annually being considered as waste or incorporated into animal feeds (Moran et.al., 1970). Wheat bran, in addition to containing proteins of high biological value, is a rich source of the **B**-complex vitamins and several minerals (Pomeranz et.al., 1976). A deeper understanding of the nutritive and physiological role of bran for humans and newer areas of bran utilization as in baked products and other cereal food products, is worthy of consideration especially in some parts of the world where the critical food situation and increased demand for food are

evident. A broader use for bran fractions of the wheat kernel for human consumption could increase the total supply of cereal foods in these regions and simultaneously improve the health condition of the people.

Isabgol (Plantago ovata) seeds are minute bean shaped, of a pinkish grey colour, belonging to family Plantaginaceae and obtainable locally under various vernacular names (Ispaghul, issufgul, spogel seeds, i shappukol virai etc.) in different parts of India. Isabgol is cultivated on 40,000 hectares of land in Gujarat and Rajasthan, producing about 39,000 tonnes of seed, yielding over 11,600 tonnes of processed seed husk, for export (Chakraborty and Patel, 1992). India provides about 85% of the isabgol husk available in the world market, where it is used commercially in the pharmaceutical and other allied industries. Presently, limited amounts of husk free seeds are marketed as a "health food", but most of it is used as seed or animal feed in India. Lack of scientific information about seed composition and insufficient research on it precludes its proper utilization. Isabgol husk has been accepted as a natural fibre laxative but has not been much used in food because its unusual hydrocolloidal

properties have not been exploited for the purpose. Again, recent research points to the possibilities of incorporation of isabgol husk in instant beverages, cereals and snacks, ice cream, yoghurt and even baked products. Recent claims of therapeutic uses have evoked increased interest on isabgol (Chan and Wypyszyk, 1988). The dehusked seed which accounts for about 70 per cent by weight of the annual crop is steadily gaining the attention of nutrition health professionals the world over. Several clinical studies indicate its beneficial effects on the gastro-intestinal tract (Heckers and Zielinsky, 1984).

Constipation apart from being a disease by itself is a major symptom of several diseases and could be a cause of great discomfort and agony. Constipation, though considered slightly and ignored by many is known to impair the quality of life of about 20 per cent of the people aged over 65 years and around 10 per cent of the adult population. It is generally agreed that dietary fibre particularly in the insoluble form is useful in its treatment and prevention. (ENCYCLOPEDIA OF FOOD SCIENCE AND TECHNOLOGY AND NUTRITION, 1993)

The present study, therefore, has been undertaken to meet the multiple aims of developing acceptable dietetic baked products from wheat bran and undehusked

isabgol seed and to evaluate their effect in terms of prevention and control of constipation.

The main objectives of the study are :

- (1) To develop ready to eat products for better utilization of wheat bran and Isabgol and to compute the proximate nutrients in the best accepted products.
- (2) To study the consumer acceptability of the above developed products.
- (3) To analyse proximates in isabgol and wheat bran and dietary fibre and its fractions in isabgol, wheat bran and selected supplemented products.
- (4) To study some of the characteristics of isabgol and wheat bran and to conduct shelf life studies on the best accepted wheat bran-isabgol blend incorporated product to be used in the bioassay.
- (5) To evaluate the effect of wheat bran-isabgol blend incorporated product in controlling constipation in human subjects.
- (6) To estimate the production cost of the best accepted developed products.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

Keeping in view the objectives set forth for the study, the available review of literature is furnished under the following headings.

- 2.1 DIETARY FIBRE : ITS PROPERTIES AND
 PHYSIOLOGICAL ROLE
- 2.1.1 Structural composition of Isabgol and Wheat
 Bran
- 2.1.2 Physical properties of Isabgol and Wheat Bran
- 2.1.3 Physiological effects of Isabgol and Wheat
 Bran
- 2.1.4 Effect of processing and storage.
- 2.1.5 Safety issues on Isabgol and Wheat bran.
- 2.2 CHEMICAL COMPOSITION OF ISABGOL AND WHEAT
 BRAN
- 2.3 DIETETIC PRODUCTS FROM ISABGOL AND WHEAT BRAN.
- 2.4 DIETETIC BAKED PRODUCTS FROM ISABGOL AND
 WHEAT BRAN
- 2.4.1 Biscuits and Cookies.
- 2.4.2 Cakes and Breads.
- 2.5 THERAPEUTIC EFFECTS OF WHEAT BRAN AND ISABGOL.
- 2.5.1 Constipation.
- 2.5.2 Hyper cholesterolemia.
- 2.5.3 Diabetes mellitus.
- 2.5.4 Other therapeutic effects.

2.1 **DIETARY FIBRE : ITS PROPERTIES AND PHYSIOLOGICAL ROLE**

As on today, dietary fibre is defined as the food component that comprises the polysaccharides (except starch) that are unavailable for digestion by the gastro intestinal enzymes, plus the phenolic polymer lignin. However, it is being debated that minor components such as acetic acid, phenolic acid, resistant or chemically modified starch or maillard products and strongly associated cell wall proteins may also be included in the dietary fibre concept. (Spiller, 1993).

2.1.1 **Structural Composition of Isabgol and Wheat Bran**

The husk from different species of Plantago appear to contain varying proportions of xylose, arabinose, rhamnose, galactose, galacturonic acid, 4-0-methyl glucuronic acid and 2-0-(2-D-galactopyranosyluronic acid)-L-rhamnose (Anderson and Fireman, 1953). Brillouet et.al. (1982) investigated the chemical structure of hemicellulose isolated from wheat bran and found that it was a complex of heteroxylan composed mostly of arabinose and xylose and minute amounts of glucose, galactose and glucuronic acid. Holloway (1983) found that the hemicellulose of wheat bran contained 32

per cent arabinose and 60 per cent xylose. Bartnik and Jakubczyk (1989) in a detailed review on wheat bran reported that bran was not a standard product with determined quality and composition and consisted of a mixture of grain fragments originating from the pericarp, testa, aleurone layer, germ and part of the endosperm, the hyaline-aleurone layers contributing the major portion.

2.1.2 Physical Properties of Isabgol and Wheat bran

Heller and Hackler (1978) conducted a study on the water holding capacity of various sources of plant fibre in terms of percentage of dry matter using an acetone dried powder fraction and reported the water-holding capacity of wheat bran to be 290.. Struthers (1986) reported that the water holding capacity of Plantago ovata (undehusked) seeds was intermediate between that of husk and wheat bran.

According to a review on dietary fibre, (Encyclopedia of Food Science and Technology and Nutrition, 1993) the particle size, chemical composition and structure of dietary fibre influence its water holding capacity. It was also reported that the mean particle size of coarse bran and fine bran were 850 microns and 308 microns respectively. Also, a reduction

in the mean particle size of wheat bran fibre from 800 microns to 180 microns was associated with a 41 per cent decrease in water holding capacity.

2.1.3 Physiological effect of Isabgol and Wheat bran

Cummings et.al., (1978) studied the colonic response of 19 healthy volunteers to an intake of approximately 20 g per day of wheat bran and found the increase in faecal weight by 127 per cent, which was correlated with an increased intake of pentose containing polysaccharides. The gastro-intestinal transit time was shortened and there was marked dilution of an inert marker in the faeces.

Vansoest (1984) compared the effect of grinding and particle size (coarse Vs fine bran) on stool characteristics and showed that fine grinding significantly decreased the faecal water uptake, which was 77 g/kg, 73g/kg and 74 g/kg in the cases of coarse bran (mean particle size 740 microns), fine bran (mean particle size 170 microns) and low fiber control respectively. Heckers and Zielinsky (1984) reported that clinical studies with Plantago ovata seed preparation consisting of the hulls together with the kernel increases stool weight and reduces intestinal transit time in healthy volunteers.

Pechlow (1990) conducted a study on 70 adult female wistar rats divided randomly into 7 groups of 10 rats each which included a control (elemental diet). Finely powdered Plantago ovata seed with husks, whole Plantago ovata husk and coarse wheat bran were added individually to the elemental diet (100 or 200 g/kg) in the respective groups. The rats were studied for a period of 4 weeks. The results showed a reduced food intake after the change to the fibre enriched diets, maximum reduction in case of husks, followed by the seeds, followed by wheat bran. The consistency of the foecal pellets of control group was small and hard, that of the seed group was well formed but increased in size and doubled in number, that of the husk was well formed but soft and the interior was gummy while in case of wheat bran, the number of foecal pellets was increased by 20-50 per cent with no change in consistency. The water content of the foeces was significantly and dose dependently higher in both Plantago ovata diets but not with wheat bran. The length of the small intestine increased with the seed containing diet by 4-8 per cent and husk containing diet by 13-24 per cent but wheat bran did not influence intestinal length. Both Plantago ovata preparations induced a 10-20 per cent increase in

the length of the colon while wheat bran could only effect a 10 per cent increase. This study was conducted to characterize the properties of Plantago ovata seed as a dietary fibre supplement which acts mainly in the large intestine, increases stool volume by a mixture of indigestible residue, water binding and increase in bacterial mass at the same time avoiding the high bulking in the upper gut characteristic of Plantago ovata husk.

Egashira et.al. (1992) conducted a study on the effect of wheat bran on gastro intestinal tract by feeding wheat bran at a level of 1 per cent to weanling rats for 28 days. They found that wheat bran was effective in shortening gastro intestinal transit time in rats to 38.9 hours (from 50.8 hours in the dietary fibre free group) without adversely affecting growth, digestion and absorption of nutrients.

2.1.4 Effect of Processing and Storage

Parrott and Thrall (1978) reported that high temperatures resulted in enlarged, elongated particles and structural damage to the wheat bran.

Dintzis et.al (1979) conducted detailed examination of wheat bran used in the preparation of

bread and showed that the baking process hydrated the bran and caused much adhering endosperm to react and become part of the crumb, much of which was retrieved as identifiable particles from the faeces.

Anderson and Clydesdale (1980) studied the effect of 30 minutes of boiling, 60 minutes of retorting, 30 minutes and 60 minutes of toasting and found that toasting significantly increased the lignin content but had little effect on other components. Wet heat processing tended to first dissolve and then destroy the pectin substances in the bran.

Chan and Wypyszyk (1988) reported that isabgol husk is relatively little affected by temperature between 20°C and 50°C and exhibited unchanged swell volume during a 3 year storage at normal warehouse conditions.

Buchowski and Vanderstoep (1988) evaluated the conversion of endogenous iron from unbaked and baked wheat bran in the form of muffins into haemoglobin on weanling anaemic rats as against control rats fed ferrous sulphate. They found that baking of the muffins significantly increased ($P < 0.05$) the haemoglobin iron regeneration efficiency which was further enhanced by supplementing the diet with orange juice or ascorbic acid.

Galliard and Gallagher (1988) studied the effects of commercial wheat brans stored upto 21 weeks (20°C) after which the bran samples were blended with flour, baked into bread and subjected to sensory analysis. Finely milled bran ($+20^{\circ}\text{C}$) after storage for four weeks gave a significantly lower loaf volume compared with untreated bran ($+20^{\circ}\text{C}$) or with finely milled bran (-20°C). The off-flavour intensity of bran-water mixtures increased as the particle size increased, with the period of storage.

Lakshmi (1991) reported the shelf life of wheat bran biscuits packed in polyethylene pouches to be nine days when they developed a dull appearance, slight off flavour, soft texture and light grey spots on the crumb.

Leelavathi and Rao (1993) conducted storage studies on high fibre biscuits incorporated with 30 per cent raw and toasted wheat bran and compared it with the control. They reported an increase in moisture for a total storage period of 4 months to be 0.9 per cent in case of control and 1.9-2 per cent for the wheat bran biscuits. There was also a "two-time" increase in free fatty acids during the storage period of raw bran

biscuits compared to the toasted bran biscuits. The raw bran biscuits became slightly damp on the fourth month storage period with an added mild rancid taste. Westerlund et. al. (1993) found that "resistant starch" which is a strongly retrograded starch is found in higher quantity in bread fractions than in the dough and decreased progressively from the crumb to the outer crust. The formation of this resistant starch increases the dietary fibre value.

2.1.5 Safety issues on Isabgol and Wheat bran

Seibel (1975) proposed microbiological standards for food grade wheat bran as < 50,000/g (total count), 0/0.1 g (coli and coliform bacteria) and no spore forming anaerobes. In a hearing held by a committee of the National Research Council (Select committee on GRAS substances, 1982) on isabgol husk, it was concluded that there is no evidence that demonstrates or suggests ground to suspect a hazard to the public on consumption of the gum. Clinical studies on the effect of isabgol husk on bowel action have revealed no significant side effects.

The specifications for isabgol husk as given in the U.S. Pharmacopeia (1986) are given in Table 1.

Table 1 : Specifications of Plantago Sp. husk

Total ash	:	Not more than 4.0%
Acid insoluble ash	:	Not more than 1.0%
Water	:	Not more than 12%
Swell volume	:	Not less than 40 ml/g for powder, Not less than 35 ml/g for whole
Extraneous matter	:	Light-not more than 15% Heavy-not more than 1.1%
Insect infestation	:	Not more than 400 insect fragments Not more than 100 fragments for whole
Microbial limits	:	Mold and yeast not to exceed 1000/g Salmonella - negative E. coli - negative

(U.S. Pharmacopeia, 1986)

ಕ್ರಷಿ ನಿತ್ಯನಿರ್ದಾನಿಲಯ
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ಗಾ ಕ್ಯ.ವಿ.ಕೆ., ಬೆಂಗಳೂರು-560 065.

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A reduction of particle size of wheat bran in the range of 7-70 microns could be associated with negative effects due to persorption of undigested wheat bran into the lymphatic and blood circulation (Encyclopedia of Food Science and Technology and Nutrition, 1993).

2.2 CHEMICAL COMPOSITION OF ISABGOL AND WHEAT BRAN

Pendse et.al., (1976) worked on the isabgol seed of Gujarat region and found that it contained 5 per cent pale yellow oil, 8.3 per cent moisture content and 6.8 per cent ash content.

Miller (1979) studied the chemical composition of brans of 4 varieties representing different wheat types and found that the chemical composition which didn't vary markedly, comprised 8.3 to 9.3 per cent moisture, 3.1 to 5.6 per cent ash, 14.1-18.3 per cent protein, 8.4-10.7 per cent crude fibre and 44.8-53.5 per cent NDF.

According to Sousulski and Cadden (1982), wheat bran had 15.4-18.7 per cent protein, 4.2-5.4 per cent fat, 8.7-12.5 per cent crude fibre, 36.4-51.7 per cent dietary fibre and 4.8-7.27 ash.

The total dietary fibre value of wheat bran amounted to 34.9-42.7 per cent and the dietary fibre components included 20.9-28.2 per cent hemicellulose, 9.6-13.2 per cent cellulose and 3.3-4.5 per cent lignin (Kunerth and Youngs, 1984).

Bartnik and Jakubczyk (1989) reviewed the nutritive value of wheat bran and found significant differences in gross and net energy values of about 1500 K.J. and 735 KJ per 100 g which were associated with limited availability of energy components.

Stankovic et.al. (1991) found that the oil in Plantago major seeds contained high values of linoleic acid (53%) and linolenic acid (23%) in addition to other unsaponifiable fractions and cholesterol. The biological value of Plantago major protein was comparable to wheat flour proteins and methionine was found to be the limiting amino acid.

Chakraborty and Patel (1992) found that the dehusked isabgol seed contained 8.61 per cent total oil, 20.9 per cent crude protein, 63.1-64.6 per cent in-vitro protein digestibility which was comparable with pigeon pea dhal. The lysine content (4.14%) was comparable with cereals but less than in pulses, tryptophan content(1.8%) met the FAO requirement and methionine

content (1.74%) was higher than in pulse protein and was comparable to cereals.

Leelavathi and Rao (1993) reported the respective composition of raw and toasted wheat bran (mean particle size 1110 microns) as 14.7 per cent and 14.5 per cent ash; 14.9 per cent and 14.8 per cent protein; 11.2 per cent and 11.0 per cent starch, 930 mg per cent and 960 mg per cent phosphorus; 8.4 mg per cent and 8.9 mg per cent iron and 46.1 per cent and 43.3 per cent total dietary fibre, all values expressed on 14 per cent moisture basis.

2.3 DIETETIC PRODUCTS FROM ISABGOL AND WHEAT BRAN

According to Costamagna and Rossi (1978) addition of 15% wheat bran to milk before incubation with 4% yoghurt culture appeared to have a positive effect on L. bulgaricus and did not impair acidification.

Kowalsky (1980) developed a dietetic product for the natural control of digestion which comprised 50-150 parts by weight of complete psyllium seed (Plantago sp), complete linseed, wheat bran and lactose respectively as well as sufficient quantity of a binding agent to bind the dry ingredients on a vegetable gum base with food colourants and/or flavouring.

Chan and Wypyszyk (1988) listed some of the potential uses of isabgol husk as a food ingredient in product such as in instant beverages, breakfast cereals, snacks, meat products, pet foods, ice cream, yoghurt, sauces, gravy soups and confectionery products.

Chavklin and Mackles (1989) gave a European patent application for the development of a palatable premixed wheat bran drink with good mouthfeel comprising heat treated degelled bran in the presence of hydrated colloidal magnesium aluminium silicate and an acidification agent.

John et.al., (1990, GDR patent) described a process for the extrusion of a wheat bran mix with an initial moisture content of 13-22 per cent extruded at 100°C without any additives apart from the seasoning which permits maximisation of the dietary fibre content of the product.

Wolever et.al. (1991) demonstrated the usefulness of incorporation of isabgol husk into ready to eat breakfast cereals without loss of physiological effects and with potential gains in palatability.

According to Dubinskaya et.al. (1991), food grade wheat bran can be prepared by steeping bran in

water at 15-20°C at a bran to water ratio of 1:2 to a moisture content of 5-7% and comminuting to a particle size of 0.1-0.6 mm for one hour to provide greatest degree of swelling.

2.4 DIETETIC BAKED PRODUCTS FROM ISABGOL AND WHEAT BRAN

Bakery products have become very popular in India as evidenced by the two fold increase in their production in the last five years. A survey covering 75 families brought to light the fact that on an average 6.5% of the monthly income was spent on bakery products both for their nutritional and convenience aspects (Kumar et.al., 1992).

2.4.1 Biscuits and Cookies

Vratannia and Zabik (1978) studied the feasibility of producing sugar-snap cookies by substituting 10, 20 or 30% wheat bran for flour and compared it with the control. Bran incorporation did not significantly affect top grain but did reduce spread, darkened the colour and produced a more tender, less crisp cookie. Flavour was adversely affected at 30% level.

Wienecke (1984) submitted a patent (Federal Republic of Germany) on the use of 5-10% by weight of bran in fillings for food bars with a water content of 5-20% by weight of wafers or biscuits.

Pflaumer et.al., (1990) submitted a U.S patent on the preparation of dietetic cookies with 5-30 per cent by weight of isabgol husk intended particularly for treating gastro intestinal disorders and reducing blood cholesterol levels.

Stanyon and Cosletto (1990) studied the effect of replacing wheat bran, on the sensory characters of rolled biscuits and found that the biscuits were more crumbly, drier and chewier as the bran level increased with a significant after taste and wheat flavour. They also found that polydextrose could be used to overcome some of the effects of wheat bran in biscuits.

Leelavathi and Rao (1993) worked on the development of high fibre biscuits and found that raw wheat bran could be incorporated into biscuits upto 30 per cent without affecting their overall quality. However, the colour and texture of the biscuits became slightly darker and harder respectively with a slightly gritty and residual branny mouthfeel at an incorporation level of 20% toasted wheat bran. Also the water

requirement increased from 15-22% in the control to 10-60% as the bran content increased.

2.4.2 Cakes and Breads

White cakes were prepared with 4,8,16% substitution of wheat bran which resulted in increased tenderness but decreased lightness of the cake crumb (Brockmole and Zabik, 1976).

Smith (1978) studied the quality characteristics of 10, 20 and 30 per cent level substitution of wheat bran on chiffon cakes. Higher levels of substitution resulted in a greater decrease in cake height with a very coarse appearance along with a significant decrease in softness and tenderness. He concluded that a substitution level of < 30% would result in an acceptable product.

Alt Rogge et.al. (1980) discussed the effects of wheat bran addition on the baking quality of bread and rolls and reported the reduction in loaf volume, dryness of dough, weak crumb elasticity and flavour loss at 10-15 per cent addition levels.

Seibel and Bretschneider (1980) reported that upto 10 per cent of wheat bran may be incorporated in

yeasted fruit bread without processing problems with enhancement of shelf life and flavour in some cases as compared with low fibre controls.

Czuchajowska et.al. (1992) studied the functional properties of isabgol husk at levels of 2%, 4%, and 8% in wheat based products such as cakes and breads. They found that isabgol impaired the volume and quality of steamed bread and increased the cake volume at 2% level. At 4% level of replacement the cake volume was decreased and the texture and the overall scores were affected negatively.

Anwar-ul-haque and Morris (1994) developed a method for producing bread from rice flour, which had aeration typical of the commercial wheat bread, by the combined use of two polysaccharide structuring agents; hydroxy propyl methyl cellulose (HPMC) (20 g) and isabgol husk (10 g). They found that the isabgol contributed to the aeration by giving a weak gel network which traps carbon-di-oxide generated during proofing while HPMC maintained the stability of gas cells at the oven temperature.

2.5 THERAPEUTIC EFFECTS OF ISABGOL AND WHEAT BRAN

Dietary fibre has been known for more than 2000 years under various terms (bran, plantix, complex

polysaccharide etc) and has carried with it the well known but as yet unestablished hypothesis, which implies that an intake of high fibre containing foods is consistent with or conduces a low occurrence of several diseases.

2.5.1 Constipation

Smith (1980) conducted a study on the effects of bran and isabgol husk by mouth in 37 constipated patients 65 to 96 years old and found that both increased the wet and dry stool weight with no serious side effect or change in colonic pressure. Also the use of the bulking agents was preferred over the traditional use of laxatives.

Erdman (1984) conducted a study on 60 patients with irritable bowel syndrome to evaluate the curative effect of coarse wheat bran supplement and found that constipation was the only symptom that improved significantly with bran treatment.

In a study by Becker and Roskamp (1987) 22 infants and children, 6-22 months old, with severe constipation were fed with a commercially produced solid food containing 4.2 g wheat bran (7 g/100g) for 41 days, 86 per cent of the children experienced normal bowel

movements within 8.2 days of treatment. Further the bran preparation increased the stool weight by 21.5 per cent in 8 healthy infants, 4.5-9 months old.

Jenkins and Peterson (1987) studied the dose response of wheat bran on faecal output in a group of healthy persons whose breakfast consisted of wheat fibre cereals in amounts that provided 0.3, 5.6, 9.5, 11.2, 19 and 28.4 of dietary fibre daily for 14 days. A linear dose response was observed producing a mean increase of 2.7 g in faecal weight per gram increase in wheat fibre. The maximum increase in faecal output due to wheat bran was reached after the first week on the supplement.

Slavin and Lampe (1992) while reviewing the beneficial effects of rice bran described both wheat bran and isabgol husk as an effective agents of laxative which increased stool weight by an average of 5.7 g/g of total dietary fibre and 3.5 g/g of total dietary fibre consumed respectively.

2.5.2 Hypercholesterolemia

Muzaffar et.al. (1989) found that a diet with 20 per cent wheat bran fed to 4 male albino rats for 8 weeks resulted in a reduction in the serum cholesterol, liver and heart triglyceride and heart phospholipid

concentration with no change in the liver cholesterol level.

Ismail and Navder (1993) compared the effects of feeding isabgol husk, sugar beet fibre, barley bran and oat bran on serum cholesterol and liver lipids in rats. The results showed that the 10% isabgol husk diet lowered the serum LDL, liver cholesterol, liver lipids and also raised the HDL and HDL/LDL cholesterol ratio, and concluded that isabgol husk was more effective than the other fibre sources used in the study.

2.5.3 Diabetes mellitus

Frat-Munari et. al. (1985) reported the beneficial effect of 10 g Plantago mucilage in a glucose tolerance test wherein the mucilage powder when given mixed with glucose, significantly lowered the serum glucose and insulin.

Gujral et. al. (1989) investigated the role of wheat bran in the control of diabetes in NIDDM patients and found that 75 g of bran biscuits providing 11 g bran for a period of one month resulted in a pronounced decrease in the post-prandial blood and urine sugar levels.

2.5.4 Other Therapeutic effects

Moreno-osset et. al. (1985) illustrated the beneficial effect of 20 g/day of coarse wheat bran in 12 patients, 51-80 years old with diverticular disease wherein all symptoms disappeared in 9 patients and all except dyspepsia in the others at the end of the study period of 6 months.

Evans and Shrouts (1992) listed the multiple benefits of bulking agents. They also mentioned the use of isabgol husk in anti diarrhoeal formulae for the correction of diarrhoea by contributing to stool bulk by maintaining their structure during passage through the gastro intestinal tract.

In a review of several experimental studies on the effect of fibre on protection against chemical carcinogens, it was found that wheat bran decreased the number of tumours in 13 out of 17 studies and increased the number of tumours compared with the control levels in only one study. (Encyclopedia of Food Science and Technology and Nutrition, 1993).

MATERIAL AND METHODS

III. MATERIALS AND METHODS

3.0 MATERIALS

Fine wheat bran was obtained from Shri Venugopal Flour Mills, Bangalore. Isabgol seeds (undehusked) were obtained from local oriental medicine shops at Hosur. Good quality margarine was obtained from Lipton Masterline Bakery Advisory Services. Other ingredients like maida, sugar, salt, cocoa, tuty-fruity, cashewnuts, eggs, essence, ingredients for green masala, dessicated coconut powder, cherries, custard powder, skim milk powder and groundnut oil were obtained from local shops. Low density polyethylene covers of 100 gms capacity, butter paper, wax paper, laminated sheets and other chemicals of research grade were also used in the study.

3.1 STUDY OF PHYSICAL CHARACTERISTICS

The fine wheat bran fraction with a particle size of 850 microns was obtained at the fourth and fifth breaks of the milling process as illustrated in figure-1

3.1.1 Thousand Kernel Weight

Weight of thousand grains of undehusked isabgol seeds was noted down and expressed in grams.

PLATE-1 : SPECIMEN SAMPLE OF ISABGOL (Plantago . ovata)
PLANT.



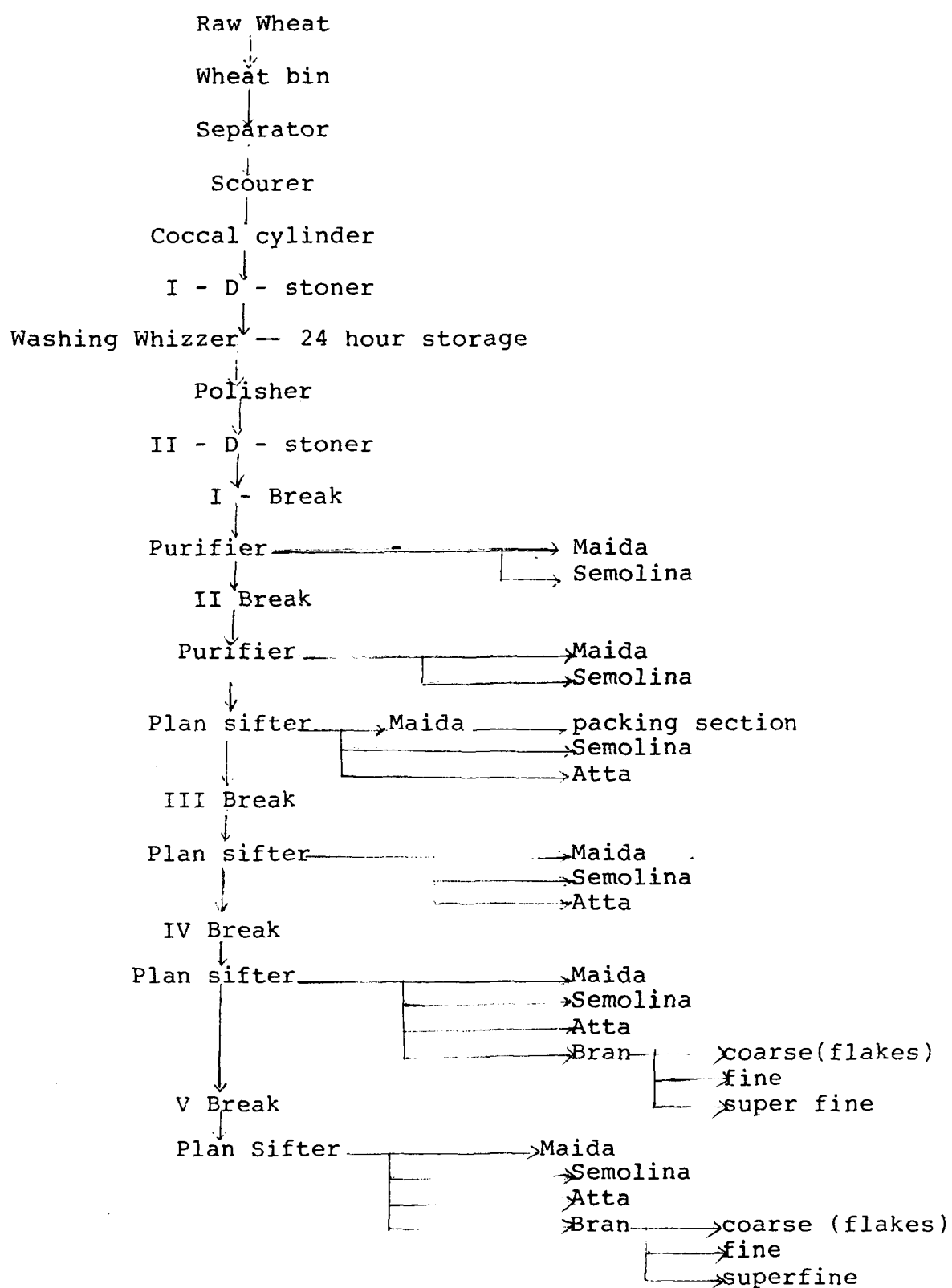


Fig - 1: Fractionation of wheat in the milling process

source: Shri Venugopal Flour Mills, Bangalore.

3.1.2 Water Absorption Capacity (Sousulski, 1962)

Water absorption capacity of isabgol seeds (undehusked) and wheat bran was determined by centrifuge method and was expressed in percentage (Annexure - I).

3.1.3 Oil Absorption Capacity (Lin et.al., 1974)

The oil absorption capacity of wheatbran and isabgol seeds (undehusked) was determined using a modified procedure of Lin et.al.(1974) and was expressed in terms of percentage. (Annexure - 1)

3.2 PROCESSING OF THE INGREDIENTS

3.2.1 Stabilization of Wheat Bran

Wheat bran was stabilized by toasting at 175°C for 40 minutes in order to inactivate the enzymes and improve the shelf life, as reported by Vetricmani and Rao (1990).

3.2.2 Processed Isabgol Seed

Undehusked isabgol seed was toasted lightly and then crushed to a fine powder in a "Rajalakshmi mini mill".

3.3 PREPARATION OF PRODUCTS

A total of 7 baked products namely, Chilly biscuits, Sacher cake, Coconut cookies, Salt biscuits,

Pound cake, Chocolate cookies and Swiss sandwich were prepared in the study. The standard recipes are given in Annexure - II. Each product was subjected to three treatments. Treatment - I (T_1), Treatment - II (T_2), and Treatment - III (T_3) comprised incorporation of different levels of isabgol, wheat bran and a blend of both isabgol and wheat bran respectively.

Products were prepared using various levels of incorporation of isabgol (I), Wheat bran (W.B) and blend of the two (I-W.B. blend). Pretesting of the products was done by subjecting all the possible combinations of the selected levels of incorporation in the various products, to sensory evaluation by a three member semi-trained panel. On the basis of pre-testing, the best three levels were selected for each product under each treatment.

During standardisation, the test ingredients (Isabgol, wheat bran and isabgol-wheat bran blend) were supplemented to the maida flour in the recipe. Hence the quantity of the test ingredients incorporated was calculated as a percentage of the maida flour in the standard recipes. The levels of supplementation are given in Table-2.

Table 2 : Levels of addition of isabgol, Wheat bran and blend in the baked products used in consumer acceptability studies.

Maida (g)	Isabgol(T ₁) (g)	Wheat bran(T ₂) (g)	Blend (T ₃) W.B+Isabgol)(g)
100	4 (3.9)	20 (16.7)	30 + 16 (23.1 + 13.8)
100	8 (7.4)	30 (23.1)	40 + 12 (28.6 + 10.7)
100	12 (10.7)	40 (28.6)	40 + 20 (28.6 + 16.7)

Note: Figures in parenthesis indicate incorporation in terms of substitution percentage of maida flour.

3.4 SENSORY EVALUATION OF THE PRODUCTS

All the seven products were evaluated by an untrained consumer panel of 35 members. The consumer panel had to evaluate three levels of incorporation under each treatment per day, as against the control for the same product without fibre incorporation (Score sheet is given in Annexure - III). The panelists were expected to rank the products according to their preference after considering all the sensory attributes.

3.5 CHEMICAL ANALYSIS

3.5.1 Estimation of Proximates.(AOAC METHODS)

Proximate chemical analysis of wheat bran and isabgol was done. Moisture was estimated by the conventional oven drying method (AOAC., 1984). Protein and fat were estimated by the micro kjeldahl method (AOAC., 1984) and crude ether extraction using the soxhlets' apparatus (AOAC., 1984) respectively. Crude fibre and total ash were estimated by the conventional methods given by the AOAC (1984). The gross energy was analysed using a manual par/bomb calorimeter while the carbohydrate content was determined by the difference method. (Annexure - IV). The dietary fibre fractions in wheat bran, isabgol and their enriched baked

products along with their respective control products were analysed. The nutritive composition of the developed baked products were computed using the values from "Nutritive value of Indian Foods" (Gopalan et.al., 1990).

3.5.2 Estimation of Iron (I.S.I. 1975)

The iron content of the test samples was estimated by the method enlisted in the I.S.I (1975) and was expressed as grams (Annexure - IV).

3.5.3 Estimation of Calcium (AOAC, 1980)

Calcium was estimated by precipitating as calcium oxalate and titrating the solution of oxalate in dilute sulphuric acid against standard potassium permanganate.(Annexure - IV)

3.5.4 Estimation of Gross Energy (Manual Parr Bomb Calorimeter)

Gross energy was analysed for the products in an isothermal bomb calorimeter and the results were expressed as Calories per 100 g of the sample (Annexure -IV)

3.5.5 Estimation of Starch and Sugars (Clegg and Carpenter)

The sugar and the starch content were analysed by the indirect acid hydrolysis method (Annexure - IV).

3.5.6 Estimation of Neutral Detergent Fibre (Robertson and Vansoest, 1977)

The neutral detergent fibre was estimated by using enzyme modified neutral detergent method as followed by Robertson and Vansoest (1977). The values are expressed in percentages (Annexure - IV).

3.5.7 Estimation of Acid Detergent Fibre (Van Soest, 1970)

The acid detergent fibre of the test samples was estimated and expressed as percentages (Annexure - IV).

3.5.8 Estimation of Lignin (Van Soest, 1970)

The lignin content of the test samples was determined by the method followed by Vansoest (1970) using 72 per cent H_2SO_4 (Annexure - IV).

3.5.9 Estimation of Cellulose and Hemicellulose (Vansoest, 1984)

The cellulose and hemicellulose content of the test samples were computed using the analysed NDF, ADF and lignin values.

3.6 STATISTICAL ANALYSIS OF PRODUCTS FOR ACCEPTABILITY

a. Friedman's test by 2-way Analysis of variance by ranks was applied to test the preference of the panel members towards dietetic products. Since this test does not give the percentage of preference within and among the treatments, the criteria of frequency of "first" ranks was used to select the best preferred level of supplementation of test ingredients (Here the ranks for control were ignored).

3.7 SELECTION OF SUBJECTS FOR BIOASSAY

Fourty constipated patients who showed a liking towards the test product were selected from the Out-Patient-Department of the Department of Gastroenterology, St. Johns Medical College Hospital, Bangalore.

3.7.1 Data Collection

General information, dietary history, clinical information and preference for the product were the data collected by personal interview method using a pretested schedule (Annexure - V).

The interview schedule consisted of five parts namely, product preference, general information, dietary

habits, clinical information and feeding and clinical records.

The various aspects and different variables included in the interview schedule were as follows:

Part-I Product Preference

This included a simple score sheet with a hedonic scale, the preference scores ranging from "I like it very much" to "I don't like it at all". Subjects were selected based on product preference.

Part-II General Information

This included the age, sex, family size, educational status, type of activity (profession), hours of work per day, leisure time activities and attitudes towards fibre consumption.

Part-III Dietary Habits

This included the type of diet consumed, average daily food intake, and frequency of consumption of greens and whole grains by the test subjects.

A three day typical dietary intake was recorded using 24 hours dietary recall method. A set of pre-standardised vessels was used to obtain estimates of

the amount of cooked food consumed. Similarly, different sizes of balls and cardboard discs were used to determine the size of ragi balls and chapati/dosa etc. Subsequently the individual nutrient intake was calculated using the data given by Rajalakshmi (1974) and the food composition tables (Gopalan et.al., 1990).

Part-IV Clinical Information

This included data on the history of occurrence of the disease and other parameters such as symptoms, frequency of bowel movement (both in normal as well as in constipated condition), frequency of incomplete passage of stools, frequency of straining at stools, frequency of occurrence of pain and severity, past attempt at treatment, attitudes towards consultation of the doctor, existence of other diseases, trend of the meal during constipated condition, frequency of suppression of stools, consistency of stools and effect of test feeding on volume of the stools.

The clinical parameters considered in this study were taken from an article in "The Hindu" by Biswas, Mahalakshmi and Rangabhashyam (1993).

Part-V Feeding and Clinical Records.

A record of the daily consumption of the test product as well as a daily record of the opinion of the test subjects regarding the day to day effect of the test product on their constipated condition was also maintained.

3.8 BIOASSAY ON SUBJECTS

Forty constipated patients were fed on the best accepted high fibre product from the T₃ group to study the combined effect of two bulking agents. The study was for a period of ten days. The test subjects were interviewed before and after the study period.

3.9 SHELF LIFE STUDY

The shelf life study was studied for only the test product used for the feeding study. A ready mix was formulated for the same product and the shelf life of the pre-prepared product and mix were studied. Hundred grams of the product mix was packed in low density polythylene covers of required capacity. The test product was packed first using butter paper and then wax paper. This was further wrapped in a laminated sheet. The control sample was prepared fresh for comparison purpose. The pre-prepared product and

product prepared from the mix were tested at weekly intervals against the control. The two samples and control were subjected to sensory evaluation by a semi-trained panel of five judges at the Department of Rural Home Science, U.A.S, Hebbal, Bangalore. The score sheet is given in Annexure - VI.

3.10 COST EVALUATION OF THE PRODUCT

The production cost of the developed products was computed based on the current cost of the raw ingredients in the retail market. This cost was compared with the production cost of the control samples.

3.6 b STATISTICAL ANALYSIS OF BIOASSAY DATA

Chi-square test was applied to test whether the effect of the treatment was independent of the number of days of feeding.

RESULTS

IV. RESULTS

The results of the study undertaken on acceptability, nutritional quality, shelf-life and therapeutic value of selected baked products with the use of wheat bran and isabgol is reported here.

4.1 PHYSICAL CHARACTERISTICS OF ISABGOL AND WHEAT BRAN

The particle size of the fine wheat bran used in the present study was found to be 850 microns. The coarse wheat bran and super fine wheat bran had particle sizes of 1800 microns and 315 microns respectively. The isabgol seeds had a thousand kernel weight of 1.7 g. and a husk percentage of about 28 g. The isabgol seed has a higher water absorption capacity than the wheat bran. However, wheat bran has a higher oil absorption capacity than the processed isabgol seeds (Table-3).

4.2 CONSUMER ACCEPTABILITY OF PRODUCTS

The developed products were evaluated by a 35-member untrained consumer panel for their overall acceptability by way of ranks. The frequency of ranks for each of the developed products under individual

Plate 2. Processed isabgol seed and wheat bran used in the study.



ISABGOL

WHEAT-BRAN

Table-3. Physical characteristics of Isabgol and Wheat bran

Characteristics	Observations
PARTICLE SIZE	
Coarse wheat bran	1800 (microns)
Fine wheat bran	850 (microns)
Superfine wheat bran	315 (microns)
THOUSAND KERNEL WEIGHT	
Isabgol seed (undehusked)	1.7 (g)
HUSK PERCENTAGE	
Isabgol seed	27.7 (%)
WATER ABSORPTION CAPACITY	
Processed isabgol seed	236 (%)
Wheat bran	185 (%)
OIL ABSORPTION CAPACITY	
Processed isabgol seed	30 (%)
Wheat bran	155 (%)

Plate 3. Best accepted supplementation levels of isabgol (8%), wheat bran (20%) and I-WB Blend [(30+16)%] in chilly biscuits

Plate 4. Best accepted supplementation levels of isabgol (12%), wheat bran (40%) and I-WB blend [(30+16)%] in sacher cake



treatments and the results of the Friedman's test in each case are presented in Tables-4, 5 and 6.

Table-4 gives the frequency of ranks for each level of isabgol supplementation (Treatment-I) for each product. Friedman's 2-way ANOVA by ranks was applied to find out any significant difference in the acceptability among the various levels of incorporation in the test products by the panel members. The results indicated a significant difference in preference for the level of incorporation in coconut cookies and pound cake.

Table-5 gives the frequency of ranks for each level of wheat bran supplementation (Treatment-II) for each product. Friedman's test applied as in the previous case showed a significant difference in acceptability among supplementation levels only in case of chilly biscuits.

Table-6 gives the frequency of ranks for each level of isabgol - wheat bran blend supplementation (Treatment-III) for each product. The Friedman's test indicates that, there is no significant difference among supplementation levels in the acceptability of the developed products and that all the levels are equally acceptable.

Table-4 Friedman's 2-way ANOVA using ranks under treatment-I for the developed baked products

Product name	Level of supplementation (%)	Frequency of ranks				χ^2 value (P<0.05)
		I	II	III	IV	
CHILLY BISUITS	0 (Control)	11	9	7	8	0.36
	4	11	13	5	6	
	8	14	7	8	6	
	12	4	13	14	4	
SACHER CAKE	0 (Control)	6	15	9	5	0.07
	4	7	16	9	3	
	8	13	9	7	6	
	12	14	9	5	7	
COCONUT COOKIES	0 (Control)	11	11	7	6	0.05*
	4	11	9	14	1	
	8	12	11	8	4	
	12	7	10	12	6	
SALT BISCUITS	0 (Control)	15	9	8	3	3.23
	4	11	10	11	3	
	8	4	6	14	11	
	12	9	18	5	3	
POUND CAKE	0 (Control)	11	12	7	5	0.03*
	4	12	9	11	3	
	8	13	12	7	3	
	12	8	13	12	2	
CHOCOLATE COOKIES	0 (Control)	12	12	4	7	0.20
	4	14	10	8	3	
	8	6	16	7	6	
	12	8	10	14	3	
SWISS SANDWICH	0 (Control)	8	12	11	4	0.51
	4	13	13	6	3	
	8	9	13	7	6	
	12	7	5	6	17	

*Significant at P < 0.05.

Plate 5. Best accepted supplementation levels of isabgol (8%), wheat bran (20%) and I-WB blend [(30+16)%] in coconut cookies

Plate 6. Best accepted supplementation levels of isabgol (4%), wheat bran (20%) and I-WB blend [(30+16)%] in Swiss sandwich.

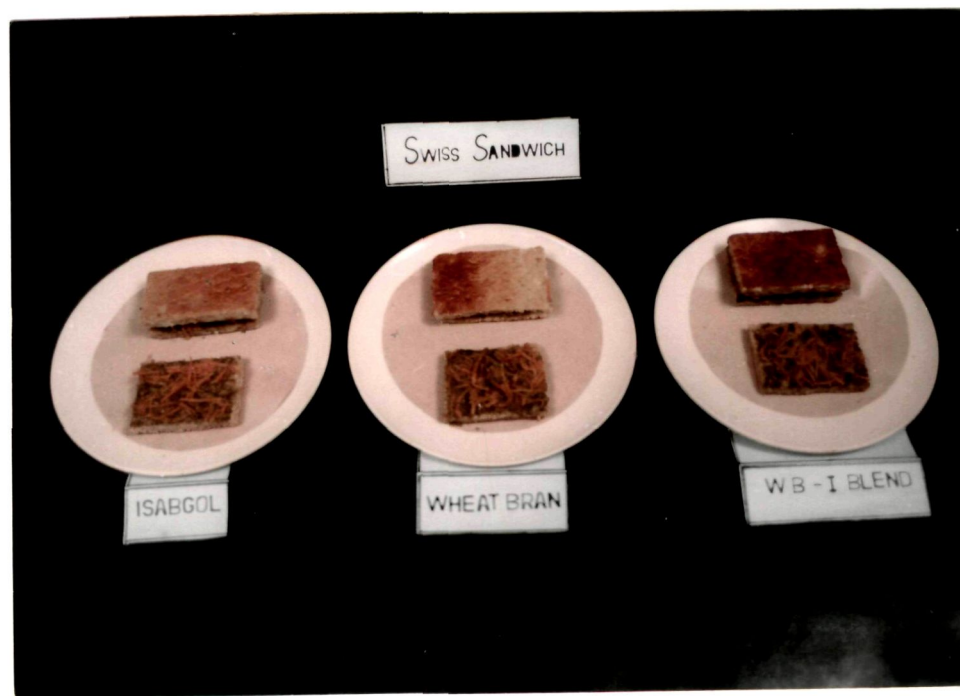
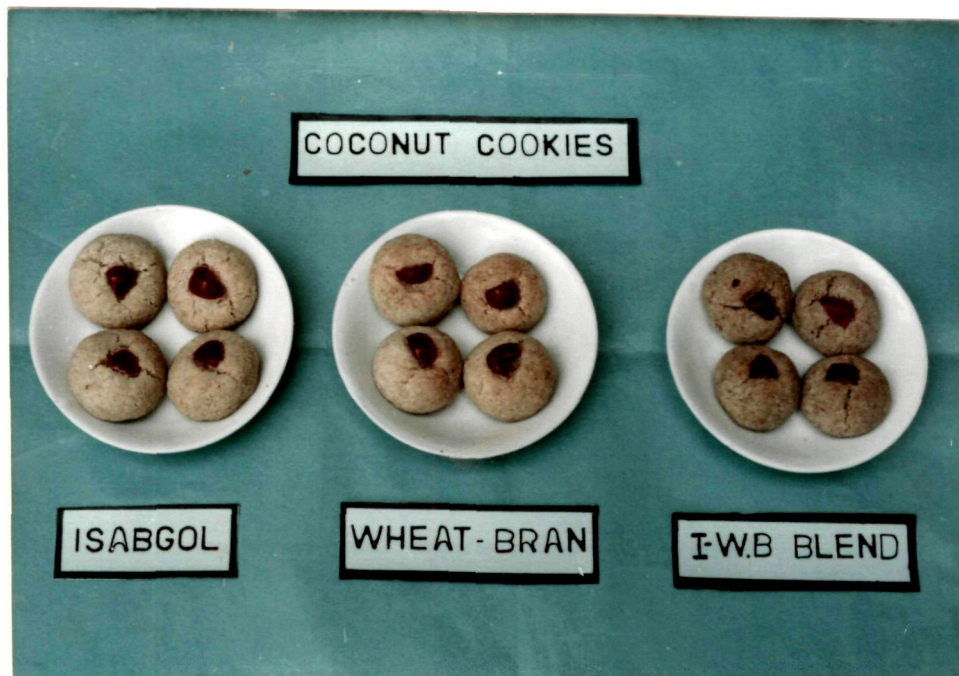


Table-5. Friedman's 2-way ANOVA by ranks under treatment-II for the developed baked products

Product name	Level of supplementation (%)	Frequency of ranks				X ² value (P<0.05)
		I	II	III	IV	
CHILLY BISUITS	0 (Control)	20	8	5	2	0.05*
	20	10	8	11	6	
	30	9	10	10	6	
	40	6	21	5	3	
SACHER CAKE	0 (Control)	14	11	9	1	0.11
	20	7	16	5	7	
	30	5	16	7	7	
	40	9	12	8	6	
COCONUT COOKIES	0 (Control)	16	11	3	5	0.20
	20	9	12	9	5	
	30	8	12	10	5	
	40	4	10	12	9	
SALT BISCUITS	0 (Control)	15	11	7	2	0.52
	20	7	19	7	2	
	30	5	5	13	12	
	40	11	9	7	8	
POUND CAKE	0 (Control)	18	8	7	2	0.24
	20	9	17	5	4	
	30	6	8	13	8	
	40	6	12	11	6	
CHOCOLATE COOKIES	0 (Control)	13	11	8	3	0.75
	20	8	9	15	3	
	30	6	15	6	8	
	40	4	4	16	11	
SWISS SANDWICH	0 (Control)	7	17	7	4	0.19
	20	2	13	17	3	
	30	1	7	19	8	
	40	2	4	10	19	

*Significant at P ≤ 0.05.

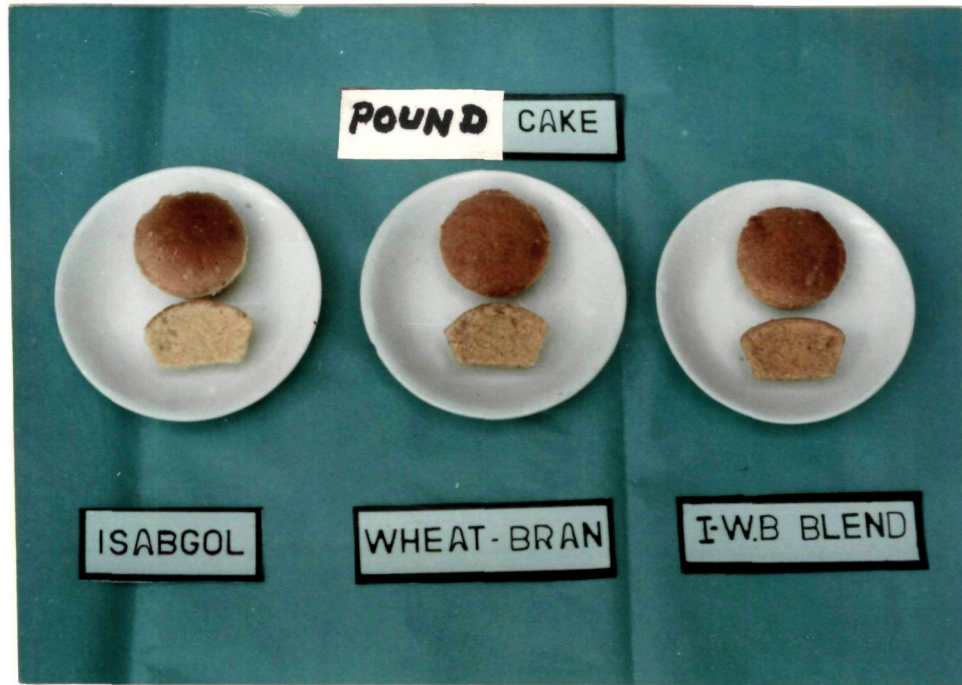
Table-6. Friedman's 2-way by ANOVA ranks under treatment-III for the developed baked products

Product name	Level of supplementation (%)	Frequency of ranks				χ^2 value (P<0.05)
		I	II	III	IV	
CHILLY BISUITS	0 (Control)	33	1	1	0	0.32
	30+16	2	21	8	4	
	40+12	2	13	13	7	
	40+20	2	9	13	11	
SACHER CAKE	0 (Control)	14	8	8	5	0.07
	30+16	9	15	8	3	
	40+12	7	16	8	5	
	40+20	8	11	8	8	
COCONUT COOKIES	0 (Control)	24	7	3	1	0.75
	30+16	5	8	9	13	
	40+12	4	7	13	11	
	40+20	3	16	14	2	
SALT BISCUITS	0 (Control)	28	4	2	1	0.75
	30+16	4	11	6	14	
	40+12	6	14	12	3	
	40+20	3	8	15	9	
POUND CAKE	0 (Control)	25	5	4	1	0.43
	30+16	2	6	17	10	
	40+12	5	9	11	10	
	40+20	1	14	13	7	
CHOCOLATE COOKIES	0 (Control)	14	9	9	3	0.80
	30+16	9	8	6	12	
	40+12	12	17	4	2	
	40+20	3	10	15	7	
SWISS SANDWICH	0 (Control)	9	9	13	4	0.19
	30+16	10	8	9	8	
	40+12	9	12	11	3	
	40+20	4	13	11	7	

*Significant at P < 0.05

Plate 7. Best accepted supplementation levels of isabgol (8%), wheat bran (20%) and I-WB blend [(40+12)%] in Pound cake.

Plate 8. Best accepted supplementation levels of isabgol (4%), wheat bran (20%) and I-WB blend [(40+12)%] in chocolate cookies



The cumulative frequency of ranks obtained in all the treatments for each product are given in Table-7. The results of the Friedman's test indicate a significant difference in acceptability among treatments in case of chilly biscuits, sacher cake and salt biscuits. In case of the other products, all the three treatments were equally preferred by the panelists.

Since the Friedman's test does not specify the extent of preference, the best accepted levels in each product under each treatment were selected based on the frequency of first ranks as compared with the controls.

4.3 QUALITY CHARACTERISTICS OF THE DEVELOPED PRODUCTS

The quality characteristics of the developed products were observed in comparison with the controls in terms of appearance, colour, crispness, mouthfeel and volume in case of cakes by the investigator. All the test products tended to get browned earlier during baking compared to the controls. The bran incorporated biscuits and cookies had a crisp texture and a drier appearance than their respective controls. Slight branny mouthfeel and after taste, was observed which increased with the level of supplementation. The products supplemented with isabgol had a pronounced branny

Table-7. Friedman's 2-way ANOVA by ranks for all the three treatments in the developed baked products

Product name	Treatment	Frequency of ranks				χ^2 value ($P < 0.05$)
		I	II	III	IV	
CHILLY BISUITS	I	40	42	34	24	0.002*
	II	45	47	31	17	
	III	39	44	35	22	
SACHER CAKE	I	40	49	30	21	0.002*
	II	35	55	29	21	
	III	38	49	32	21	
COCONUT COOKIES	I	41	41	41	17	0.15
	II	37	45	34	24	
	III	36	38	39	27	
SALT BISCUITS	I	39	43	38	20	0.02*
	II	38	44	34	24	
	III	41	37	35	27	
POUND CAKE	I	44	46	37	13	0.08
	II	39	45	36	20	
	III	33	34	45	28	
CHOCOLATE COOKIES	I	40	48	33	19	0.08
	II	31	39	45	25	
	III	38	44	34	24	
SWISS SANDWICH	I	37	43	30	30	0.30
	II	12	41	53	34	
	III	32	42	44	22	

*Significant at $P \leq 0.05$.

mouthfeel at very low incorporation levels and were more dense than the controls. There was a prominent decrease in the volume of cakes incorporated with wheat bran, while in case of isabgol, the decrease in volume was not evident.

4.4 CHEMICAL COMPOSITION OF PROCESSED ISABGOL SEED AND WHEAT BRAN

The analysed values of the various chemical constituents are presented in Table-8. Processed isabgol seed was found to be a richer source of fat, starch, dietary fibre and calcium than wheat bran. However, wheat bran had higher levels of protein, total ash, sugar and iron than the processed isabgol seed.

4.5 SELECTED NUTRIENT COMPOSITON OF PRODUCTS

Table-9 shows the nutrient composition of the dietetic products in comparison with their respective controls. The results indicate that the moisture content of biscuits and cookies was much lesser than that of the cakes and swiss sandwich.

The protein content of the control cookies and biscuits ranged between 4.5 to 6.8 g per 100 g while that of the dietetic cookies and biscuits increased to 4.7 to 7.1 g per 100 g by the isabgol supplementation,

Table-8. Selected chemical composition of wheat bran and the processed Isabgol seed flour (per 100 g).

Sl. No.	Nutrient	Processed Isabgol seed flour	Wheat bran
1	Moisture (g)	4.4	4.6
2	Crude protein (g)	14.2	16.0
3	Crude fat (g)	6.2	4.0
4	Energy (Cal)	247	234
5	Total ash (g)	2.2	3.5
6	Starch (g)	22.9	16.1
7	Sugar (g)	4.1	10.5
8	Neutral Detergent fibre (g)	43.4	35.9
9	Acid Detergent Fibre(g)	24.3	11.0
10	Lignin (g)	3.4	3.1
11	Hemicellulose (g)	19.1	24.9
12	Cellulose (g)	20.9	7.9
13	Calcium (mg)	77.0	57.0
14	Iron (mg)	8.9	9.2
15	Crude fibre (g)	13.0	7.6

5.1 to 8.5 g per 100 g by the wheat bran supplementation and 6.1 to 8.7 g per 100 g by the blend supplementation. The protein content of the control cakes and swiss sandwich ranged between 6.6 to 8.3 g per 100 g. This value was increased in the corresponding dietetic products to 6.8 to 8.4 g per 100 g by the isabgol supplementation, 7.2 to 8.7 g per 100 g by wheat bran supplementation and 7.6 to 9.0 g per 100 g by the blend supplementation.

The fat content of the biscuits and cookies which ranged from 29.4 to 40.6 g in the controls decreased to 24.5 to 37.9 g per 100 g in the dietetic products. Controls of cakes and swiss sandwich had fat content in the range of 17.7 to 19.6 g. which decreased to 16.4 to 18.6 g. per 100g. in the supplemented products.

The calcium content of the control products which ranged between 26.0 to 71.4 mg was increased to 26.7 to 73.8 mg per 100 g in all except coconut cookies, Supplemented with wheat bran. This is because the supplementation provided lesser quantity of calcium per gram of the product than the control in case of coconut cookies.

Table-9. Proximate composition of the dietetic baked products and their respective controls (per 100 g).

Product name	Treatment and level of supplementation (%)	Mois- ture* (g)	Pro- tein (g)	Fat (g)	Carbo- hydrate (g)	Calcium (mg)	Iron (mg)	Energy (Cal)
Chilly biscuits	0 (Control)	3.8	6.8	30.6	48.7	27.1	1.7	497
	4(T ₁)	3.9	7.1	29.5	47.7	29.4	2.1	486
	20(T ₂)	3.9	7.7	27.7	46.4	30.3	2.5	469
	40+12(T ₃)	4.0	8.6	25.0	44.0	35.1	3.3	441
Sacher cake	0 (Control)	10.6	7.1	19.6	37.9	31.5	1.3	356
	12(T ₁)	10.9	7.2	19.3	37.7	32.3	1.4	354
	40(T ₂)	10.8	7.6	18.7	37.3	32.9	1.7	350
	30+15(T ₃)	10.9	7.6	18.6	37.2	33.5	1.8	349
Coconut cookies	0 (Control)	3.2	4.5	40.6	48.5	71.4	2.1	578
	8(T ₁)	3.4	4.7	39.8	48.0	71.5	2.2	570
	20(T ₂)	3.4	5.1	38.5	47.2	70.5	2.5	558
	30+15(T ₃)	3.5	6.1	37.9	48.0	73.8	3.1	561
Salt biscuits	0	3.0	6.8	34.1	49.9	49.0	1.6	533
	4(T ₁)	2.8	7.0	33.6	49.6	49.8	1.8	530
	40(T ₂)	2.4	8.5	28.8	45.8	50.4	3.0	481
	40+12(T ₃)	3.0	8.7	27.6	44.8	51.7	3.3	469
Pound cake	0 (Control)	12.8	6.7	18.6	52.0	25.5	1.4	402
	8(T ₁)	12.9	6.8	18.3	51.4	26.7	1.6	398
	20(T ₂)	12.8	7.2	17.8	50.6	27.3	1.8	393
	40+12(T ₃)	13.0	7.9	16.7	48.6	30.4	2.4	380
Chocolate cookies	0 (Control)	4.0	5.7	29.4	58.0	33.3	1.3	519
	4(T ₁)	3.9	5.8	28.9	57.4	34.1	1.4	514
	20(T ₂)	3.8	6.6	27.2	55.3	35.3	2.0	495
	40+12(T ₃)	4.0	7.6	24.5	51.9	38.8	2.8	464
Swiss sandwich	0 (Control)	12.9	8.3	17.7	45.6	68.9	1.9	300
	4(T ₁)	12.8	8.4	17.6	45.4	68.7	1.9	300
	20(T ₂)	12.7	8.7	17.0	44.7	68.2	2.2	297
	30+15(T ₃)	13.0	9.0	16.4	43.7	68.4	2.6	294

*Analysed values.

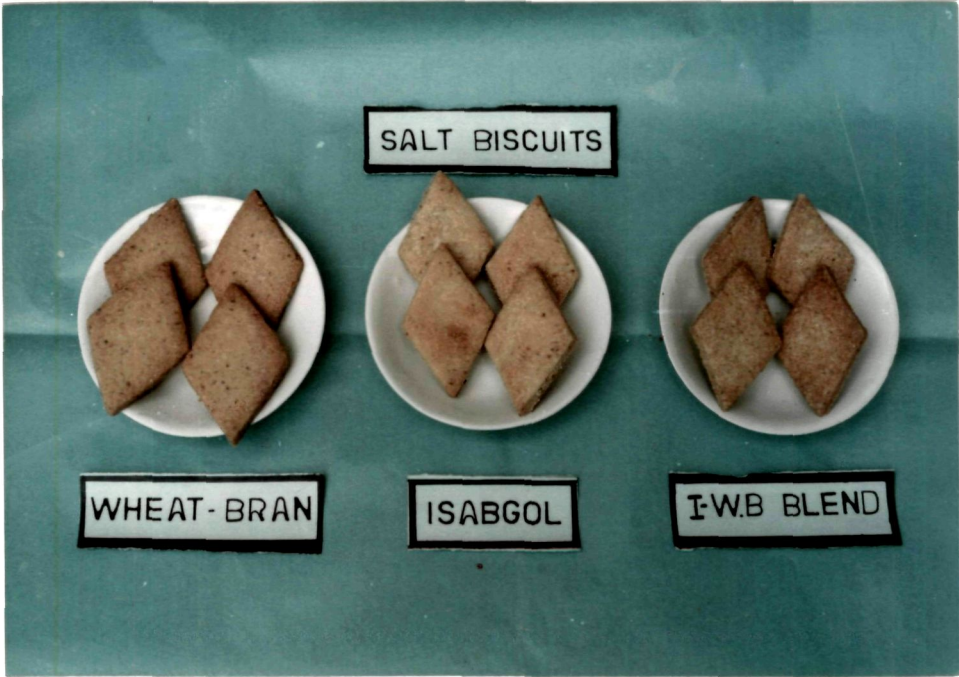
The iron content of the dietetic products indicated a proportionate increase to 1.4 to 3.3 mg from 1.3 to 2.1 mg per 100 g in the controls.

It is also clear from the table that the supplementations had a calorie reducing effect on the developed products. The calorific value of the products decreased from 300 to 578 Cal in the controls to 294 to 570 Cal in the dietetic products.

The content of the various dietary fibre fractions in the developed products are given in Table-10. The neutral detergent fibres and acid detergent fibre values increased from 1.4 to 3.7 g. and 0.4 to 1.9 g. in the controls respectively, 2.1 to 10.4 g and 1.0 to 5.8 g. in the dietetic products respectively.

While the increase in lignin content was only marginal by the various supplementations in the products compared with the controls, there was a greater increase in the cellulose and hemicellulose values by the various supplementations. The lignin, hemicellulose and cellulose content increased to 0.2 to 1.4 g, 0.9 to 5.0 g. and 0.5 to 4.8 g per 100 g respectively in the developed dietetic products.

Plate 9. Best accepted supplementation levels of isabgol (4%), wheat bran (40%) and I-WB blend [(40+12)%] in salt biscuits



SALT BISCUITS

WHEAT-BRAN

ISABGOL

I-W.B BLEND

Table-10. Dietary fibre fractions in the developed baked products compared with their controls (per 100g.)

Product name	Treatment and level of supplementation (%)	NDF* (g)	ADF* (g)	Lignin* (g)	Cellulose (g)	Hemi-cellulose (g)	Crude fibre (g)
Chilly biscuits	0 (Control)	2.8	1.1	0.7	0.5	1.7	0.4
	4(T ₁)	4.6	2.6	0.8	1.8	2.1	0.9
	20(T ₂)	6.3	2.9	0.9	2.0	3.4	1.1
	40+12(T ₃)	10.4	5.5	1.2	4.3	5.0	2.3
Sacher cake	0 (Control)	1.4	0.4	0.2	0.2	0.9	0.04
	12(T ₁)	2.1	0.9	0.2	0.7	1.2	0.3
	40(T ₂)	3.3	1.1	0.3	0.8	2.2	0.4
	30+16(T ₃)	3.8	1.4	0.4	1.0	2.4	0.6
Coconut cookies	0 (Control)	3.7	1.9	0.4	1.5	1.8	1.1
	8(T ₁)	4.7	2.5	0.5	2.1	2.2	1.4
	20(T ₂)	5.6	2.7	0.6	2.2	2.9	1.5
	30+16(T ₃)	8.1	4.1	0.8	3.4	4.0	2.1
Salt biscuits	0 (Cookies)	2.7	1.0	0.3	1.6	0.7	0.4
	4(T ₁)	3.5	2.6	0.3	2.2	0.9	0.7
	40(T ₂)	8.5	4.1	0.8	3.3	4.4	1.6
	40+12(T ₃)	10.2	5.7	0.9	4.8	4.5	2.2
Pound cake	0 (Control)	1.6	0.8	0.1	0.7	0.8	0.1
	8(T ₁)	2.6	1.4	0.2	1.2	1.3	0.4
	20(T ₂)	3.5	1.4	0.3	1.1	2.1	0.5
	40+12(T ₃)	6.6	3.6	0.5	3.1	3.0	1.3
Chocolate cookies	0 (Control)	1.9	0.9	0.5	0.4	1.1	0.1
	4(T ₁)	2.5	1.1	0.6	0.5	1.4	0.4
	20(T ₂)	4.8	2.5	0.7	1.8	2.2	0.8
	40+12(T ₃)	8.9	5.8	1.0	4.8	3.2	1.8
Swiss sandwich	0 (Control)	3.6	1.9	0.7	1.2	1.7	0.5
	4(T ₁)	4.0	2.2	0.8	1.4	1.8	0.7
	20(T ₂)	5.1	2.4	0.9	1.6	2.7	0.9
	30+16(T ₃)	6.8	3.5	1.4	2.1	3.3	1.5

*Analysed values.

4.6 SELECTION OF PRODUCT FOR FEEDING STUDY

Salt biscuits were selected among the dietetic products for the feeding study. Based on the frequency of first ranks, the level of (40+12) per cent supplementation under the third treatment was chosen from Tables 6 and 7. Further, studies were carried out only on this product.

4.7 SHELF-LIFE STUDY OF SALT BISCUITS

The storage study was conducted for a period of 35 days on the dietetic salt biscuit ready-to-prepare mix as well as the ready-to-eat product. At a regular interval of 7 days, the ready-to-eat product, the salt biscuits prepared from the ready-to-prepare mix and the freshly prepared product (control) were subjected for sensory analysis. The results are given in Table-11. Fig.2 shows the steady decrease in mean scores for overall acceptability of the dietetic product and the ready-to-prepare mix with the increase in the length of storage period. The overall acceptability of the ready-to-prepare mix is much closer to the control and can be stored upto a period of 28 days, while the ready-to-eat product shows a steady decline in the mean scores for overall acceptability and hence can be stored upto 7 days without significant changes in sensory quality.

Plate 10. Specimen sample of ready to eat dietetic
salt biscuits during the shelf life study

Plate 11. Specimen sample of ready to eat dietetic
salt biscuit mix during the shelf life study

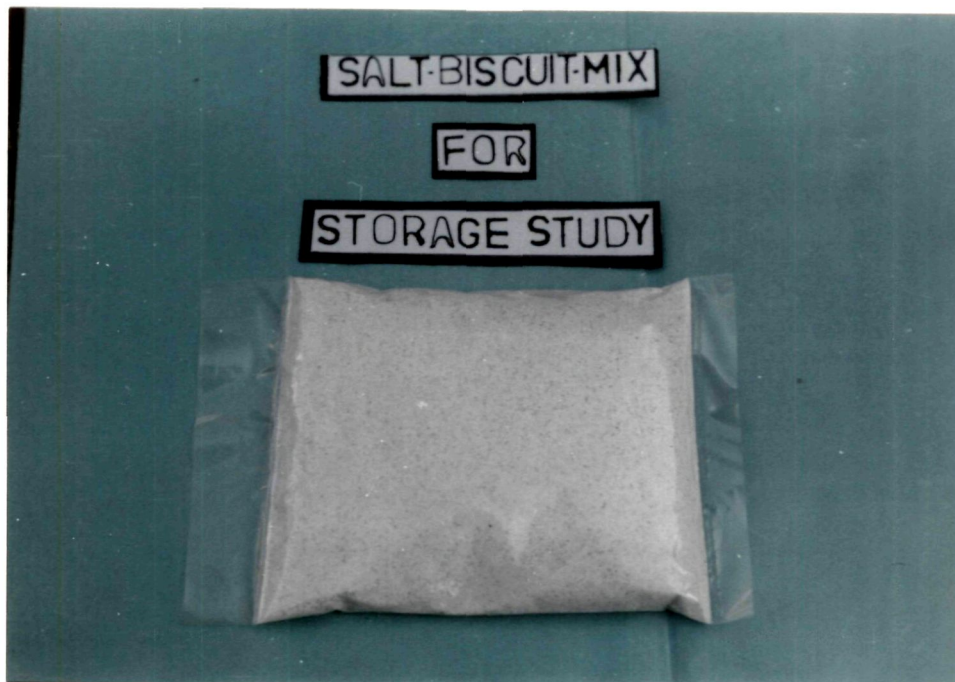
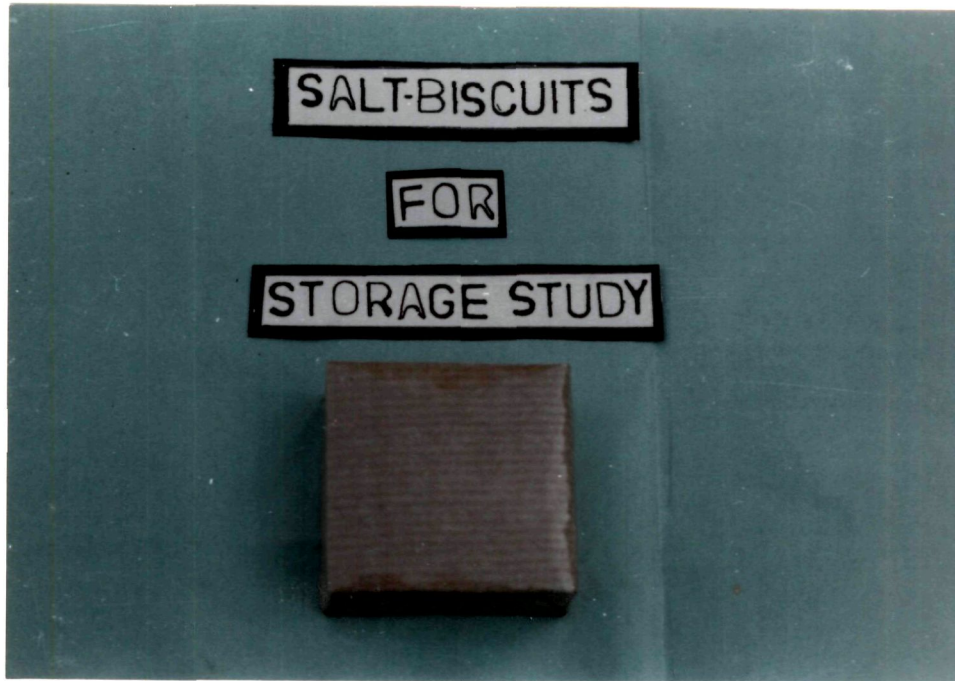


Table-11. Mean scores for the various sensory attributes during the storage study of dietetic salt biscuits (test product) and ready to prepare mix compared with the control*

Sensory attributes	DAYS															
	7			14			21			28			35			
	C	P	M	C	P	M	C	P	M	C	P	M	C	P	M	
Appearance	3.8	3.0	3.4	3.4	1.6	3.2	3.4	3.4	0	3.0	3.6	0	2.6	3.2	0	1.8
Texture	4.0	3.4	3.6	4.0	2.8	3.6	4.0	4.0	0	3.6	4.0	0	3.4	3.8	0	2.6
Flavour	3.6	2.2	3.4	3.8	1.0	2.6	3.4	3.4	0	2.6	3.0	0	2.2	3.2	0	1.0
Overall Acceptability	3.8	2.6	3.4	3.8	1.4	3.0	3.8	3.8	0	3.0	3.6	0	2.4	3.6	0	1.2

* Freshly prepared fibre incorporated salt biscuit.

C = Control
P = Ready-to-eat product
M = Ready-to-prepare mix

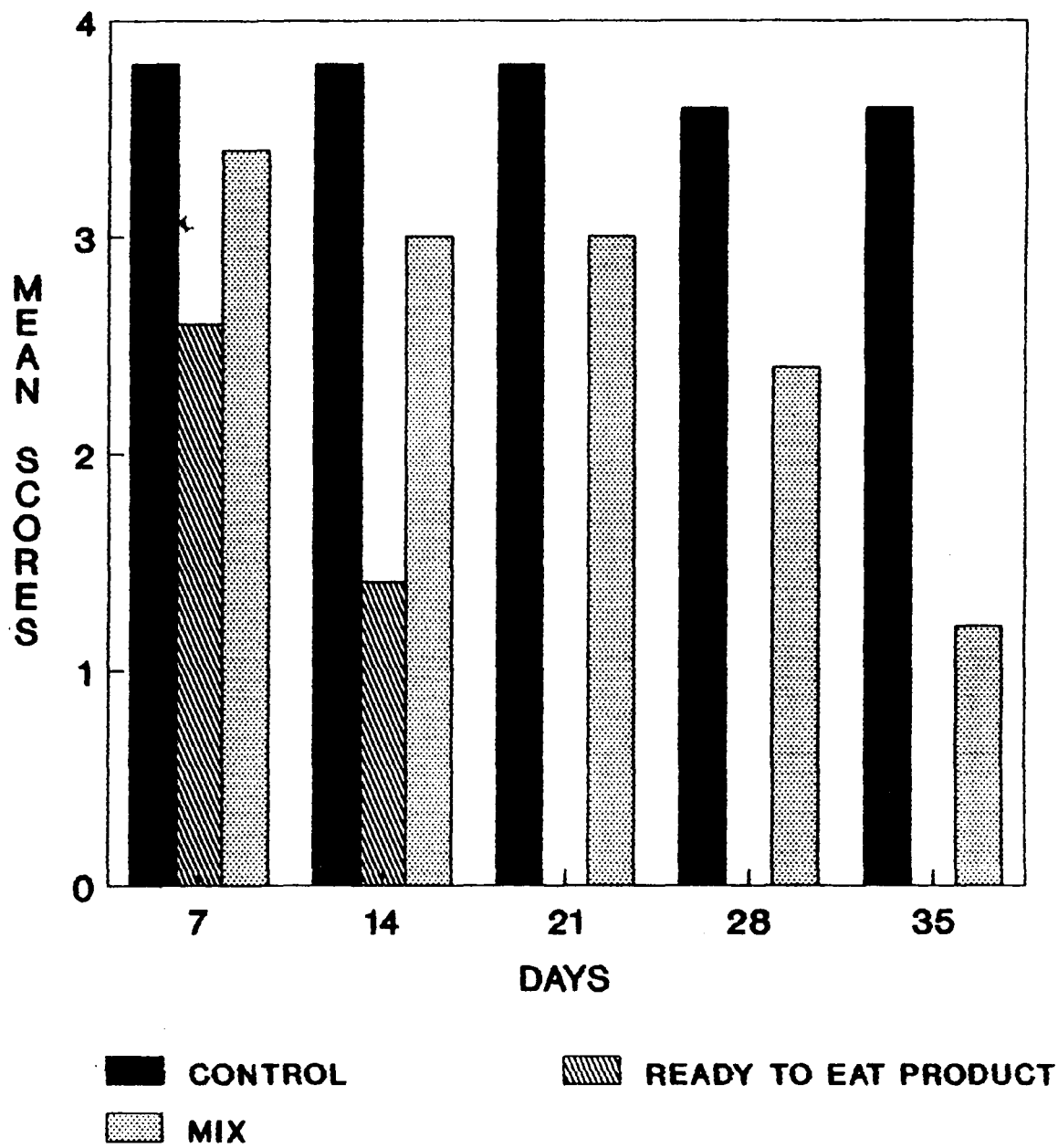


Fig. 2 Effect of storage period on the overall acceptability of dietetic salt biscuits (test product) and mix compared to the control.

4.8 BIOASSAY ON SUBJECTS

The subjects selected were those having liking for baked products (Fig. 3) and to whom these products were not recommended due to their present condition. Fig.3 illustrates the extent of liking by the test subjects for the test product. The demographic profile, dietary habits and clinical profile were recorded using interview schedule.

4.8.1 Profile of the Subjects

A general study of the demographic profile of the test subjects indicated that their ages ranged between 19 and 72 years and of them 63 per cent (25) were males. 80 per cent (32) of the subjects had passed high school while only 5 per cent were illiterate. 70 per cent of them (30) were employed in occupations of sedentary nature and more than 80 per cent (33) worked on an < 8 hour schedule. Nearly 50 per cent (19) of them preferred to rest during their free hours, while many others resorted to equally inactive forms of recreation like reading or watching television.

4.8.2 Dietary Pattern of the Test Subjects

The observations indicate that the percentage of Vegetarians (21) marginally exceeded that of Non-

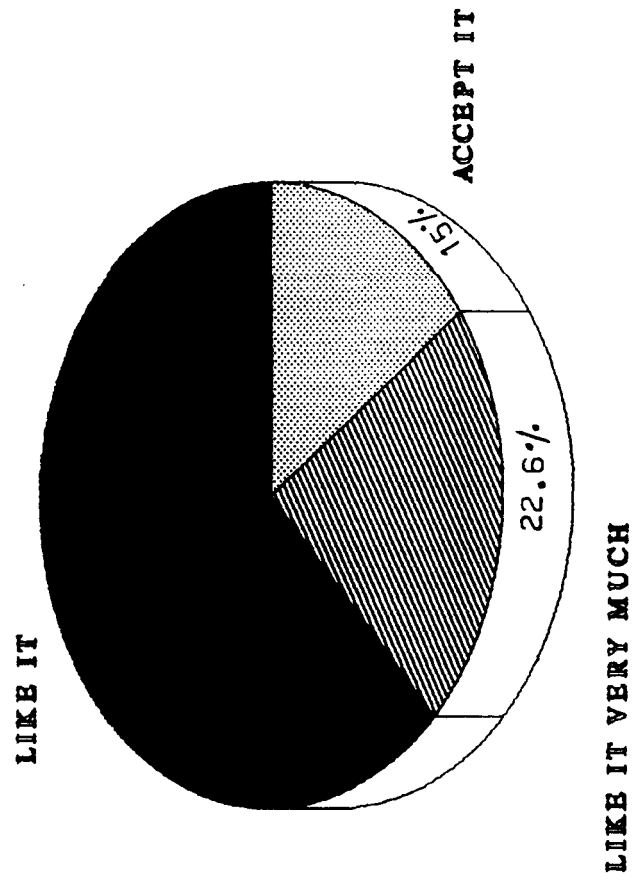


Fig.3 Extent of Preference for the dietetic salt biscuits by the test subjects for use in the feeding study

vegetarians (19). 40 per cent (16) of the subjects reported that they seldom consumed green leafy vegetables, while a similar percentage reported a weekly intake of green leafy vegetables. More than 80 per cent (33) of the subjects negated the consumption of whole or sprouted grains.

4.8.3 Dietary Intake

The nutritive value of a typical day's menu was calculated from the average of the 3-day menu obtained from the test subjects (Table-12). Some of the common menu items in a day's meal of the subjects are given in Appendix-VI. The dietary intake was recorded to know the daily fibre consumption of the subjects. The results indicate a very low intake of crude fibre (3.0 g).

4.8.4 Clinical Profile of the Test Subjects

The data indicated that in more than 40 per cent of the subjects. (17), constipation was a year old problem. In 78 per cent of the patients (31), a daily bowel evacuation represented normal frequency. Majority of the subjects (26) agreed that there was an alteration of their meal pattern during constipation. The trend of change was towards general reduction in the amount

Table-12. Typical nutrient intake of the test subjects per day.

Nutrients	Amount (g)
Protein	42
Carbohydrate	237
Fat	30
Energy	1474*
Crude fibre	3.0

* Calories.

consumed in case of 53 per cent (21) while 20 per cent (8) tended to miss specific meals of the day. 85 per cent (35) of the patients expressed severity of their constipated condition as a criterion to consult a doctor. More than 40 per cent (17) reported to have a tendency towards suppression of stools. Nearly 50 per cent of the test subjects (19) reported that they had not undergone any treatment in the past for the present condition. 30 per cent (12) and 20 per cent (8) depended on commercial laxatives and purgatives while only about 13 per cent (5) depended on ayurveda and home remedies. A very small percent of the patients were found to suffer from diabetes (2), ulcer (1) and hypertension (2).

4.8.5 Feeding Study

Salt biscuits incorporated with blend of wheat bran and isabgol at a supplementation level of (40+12) per cent were selected for the feeding study. The aim was to partially substitute the test subjects' diet with at least 20 g fibre source per day. Hence, the biscuits were standardised and weighed (about 11 g per biscuit) and the subjects were asked to consume at least eight biscuits a day, for a period of ten days. The effect of the partial substitution by the fibre

supplemented products was observed by the clinical parameters before the start and on the last day of the test period as given in Table-13 and 14.

The results of Table-13 indicate that 82.5 per cent of the subjects experienced a normal frequency of bowel evacuation on the final day of the feeding study. 70 per cent and 30 per cent of the subjects complained of experiencing incomplete bowel evacuation always and sometimes respectively, at the start of the feeding study. On the final day however, 82.5 per cent reported complete treatment of this condition.

The consistency of the stools reached normalcy in case of 45 per cent of the subjects at the end of the test period as against 5 per cent at the start.

Table-14 shows the frequency of occurrence of the various symptoms and the frequency of straining during bowel evacuation which was significantly decreased on the final day of the feeding study.

The personal response of the test subjects regarding the day to day effect of the test product on their constipated condition during the period of the feeding study is given in Table-15. A chi-square test

Table 13 : Clinical profile of the test subjects before and after the study period.

N = 40

Parameters Measured	Clinical Status(%)	
	Before	After 10 days
1 Frequency of bowel evacuation during constipation.		
Twice a day but small quantity	2.5	15.0
Daily	30.0	82.5
Once in two days	55.0	2.5
Once in >two days	12.5	0.0
2 Frequency of incomplete bowel evacuation		
Always	70.0	7.5
Sometimes	30.0	10.0
Never	0.0	82.5
3 Consistency of Stools		
Hard	95.0	7.5
Normal	5.0	45.0
Slightly loose	0.0	40.0
Diarrhoeic	0.0	5.0

Table 14 : Clinical status of the test subjects before and after the study period.

N = 40

Parameters Measured	Clinical Status (%)	
	Before	After
1 Symptoms Experienced:		
Uneasiness	52.5	20.0
Stomach heaviness	77.5	12.5
Difficulty in evacuation	77.5	25.0
Stomach pain	40.0	32.5
Psychological discomfort	15.0	5.0
Stomach distention	52.5	17.5
Headache	32.5	15.0
Nausea	17.5	10.0
Vomiting	5.0	2.5
Back pain	5.0	0.0
Gas formation	55.0	20.0
Any other	22.5	17.5
2 Pain during bowel evacuation:		
Always	17.5	7.5
Sometimes	17.5	7.5
Never	65.0	85.0
3 Severity of the pain :		
Very severe	5.0	2.5
Tolerable	25.0	5.0
Mild	5.0	7.5
4 Frequency of straining during bowel evacuation :		
Always	50.0	45.0
Sometimes	22.5	10.0
Never	27.5	45.0

was conducted to test whether the effect of the treatment was dependent on the days of feeding. The test was found to be significant at 1 per cent ($P < 0.01$).

The personal response of the test subjects was represented in terms of "no change", "slight improvement" and "marked improvement". Gradually increasing frequency of the test subjects experienced "slight improvement" and "marked improvement" respectively from the first day to the last day of the feeding study (Fig.4).

4.9 COST EVALUATION OF PRODUCTS

The production cost of the developed dietetic baked products was compared with the production cost of their respective controls (Table-16).

Table 15 : Personal opinion of the test subjects regarding the day-to-day effect of the test product on their constipated condition during the study period.

Number of days	Frequency of Response			χ^2
	No change	Slight improvement	Marked improvement	
1	40	0	0	
2	33	6	1	
3	21	18	1	
4	13	26	1	
5	8	27	5	
6	4	29	7	575.9*
7	5	28	7	
8	4	29	7	
9	2	32	6	
10	2	32	6	

* Significant at < 0.01

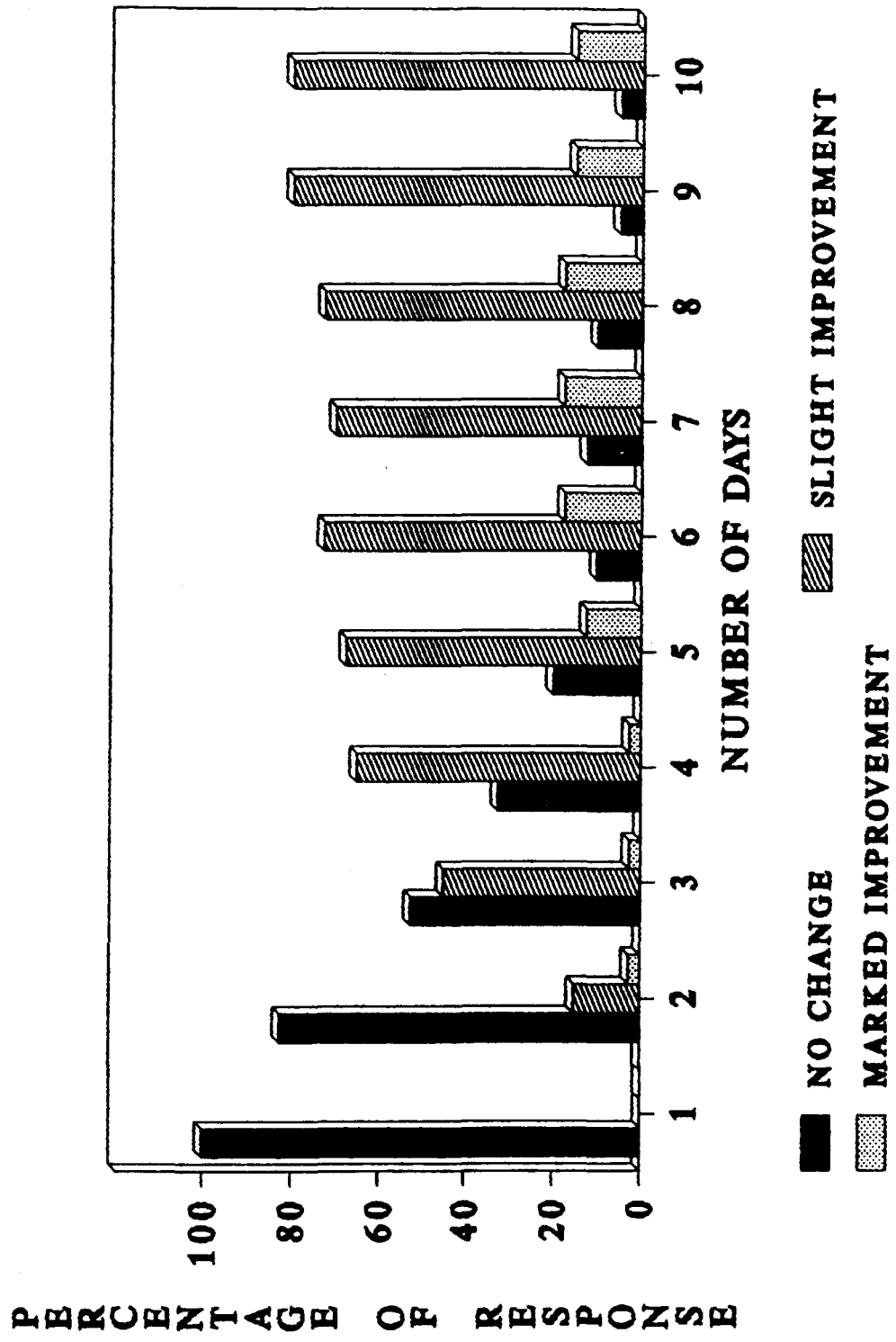


Fig.4 Personal opinion of the test subjects on the day to day effect of the feeding study.

Table 16 : Production cost of best accepted test products.

Name of the product/ Treatment	Percent incorporation	Cost per 100 g (Rs)
1 SALT BISCUITS		
T ₀	control	2.4
T ₁	4	2.5
T ₂	40	2.0
T ₃	40+12	2.3
2 CHILLY BISCUITS		
T ₀	control	2.2
T ₁	8	2.5
T ₂	20	2.0
T ₃	30+16	2.4
3 SACHER CAKE		
T ₀	control	2.6
T ₁	12	2.7
T ₂	40	2.5
T ₃	30+16	2.6
4 COCONUT COOKIES		
T ₀	control	5.9
T ₁	8	4.3
T ₂	20	3.9
T ₃	30+16	4.0
5 POUND CAKE		
T ₀	control	1.8
T ₁	8	1.9
T ₂	20	1.7
T ₃	40+12	1.3
6 CHOCOLATE COOKIES		
T ₀	control	2.3
T ₁	4	2.4
T ₂	20	2.3
T ₃	40+12	2.3
7 SWISS SANDWICH		
T ₀	control	2.3
T ₁	4	2.4
T ₂	20	2.2
T ₃	30+16	2.4

DISCUSSION

V. DISCUSSION

The salient features of the study on acceptability, nutritive value, storage, therapeutic effect and production cost of selected baked products supplemented with isabgol and wheat bran are discussed below.

5.1 PHYSICAL CHARACTERISTICS OF ISABGOL AND WHEAT BRAN

The physical properties of the fibre source can be used to understand the physiological effects of its consumption. Many of these properties are inter-related (Table-3). The particle size of the fine wheat bran used in the study was 850 microns. A decrease in the particle size of wheat bran from 800 to 180 microns is associated with a 41 per cent decrease in its water absorption capacity and hence its laxative effect which is further reduced due to collapse of fibre structure during food preparation and mastication (Encyclopedia of Food Science and Technology and Nutrition, 1993). From Table-3 it is seen that the water holding capacity of wheat bran and isabgol seed preparation are 185 and 236 respectively. These values support the observation by Struthers (1986) that the water holding capacity of isabgol (undehusked seed) is intermediate between bran

and husk, which form a gelatinous mass even at 2 per cent concentrations. Smith (1981) reported the decrease in transit time from 61-21 hours and 56-51 hours in individuals kept on coarse bran and fine bran diets respectively. Hence, coarse bran had higher water absorption capacity than fine bran. The stimulation of peristaltic action is the result of the ability of the fibre to absorb or hold water in the stools as it passes through the colon (Southgate, 1973). Isabgol husk, which accounts for approximately 30 per cent of the entire seed (undehusked) is digested upto 70-90 per cent by the large intestinal microflora and wheat bran upto only 40 per cent, while the digestibility of the isabgol seed (undehusked) is presumed to be between that of husks and bran. The faecal water content of rats fed 100 g/kg isabgol seeds (undehusked), wheat bran, isabgol husks and the fibre free control were 600, 514, 590 and 480 (g per kg faeces) respectively. Hence, the effect of the fibre sources on increasing stool weight were concluded to be due to the presence of undigestible residue, water holding capacity and the bacterial load (Peschlow, 1990).

The fat absorption capacity of wheat bran was found to be nearly five times that of the processed

isabgol seed. The ability of dietary fibre to bind with oils has not been extensively investigated but it is believed to interfere with pancreatic enzyme action on the fat present in micelles bound to bile acids thereby altering fat absorption (Augustin et al., 1989).

The thousand kernel weight of the isabgol seed (undehusked) was found to be 1.65 g and the husk accounted for approximately 28 per cent of its weight. This is in accordance with the value of 30 per cent husk percentage as observed by Chakraborty and Patel (1992).

5.2 CONSUMER ACCEPTABILITY OF PRODUCTS

The Friedman's 2-way ANOVA indicated that a differential preference exists among levels of supplementation of isabgol in coconut cookies and pound cake. In case of the rest of the products, all the levels of isabgol supplementation were equally preferred (Table-4). Hence, going by the frequency of first ranks, with the exception of salt biscuits, the control products were preferred over the isabgol supplemented products.

The Friedman's test on the wheat bran supplemented products indicates that only chilly biscuits evoked a significant difference in preference

among wheat bran supplementation levels. However, the control products in each case enjoyed a higher frequency of first ranks (Table-5).

The Friedman's test on the blend incorporated products indicated that all the products were equally preferred irrespective of the level of incorporation. However, going by the frequency of first ranks, with the exception of swiss sandwich, in all other products, the control products were given a higher frequency of first ranks than the supplemented products (Ttable-6).

Thus from Tables 4, 5 and 6 it is clear that while all the levels of supplementation were acceptable, the panelists were able to easily identify the respective controls. This could be attributed to the typical branny mouthfeel and dry appearance of the supplemented products. However, a majority of the panelists gave higher ranking for 4 per cent and 8 per cent isabgol, 20 per cent wheat bran and (30+16) per cent blended supplementation levels in most of the products.

The Friedman's test was also applied to see whether any difference in preference among treatments existed among the panelists. From Table 7 it is seen that with the exception of chilly biscuits, sacher cake

and salt biscuits, the three treatments were equally preferred in all the other products. In these cases, the best preferred treatment was selected based on the frequency of first ranks. However, for the further study, the best preferred treatment of each product was to be chosen from among salt biscuits, chilly biscuits and sacher cake.

5.3 QUALITY CHARACTERISTICS OF THE DEVELOPED PRODUCTS

Fibre incorporation into baked products is known to bring certain changes in sensory attributes. According to Jeltema et.al. (1983) wheat bran affects surface colour. Cookies containing wheat bran were significantly darker than the control. An increase in fibre components significantly correlated with poorer top grain characteristics. Similar observations were noted in the present study. Czuchajowska et al. (1992) found that isabgol husk caused an increase in cake volume while wheat bran decreased the cake volume in Japanese sponge cakes. In the present study, cakes incorporated with wheat bran showed visible decrease in volume, but this decrease was not so evident with isabgol supplementation. A typical branny mouthfeel with slight after taste was observed in the wheat bran

and blend supplemented products. Leelavathi and Rao (1993) reported that biscuits containing 20 per cent toasted bran were slightly gritty and had a residual branny mouthfeel. They further carried out studies to improve the textural characteristics by using certain additives. They concluded that incorporation of glycerol-monostearate (GMS) at 0.5 per cent improved the crispness and overall quality of salt biscuits incorporated with 30 per cent wheat bran.

Since fibre incorporation causes such specific effects on sensory quality, further attempts have to be undertaken to overcome these effects by the use of such surfactants or functional ingredients with the objective of bringing the quality of the dietetic products closer to the control.

5.4 **SELECTED CHEMICAL COMPOSITION OF WHEAT BRAN AND THE PROCESSED ISABGOL SEED**

The values for the chemical composition of wheat bran (Table-8) are comparable to the values obtained by Sousulski and Cadden (1982) and Kunnerth and Youngs (1984). Peterson et al. (1983) reported the calcium and iron content of wheat bran to be between 63-131 mg and 7.2-11.6 mg per 100 g. which is comparable to the present study.

The nutritive value of bran protein is higher than that of the endosperm protein because of the high lysine content in bran (Bartnik and Jakubczyk, 1989). Isabgol seed too has a protein with high nutritive value with adequate amounts of lysine, methionine and tryptophan (Chakrabarty and Patel, 1992).

According to Prosky et.al. (1985), isabgol seeds and isabgol husk have a total dietary fibre value of 86 per cent and 94.8 per cent respectively with a ratio of soluble to insoluble fibre of 47:53 and 67:33 respectively. Based on the ratio and considering that the husk accounts for 30 per cent of the undehusked seed, the calculated value of insoluble fibre in 100 g of isabgol seed amounts to 41.3 per cent which is comparable to 43.4 per cent as analysed in the present study. Thus both wheat bran and isabgol seed are good sources of dietary fibre and protein and are promising ingredients in the development of low calorie foods.

5.5 SELECTED NUTRIENT COMPOSITION OF PRODUCTS

The composition of proximate nutrients in the dietetic products and their respective controls are shown in Table-9.

Table-9 illustrates the fact that considerable reduction in fats, carbohydrates and energy and a similar increase in protein, calcium and iron has been achieved by the supplementation at various levels. This increase or decrease in the respective nutrients is more for the blend supplementation followed by the supplementations by wheat bran and isabgol respectively. This can be attributed to the higher incorporation levels in case of the blend supplementation followed by wheat bran followed by isabgol supplementation.

Among the developed dietetic products, coconut cookies, salt biscuits, chilly biscuits and swiss sandwich were found to have comparatively higher dietary fibre values in the control because of their content of fibre rich components such as coconut, ajwan and green masala.

According to Chavan and Kadam (1993), biscuits and muffins contain about 5-10 per cent protein, 10-27 per cent fat and a calorific value of 450-550 Calories per 100 g, with a higher fat content in case of cookies. The protein content of the wheat bran and blend supplemented products was found to be higher than that of the isabgol supplemented products as the level of incorporation and the inherent protein content of wheat

bran is higher than that of isabgol. Similarly, the fat content of the developed products decreased more with the wheat bran-isabgol blend supplementation, followed by wheat bran and finally the isabgol supplementation. This is because of the higher level of incorporation and lower inherent fat content of wheat bran.

The calcium content in all the supplemented products except coconut cookies was higher than the controls. In coconut cookies, a marginal decrease in the calcium content was observed for the wheat bran supplementation. This could be attributed to the fact that the supplementation provided lesser amounts of calcium than the controls per gram of the product.

The supplementations also achieved an increase in the iron content compared with the controls. Buchowski and Vanderstoep (1989) evaluated the conversion of endogenous iron from wheat bran into haemoglobin and found that baking of the wheat bran as a constituent of muffins significantly ($P < 0.05$) increased the haemoglobin iron regeneration efficiency.

The isabgol supplementation among the three treatments caused a further decrease in the carbohydrate values than the controls. This is due to the low level

of its supplementation and the marginally higher inherent content of digestible carbohydrates. All the supplementations however have a calorie reducing effect. According to VanSoest and Robertson (1977) the dietary fibre content in a food is two to five times higher than the corresponding crude fibre content. This is illustrated in Table-9.

All the supplementations also caused an increase in the values for the neutral detergent fibre and acid detergent fibre fractions by at least one and a half times than the controls (Table-10). Although the lignin and hemicellulose content of isabgol are higher than that of wheat bran because of the higher level of incorporation, the wheat bran supplemented products show a higher lignin content.

Similarly the cellulose values in the wheat bran and isabgol supplementations do not show much differences because of the higher level of wheat bran incorporation although the cellulose content of isabgol is more than twice that of wheat bran.

Thus the inference that can be drawn from the above data is that the dietetic products developed in the present study have high protein, dietary fibre, calcium and iron and a lower value of fats, carbo-

hydrates and therefore energy than their respective controls. Hence they further reinforce the usefulness of incorporation of fibre and protein rich non-conventional food sources into baked products not only for improving the nutrition of the community but also to evolve a natural dietary means for the prevention and control of several diseases be it diabetes, hypercholesterolemia, heart disease or constipation.

5.6 SELECTION OF PRODUCT FOR FEEDING STUDY

From Table-7, chilly biscuits, salt biscuits, and sacher cake were the only three products wherein a significant difference in preference was seen among treatments. Since limitations of time would not permit individual feeding studies on isabgol alone or wheat bran alone, and since the object of the study was to establish the therapeutic effect of the two test ingredients, it was decided to consider the combined therapeutic effect of the two. Since salt biscuits was the only product in which the best accepted treatment was blend supplementation and also because of ease of preparation and better shelf-life than sacher cake, this product was chosen for the feeding study.

5.7 SHELF-LIFE STUDY OF SALT BISCUITS

From the results given in Table-11, it is seen that the mean scores for appearance and texture of the freshly prepared salt biscuit (control) is comparable to the ready to prepare mix upto 28 days and upto 7 days for the ready to eat product. However, after a period of 7 days, for the ready to eat product and after 14 days for the mix, much of the flavour was lost. In the study, it was generally observed that wheat bran tends to absorb smell, and the loss of flavour was mainly due to the loss of the smell of ajwan which was added as the flavouring agent. Since, flavour is a complex sensory characteristic that is evaluated considering, taste, mouthfeel and odour, the typical branny mouthfeel and slight after-taste which became prominent with decreased aroma, might have influenced the judges' rating for flavour.

The drastic decrease in mean scores for appearance and texture for the ready to eat product at the end of the second week could be attributed to the hygroscopicity of the dietary fibre sources.

From Fig.2, it is seen that the overall acceptability of the ready to eat product was comparable to the control upto 1 week of storage. However, the

overall acceptability sharply decreased between 7-14 days probably due to the loss of flavour. In case of the mix, the overall acceptability was comparable to the freshly prepared product upto 28 days. A sharp decline in the mean scores for overall acceptability after 28 days was observed which could be due to staling of the wheat bran used in the mix.

Hence, the ready to eat product and mix can be stored for optimal periods of 7 days and 28 days respectively, without much changes in sensory characteristics. The mix had a longer shelf-life than the product because of being devoid of margarine.

In the present study no additives were used and the shelf-life was determined based on the comparability of sensory attributes with the freshly prepared product. As the storage period increased there was a decrease in the mean scores for the various sensory characteristics but no visible or obvious signs of rancidity or spoilage. Because of limitations of time, tests for free fatty acid content and peroxide value were not conducted. Hence, if surfactants and gluten along with preservatives could be used to counteract the effects of fibre incorporation it would be possible to keep the products at an acceptable level

for a longer period as observed by Shogren et.al. (1981) and Leelavathi and Rao (1993).

5.8 BIOASSAY ON SUBJECTS

The subjects selected for the feeding study were those who rated positive to the test product for its overall acceptability and use in the treatment of their condition (Fig. 3). The subjects were further questioned to see if they were aware of the beneficial effects of fibre. While 25 per cent of them rated positive to fibre consumption for relief from constipation, and only 2.5 per cent rated negative, more than 70 per cent of them pleaded ignorance. This data indicates the need for nutrition awareness.

5.8.1 Demographic Profile of the Subjects

A majority of the patients were around 40 years old. Shubra et.al. (1983) suggest lack of muscle tone and reduced activity, which are characteristic of increasing age, to be causative factors in the occurrence of constipation. The present study shows that majority of the subjects did not engage in hard work or active forms of recreation.

Since a majority of the test subjects were educated beyond high school, they were more open and acceptable to the feeding study. However, the fact that a majority of them were unaware of fibre and its beneficial effects further emphasizes the need for imparting nutrition education.

5.8.2 Dietary Pattern of the Test Subjects

A survey of the dietary pattern of the test subjects indicated that their consumption of both green leafy vegetables and whole or sprouted grains was grossly inadequate. Greens and whole grains are established sources of fibre in the Indian diet. Hence, a decreased intake of these would mean lack of sufficient roughage which can also cause constipation in the long run (Antia, 1973).

5.8.3 Dietary Intake

The dietary intake was recorded to know the mean intake of fibre among the test subjects. It was found that the subjects consumed on an average 3 g. of crude fibre per day. This value is very low for crude fibre compared to the recommended dosage of 11 g. per day for sedentary workers (ICMR, 1981). Table-11 shows that the subjects averaged a daily intake of 42g. of

protein, 237 g. of carbohydrates, 30 g. of fat and 1474 K.Cal. of energy.

5.8.4 Clinical Profile of the Test Subjects

Each subject served as his or her own control. Hence, the clinical history of each test subjects was recorded individually and used either as an index of recovery or to find the cause of their condition. A majority of the test subjects expressed that they tended to decrease their food consumption thereby further decreasing their fibre intake. A majority of the test subjects considered severity to be a major criterion to consult a doctor. This shows that constipation is a condition which is not taken seriously by many and hence there could be a larger percentage of individuals suffering from milder forms of constipation. The ~~test~~ subjects stated reasons such as insufficient lavatory facilities at their place of work, shift system and negligence of the urge to defecate because of being engaged in work that could not be left incomplete, for suppressing stools. A condition worsens if no attempt is made to treat it, and the present study showed that nearly 50 per cent of the test subjects had not undergone any treatment, while few of them depended on purgatives and laxatives. But, purgatives consumed

regularly and in increasing doses, acting by irritating the digestive tract in order to enhance peristalsis, may prove problematic in the long run. Bulk laxatives are the natural, non habit forming and harmless means to effect a cure. The present study is an attempt to establish the use of bulk laxatives (Isabgol and Wheat bran) in foods to control constipation.

5.8.5 Feeding Study

Table-13 and 14, give the detail clinical profile of the test subjects before the start and on the final day of the feeding study. In a study by Becker and Rosskamp (1987), 22 infants and children were fed a commercially produced solid food providing 7 g/100g of wheat bran for 41 days. Normal bowel movements were seen in 86 per cent of the children within 8.2 days of treatment and the stool weight was increased by 21.5 per cent in 8 children. The results of Table-13 indicated that 83 per cent of the subjects reported a daily bowel evacuation at the end as against 30 per cent before the start of the feeding. 83 per cent of the subjects also reported complete relief from incomplete bowel evacuation at the end of the feeding study. Jenkins et al (1987) studied the effect of dose response of

wheat bran on faecal output. They found that an increase of 1 g. wheat bran produced a mean increase of 2.7 g. in faecal weight. This change was achieved by feeding dietary fibre in amounts varying between 0.3 to 28.4 g. daily for 14 days to a healthy group of volunteers.

While 45 per cent of the subjects reported that the consistency of their stools returned to normal, 40 per cent reported slightly loose but well formed stools, and 5 per cent reported diarrhoeic stools, only 7.5 per cent reported no change in stool consistency (Table-13). 85 per cent of the subjects reported an increase in the quantity of their stools during the period of the study. A study similar to the present study was conducted by Peschlow (1990) on female adult wistar rats. He found that the isabgol seeds increased the foecal weight up to 100 per cent, the isabgol husks only at high concentrations were effective and wheat bran was less effective than the other two. He concluded that isabgol seeds (undehusked) being a partly fermentable dietary fibre supplement, increased stool bulk and may also have metabolic and mucosa protective effects.

From Table-14 it was observed that there was decreased incidence of all the symptoms. Some of the

typical symptoms such as uneasiness, heaviness of the stomach, difficulty in evacuation, distention of the stomach and gas formation were seen to decrease in at least 50 per cent of the subjects. Other symptoms such as stomach pain, psychological discomfort, nausea, vomiting, back pain etc, which could also be due to other reasons and diseases were also found to decrease. Several clinicians (Spiller and Shipley , 1977) reported that wheat bran and isabgol husk and seed have been successfully used to relieve the pain of irritable colon syndrome, diverticulosis and haemorrhoids.

Straining at stools is a typical symptom of constipated persons. The percentage of subjects experiencing this symptom decreased from 73 to 55 per cent in the test subjects. Unnecessary straining during defecation results in rubbing of mucosal surfaces, inflammation and a foreign body sensation, which might lead to complications like piles, diverticulosis etc. (Anita, 1973). Smith et al (1980) compared the effect of isabgol husk and wheat bran by mouth in 37 constipated patients 65 to 96 years old, and found that there was no serious side effect or change in colonic pressure. They concluded that the use of these bulking agents was better than the traditional use of cathartics in the elderly.

A record of the personal opinion of the test subjects regarding the effectiveness of the treatment indicated that a majority of the patients experienced definite signs of improvement. The results of the chi-square test applied, indicated that the number of days of feeding had a significant effect on the extent of treatment (Table-15).

Further, an observation made in the present study was that the therapeutic effect of laxation existed as long as the feeding was continued. Many of the subjects complained of a return to the previous constipated condition after the duration of the feeding study. This further illustrates the fact that the duration of feeding has to be increased to bring about a complete cure.

5.9 COST EVALUATION OF PRODUCTS

The production cost of the dietetic baked products was compared with the respective controls (Table-16). It is seen that the isabgol supplementation increased the cost. However, in all the products, wheat bran supplementation decreased the cost of production. The blend supplementation, increased the cost only for chilly biscuits and swiss sandwich.

The cost of the control products ranged from Rs.1.80 to Rs.4.20 per 100 g. The cost of the dietetic products ranged from Rs. 1.9 to Rs. 4.3 per 100 g. for the isabgol supplementation, Rs. 1.70 to Rs. 3.9 per 100 g for the wheat bran supplementation and Rs. 1.3 to Rs. 4.0 per 100 g for the blend supplementation.

Hence, the above supplementations could serve multiple purposes such as wheat by-product utilisation with increased nutrition for the consumers and prevention of constipation.

SUMMARY

VI. SUMMARY

Over the last decade or more, scientists, nutritionists and technologists in India have been conceptualizing the idea of special types of processed foods for special dietary requirements. This is a vast and highly specialized subject and the development of such products throws a big challenge.

In India, since processed foods do not constitute the staple diet, regimen designed to go with the habitual diet pattern making available such food ingredients which possess therapeutic as well as nutritive value are required. Dietary fibre is an ingredient, the deficiency of which has been implicated in a number of diseases such as diabetes, hypertension, hypercholesterolemia, irritable colon syndrome, gall stones, diverticulosis, and colon cancer besides constipation.

While medical treatment is available for arresting many disease conditions, corrective measures by way of proper food and nutrition would go a long way in preventing them. Medicines and drugs are specific to ailments but foods are specific to risk factors. Since constipation, apart from being a disease by itself, is the commonest physiological disorder of the alimentary

tract, a dietetic product which could effect a cure for constipation would mean relief for patients suffering from several diseases. In this attempt if non-conventional foods or waste or byproducts could be used as sources of fibre, it would also serve the added purpose of increasing the food available to feed the ever growing population.

India is the largest producer of isabgol (Plantago ovata) seeds in the world providing about 85 per cent of the isabgol available in the world market, the husk being the economic part. In India most of the remaining seed which accounts for 70 per cent of the produce, is used as animal feed. Various studies conducted have suggested that bakery products serve as an effective carrier of such specific functional food ingredients. Hence, the present study was undertaken with the objective of developing baked products with isabgol (undehusked) and wheat bran and establish its curative effect on constipated individuals.

Since some of the characteristics of the test ingredients determine its end use and mode of action, the water absorption capacity and oil absorption capacity of isabgol and wheat bran and the particle size of wheat bran were determined.

Seven baked products were selected and after pretesting, incorporation levels were fixed for isabgol at 4, 8 and 12 per cent; 20, 30 and 40 per cent for wheat bran and (30+16), (40+12) and (40+20) per cent for blend supplementation. The products were subjected to sensory analysis by a consumer panel of 35 members. Statistical tests were applied to select the best accepted level for each treatment under each product. The results indicated that 20 per cent incorporation of wheat bran, 4 and 8 per cent incorporation of isabgol and (30+16) per cent levels for blended products could be acceptable in majority of the products. The protein, dietary fibre, calcium and iron values were increased and fat, carbohydrates and therefore energy values were decreased as a result of incorporation of test ingredients, compared to the controls. The selected nutrient content per 100 g of the dietetic products ranged between 4.7 to 9.0 g for protein, 16.7 to 39.8 g for fat, 37.2 to 57.4 g. for carbohydrates, 26.7 to 73.8 mg for calcium, 1.4 to 3.1 mg for iron, 294 to 570 K.Cal and 2.1 to 10.4 per cent insoluble dietary fibre (Neutral detergent fibre) per 100 g. It was also observed that the respective increase or decrease of the respective nutrients would be proportionately more in

the blend supplemented products. The salt biscuits prepared with a blend of (40+12) per cent wheat bran and isabgol were selected for the feeding study on constipated patients.

Storage study was conducted to ascertain the shelf-life of ready-to-eat salt biscuits and salt biscuits prepared from the ready to prepare mix. The results indicated that the ready-to-eat salt biscuits could be stored for 7 days while the ready to prepare salt biscuit mix could be stored for 28 days without significant changes in sensory characteristics.

A ten-day feeding study was conducted on 40 constipated patients to evaluate the effect of isabgol and wheat bran blend (40+12) per cent in salt biscuits on the treatment of their condition. The results showed considerable reduction in the frequency of occurrence of several symptoms associated closely with constipation such as uneasiness, difficulty in evacuation, distention and heaviness of the stomach, gas production, frequency of incomplete bowel evacuation and frequency of straining at stools. Eighty per cent of the test subjects expressed slight improvement in their constipated condition and 15 per cent of them expressed marked improvement on the final day of the feeding as

against 100 per cent who expressed no change in their constipated condition on the first day of feeding. The results of a chi-square test indicated that the therapeutic effect could be further enhanced, if the duration of the feeding period is increased.

The production cost of the developed dietetic products ranged from Rs. 1.30 to 4.30 per 100 g. The cost of the dietetic products was marginally increased compared with the control products only in case of isabgol supplementation. Hence, they are affordable by all classes of people as seen from the two fold increase in demand for bakery products in India, over the last five years.

RECOMMENDATIONS

A clear understanding of human nutrition and the nexus between diet and disease would forge a healthy collaboration of nutritionists and food processors in India. It would help in marketing a whole range of dietetic foods for specific metabolic disorders such as constipation. Specialised stores for health foods are fast coming up in many parts of the country such as in Bombay, Delhi and Calcutta dealing only with health foods ranging from fresh fruit juice to wheat bran, wheat germ, alfa-alfa sprouts, organically grown

vegetables and even fresh tofu. While Bangalore city does not have specialised stores dealing exclusively with health foods, stores with separate counters for health foods, have come up.

In conclusion, the dietetic products developed in the present study could be considered as healthy foods with nutritional and dietetic advantages to meet the needs of the normal and several diseased conditions related to low fibre intake. Results of this study deserve industrial application as early as possible to prevent wastage of wheat bran and to ensure effective utilization of isabgol.

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APPENDICES

ANNEXURE - I

I. 1. ESTIMATION OF WATER ABSORPTION CAPACITY (Sousulski, 1962)

(1) 30 ml of distilled water was added to 5 g of the sample placed in a 50 ml centrifuge tube washing down the inside of the tube.

(2) Using a stirrer, sample and water were mixed for 30 seconds with vigour to bring the sample into suspension.

(3) The suspension was allowed to stand for 10 seconds.

(4) Several mixings were done with 10 minutes rest period following each mixing to bring at the entire sample into suspension.

(5) 10 ml of distilled water was used to wash the particles adhering to the rod into the sample.

(6) The suspension was centrifuged at 2300 rpm for 25 minutes.

(7) Supernatant liquid was decanted and the centrifuge tube was dried in a forced draft air oven at an angle of 15° - 20° .

(8) The tube was allowed to dry for 25 minutes at 50°C and cooled in a dessicator and weighed.

$$\text{Per cent water absorption} = (x + y - 5) 20$$

Where x = increase in weight of the sample (g)

y = "as-is" weight of the sample (g)

I. 2 ESTIMATION OF OIL ABSORPTION CAPACITY (Lin et al., 1974)

(1) 3 ml of groundnut oil was added to 0.5 g of the sample placed in a 15 ml conical graduated centrifuge tube.

(2) The contents were stirred for one minute to disperse the sample into the oil.

(3) After a holding period of 30 minutes, the tube was centrifuged at 1610 rpm for 25 minutes.

(4) The oil absorbed was determined by the difference of the volume of the free oil read from the total.

ANNEXURE - II

1. CHILLY BISCUITS

Ingredients :

Maida	150 g
Margarine	75 g
Sugar	10 g
Salt	5 g
Baking Powder	3/4 tsp

Green Masala :

Green Chillies	
Curry leaves	→ 10 g
Ginger	
Coriander leaves	

Method

- > Sieve the maida with baking powder and salt twice.
- > Rub in fat and then add sugar.
- > Mix the chilly mixture and knead it to a soft dough.
- > Roll the dough into a thin sheet and cut into desired shaped.
- > Bake at 175°C for 15 minutes.

2. POUND CAKE

Ingredients :

Maida	120 g
Margarine	60 g
Sugar	120 g
Egg	2 Nos
Vanilla	Few drops
Baking powder	1/4 tsp
Salt	A pinch

Method

- > Sieve maida, salt and baking powder twice.
- > Creame margarine and sugar till light and fluffy.
- > Beat the egg with vanilla to a stiff froth.
- > Add beaten egg to the creamed mixture little by little beating all the time.
- > Fold in flour gently.
- > Make into a batter with water.
- > Bake at 190°C for about 20 minutes.

3. COCONUT COOKIES

Ingredients :

Maida	60 g
Coconut powder	30 g
Sugar	30 g
Margarine	60 g
Flavour	Few drops
Cherry	5 Nos (for topping)
Grain sugar	15 g

Method

- > Mix all the ingredients in a clean bowl and knead till they are soft and smooth (except cherries).
- > Mix small round balls from the dough and arrange 1/2" apart on baking trays.
- > Cut each cherry into eight parts and press one piece on each cookie.
- > Bake at 275°C F for 15-20 minutes.

4. SWISS SANDWICH

Ingredients :

Maida	100 g
Sugar	100 g
Baking powder	1/4 tsp
Eggs	3 Nos
Vanilla	Few drops

Green Masala:

Curry leaves	
Coriander leaves	
Ghee	45 g
Garlic	
Ginger	
Dry coconut	
Turmeric powder	
Chilli powder	
Pepper	
Tamarind	
Onion	
Salt	

Method

- > Beat eggs into a clean dry bowl with sugar and flavour.
- > Sieve the flour and baking powder twice.
- > Fold in the flour to the above mixture and make into a batter of required consistency with water.
- > Bake in a swiss roll in at 375° F for 10 minutes.
- > Quickly turn on a sheet of butter paper and spread green masala over the sheet and make into sandwiches.
- > Cool it thoroughly and serve.

5. SALT BISCUITS

Ingredients :

Maida	1.6 kg
Margarine	1 kg
Sugar	200 g
Skim milk powder	50 g
Corn flour	50 g
Salt	25 g
Ajwan	20 g

Method

- > Cream margarine and sugar till light and fluffy.
- > Sieve maida, salt, skim milk powder, corn flour and powdered ajwan twice.
- > Now mix the flour mixture and creamed margarine-sugar blend and make into a dough.
- > Cover the dough with butter paper and roll till you get the desired thickness of biscuits.
- > Cut into desired shapes and bake at 150°C till done.

6. CHOCOLATE COOKIES

Ingredients :

Maida	1.6 kg
Margarine	1 kg
Sugar	800 g
Skim milk powder	50 g
Salt	5 g
Baking powder	8 g
Cocoa (flavour)	As required
Cashewnuts	50 g
Tuty Fruity	50 g

Method

- > Cream the margarine and powdered sugar. Now slowly add cocoa powder for flavour and continue creaming till light and fluffy.
- > Sieve the maida, cornflour, skim milk powder, salt and baking powder twice.
- > Mix the slightly roasted fruits of cashewnuts and finely cut pieces of tuty fruity into the flour mixture.
- > Add the creamed contents to the flour mixture.
- > Cover with butter paper and roll till desired thickness of the cookie is obtained.
- > Cut into desired shapes and bake at 130°C till done.

Note: The top surface of the cookie can be glazed with egg white or thin sugar syrup and powdered cashewnuts and tuty fruity sprinkled.

7. SACHER CAKE

Ingredients :

Margarine	100 g
Powdered sugar (A)	100 g
Cocoa powder	50 g
Egg yolk	6 Nos
Egg white	6 Nos
Powdered sugar (B)	100 g
Flour	100 g
Baking powder	1.5 g

Method

- > Mix margarine and sugar (A) well.
- > Add cocoa powder and mix further.
- > Gradually add egg yolk and continue mixing till it is light and fluffy. Beat egg white and sugar (B) to light meringue.
- > Sieve flour with baking powder.
- > Bake at a light temperature, remove and cool.

ANNEXURE - III

Score Sheet for Consumer Acceptability

UNIVERSITY OF AGRICULTURAL SCIENCES, BANGALORE
DEPARTMENT OF RURAL HOME SCIENCE

Name of the product: _____ Sl.No.: _____
Treatment : I/II/III Date :

INSTRUCTIONS :

- (1) Taste one sample at a time.
- (2) Rinse your mouth with water before tasting the next sample.
- (3) Give ranks to the products from high to low (Rank I to the best product of the lot) considering appearance, texture, smell, taste and overall eating quality.

Product Codes	Ranks			
	I	II	III	IV
A				
B				
C				
D				

Additional Comments :

ANNEXURE - IV

Estimation of moisture (AOAC, 1984) : About 10 g. of the powdered sample was weighed into a previously weighed petridish and dried in an oven at 80 C till the weight of the dish with its content became constant. Each time, before weighing, the dish was cooled in a desiccator, moisture was reported as loss in weight.

$$\text{Moisture} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Weight of the sample taken}} \times 100$$

Estimation of Protein (AOAC, 1984): Protein content was determined by micro-kjeldahl method. About 50-100 mg. of the sample was weighed into kjeldahl flask. 2 to 2.5 ml. of concentrated H_2SO_4 and 1/4 spatula of digestion mixture (0.7 g. of redmercuric oxide and 15 g of potassium sulphate) were added to the flask. The sample was digested till the contents of the flask were clear and free from any yellowish tinge. The digested material was transferred to the kjeldahl distillation apparatus. Sufficient amount of 40% sodium hydroxide (about 10 ml) was added. The ammonia liberated was observed in the 10 ml. solution of 2 per cent boric acid containing mixed indicator. The distillate collected was titrated against standard. A blank was run simultaneously. The results were expressed as percentage total protein and was calculated by multiplying the nitrogen percentage by the factor 6.25.

Protein (g/100 g. of the sample) =

$$\frac{\text{Normality of } \text{H}_2\text{SO}_4 \text{ titre value} \times 0.015 \times 6.25 \times \text{titre value} - \text{blank value}}{100 \times 1000}$$

Weight of sample taken (in mg.)

Estimation of total ash (AOAC, 1984): 5 g. of dried sample was weighed into a crucible and was placed on the wire gauze and heated over a low flame till the material was completely charred and then the crucible was heated in a muffle furnace for about 4 hours at 600 C. It was then cooled in a desiccator and weighed. To ensure the

completion of ashing, the crucible was again heated in the furnace for 2 hours cooled and weighed. This was repeatedly done till two consecutive weights were the same and the ash was almost white or greyish colour. The estimation were done in duplicate.

$$\% \text{ total ash} = \frac{\text{Weight of the ash}}{\text{Weight of the sample}} \times 100$$

Estimation of fat (AOAC, 1984): About 5 to 10 g. of the dried sample was weighed accurately into a thimble and plugged with fat free cotton. The thimble was then placed in a soxhlet apparatus and extracted with anhydrous ether for about 16 hours. The flask was then kept on the water bath to evaporate the ether present in it. Then it was cooled in a desiccator and weighed to estimate fat.

$$\text{Fat content (g/100 g.)} = \frac{\text{Weight of ether extract}}{\text{Weight of the sample taken}} \times 100$$

Estimation of crude fibre (AOAC, 1984) : About 2 to 5 g. of moisture and fat free sample was weighed into a 500 ml. beaker and 200 ml. of boiling 0.255 N (1.25% w/v) Sulphuric acid added. The mixture was boiled for 30 minutes keeping the volume constant by the addition of water at frequent intervals (a glass rod inserted in the beaker helps smooth boiling). At the end of this period, the mixture was filtered through a muslin cloth and the residue washed with hot water till free from acid. The material was then transferred to the same beaker and 200 ml. of boiling for 30 minutes (keeping the volume constant as before) the mixture was filtered through muslin cloth. The residue was washed with hot water till free from alkali followed by washing with some alcohol and ether. It was then transferred to a crucible, dried overnight at 80-100 C and weighed (We). the crucible was heated in a muffle furnace at 600 C for two to three hours. Cooled and weighed again (wa.). The difference in the weights (we-wa) represents the weight of crude fibre.

$$\text{Crude fibre (g/100g. sample)} = \frac{100 - (\text{Moisture} + \text{Fat}) \times \text{Wt. of fibre}}{\text{Wt. of sample taken (Moisture \& Fat free)}}$$

Estimation of Gross energy : Using a oxygen bomb plain jacket type with double value par calorimeter.

Bomb standardization :

1. 1 g. Benzoic acid pellet was weighed to nearest 0.1 mg. in cup.
2. The cup is placed in the circular electrode and a 10 cm. fuse wire was attached to each of the electrode by touching the fuse wire to the pellet.
3. Bomb was assembled and was filled with oxygen (15 atmospheric pressure).
4. The bomb was placed in the bucket and the bucket in jacket. A contact wire was attached and the bucket was filled with 1.5 litre of distilled water.
5. The cover was closed, thermometer - thermistor units lowered and the motor was started for stirring.
6. The jacket temperature was adjusted to near the bucket temperature manually.
7. Four minutes were allowed at equilibrium temperature.
8. The initial temperature of the bucket was noted and fuse wire ignited; there was rise in temperature.
9. The final temperature was noted after 8 minutes.
10. The pressure from bomb was released slowly.
11. The inside of the bomb was rinsed with distilled water and titrated with sodium carbonate using methyle orange indicator.
12. The unburnt fuse wire was measured and this gives the wire correction.

Calculation for standardization.

$$W = \frac{Hm + a + b}{t}$$

Where: W = Energy of calorimeter.
 H = Heat of combination of benzoic acid.
 (63138 cal/g.)
 m = Mass of benzoic acid pellet.
 a = ml. of Na₂ CO₃ used.
 b = Calories used in ignition of fuse wire.
 t = Difference between two initial and true
 final bucket temperature.

Samples determinations.

1. On a piece of paper the sample given was weight (1 g.) with the weight of paper noted.
2. The steps at standarization were repeated.

$$\text{Calculation. } H = \frac{tw-a-b-c}{t}$$

Where : H = Heat of combustion of sample.
 t = True temperature difference.
 a = Acid correction.
 b = Paper correction.
 c = Wire correction.
 m = Weight of sample.

Duplicate should agree within 0.1 K cal per g. and preferably 0.05 K cal/g.

Note : W = Water equivalent of calorimeter (2009.67 cal)
 b = Paper correction (3800 cal/g.)
 c = Wire correction (2.3 cal/cm.)

Estimation of Carbohydrates (by difference method)

The carbohydrate content of the sampes was determined by subtracting from 100, the sum of the values (per 100g) for moisture, protein, fat and crude fibre.

**Estimation of Neutral Detergent Fibre (Robertson,
Van Soest, 1977)**

Reagents :

(a) Amylase Solution: Dissolve 2 g enzyme in 90 ml water, filter through Whatman No.54 paper and add 10 ml ethoxyethanol. Store at 5°C.

(b) Preparation of Neutral Detergent Solution :

30 g. of sodium lauryl sulphate, 18.61 g of EDTA di sodium salt, 6.81 g of sodium borate, 4.56 of di sodium hydrogen phosphate and 10 ml ethylene glycol were mixed well in a 100 ml beaker with distilled water. The volume was made up to 1 litre in a 1000 ml volumetric flask and the PH was adjusted to 6.9-7.1.

(c) Decalin has been eliminated from the method. Sodium sulfite is not used in the modified procedure.

PROCEDURE

Weigh 0.5 to 1.0 g sample into a 600 ml Berzelius beaker. Add 50 ml cold neutral detergent solution. Place on hot plate and heat to boiling. Adjust heat to reduce foaming but boiling sufficiently to keep food particles suspended. Thirty minutes from the onset of boiling, remove beaker and add 50 ml cold neutral-detergent solution and 2 ml of the enzyme solution. Return beaker to hot plate without adjusting the thermostat and allow to return to boiling. One hour after the initial onset of boiling, filter on a pretared sintered-glass crucible or Whatman No.54 paper. Wash twice with boiling water to remove the detergent. If filtering problems occur, 1 and 2 ml of the enzyme solution. Add 2 ml of the enzyme solution to the crucible containing about 30 ml hot (80°C) water, let stand 10-15 minutes, then filter, wash twice with boiling water and twice with acetone. Dry overnight at 105°C for 3 hours and weigh. The loss in weight on ashing is an estimate of the plant cell wall constituents.

Estimation of Acid Detergent Fiber (Van Soest 1970).

Reagents:

n-cetyl-n-trimethyl ammonium bromide (CTAB) LR grade
sulphuric acid AR.

Preparation of reagents:

Weigh 19.04 g of sulphuric acid and make up the volume to 1 litre with distilled water at 20°C check normality by titration before addition of detergent. Then add CTAB and stir.

Procedure:

- (1) Weight 1 g air dry sample into a beaker suitable for refluxing.
- (2) Add 100 ml acid detergent solution.
- (3) Reflux for 60 minutes from onset of boiling adjust the boiling to a slow and even level.
- (4) Filter in a previously fared gooch crucible.
- (5) Wash twice with hot water and then with acetone.
- (6) Dry at 100°C for 8 hours or overnight and weigh.
- (7) Calculate acid detergent fibre:

$$\frac{(W_o - W_t) 100}{S} = \text{ADF}$$

Where:

W_o = Weight of oven dry crucible including fibre.
 W_t = Weight of oven dry crucible.
 S = Oven dry sample weight.

Determination of Lignin:**Reagents:**

72 per cent sulphuric acid by weight - calculated grams acid and water needed in 1 litre solution by:

$$\frac{100 \times 98.08 \times 12 \text{ moles}}{\text{H}_2\text{SO}_4 \text{ assay (Percent)}} = \text{grams acid needed}$$

$$(1000 \times 1.634)^3 - \text{grams acid needed} = \text{Grams water needed}$$

PROCEDURE

1. Prepare the acid detergent fibre.
2. Immerse the contents of the crucible with 72 per cent sulphuric acid and stir with a glass rod to a smooth paste to break all lumps.
3. Refill the crucible with 72 per cent sulphuric acid and stir at hourly intervals as acid drains away.
4. Three such additions will suffice.
5. After 3 hours, filter off as much acid as possible with vacuum.
6. Wash the contents with hot water until free from acid.
7. Dry the crucible at 100°C and weigh.
8. Ignite crucible at 500°C in a muffle furnace for 3. hours, cool to 100°C and weigh.
9. Calculate lignin:

$$\frac{L \times 100}{S} = \text{lignin}$$

Where:

L = loss upon ignition after 72 per cent
H₂SO₄.

S = Oven dry sample weight.

Determination of Cellulose and Hemicellulose

(VanSoest and McQueen, 1973)

The cellulose content is calculated as a difference between the ADF and lignin while the Hemicellulose content is calculated as a difference between the NDF and ADF. Both cellulose and hemicellulose are expressed per 100 g. of the sample.

Determination of Iron:**Reagents:**

Distilled water - redistilled
Concentrated Sulphuric Acid - r.d. 1.84 (see IS: 266 - 1961*)
Perchloric Acid - 60% (m/m) solution.
Concentrated Nitric Acid - 60% (m/m).
Ammonium Hydroxide Solution - 25% (m/m)
Concentrated Hydrochloric Acid - 35% (m/m).
Hydrogen Peroxide Solution - 0.1% (m/m) solution in water stored in a brown bottle in a refrigerator.
Isoamyl Alcohol - of boiling pt 129 to 132 C.
Potassium Thiocyanate Solution - Dissolve 50 g of potassium thiocyanate (KSCN) in 100 ml of water.

Std Iron Solution - Dissolve 0.7022 g of ferrous ammonium sulphate ($\text{FeSO}_4(\text{NH}_4)_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$) in 100 ml of water, add 5 ml of concentrated sulphuric acid, warm slightly and add potassium permanganate solution (app. 0.1N) drop by drop until the solution shows a slight pink colouration. Make up the volume to one litre in a graduated flask, add 10 ml of hydrogen peroxide solution and make up the volume with water. This solution contains 1 mg of iron per milli litre.

Procedure :

Preparation of the Test Solution - Weigh accurately about 2.0 of the material and transfer to a 200 ml Erkenmeyer flask. Add 2 ml of concentrated sulphuric acid, 3 ml of perchloric acid and 5 ml of concentrated nitric acid. Digest until a clear solution is obtained and white fumes of sulphuric acid are evolved. Dilute with 10 ml of water and make up the volume to 200 ml with water in a graduated flask. Preserve this solution for the determination of copper and cobalt. Take a suitable aliquot of the test solution containing about 10 mg of iron and transfer to the heat resistant glass tube. Add ammonium hydroxide solution until the solution is just alkaline to phenolphthalein. Add 1 ml of concentrated hydrochloric acid and 1 ml of hydrogen peroxide solution and make up the volume in the tube to 30 ml of potassium thiocyanate solution, stopper the

tube and shake for 20 secs. Transfer enough of the isoamyl alcohol phase meant for colour measurement to the centrifuge tubes, and centrifuge for 5 mins at about 3000 rev/min. Measure the absorption of the solution in a suitable photo-electric colorimeter at 495 nm setting the reading of the blank at zero absorption. The blank is prepared simultaneously by using the same quantities of acid employed in the digestion, making up the volume and developing the colour in the same size aliquot and in the same manner as in the case of the test solution.

Prepare a series of standards by treating aliquots of the standard iron solution

(1) In the same manner as the test solution. From the absorption of the standard solutions, prepare a standard curve plotting absorption values against concentrations. From this curve, obtain the mass of iron present in the test solution and calculate the quantity of iron present in 100 g of the material.

Estimation of calcium (AOAC 1980): An aliquot (25 ml) of the mineral solution is diluted to about 150 ml with distilled water. A few drops of methyl red indicator are added and the mixture neutralised with ammonium is heated to boiling and 10 ml of 6 per cent ammonium oxalate are added. The mixture is then allowed to boil for a few minutes and glacial acetic acid added till the colour is distinctly pink. The mixture is kept aside in a warm place overnight and when the precipitate settles down the supernatant is tested with a drop of ammonium oxalate solution to ensure the completion of the precipitation. The precipitate is then filtered through What man No. 44 or 42 filter paper and washed with warm water till free of oxalate. The precipitate is transferred along with filter paper and pouring over it 2N H_2SO_4 about 5 to 10 ml. The solution is then heated to about $70^\circ C$ and titrated against $n/10$ $KMnO_4$ solution.

1 ml of $n/100$ $KMnO_4$ = 0.2004 mg of calcium.

Determination of Starch and Sugars (Clegg and Carpenter)

Reagents:

1. Anthrone reagent (0.1%)
2. Standard glucose solution (100 μ g/ml)
3. Ethanol (80%)
4. Perchloric acid (52%)

Extraction of Sugars :

1. To 0.2 g finely ground material in 50 ml centrifuge tube add 2 drops of 80% ethanol, mix, add 5 ml water stir.
2. Add to (1), 25 ml hot 80% ethanol, stir, set aside for 5 min. centrifuge.
3. Decant supernatant, repeat extraction with 30 ml hot 80% ethanol, centrifuge (save the residue for starch extraction).
4. Combine the two alcoholic extracts ; evaporate ethanol under reduced pressure and dilute the extract to 100 ml with water.

Extraction of starch:

1. Start with the residue saved during the extraction of sugars.
2. Add to (1), 5 ml water and while stirring add 6.5 ml of 52% perchloric acid, mix continuously for 5 min. and occasionally for next 15 min.
3. Add to (2), 20 ml water, centrifuge; pour off the supernatant into a 100 ml volumetric flask.
4. Repeat steps (2) continue stirring for 30 min and add all the contents to the volumetric flask with water washings.
5. Make the volume to 100 ml with water, filter and dilute 1 ml to 25 ml in a volumetric flask.

Extracts:

1. Add 50, 100 150 and 200ug of standard glucose solution (0.5, 1.0, 1.5 and 2.0) and make volume to 2 ml with water in 4 test tubes.
2. To all tubes, add 10 ml anthrone reagent, mix thoroughly ; heat in boiling water bath for 12 ml (put marble stones on test tubes), and cool.
3. Read the colour at 630 nm against the water anthr reagent blank.

4. Calculate the per cent of sugars as follows:

$$\text{Percent sugars} = \frac{\text{O.D. of sample}}{\text{Wt. of sample used} \times \text{O.D. of 100 ug glucose}}$$

5. Calculate the per cent of starch as follows :

$$\text{Per cent of starch} = \frac{22.5 \times \text{O.D of sample}}{\text{Wt. of sample} \times \text{O.D of 100 ug st glucose.}}$$

ANNEXURE - V

QUESTIONNAIRE ON CONSTIPATION - NATURE AND STATUS OF
INDIVIDUALS

PART - I

GENERAL INFORMATION

1. Name of the respondent :
2. Address :
3. Age :
4. Sex : Male/Female
5. Size of the family : Adult/Teenagers/
School/Preschool/
Infants.
6. Educational status : Illiterate/Higher
secondary/any other
7. Working hours :
8. Occupational nature : (a) Sedentary work
(b) Moderate work
(c) Heavy work
9. Leisure time activity : (a) Yoga
(b) Outdoor games
(c) Watching TV
(d) Reading books
(e) Walking
(f) Going to club
(g) Rest
10. Type of diet : Vegetarian/
Non-Vegetarian

11. (a) Dietary Intake of 3 typical days

FIRST DAY / SECOND DAY / THIRD DAY

Meal pattern	Items	Ingredients	Cup in size	Weight in gms

BREAKFAST				

LUNCH				

TEA				

DINNER				

BETWEEN MEALS				

11. (b) How often do you consume greenleafy vegetables. : Daily/Weekly/ Twice a week/Thrice a week/ Any other.
- (c) Whole grains or sprouted grains : Daily/Weekly/ Twice a week/Thrice a week/ Any other.
12. Attitudes of the individual towards fibre consumption:
- (i) What is your opinion on the inclusion of fibre in your diet. Give reasons. : (a) Should be done (b) Should not be done (c) I don't know
- (ii) Do you have any information relation fibre with health. : (a) Fibre rich foods have beneficial effect on health. (b) Fibre is not necessary for consumption. (c) Fibre is harmful to health. (d) Any other.

- (iii) If you do have any information relating fibre with health, what health, what are the sources of your information. :
- (a) Books/Magazines
 - (b) Doctor
 - (c) Media
 - (d) Any other
Please mention.

PART - II

CLINICAL INFORMATION

1. Describe the nature of constipation and frequency of occurrence.
 - (a) Daily; (b) Since childhood; (c) Sometimes;
 - (d) Since been affected by disease in which bed ridden; (e) Since the attack of other diseases; (f) Since past few days; (g) Any other.
2. What are the symptoms you have experienced.
 - (a) Uneasiness; (b) Heaviness of the stomach; (c) Difficulty in passing stools; (d) Stomach pain; (e) Psychological discomfort, (f) Distention of the stomach; (g) Headache; (h) Nausea; (i) Vomiting.
3. What is your regular frequency of passing stools:
 - (a) Once a day; (b) Twice a day; (c) More than twice a day; (d) Once in 2 days; (e) Any other.
4. Do you miss your meals when constipated:

Yes/No
5. If yes, Describe the trend of your meal in the dieting period:
 - (a) Reduce the amount eaten; (b) Skip meals either breakfast; Lunch; Tea or dinner or any other. (c) Incorporate other foods (Mention).
6. What has been your past attempt at treating constipation?

Treatment	Qty.of intake	Frequency of intake
-----------	---------------	---------------------

- (a) Use of Purgative or Enema
- (b) Use of commercial laxatives
- (c) Natural or Home therapy
- (d) Dietary management by eating particular foods like

(Please mention)

7. How often do you consult your doctor for this problem.

(a) Always; (b) Sometime when serve; (c) Never

8. What is your frequency of passing stools when constipated?

Frequency	Consumption of test product	
	Before	After
(a) Daily		
(b) Once in 2 days		
(c) Once in 3 days		
(d) Any other Please mention.		

9. (i) Do you suffer from any other diseases of the Gastrointestinal tract of otherwise:

Yes/No

(ii) If yes mention:

10. Have you ever had a tendency to suppress your stools.

Yes/No

11. If yes give reasons:

- (a) Social impropriety
- (b) Scared that the disease may further worsen
- (c) Improper child training
- (d) Irregular bowel movement during childhood
- (e) Any other (Please mention).

12. If you do suppress your stools, how often do you do so?

- (a) Quite frequently.
- (b) Every day
- (c) Some times
- (d) Rarely
- (e) Any other (Please mention).

17. Do you strain while passing stools:

Frequency	Consumption of test product	
	Before	After
(a) Always		
(b) Sometime		
(c) Never		
(d) Any other (Please mentions)		

18. What is the nature/consistency of the stools you pass (Soft, Hard, Watery etc.)

Normal	Consumption of test product	
	Before	After

FEEDING AND CLINICAL RECORDS

DIRECTION:

Please tick or fill in answers as and when required.

Schedule No. _____ Amount given for
consumption : _____

INSTRUCTIONS:

1. Please consume a minimum of ____ numbers of the product per day.
2. Please drink a glass of water/hot beverage after consuming the product for best effect.
3. Please keep a note of any amount of the product given to any others if any.

Amount given to others if any:

Reason: (1) Wanted to test the opinion of others

(2) Since they were accompanying me during meals.

(3) Any other.

No. of days	Date	Product name	Amount consumed
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			

CLINICAL RECORDS

DIRECTION:

Please tick the right answer once every day with regard to your condition.

Days	No change	Slight improvement	Marked improvement
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			

ANNEXURE VI

Score Sheet for the Shelf - Life StudyScore Key

<u>Points</u>	<u>Quality</u>
4	Highly acceptable
3	Moderately acceptable
2	Acceptable
1	Slightly unacceptable
0	Not acceptable

INSTRUCTIONS

- (1) Rinse your mouth before evaluation.
- (2) Score according to the key provided.
- (3) Evaluate on individual basis.

 Sample : Salt Biscuits

Sensory	-----		
Characteri-	Ready to Eat	Mix	Control
stics	- Product		

Appearance

Texture

Flavour

Overall Acceptability

ANNEXURE - VII

Typical menu items in a day's meal of the test subjects

Break fast	:	Idli/ Dosa/ Chapatti/ Rice/ Coffee/Tea
Lunch	:	Rice Sambar (with/without vegetables) Curry (Daily/sometimes) Chicken/Fish fry/Eggs* Curds
Tea	:	Tea/Coffee Biscuits (rarely)
Dinner	:	Rice Sambar Curds Banana (sometimes)

* In case of non-vegetarians.

ANNEXURE - VIII

Friedman's two way analysis of variance by ranks:

It is a test for several related samples. The test statistic is

$$T = \frac{12}{bk(k+1)} \sum_{j=1}^k \left[R_j - \frac{b(k+1)}{2} \right]^2$$

Where,

- b - is the number of blocks
- k - is the number of variables
- R_j - is the sum of ranks in the jth column

The above statistic follows χ^2 with (k-1) degrees of freedom.

Chi-Square Test :

The general strategy of chi - square consists of comparing the observed frequencies obtained from the sample with the expected frequencies computed for the theoretical situation where there is no relationship between the variables.

The formula for computing the chi-square test is

$$\chi^2 = \sum \frac{(O-E)^2}{E} \quad \text{with } (r-1)(c-1) \text{ degrees of freedom}$$

Where,

- O is observed frequency
- E is expected frequency
- r is number of rows
- c is number of columns.

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ವಿಶ್ವವಿದ್ಯಾನಿಲಯ ಗ್ರಂಥಾಲಯ
ಕೆ.ಆರ್.ಪಿ.ಓ., ಬೆಂಗಳೂರು-65.
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