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Effect of adding wheat bran and germ fractions on the chemical composition of high-fiber toast bread

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Abstract

The effect of the type of bran, level of addition, particle size and addition of wheat germ on the chemical composition of high-fiber toast bread was investigated. The bran and germ fractions were found to be high in ash, protein, fat and total dietary fiber contents. The wheat germ had a protein content of 27.88% compared with 11.35, 12.69 and 15.76% for white flour, whole wheat flour and red fine bran, respectively. The chemical composition of high-fiber breads, in terms of minerals, protein, fat and dietary fiber contents, was found to be far superior than that of the whole wheat flour (control) bread sample. Considering these results, it can be concluded that high-fiber toast bread, with lighter crumb color and improved sensory and nutritional qualities than the whole wheat flour bread, can be produced using white flour, and equal proportions of coarse and fine bran at 20%, germ at 7.5%, and sodium stearoyl-2-lactylate at 0.5% levels.

1. Introduction

A diet low in dietary fiber is associated with a spectrum of degenerative diseases, e.g. constipation, diverticular disease, hiatus hernia, appendicitis, varicose veins, piles, diabetes, obesity, coronary heart disease, bowl cancer and gallstones (Cleave, 1956). Now, it is a well-established fact that the consumption of adequate amounts of dietary fiber reduces the risk of these diseases significantly. With current projections, cardiovascular diseases and cancer will emerge as substantial health problems in virtually every country of the world by the beginning of the next century.

A diet rich in foods of animal origin as well as high-fat and high-sugar foods is being consumed by Kuwaiti people (Himmo & Al-Hooti, 1993). Moreover, the Kuwaiti population mainly consumes white Arabic flat bread, white toast bread and highly polished rice; this results in lower intake of dietary fiber. The incidence of constipation and its related diseases like diverticular, appendicitis, piles, haemorrhoids and anal fissures is increasing significantly among children, adults and the elderly in the Kuwaiti population. Kuwaities have an average life span of 73.8 years as in any western country. The advancing age and increased life span make enormous differences in our susceptibility to various degenerative diseases. According to the latest figures available (Al-Awadi, 1996), a total of 24,300 inpatients (diabetics, and cardiac, hypertension and cancer cases) have to be served with daily meals having high fiber contents in the various clinics of the country. The catering companies would have to produce nearly 16,000 loaves of bread/buns daily to meet these requirements. In addition, many thousands of outpatients visiting weight clinics would like to consume such high-fiber baked products.

Wheat and wheat products, long recognized as a major staple and source of calories, also contribute significant quantities of other nutrients (vitamins, minerals and dietary fiber) in the diet of people. Wheat products consumption in the State of Kuwait comes to around 277 g/d (Eid & Bourisly, 1986) compared with 170 g/d in the United States (Nelson, 1985). Wheat milling and utilization has emerged as one of the largest food processing industries in the State of Kuwait. The consumption of toast bread is steadily increasing at about 10% per annum, whereas Arabic bread consumption has not shown any significant increases. More than 90% of the toast bread being consumed in Kuwait is made from white flour, which is depleted of natural dietary

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fiber. The total dietary fiber content of whole wheat flour is 10.2% compared with 2.5% for white flour. On the other hand, the values for total dietary fiber in wheat bran range between 40 and 44%, thus making it an ideal natural supplement for producing high-fiber baked products (Ranhotra, Gelroth, Astroth, & Posner, 1990). The Kuwaiti consumers prefer white toast bread over that of whole wheat flour bread, mainly because of its light crumb color and superior eating quality.

The actual data on average dietary fiber intake among the Kuwaiti population are not available. Considering the amount of cereals and other foods intake, theoretically, this value can be calculated to be around 17–18 g of total dietary fiber per day. This figure is not much different than that reported for average dietary fiber intake (13 g/d) for the U.S. population, whereas, for a healthy adult, the recommended dietary fiber intake is 20–35 g/d (Anderson, Deakins, Floore, Smith, & Whitis, 1990). To obtain critical fecal wet weight of 200 g/day, an intake of 35–45 g of total dietary fiber is recommended (Spiller, 1993), with two-thirds of it coming from whole wheat and one-third coming from beans, oats, fruits and vegetables.

Keeping in view the necessity of increasing dietary fiber content in Kuwaiti diet, this research work was focused mainly on developing a few optimized formulations of toast bread containing higher amounts of dietary fiber, but, at the same time, having lighter crumb color and superior eating qualities than the whole wheat flour bread, so that bread consumption could be increased. Wheat bran was selected because of its natural wheat flavour, and also being a good source of proteins as well as a rich source of B-complex vitamins and minerals (Pomeranz, Shogren, & Finney, 1976). The results showing the effect of bran addition on the proximate composition and total dietary fiber content are presented here.

2. Materials and methods

2.1. Raw materials

Whole wheat flour (WWF), unbleached white flour (WF), wheat germ (WG), red coarse bran (RCB), red fine bran (RFB), white coarse bran (WCB), white fine bran (WFB) and vital wheat gluten samples were collected from the Kuwait Flour Mills and Bakeries Co., Shuwaikh. These samples were analyzed for moisture, protein, fat, and ash contents, according to standard AACC methods (AACC, 1983). Fine granulated sugar, common salt, bakery shortening (Wesson, USA), instant dry yeast and non-fat dry milk were procured from the local market. Sodium stearoyl-2-lactylate (SSL) was provided free of cost by American Ingredients Co., Kansas City, Missouri, USA.

2.2. Sieve analysis of bran and germ

Sieve analysis of all the bran and germ samples was carried out in an Endecotts (UK) test sieve shaker (model Octagon 200) using different mesh sizes. Exactly 100 g of bran or germ sample was loaded on the top sieve and the shaker was run at an amplitude setting of 6 and the overs on each sieve were weighed after running the shaker for 5 min and the percentage overs were calculated. An average of three trials was recorded.

2.3. Optimization of toast bread formulations

Bran and germ fractions were added to the straight-grade flour with about 72% extraction. These bread formulations were optimized using the straight-dough bread-making method of AACC (Method 10-10B, AACC, 1983). The white flour was replaced with wheat bran at 10, 20, 30% and with germ at 5, 7.5, 10% levels, respectively. The amount of flour, bran and germ used in these trials were calculated on a 14% moisture content basis. After preliminary trials, the use levels of vital wheat gluten (2–6% level) and sodium stearoyl-2-lactylate (0–1.0% level) were optimized for these bread formulations. Vital gluten and sodium stearoyl-2-lactylate (SSL) were added to counteract the deleterious effect of bran addition on the bread loaf volume reduction. Therefore, the addition of vital gluten and SSL restore the bread loaf volume and improve the eating quality.

2.4. Chemical analysis of bread samples

The bread samples (sealed in 150 gauge polyethylene bags) were stored at room temperature (22 ± 1°C) for 24 h and were analyzed for moisture content and water activity. For moisture content determination, 2 g of bread was weighed, in duplicate, in aluminum dishes and dried to a constant weight in a hot air oven at 103 ± 1°C for 14–16 h. For water activity (a_w), 50 g of bread was manually chopped into small pieces, poured into a conical flask, a digital water activity probe inserted, and the flask contents were shaken lightly and allowed to equilibrate at room temperature (22 ± 1°C). After about 5 minutes, water activity (a_w) was measured by a hand-held digital water activity probe (Vaisala Oy, Finland). This observation was repeated thrice and the average values were recorded.

All the bread samples were freeze-dried and powdered in a Falling Number Mill (model 3100, Sweden) to pass through a 100 mesh sieve and stored in airtight containers in a refrigerator till further chemical analysis. All these freeze-dried samples were analyzed for moisture, ash, protein and fat contents using standard AACC procedures (AACC, 1983). Some of the optimized bread formulations were also analyzed for total dietary fiber.

2.5. Total dietary fiber determination

Total dietary fiber (TDF) content of white flour, whole wheat flour, bran, germ and freeze-dried bread samples was determined, in triplicate, according to the AOAC method (AOAC, 1995). TDF determinations are based on using termyl (amylolytic), protease (proteolytic) and amylo-glucosidase (amylolytic) as the active enzymes. The enzyme kits were procured from Tecator AB, Sweden. All reagents used were of analytical grade.

All the chemical analyses are reported on a moisture-free basis. For all the results, mean values and standard deviations are reported.

3. Results and discussion

3.1. Sieve analysis

The various bran and germ fractions used in this study were analyzed for particle size distribution by sieve analysis and the results are presented in Table 1. The particle size of white coarse bran was observed to be larger than that of red coarse bran samples, as 20% of the former tailed over the sieve having 2.36 mm openings compared with only 4.7% of the red coarse bran. Most of the coarse bran fractions stayed on the coarser sieves (sieve openings 1.18–2.36 mm) compared with the fine bran fractions, where about 86% of the material stayed on finer sieves (openings 0.425–0.6 mm). In the case of fine bran and germ fractions, nothing stayed on the top coarser sieve (openings 2.36 mm). The particle size of germ fraction was somewhat in between the coarse bran and fine bran fractions, as most of germ particles stayed on the medium size sieves (openings from 0.6 to 1.18 mm).

As the particle size of bran fractions has been shown to affect the nutritional and baking qualities of bread, sieve analysis was carried out to characterize the granulations of coarse and fine bran fractions used in this study. Mongeau & Brassard (1985) reported that coarse wheat bran is more effective in reducing the fecal density in rats. The results from a study by Heller et al. (1980) indicated that finely ground wheat bran is less effective in holding water in faeces and in promoting rapid transit of digesta through the gut. The water-holding capacities for the coarse and fine brans were reported to be 5.27 and 3.60 g of water per gram of dry bran weight, respectively. They suggested that coarse bran and food products fortified with coarse bran should be the choice of patients with diverticular disease and of people needing a high fiber diet to promote colonic health. Increasing starch intake in the human diet has also been shown to increase fecal bulking (Shetty & Kurpad, 1986). Wheat bran has been shown to have the highest ion exchange capacity and is effective in binding mutagen like 2-amino anthracene (Moorman, Moon, & Worthington, 1983). Recent studies (Takeuchi, Hara, Inoue, & Kada, 1988; Roberton, Harris, Hollands, & Ferguson, 1990) proposed possible mechanisms for the different fiber sources and revealed that corn bran, wheat bran and alfalfa directly bind carcinogen in the pH range of 4–6 found in the human gastrointestinal tract and apparently through a mechanism of cation exchange.

Table 1
Particle size distribution (%, overs) of wheat bran and wheat germ samples[a]

Sieve opening (mm)	Red coarse bran	White coarse bran	Red fine bran	White fine bran	Wheat germ
2.360	4.7	20.0	0.0	0.0	0.0
1.180	64.9	58.9	1.9	1.6	31.2
1.000	5.6	3.9	8.6	7.3	20.3
0.600	19.1	14.7	70.8	71.5	40.7
0.425	2.8	1.6	16.9	15.6	4.3
0.150	1.8	0.6	1.1	3.1	3.1
Pan	1.1	0.3	0.7	0.9	0.4

[a] Average of duplicates.

3.2. Chemical analysis

During this study, whole wheat flour bread was used as control, mainly because of two reasons. First, whole wheat flour is nearly closer in bran content and chemical composition to these optimized bread formulations containing different levels of bran additions. Secondly, white bread is already quite popular among the Kuwaiti consumers, however, our intention was to offer to the consumers a variety of alternate bread formulations containing equal or higher amounts of dietary fiber, but with lighter crumb color and improved sensory quality. Whole wheat flour, white flour, bran and germ used in this study were analyzed for ash, protein, fat contents and objective color. The wheat bran and germ samples were also evaluated for particle size distribution. Proximate composition of flour, bran and germ samples is presented in Table 2. The ash, protein and fat contents of flour, bran and germ were similar to those reported in the literature (Pomeranz, 1988). Bran fractions were found to be rich in minerals and protein. The wheat germ, as expected, was especially richer in proteins (27.88%) and fat (9.86%) contents. The higher fat contents of fine bran samples compared with coarse bran may be due to germ inclusions because most of the germ particles end up in these fine bran mill fractions during the normal wheat milling process.

3.3. Chemical composition of high-fiber breads

The control as well as test bread samples containing various levels of coarse and fine brans were analyzed for ash, protein and fat contents and the results are summarized in Table 3. The white flour, which is lower in these nutrients in comparison with whole wheat flour was used in the production of test breads. With the addition of coarse or fine bran at a level of 20% or more, the amounts of these nutrients (ash, protein and fat) more or less levelled or even exceeded those of the control bread. The data in Table 3 show that the high-fiber test bread samples containing bran at 20% or higher level would become a good source of these valuable nutrients if consumed in the diet.

To further improve the nutrition profile of these high-fiber test breads, wheat germ was added at varying levels (5–10%) along with the coarse and fine bran (in equal proportions) and the results of proximate composition of these breads are presented in Fig. 1. Compared with the control whole wheat bread, the ash, protein and fat contents improved in all the test bread samples containing increased levels of bran as well as germ additions. A consistent improvement in the nutritional profile of these test breads, in terms of ash, protein or fat contents, was observed at all levels of bran or germ, especially at 30% bran addition. Considering the contribution of germ addition in improving the sensory scores of these high-fiber breads, the enhanced nutritional profile of these samples makes it all the more desirable an achievement for making them good candidates for adoption in our dietary patterns. The objective color, instrumental texture and sensory quality of these high-fiber bread formulations have been reported elsewhere (Sidhu, Al-Hooti & Al-Saqer, 1998).

Table 2
Proximate composition[a] (mean ± SD) of wheat bran, wheat germ and flour samples (%, dry basis)

Sample description	Ash, %	Protein, % (N X 5.7)	Fat, %
Whole wheat flour (WWF)	1.32 ± 0.02	12.69 ± 0.15	1.61 ± 0.10
Straight grade flour (WF)	0.61 ± 0.02	11.35 ± 0.10	1.26 ± 0.20
Red coarse bran (RCB)	4.50 ± 0.18	14.63 ± 0.45	2.31 ± 0.29
Red fine bran (RFB)	3.56 ± 0.16	15.76 ± 0.32	3.90 ± 0.15
White coarse bran (WCB)	5.20 ± 0.16	13.36 ± 0.17	1.99 ± 0.04
White fine bran (WFB)	3.06 ± 0.12	14.42 ± 0.15	4.01 ± 0.17
Wheat germ (WG)	4.33 ± 0.12	27.88 ± 0.28	9.86 ± 0.11

[a] Average of six replications.

Table 3
Chemical composition[a] of bread samples containing different levels of coarse and fine wheat bran fractions

Type of bran	Bran level, %	Ash[b], %	Protein[b], % (N X 5.7)	Fat[b], %
Control[c]	0	2.54	12.60	3.07
Red coarse bran	10	2.35	12.08	3.24
	20	2.64	12.31	3.65
	30	2.96	12.80	4.04
Red fine bran	10	2.31	11.76	3.63
	20	2.55	12.62	3.99
	30	2.97	12.65	4.23
White coarse bran	10	2.42	11.42	3.49
	20	2.63	11.76	3.66
	30	3.05	12.00	3.79
White fine bran	10	2.60	11.51	3.13
	20	2.75	12.24	3.57
	30	2.91	12.36	3.90

[a] Average values from duplicate bakes.
[b] %, Dry basis.
[c] Whole wheat flour bread.

3.4. Moisture content and water activity

The control as well as test bread samples were packaged in polyethylene bags and stored at room temperature (22 ± 1°C) for one day for moisture and water activity determination. Compared with control bread, the moisture content and water activity values were found to be significantly higher for test bread samples at all levels of bran addition (Table 4). This may possibly be due to the higher levels of water used during the dough preparation stage for samples containing different bran fractions. Similarly, the moisture content and water activity were observed to be slightly higher for the test breads than the control sample at increasing levels of bran addition (10–30%), but the germ addition at different levels (5–10%) did not affect these values to any significant level (Table 5). In comparison with Arabic bread, the moisture content values for toast bread were found to be higher and water activity to be lower than those reported earlier by Sidhu, Al-Saqer and Al-Zenki (1997).

3.5. Total dietary fiber

The wheat flour, germ and bran fractions used in this study were also analyzed for total dietary fiber contents and the results are presented (as %, dry basis) in Fig. 2. The red coarse bran had the highest TDF value (51.65%), whereas the white flour (straight-grade flour) had the lowest value (3.88%). The fine bran fractions were found to be slightly lower in TDF contents than the coarse bran fractions. The wheat germ (12.52%) and whole wheat flour (11.25%) TDF contents were quite comparable with each other. White flour seems to be a poor source of dietary fiber because bran fractions, being highest in TDF content, are removed during the milling process.

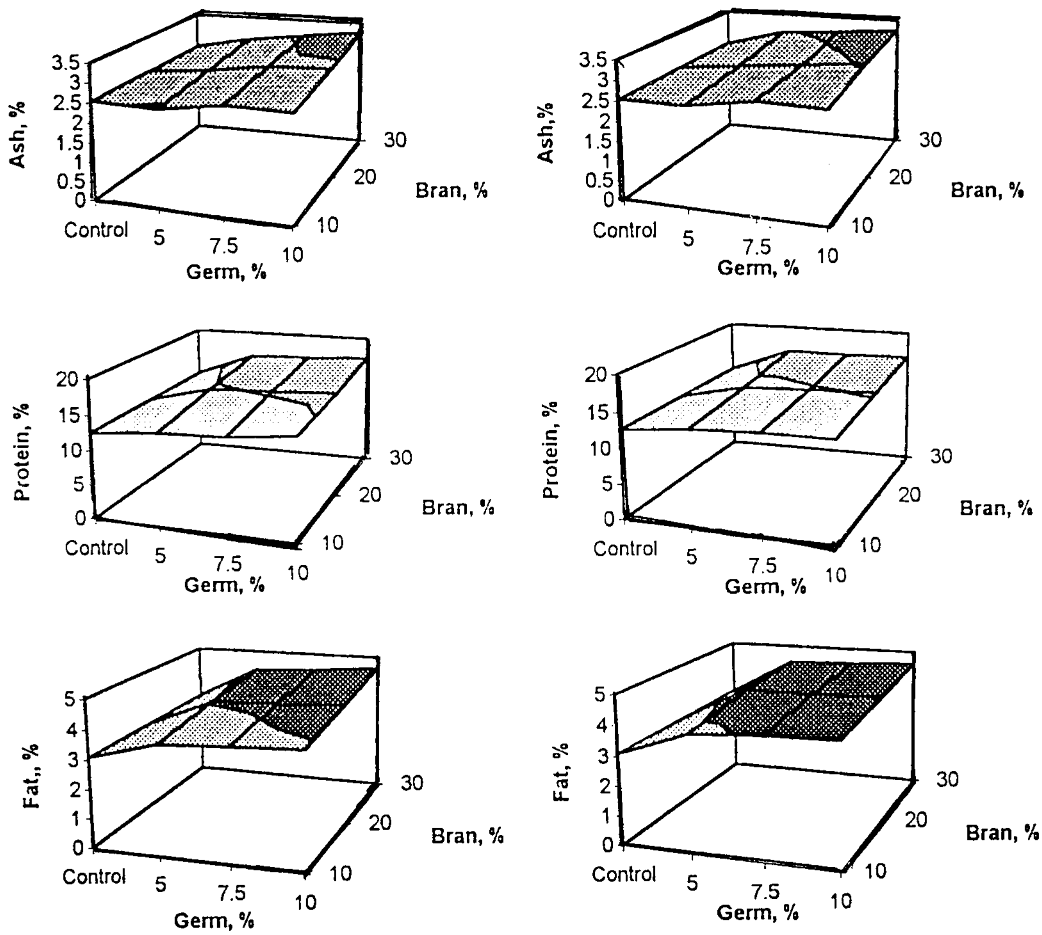

Fig. 1. Proximate composition (%, dry basis) of bread samples containing different levels of wheat germ and equal ration of coarse and fine bran additions.

Table 4
Moisture content and water activity (a_w) of bread samples containing different levels of coarse and fine bran additions[a]

Type of bran	Bran level, %	Moisture content, %	Water activity (a_w)
control[b]	0	39.29 ± 0.34	0.745
Red coarse bran	10	41.86 ± 0.07	0.778
	20	42.40 ± 0.16	0.776
	30	42.60 ± 0.13	0.778
Red fine bran	10	41.51 ± 0.18	0.780
	20	42.24 ± 0.30	0.780
	30	42.25 ± 0.06	0.795
White coarse bran	10	41.83 ± 0.09	0.798
	20	42.44 ± 0.30	0.790
	30	42.80 ± 0.42	0.787
White fine bran	10	42.25 ± 0.24	0.783
	20	42.09 ± 0.12	0.783
	30	41.18 ± 0.09	0.789

[a] Vital wheat gluten 0.4 g were added for each percent of wheat bran used in the bread formulation.
[b] Whole wheat flour bread.

The total dietary fiber contents of whole wheat grain, wheat bran (coarse) and wheat germ have been reported to be 10.2, 44 and 9.3%, respectively (Ranhotra et al., 1990). Saunders and Betschart (1980) showed that wheat bran protein is not totally digested (typically 65–85%). According to them, bran dietary fiber contains about 10% crude protein and 7% lignin content, and the indigestible protein should be considered as a component of dietary fiber. This indigestible protein could play a significant role in the observed physiological effects of dietary fiber in the lower digestive tract. Wheat bran is one of the most effective fecal-bulking agents and is effective in the treatment of constipation and diverticular disease (Anderson, 1985; Wisker, Feldheim, Pomeranz & Meuser, 1985).

When the red coarse and fine bran fractions were added to white flour for producing high-fiber bread, the TDF content of these bread samples improved significantly (Fig. 3) in comparison with whole wheat flour control bread. As the level of addition of either coarse or fine bran fraction was increased to 20%, the TDF

Table 5
Moisture content and water activity (a_w) of bread samples containing different levels of wheat germ and equal ratio of coarse and fine bran additions

Type of bran level	Bran level %	Wheat germ level, %					
		5.0		7.5		10.0	
		Moisture Content, %	a_w	Moisture Content, %	a_w	Moisture Content, %	a_w
Control[a]	0	39.29 ± 0.34	0.745	39.29 ± 0.34	0.745	39.29 ± 0.34	0.745
Red coarse bran:red fine bran ratio (2:2)	10	40.20 ± 0.76	0.782	41.57 ± 0.33	0.796	41.82 ± 0.15	0.791
	20	41.00 ± 0.06	0.771	41.54 ± 0.57	0.783	41.65 ± 0.49	0.784
	30	42.17 ± 0.50	0.767	41.54 ± 0.59	0.786	41.49 ± 0.31	0.792
White coarse bran:white fine bran ratio (2:2)	10	41.28 ± 0.66	0.779	41.68 ± 0.23	0.780	41.64 ± 0.04	0.787
	20	41.74 ± 0.40	0.778	41.53 ± 0.34	0.776	41.74 ± 0.35	0.783
	30	42.25 ± 0.38	0.771	41.81 ± 0.06	0.787	41.66 ± 0.51	0.780

[a] Whole wheat flour bread.

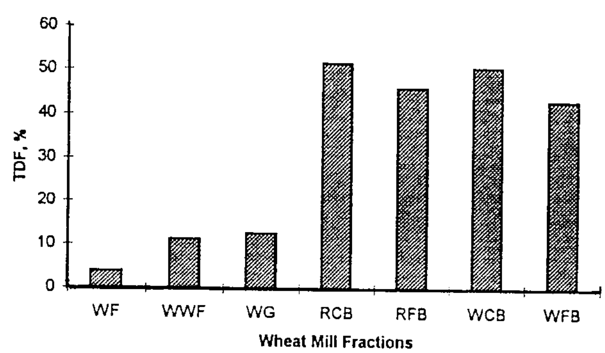

Fig. 2. Total dietary fiber contents (%, dry basis) of wheat germ, bran fractions, straight-grade flour and whole wheat flour.

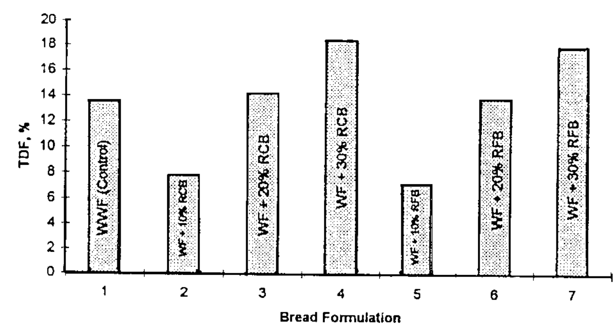

Fig. 3. Total fiber contents (%, dry basis) of bread samples containing different levels of red coarse bran (RCB) and red fine bran (RFB) fractions.

values for these high-fiber bread samples surpassed that of the control bread sample. At the highest level of coarse bran incorporation into the high-fiber bread formulation, the TDF value was enhanced to 18.47%, but with fine bran addition, the TDF value was slightly on the lower side (17.96%). Thus, even an addition of 20% of either coarse or fine bran fraction to the white flour brings it up to a higher level of TDF content than the control bread made from whole wheat flour.

To improve the nutritional and taste profile of high-fiber breads, wheat germ was added at varying levels, along with different levels of bran fractions. The total dietary fiber contents (%, dry basis) of wheat bread samples containing 7.5% of wheat germ and equal proportions of coarse and fine bran fractions at different levels of addition are presented in Fig. 4. The test bread containing 10% red bran and 7.5% wheat germ had a lower TDF content (9.52%) than the control bread made from whole wheat flour (13.6%), and the same was true for the test bread sample made with 10% white bran and 7.5% wheat germ. As the level of red or white bran level was increased to 20%, the TDF values were enhanced significantly and exceeded the control bread samples made from whole wheat flour. The high-fiber breads made with 7.5% wheat germ and 20% red bran had a TDF value of 14.89%, whereas the bread with

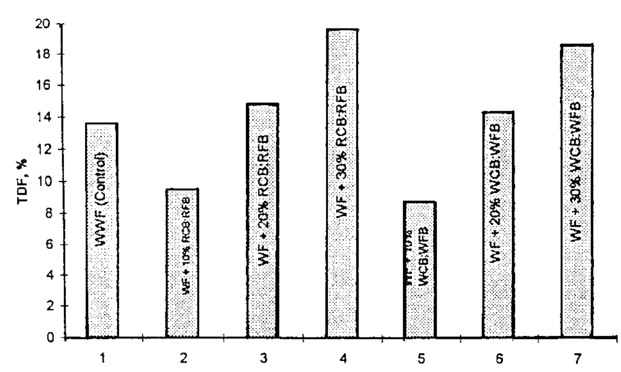

Fig. 4. Total dietary fiber contents (%, dry basis) of bread samples containing 7.5% wheat germ and equal proportions of coarse and fine bran fractions at different levels of addition.

20% white bran had a TDF content of 14.39%, both values being well above the control bread sample (13.6%). When the bran level was increased to 30%, the TDF values were enhanced further to 19.72 and 18.66% for red bran and white bran, respectively, but their objective color, texture, sensory and baking qualities were adversely affected (Sidhu et al., 1998). Therefore, the optimized formulation of high-fiber bread produced by adding 20% bran and 7.5% wheat germ, would provide the consumer with higher amounts of total dietary fiber but at the same time giving lighter crumb color and superior eating qualities than the conventional whole wheat flour bread.

4. Conclusions

The effect of type of bran, level of addition, particle size and addition of wheat germ on the chemical composition of high-fiber toast bread was investigated. The bran and germ fractions were found to be high in ash, protein, fat and total dietary fiber contents. The wheat germ had a protein content of 27.88% compared with 11.35, 12.69 and 15.76% for white flour, whole wheat flour and red fine bran, respectively. The chemical composition of high-fiber breads, in terms of minerals, protein, fat and dietary fiber contents, was found to be far superior than that of the whole wheat flour bread (control) sample. Considering these results, it can be concluded that high-fiber toast bread, with lighter crumb color and improved sensory and nutritional qualities than the whole wheat flour bread, can be produced using white flour, and equal proportions of coarse and fine bran at 20%, germ at 7.5%, and sodium stearoyl-2-lactylate at 0.5% levels.

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