

Effect of Wheat Bran Particle Size and Level of Substitution on the Physicochemical, Textural and Sensory Quality of Fibre-Enriched Cookies

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Abstract : Wheat bran is an abundant by-product of roller milling and a rich source of dietary fibre, minerals and B vitamins, yet its incorporation into baked goods is limited by adverse effects on texture, colour and flavour. This study examined how bran particle size and substitution level affect cookie quality. Wheat bran was fractionated using 30-, 36- and 52-mesh sieves and substituted for refined wheat flour (maida) at 5, 10 and 15% (w/w), giving nine treatments (T1–T9) plus a 100% flour control (T0). Cookies were baked at 160 °C for 30 min and evaluated for diameter, thickness, spread ratio, proximate composition (moisture, fat, protein, ash, crude fibre and carbohydrate by difference), instrumental hardness and sensory acceptability using a 9-point hedonic scale. Bran incorporation raised crude fibre from 2.55% in the control to 4.52–7.28% and increased moisture, fat, protein and ash slightly, while carbohydrate by difference fell from 72.59% to 66.91%. Cookies with 5% bran generally spread more than the control, whereas spread tended to fall as bran level rose. Peak cutting force rose with bran level within each mesh size (for example, 5.66 → 10.39 → 11.70 kg for 52-mesh bran at 5, 10 and 15%). Cookies made with the finest bran (52 mesh) received the highest sensory scores, with T9 (15% bran, 52 mesh) rated highest for overall acceptability (7.85/9) and texture (8.00/9). Fine bran therefore allowed a substantial fibre increase with acceptable sensory quality in this panel

IndexTerms -wheat bran; particle size; dietary fibre; cookies; texture analysis; sensory evaluation; bakery product development

INTRODUCTION

Consumers increasingly look for foods that support health without sacrificing taste, and bakery products—bread, biscuits and cookies in particular—are among the most widely consumed processed foods worldwide. In India, bread and biscuits account for a large share of the organised bakery sector. Cookies are typically formulated from refined wheat flour, sugar and fat and are therefore energy-dense but relatively low in dietary fibre, protein and micronutrients. Their long shelf life, low production cost and convenience make them an attractive vehicle for nutritional enrichment (Akubor, 2003).

Wheat bran, the outer layers of the grain comprising pericarp and aleurone, is removed during refining and is widely available at low cost. It is rich in insoluble dietary fibre, notably arabinoxylans and cellulose, minerals, B-group vitamins and phenolic antioxidants (Pomeranz, 1988; Shewry, 2009). Dietary fibre is associated with improved bowel function, better glycaemic control, lower plasma cholesterol and increased satiety. However, bran addition to baked goods can darken colour, introduce a bran flavour and alter dough water absorption, spread and texture (Vratanina and Zabik, 1978; Sharma and Chauhan, 2002). Bran also contains phytate, which can reduce mineral bioavailability (López et al., 2002).

Particle size is a key but under-studied factor for managing these trade-offs. Coarse bran may feel gritty and disrupt dough structure, whereas finer fractions have greater surface area and water-holding capacity and may be less perceptible in the mouth (Agrobio, 2010). Previous work has reported acceptable muffins with up to 30% bran (Golden et al., 1995), acceptable cookies with 20% coconut dietary fibre (Yalegama and Chavan, 2006), and reduced spread with defatted rice bran in cookies (Sekhon et al., 1997) and biscuits (Haque and Shams-ud-din, 2002). Systematic comparisons of several bran particle sizes at multiple substitution levels, combined with instrumental texture measurement, remain useful for product development.

NEED OF THE STUDY.

The objectives of this study were to develop cookies incorporating wheat bran of three particle-size fractions at three substitution levels; determine their physical, proximate and sensory properties; assess the effect of bran particle size on cookie quality; and characterise cookie hardness using a texture analyser.

2. MATERIALS AND METHODS

2.1 Raw materials

Refined wheat flour (maida), wheat bran, vanaspati (hydrogenated vegetable fat, used as shortening), sugar, salt, baking powder and eggs were purchased from the local market in Allahabad, India.

2.2 Bran fractionation

Wheat bran was sieved through 30-, 36- and 52-mesh sieves to obtain fractions of different particle sizes. Sugar was ground before use.

2.3 Experimental design and cookie preparation

Nine treatments were prepared by replacing refined flour with bran at 5, 10 or 15% (w/w) for each of the three mesh sizes, together with a control containing 100% refined flour (Table 1). Flour and bran were mixed thoroughly. Sugar and fat were creamed to a paste, and the dry mix, egg and baking powder were added and mixed into a dough. The dough was sheeted, cut with a cutter, baked at 160 °C for 30 min, cooled to room temperature and packed in low-density polyethylene (LDPE) pouches. The pouches were heat-sealed and stored at ambient temperature.

Table 1. Cookie treatments and flour–bran substitution levels.

Code	Bran mesh	Bran (%)	Flour (%)
T0 (control)	—	0	100
T1	30	5	95
T2	30	10	90
T3	30	15	85
T4	36	5	95
T5	36	10	90
T6	36	15	85
T7	52	5	95
T8	52	10	90
T9	52	15	85

2.4 Physical characteristics

Weight was measured using an electronic balance (0.01 g). Diameter and thickness were measured following AACC (2000). For diameter, six cookies were placed edge to edge, measured with a ruler, rotated 90° and re-measured; the mean was taken. For thickness, six cookies were stacked and the total height measured; this was repeated five times. Spread ratio was calculated as (width/thickness) × 10. The supplied manuscript contains some inconsistencies between the reported spread ratios and values recalculated from the stated formula; both are presented in Table 2 for transparency.

2.5 Proximate composition

Moisture was determined by oven drying at 130 ± 1 °C for 1 h (Kent-Jones, 1962). Protein was determined by micro-Kjeldahl (N × 6.25; AOAC, 1984). Fat was determined by Soxhlet extraction with petroleum ether (boiling point 60–80 °C; AOAC, 1990). Ash was determined by incineration at 550 ± 5 °C. Crude fibre was determined by sequential digestion with 1.25% H₂SO₄ and 1.25% NaOH (AOAC, 1975). Carbohydrate was calculated by difference: 100 – (moisture + fat + protein + ash + fibre).

2.6 Texture analysis

Hardness was measured with a texture analyser fitted with a Warner–Bratzler blade (knife edge, slotted insert) and a 25 kg load cell, in compression mode with return-to-start. Pre-test, test and post-test speeds were 1.5, 2.0 and 10.0 mm/s, respectively; travel distance was 5 mm and auto-trigger force was 25 g. Cookies were placed centrally under the blade, and peak force at the first major fracture peak was taken as hardness.

2.7 Sensory evaluation

Cookies were evaluated for colour, taste, aroma, flavour, texture, appearance and overall acceptability on a 9-point hedonic scale (1 = dislike extremely; 9 = like extremely) (Ranganna, 1986). The panel size, panel characteristics, serving order, blinding procedure and replication were not specified in the supplied study information.

2.8 Statistical analysis

The experiment was described as following a completely randomised design. However, replicate counts, standard deviations or standard errors, and inferential statistical tests were not provided in the supplied data. Accordingly, results are reported descriptively; treatment differences should not be interpreted as statistically significant without replicated observations and appropriate analysis of variance and post-hoc comparisons.

3. RESULTS AND DISCUSSION

3.1 Physical characteristics

Cookie diameter ranged from 46.2 to 50.0 mm and thickness from 8.3 to 9.4 mm (Table 2). The control (47.0 mm, 9.2 mm) was exceeded in diameter by 5% bran cookies of every mesh size, with 30-mesh bran giving the greatest value (T1, 50.0 mm). Diameter then declined with increasing bran level within each mesh size, to 46.2–48.0 mm at 15%. This biphasic pattern—an initial increase followed by a decrease—agrees with the report of Haque and Shams-ud-din (2002) for bran-supplemented biscuits.

Spread ratio is an established quality indicator for cookies, with larger spread generally preferred (Finney and Morris, 1950). Reported spread ratios were higher than the control (51.08) in all bran treatments and decreased as bran level rose within each mesh size (for example, 56.32 → 54.88 → 52.47 for 36-mesh bran). Reduced spread at higher bran levels is consistent with the greater water absorption of bran, which increases dough viscosity and limits flow during baking (Vratanina and Zabik, 1978; Sekhon et al., 1997). The initial increase at 5% may reflect incomplete hydration of coarse particles at low inclusion levels, although this was not tested here.

Table 2. Diameter, thickness and spread ratio of cookies.

Treatment	Diameter (mm)	Thickness (mm)	Spread ratio (reported)	Spread ratio (recalculated)
T0	47.0	9.2	51.08	51.09
T1	50.0	9.4	55.83	53.19
T2	48.0	8.9	53.93	53.93
T3	48.0	8.3	52.86	57.83
T4	49.0	8.7	56.32	56.32
T5	48.3	8.8	54.88	54.89
T6	46.2	9.4	52.47	49.15
T7	47.8	8.6	55.58	55.58
T8	47.6	8.6	54.23	55.35
T9	46.4	8.5	52.90	54.59

3.2 Proximate composition

Proximate results are summarised in Table 3. Moisture rose slightly with bran level, from 3.39% in the control to 3.52% in T9, consistent with the high water-binding capacity of bran fibre (Vratanina and Zabik, 1978). These moisture values are low and consistent with the crisp texture expected of cookies, although shelf stability was not directly measured.

Crude fibre was the attribute most affected numerically by bran addition, rising from 2.55% in the control to 4.52–4.58% at 5% bran, 6.55–6.63% at 10% and 6.80–7.28% at 15%. T9 (15% bran, 52 mesh) had the highest fibre content (7.28%), nearly three times the control. Increases of this kind with wheat bran have been reported in biscuits (Rauf, 2004). Differences between mesh sizes within a level were small and inconsistent, so a particle-size effect on measured crude fibre cannot be established from these data. Increases in protein (7.055 to 7.075–7.089%), fat (13.45 to 13.48–13.56%) and ash (0.919 to 0.923–0.944%) were similarly modest and require replicated analysis before interpretation. Carbohydrate by difference decreased from 72.59% in the control to 66.91% in T9, as expected when starch-rich flour is replaced by fibre- and protein-containing bran.

Table 3. Proximate composition of cookies (%).

Treatment	Moisture	Fat	Protein	Ash	Crude fibre	Carbohydrate
T0	3.39	13.45	7.055	0.919	2.55	72.59
T1	3.42	13.48	7.075	0.923	4.52	70.53
T2	3.43	13.50	7.077	0.930	6.55	68.51
T3	3.45	13.52	7.082	0.935	6.92	68.12
T4	3.49	13.50	7.078	0.926	4.55	70.45
T5	3.50	13.52	7.081	0.931	6.59	68.33
T6	3.51	13.54	7.084	0.938	6.80	68.13
T7	3.46	13.52	7.082	0.929	4.58	70.43
T8	3.48	13.54	7.086	0.935	6.63	68.33
T9	3.52	13.56	7.089	0.944	7.28	66.91

3.3 Instrumental hardness

Peak cutting force (Table 4) was lowest for 5% bran cookies made with 36- and 52-mesh bran (T4, 5.55 kg; T7, 5.66 kg) and 30-mesh bran (T1, 6.78 kg), all below the control (10.208 kg). This indicates lower fracture force under the specified test conditions at low bran inclusion. Force then increased with bran level within every mesh size: 6.776 → 7.715 → 11.285 kg (30 mesh), 5.550 → 9.947 → 12.967 kg (36 mesh) and 5.657 → 10.393 → 11.70 kg (52 mesh). Bran fibre may dilute and interrupt the gluten–starch matrix while binding water, producing a denser or harder structure at higher inclusion; the lower force at 5% may also relate to the greater spread and thinner structure at this level.

At 15% bran, the 52-mesh cookies (T9, 11.70 kg) required less force than the 36-mesh cookies (T6, 12.967 kg) but more than the 30-mesh cookies (T3, 11.285 kg). Therefore, a consistent benefit of finer bran for instrumental hardness is not demonstrated by

these data. Hardness is influenced by cookie dimensions as well as formulation; the dimensions of the samples tested should be reported in future work.

Table 4. Instrumental hardness expressed as peak cutting force.

Treatment	Peak force (kg)
T0	10.208
T1	6.776
T2	7.715
T3	11.285
T4	5.550
T5	9.947
T6	12.967
T7	5.657
T8	10.393
T9	11.70

3.4 Sensory evaluation

Sensory scores are given in Table 5. Control and 30-/36-mesh cookies were generally rated between “like slightly” and “like moderately” (mostly 5.28–6.57), whereas 52-mesh cookies, particularly T8 and T9, scored higher (approximately 7.42–8.00 for several attributes). T9 had the highest overall acceptability (7.85) and texture score (8.00), followed by T8 for overall acceptability (7.71). The pattern is consistent with the possibility that finer bran produces a smoother mouthfeel and less visible speckling than coarse bran. Within the 52-mesh series, acceptability rose with bran level (6.42, 7.71 and 7.85), contrary to some reports in which sensory response declines as bran level rises (Sharma and Chauhan, 2002). This unusual pattern should be interpreted cautiously because panel size and sample-order effects were not reported. The authors observed slightly darker colour at 15% bran, which remained within acceptable limits.

Table 5. Sensory scores on a 9-point hedonic scale (means).

Treatment	Colour	Taste	Aroma	Flavour	Texture	Appearance	Overall acceptability
T0	6.28	6.14	5.85	5.57	6.00	5.42	5.57
T1	6.71	6.42	7.42	6.00	6.00	5.57	5.57
T2	6.42	6.57	7.42	6.42	6.00	5.57	5.42
T3	6.14	6.57	5.57	6.00	5.57	6.14	6.00
T4	5.85	6.42	5.71	6.42	6.00	6.14	5.28
T5	6.42	6.57	6.42	6.28	6.28	6.42	6.28
T6	6.28	6.57	6.14	6.57	6.14	6.28	6.28
T7	7.71	7.57	7.42	7.42	7.42	6.14	6.42
T8	7.57	7.42	7.71	7.57	7.57	7.42	7.71
T9	7.71	7.71	7.57	7.71	8.00	7.71	7.85

3.5 Statistical analysis

Because replicate numbers and measures of variability were not supplied, no statistical significance can be assigned to the observed differences. The trends in Tables 2–5 are descriptive. Future analysis should report independent production batches and analytical replicates, mean $\pm$ standard deviation, and suitable factorial ANOVA to test bran mesh size, substitution level and their interaction, followed by an appropriate multiple-comparison procedure.

3.6 Nutritional and practical implications

A 15% substitution with 52-mesh bran raised crude fibre by 4.73 percentage points relative to the control, while this formulation also had the highest sensory acceptability in the reported panel. Fibre content is reported on the basis used in the supplied proximate data; a 30 g serving would provide approximately 2.18 g crude fibre if the reported 7.28% value applies on an as-served basis. The study did not measure physiological or clinical outcomes, so health-effect claims should be limited to established general knowledge about dietary fibre. Phytate content and mineral bioavailability were not assessed and warrant investigation because bran may reduce the availability of some minerals (López et al., 2002).

4. CONCLUSIONS

Substituting refined flour with wheat bran at 5–15% increased the crude fibre content of cookies to as much as approximately 2.9 times the control and produced modest numerical increases in moisture, protein, fat and ash. Higher bran levels generally increased cutting force, while reported spread tended to decline as bran level rose within each mesh-size series. Cookies made with the finest bran fraction (52 mesh) received the highest sensory scores, and the 52-mesh, 15% bran formulation (T9) scored highest for overall acceptability, texture and fibre content. Fine bran therefore appears promising for fibre-enriched cookies under the conditions tested. Future work should include replicated experiments with variance estimates, particle-size distribution

measurement, water absorption and dough rheology, shelf-life testing, phytate and mineral-bioavailability assessment, and consumer testing.

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DECLARATIONS

Conflict of interest: The author declares no conflict of interest.

Author contributions (CRediT): Conceptualization, investigation/analysis, and writing of the original draft. The contribution statement should be confirmed and expanded by the author to reflect the work actually performed.

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