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Development and Nutritional Evaluation of Maize Chapattis Supplemented with Psyllium Husk

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ABSTRACT: The increasing prevalence of obesity and overweight, recognized as major public health concerns, has prompted various interventions for their prevention and management. Dietary modifications have shown promise in combating these issues, particularly through increased fibre consumption. Psyllium, derived from *Plantago ovata* seeds, is a concentrated source of soluble fibre, known for its low susceptibility to fermentation and various health benefits. This paper explores the potential of psyllium supplementation in promoting weight management and overall health. The study focuses on incorporating psyllium husk into maize *chapattis* and evaluates the nutritional and sensory aspects of the resulting products. Results show that psyllium-enriched *chapatti*s have increased moisture content, dietary fibre and reduced protein, fat and total carbohydrate levels. Sensory evaluation indicates that lower psyllium concentrations result in more favourable attributes. This research sheds light on the potential of psyllium as a functional ingredient in food products, offering health benefits and enhancing dietary fibre intake.

Keywords: Psyllium, Husk, *Chapatti*, Maize, Fibre, Sensory.

INTRODUCTION

Obesity and overweight stand as significant public health challenges (WHO, 2003). Addressing the escalating obesity rates proves complex due to the multifaceted nature of the problem, necessitating a diverse range of interventions for effective prevention and management. Dietary modifications emerge as a promising avenue for combating obesity and supporting weight management (Fock and Khoo 2013). Epidemiological studies consistently reveal a positive correlation between higher fibre consumption and lower indicators such as body weight, BMI and waist circumference (Thompson *et al*., 2017). Moreover, increased fibre intake shows associations with improved blood lipids, glycemic control, and insulin response (Lairon *et al*., 2005). However, the challenge arises for individuals to consume ample fruits and vegetables to meet the necessary fibre requirements (Clemens *et al*., 2012; Trumbo *et al*., 2002). Consequently, supplementing with fibre presents a convenient and cost-effective approach to augment fibre intake. The psyllium plant, scientifically known as *Plantago ovata*, is indigenous to the Mediterranean region, with a notable presence in Spain, France, North Africa and Asia (Tewari *et al*., 2014). Psyllium husk, derived from the husks of blonde psyllium seeds, represents a natural and concentrated source of soluble fibre. Referred to as *ispaghula*, psyllium finds commercial use in producing mucilage, with seed from P. ovate known as white or blonde psyllium, *Indian plantago*, or isabgol. The term "isabgol" in India originates from Sanskrit words meaning "horse flower," reflecting the seed's distinctive shape. Psyllium supplements, available in various forms like capsules, wafers and powdered drink mixes, gain popularity among consumers for their financial practicality and diverse flavours. Distinguished by its reduced susceptibility to fermentation, psyllium exhibits advantages over other soluble fibres, resulting in a lower incidence of flatulence and abdominal bloating (Blackwood *et al*., 2000). Numerous human studies explore the impact of psyllium on various health markers, including glucose and insulin homeostasis, lipids, body weight, composition, and appetite (Anderson *et al*., 2000; Delargy *et al*., 1997; Pal *et al*., 2011; Ziai *et al*., 2005). Psyllium influences body composition through mechanisms such as gastric emptying, satiety, modulation of gut hormones like cholecystokinin (Yao and Roberts 2001; Burton-Freeman *et al*., 2002) and changes in the glycemic index or insulin response (Anderson *et al*., 2004). Ingested of fibre rich food can form a viscous gel-like substance in the gastrointestinal tract, promoting feelings of fullness, reducing appetite and facilitating regular bowel movements to prevent constipation and toxic buildup (Jesly *et al.*, 2023). Additionally, psyllium husk demonstrates the ability to lower cholesterol levels, reducing the risk of heart disease and related health problems.

The weight loss benefits of psyllium husk can be attributed to factors such as its appetite-reducing effects, impact on gastric emptying rate and promotion of regular bowel movements. Psyllium husk's ability to absorb water in the gastrointestinal tract and swell forms a gel-like substance that reduces food consumption. This process may also slow down gastric emptying, further enhancing feelings of fullness. Psyllium husk's contribution to regular bowel movements is crucial for weight loss efforts by preventing constipation and reducing toxin buildup, which can impede metabolism. Furthermore, the FDA's approval of food products containing psyllium husk underscores its recognized health benefits (Leeds, 2009). Consumers appreciate fibre supplementation not only for its health advantages but also for its appealing taste and improved storage stability. Traditional Iranian medicinal practices have incorporated psyllium seeds for centuries due to their pharmacological effects. Psyllium supplements, available in granule, powder, wafer, and capsule forms, offer flexibility in consumption. Psyllium aids in fulfilling daily dietary fibre recommendations more easily due to its higher soluble fibre content. Its impact on body lipids and proteins associated with the metabolic process highlights the potential benefits of soluble fibre from psyllium.

In the realm of functional and nutraceutical foods, fibre-containing products are undergoing development and scrutiny. Special attention is given to bakery products, yoghurt, and drinks (Martin *et al*., 2008; Perrigue*et al*., 2009). Studies suggest that bakery products can incorporate up to 50% replacement of psyllium husk without compromising quality (Ganji and Kuo 2008). Considering the limited use of psyllium husk in Indian day-to-day cuisine, the present study focuses on the development, nutritional evaluation and sensory assessment of maize *chapattis* incorporating psyllium husk.

MATERIAL AND METHODS

The maize grains, psyllium husk and all other components essential for *Chapatti* preparation were procured from the local market. The maize grains underwent a cleaning process and were subsequently subjected to grinding using an electric grinder (Cyclotec, M/s Tecator, Hoganas, Sweden). The resulting flour was sieved through a 60-mesh sieve and then stored in hermetic plastic containers for future utilization. For dough preparation, 100 g of either plain flour or a mixture of flour and Psyllium husk was accurately measured. The calculated amount of water, as specified in Table 1, was added, and the dough was kneaded manually for approximately 5 minutes. The resulting dough was covered with a damp cloth and allowed to rest for 10 minutes at room temperature to facilitate relaxation. This process was replicated for additional batches as detailed in Table 1.

Nutritional Evaluation of Chapattis

Both the control and the composite flour *chapatti*s underwent desiccation in an oven maintained at 60°± 2° C until a state of constant weight was attained. After the drying process, the samples were finely powdered and subjected to analysis for the parameters outlined below.

Proximate Analysis. The moisture, ash, protein, fat, crude fibre and carbohydrate contents of both the flours and the studied *chapatti*s were determined following the methodology prescribed by AOAC (2000).

Sensory Evaluation of Biscuits

The evaluation of biscuits' sensory attributes, encompassing color, appearance, aroma, texture, taste, and overall acceptability, utilized a 9-point hedonic scale. A panel comprising 20 semi-trained judges from Chaudhary Charan Singh Haryana Agricultural University, Hisar, India, conducted the assessment.

Statistical Analysis. For statistical analysis, a one-factor completely randomized design (CRD) with three replications was employed. Duncan's multiple range tests were applied to determine the significance of differences ($P<0.05$) among the means. The data analysis utilized IBM® SPSS® Statistics 19.0 software (IBM, Armonk, USA).

RESULTS AND DISCUSSION

Moisture content. The developed *chapattis*can be depicted in Fig. 1. The moisture content of *chapatti*s was increased from 29.78% (w.b.) to 33.95% (w.b.) with an increase in the concentration of psyllium husk from 0 to 20 g/100g (Table 2). The probable reason could be the hygroscopicity of fibres in psyllium husk in *chapatti* which might have increased the water-holding capacity of *chapatti* with increased concentration (Uysal *et al.*, 2007). There was no significant difference in moisture content was observed between the *chapatti* with 5/100g psyllium husk and the *chapatti* without psyllium husk. The effect of psyllium husk concentration was highly significant ($p<0.01$) on the moisture content of different *chapatti*s. Maximum moisture content was 33.95% in Type 4 *chapatti* (with dough concentration of psyllium husk at 20 g/100g of flour).

True protein. The true protein of *chapatti*s varied extremely significantly ($p<0.001$) with different dough concentrations of psyllium husk. The true protein of *chapatti*s was reduced from 10.46% to 8.72% with an increase in the concentration of psyllium husk from 0 to 20 g/100g (Table 2). The maximum true protein of *chapatti* was 10.46% in *chapatti* without psyllium husk, followed by 10.20% in Type 1 *chapatti* (with dough concentration of psyllium husk at 5 g/100 g of flour). The probable reason for the decrease in true protein could be due to the increase in moisture content of *chapatti* because of the incorporation of psyllium husk and the lower protein content of psyllium husk compared to maize. Qaisrani *et al.* (2014) observed a similar decrease in crude protein in cookies made from wheat flour with 5 to 25% concentration of psyllium husk.

Total fat. The total fat content of *chapatti* without psyllium husk was found to be 4.48%. The total fat content of *chapatti* varied extremely significantly ($p<0.001$) with different concentrations of psyllium husk. Increasing the concertation of psyllium husk from 0 to 20 g/100g of flour in *chapatti* reduced the total fat content from 4.48 to 3.89% (Table 2). The lowest fat content (3.89%) was found in Type 4 *chapatti* (with dough concertation of psyllium husk at 20g/100g of flour). Change in the formulation of flour might have resulted in a change in total fat content. Pasha *et al.* (2002) observed a similar decrease in fat content in bakery products made from wheat and mung bean flour.

Total ash. The average total ash content of the control sample (*chapatti* without psyllium husk) was 1.69%. A slight increase in ash content was observed by increasing the concentration of psyllium husk. However, the total ash content of *chapatti* with different concentrations of psyllium husk did not vary significantly. The total ash content of different *chapatti*s varied from 1.69% to 1.84% (Table 2).

Crude Fibre. The crude fibre of different *chapatti*s varied from 0.98% to 1.35% (Table 2). The crude fibre of the control sample was 0.98% which was further increased with increasing the concentration of psyllium husk from 5 to 20 g/100g of flour. The maximum crude fibre was observed in Type 4 *chapatti* (with a concentration of psyllium husk at 20 g/100g of flour). The incorporation of psyllium husk in flour significantly ($p<0.001$) affected the crude fibre concentration of *chapatti*s. Similar increase of crude fibre in cookies made from wheat flour and psyllium husk (Qaisrani *et al.,* 2014).

Total carbohydrate. The total carbohydrate of *chapatti*s ranged from 51.57% to 53.59% (Table 2) with different dough concentrations of psyllium husk in flour. The total carbohydrate of the control sample was 53.59% which was reduced with an increase in incorporation of psyllium husk from 5 to 20 g/100g. The effect of dough concentration of psyllium husk was found to be significant on the total carbohydrate of *chapatti*s. The lowest total carbohydrate (51.57%) was observed in Type 4 *chapatti* (with a concentration of psyllium husk at 20 g/100g of flour). A decrease in wheat flour with the incorporation of psyllium husk could be the probable reason for the decrease in the total carbohydrate of *chapatti*s. A similar observation was found in digestive cookies incorporated with psyllium husk and pomegranate juice (Anitha and Ramya 2020).

Dietary fibre. The total dietary fibre of *chapatti*s with different dough concentrations of psyllium husk was varied from 10.52% to 23.55% with different treatment combinations (Table 3). Incorporating the psyllium husk in maize flour positively increased the concentration of total dietary fibre of *chapatti*s. The total dietary fibre of *chapatti*s was increased with an increase in dough concentration of psyllium husk in flour. The highest total dietary fibre (23.55%) was observed in Type 4 *chapatti* followed by Type 3 *chapatti*. The change in formulation in flour by replacing maize flour with psyllium husk might have caused an increase in total dietary fibre content. The soluble dietary fibre of *chapatti*s with different concentrations of psyllium husk varied from 2.15% to 2.79% with different treatment combinations (Table 3). There was a slight increase in the soluble dietary fibre content of *chapatti*s with the addition of the psyllium husk in maize flour. The soluble dietary fibre of *chapatti*s was increased with an increase in dough concentration of psyllium husk in flour. The effect of the addition of psyllium husk on the soluble dietary fibre of *chapatti*s was highly significant ($p<0.01$). The highest soluble dietary fibre (2.79%) was observed in Type 4 *chapatti*. The insoluble dietary fibre of different *chapatti*s varied from 8.35% to 20.65% with different formulations. The insoluble dietary fibre of different *chapatti*s increased significantly ($p<0.001$) with the addition of psyllium husk. The substantial increase in insoluble dietary fibre of *chapatti*s could be attributed to the addition of psyllium husk which is largely composed of insoluble dietary fibre. The highest insoluble dietary fibre (20.65%) was observed in Type 4 *chapatti*s. A similar increase in dietary fibre was observed in biscuits supplemented with 25% citrus pulp and peel (Nassar *et al.*, 2001) and cookies containing 30% to 50% rice bran (Sharif *et al.*, 2009).

Sensory evaluation of different *chapatti*s from psyllium husk: The sensory evaluation of different *chapattis* was evaluated based on a nine-point hedonic scale. The average scores of ten different panellists were collected. The observation of sensory evaluation revealed that the different scores of colour, appearance, aroma, texture, taste and overall acceptability were found to decrease with an increase in the concentration of psyllium husk (Table 4, Fig. 2). Based on sensory evaluation for different treatments, Type 1 *chapatti*was found to be most likeable by different panellists among psyllium husk assisted *chapatti*.

Table 1: Formulation of Dough for various *chapattis.*

Ingredients(g)	Control	Type-I	Type-II	Type-III	Type-IV
Maize flour	100	95	90	85	80
Psyllium husk	0	5	10	15	20

Table 2: Proximate composition of maize *chapatti* supplemented with psyllium husk (g/100g, on dry weight basis).

Treatment	Moisture* content	True Protein	Total Fat	Total ash	Crude Fibre	Total Carbohydrate
Control	29.78 ± 1.2^{A}	10.46 ± 0.33^{D}	4.48 ± 0.09^{D}	1.69 ± 0.05^{A}	0.98 ± 0.05^{A}	53.59 ± 0.48^{C}
Type 1	30.68 ± 0.75^{A}	10.20 ± 0.35^{CD}	4.35 ± 0.10^{CD}	1.74 ± 0.09^{A}	1.09 ± 0.06^{AB}	53.12 ± 0.45^{BC}
Type 2	31.44 ± 0.9^{AB}	9.65 ± 0.38^{BC}	4.18 ± 0.11^{BC}	1.77 ± 0.08^{A}	1.19 ± 0.09^{BC}	52.89 ± 0.54^{BC}
Type 3	32.64 ± 1.2^{BC}	9.16 ± 0.35^{AB}	4.04 ± 0.12^{AB}	1.81 ± 0.09^{A}	1.28 ± 0.07^{CD}	52.28 ± 0.84^{AB}
Type 4	33.95 ± 0.85^{C}	8.72 ± 0.38^{A}	3.89 ± 0.10^{A}	1.84 ± 0.06^{A}	1.35 ± 0.06^{D}	51.57 ± 0.85^{A}

Values are expressed as mean ± SD; *On fresh weight basis; Means with the same letter within a column are not significantly different

Table 3: Dietary fibre content of maize *chapatti* supplemented with psyllium husk (g/100g, on dry weight basis.

Treatment	Total dietary fibre	Soluble dietary fibre	Insoluble dietary fibre
Control	10.52 ± 1.74^{A}	2.15 ± 0.20^{A}	8.35 ± 1.95^{A}
Type 1	13.65 ± 1.69^{AB}	2.45 ± 0.17^{B}	11.15 ± 1.68^{AB}
Type 2	16.78 ± 1.87^{B}	2.52 ± 0.12^{BC}	14.18 ± 1.38^{B}
Type 3	20.38 ± 1.75^{C}	2.71 ± 0.10^{BC}	17.65 ± 1.62^{C}
Type 4	23.55 ± 1.68^{C}	2.79 ± 0.09^{C}	20.65 ± 1.72^{D}

Values are expressed as mean ± SD; Means with the same letter within a column are not significantly different

Table 4: Mean scores of sensory characteristics of maize *chapatti* supplemented with psyllium husk.

Treatment	Colour	Appearance	Aroma	Texture	Taste	Overall acceptability
Control	8.1 ± 0.3^{A}	8.2 ± 0.4^{A}	8.1 ± 0.54^{A}	8.2 ± 0.40^{A}	8.3 ± 0.64^{A}	8 ± 0.27^{A}
Type 1	7.8 ± 0.4^{A}	7.7 ± 0.64^{A}	7.9 ± 0.70^{A}	7.7 ± 0.78^{A}	7.6 ± 0.49^{B}	7.8 ± 0.23^{B}
Type 2	7.2 ± 0.87^{B}	7 ± 0.63^{B}	7.1 ± 0.54^{B}	6.9 ± 0.30^{B}	7.1 ± 0.54^{BC}	6.8 ± 0.44^{CD}
Type 3	6.4 ± 0.66^{C}	6.4 ± 0.66^{BC}	6.5 ± 0.50^{C}	6.2 ± 0.60^{C}	6.6 ± 0.80^{CD}	6.8 ± 0.33^{D}
Type 4	5.9 ± 0.3^{C}	6 ± 0.77^{C}	6 ± 0.77^{C}	5.8 ± 0.60^{C}	6.2 ± 0.40^{D}	5.8 ± 0.27^{E}

Values are expressed as mean ± SD; Means with the same letter within a column are not significantly different

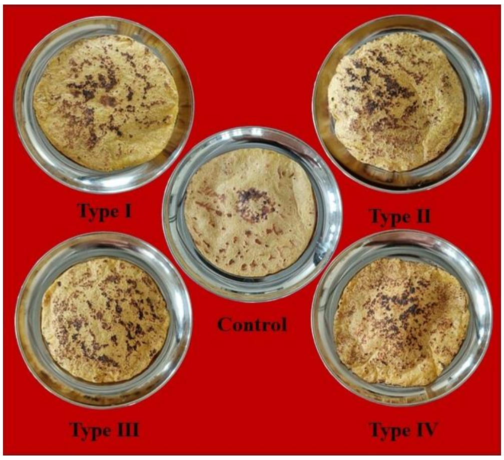

Plate. 1. Developed maize *chapatti* supplemented with psyllium husk.

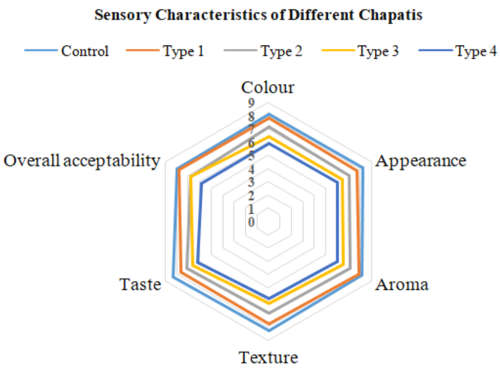

Fig. 1. Sensory evaluation of different *chapattis.*

CONCLUSIONS

In conclusion, the incorporation of psyllium husk into maize *chapatti*s has led to several notable changes in their proximate composition. The moisture content of the *chapatti*s significantly increased with higher concentrations of psyllium husk, likely due to the hygroscopic nature of psyllium fibres, which enhanced water retention. There was a significant reduction in true protein in *chapatti*s with increasing psyllium husk concentration. Total fat content decreased as well, likely due to changes in the flour formulation. The total ash content exhibited a slight increase with higher psyllium husk concentration, while crude fibre content showed a significant increase, especially in *chapatti*s with 20 g/100g psyllium husk. Total carbohydrate content decreased as psyllium husk concentration increased, possibly due to the reduction of wheat flour in the formulation. Furthermore, the total dietary fibre content notably increased with the addition of psyllium husk, with the highest levels observed in Type 4 *chapatti*s. Both soluble and insoluble dietary fibre content increased as well, indicating the potential health benefits of psyllium-enriched *chapatti*s. In terms of sensory evaluation, as the concentration of psyllium husk increased, the scores for color, appearance, aroma, texture, taste, and overall acceptability decreased. Type 1 *chapatti*s were found to be the most likeable among the different treatments, suggesting that moderate psyllium husk incorporation maintains the sensory attributes of *chapatti*s. Overall, this study highlights the potential of psyllium husk as a functional ingredient to enhance dietary fibre content in *chapatti*s. While the nutritional composition was affected by psyllium husk, sensory attributes may need to be considered when determining the optimal level of psyllium husk for consumer acceptance. These findings provide insights for the development of healthier and more nutritious food products.

FUTURE SCOPE

The future scope lies in fine-tuning psyllium husk concentrations to strike a balance between enhanced nutritional content and sensory acceptance in maize chapattis. Further research could explore innovative formulations and processing techniques to mitigate the sensory impact while maximizing the health benefits. Additionally, investigating the application of psyllium husk in diverse food products and understanding its long-term dietary implications would contribute to advancing functional food development.

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Conflict of Interest. None.

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