International Journal of Engineering and Science Invention (IJESI)
ISSN (Online): 2319-6734, ISSN (Print): 2319-6726
www.ijesi.org ||Volume 14 Issue 2 February 2025 || PP 68-73

Development and Quality Characterization of Cookies Enriched with Horse Gram Flour

Jyoti Narwal[1] and Ritika B. Yadav[1]*
[1]*Department of Food Technology*
Maharshi Dayanand University, Rohtak (Haryana)-India
**Corresponding author: Dr. Ritika B. Yadav, Department of Food Technology, M.D.U., Rohtak (Haryana)-India*

Abstract
Horse gram (Macrotyloma uniflorum), an underutilized legume, is rich in protein, fiber, minerals, and antioxidants, making it a valuable ingredient for improving the nutritional quality of bakery products. This study aimed to develop cookies by partially substituting refined wheat flour (RWF) with germinated horse gram flour (GHF) at levels of 10%, 20%, 30%, and 40%. Germination was used to enhance the nutritional value and reduce anti-nutritional factors. The functional properties of the flours, such as water and oil absorption capacities, were evaluated, along with the physical, color, and sensory attributes of the cookies. Results showed that increasing GHF levels significantly improved the water and oil absorption capacities of flour blends, with the S_4 formulation (40% GHF) recording the highest values. Cookies made with higher GHF content exhibited increased diameter, thickness, and weight, along with darker coloration due to the natural pigments in horse gram. However, sensory evaluation revealed that higher GHF levels led to decreased acceptability, with the 10% GHF blend (S_1) showing the best balance of improved nutrition and sensory appeal. This study demonstrates the feasibility of incorporating germinated horse gram flour into cookies for enhanced nutritional benefits, with up to 10–20% substitution recommended for optimal sensory acceptance.

Keywords: *Horse gram; Germination; Cookies; Physical parameters; Sensory parameters*

I. Introduction

Horse gram (*Macrotyloma uniflorum*) is an underutilized legume primarily grown in the dry tropical regions, especially across southern Indian states such as Andhra Pradesh, Karnataka, and Tamil Nadu. It stands out among legumes due to its notably higher content of non-protein nitrogen (Kadam & Salunkhe. 1985). Typically consumed as whole seeds, dhal (splits), flour, or sprouts, horse gram is recognized for its rich nutritional profile. The seeds contain around 60% carbohydrates, 25% protein, minimal fat (approximately 0.58%), and essential amino acids. The seeds also possess dietary fiber, iron, calcium, and trace elements like molybdenum (Bravo et al. 1999). Horse gram has been associated with various health benefits, including aiding in the management of conditions such as jaundice, arthritis, skin issues, elevated blood sugar, abdominal masses, and respiratory problems like bronchitis (Kadam & Salunkhe. 1985). Its antioxidant properties are attributed to the presence of polyphenolic compounds. However, like many legumes, its seeds also have anti-nutritional compounds such as oxalic acid, phytic acid, and tannins, that can reduce the absorption of key minerals like calcium and iron (Parmar et al., 2017). The various processing techniques like soaking, dehulling, fermentation, and germination, have been known to effectively reduce the anti-nutritional compounds while enhancing the overall nutritional value (Deshpande et al., 1982). Specifically, germination has been reported to lower the levels of oxalic acid, phytic acid, and polyphenols, and improve protein digestibility.

In recent years, the demand for nutritious and value-added food products like cookies, noodles, & bread have risen considerably. While wheat flour contains about 10–14% protein, it is relatively deficient in certain essential amino acids such as lysine and threonine. The fortification of wheat flour with nutrient-rich alternatives like horse gram flour has been explored to enhance the nutritional value of baked products. Previous research has demonstrated that incorporating germinated horse gram flour into baked products such as bread led to enhanced levels of iron, calcium, antioxidant activity, and polyphenols (Moktan and Ojha, 2016). Studies have also reported the successful fortification of noodles using horse gram flour (Narwal and Yadav, 2022). Despite this, the use of horse gram flour in cookie production remains largely unexplored. Keeping in view the nutritional value of horse gram seeds, the current work was undertaken to formulate and analyse the quality characteristics of cookies supplemented with germinated horse gram flour (GHF).

II. Materials and Methods

2.1 Preparation of germinated horse gram flour (GHF)
A quantity of 100 grams of horse gram seeds was thoroughly rinsed and soaked in 500 mL of distilled water at ambient temperature for 10 hours. Post-soaking, the water was drained off, and the seeds were left to germinate at 25 ± 2°C for 24 hours. After the germination period, the seeds were dried in a tray dryer at 55°C for 5 hours. After proper drying, the seeds were finely ground using a grinder and then sieved through a 100-mesh screen to produce GHF.

2.2 Formulation of composite flour blends
To prepare various blends, GHF was mixed with refined wheat flour (RWF) in specific ratios. The formulations included a control sample containing 100% RWF and four experimental blends as follows:

Table 1. Formulation of flour blends

Sample	RWF (%)	GHF (%)	Total conc. (%)
RWF	100	-	100
GHF	100	-	100
S_1	90	10	100
S_2	80	20	100
S_3	70	30	100
S_4	60	40	100

2.3 Preparation of cookies
Cookies were prepared using composite blends of RWF and GHF as given in Table 1, following the method described by Narwal et al. (2024) with slight modifications. The formulation consisted of 100 g of flour, 40 g of powdered sugar, 30 g of butter, 2.0 g of baking soda, 0.5 g of salt, 2 g of skim-milk powder (SMP), and a suitable amount of water. To begin, the butter and powdered sugar were thoroughly mixed to achieve a light and creamy texture. Next, the appropriate amounts of RWF, GHF, and other dry ingredients were incorporated into the creamed mixture. Water was gradually added, and the dough was prepared using a dough mixer until a smooth consistency was achieved. The dough was subsequently left to rest for 10 minutes. After resting, the dough was rolled out evenly and cut into circular shapes with the help of cookie cutter. These were baked in a preheated oven at 180°C for 20 minutes. Once baked, the cookies were cooled and stored in airtight containers at room temperature for further evaluation.

2.4 Water and oil absorption capacity

The water and oil absorption capacity (WAC, OAC, respectively) of RWF, raw horse gram flour (RHF), and GHF were examined. These properties were measured using a modified version of the method by Sosulski et al. (1976).

2.5 Analysis of cookies
For physical characterization of the cookies, diameter was recorded by placing six cookies in a straight line and averaging their total width. Thickness was measured by stacking six cookies on top of each other and computing the average height. The weight of individual cookies was recorded using a digital balance. Spread ratio (SR) was obtained by dividing the average diameter by the average thickness.

The color attributes of all cookie samples were assessed using a ColorFlex EZ colorimeter (Model: 45/0, USA). The measurements were recorded based on the CIE Lab color system, which includes three key parameters: L*, a*, and b*. The L* value represents the lightness of the sample, ranging from 0 (black) to 100 (white). The a* value reflects the red to green range, with +ve values indicating redness and -ve values reflecting greenness. The b* value corresponds to the yellow to blue range, where +ve values denote yellowness and -ve values denote blueness.

The sensory evaluation of the cookie samples was conducted using a 9-point hedonic scale, with a score of 1 signifying intense dislike and a score of 9 indicating a high level of preference. A group of 20 semi-trained panellists evaluated the cookies based on sensory attributes including color, texture, appearance, taste, flavor, and overall acceptability.

2.6 Statistical analysis
Statistical analysis of the data was performed using analysis of variance (ANOVA) with SPSS software (version 19). Results were reported as mean ± standard deviation, and a p-value of less than 0.05 was considered to indicate statistical significance.

III. Results and Discussion

3.1 Water (WAC) and oil (OAC) absorption capacity of flour and their blends

Understanding the functional characteristics of different flours such as water and oil absorption capacities, are essential to determine their roles and suitability in various food applications. WAC indicates how effectively a flour can retain water when mixed with a known quantity. Figure 1. and 2. presents the physicochemical parameters i.e., WAC and OAC of RWF, RHF, GHF, and various blends. WAC values ranged from 160 to 225%, with S_4 blends recording the highest WAC (225%), which was significantly greater than another sample.

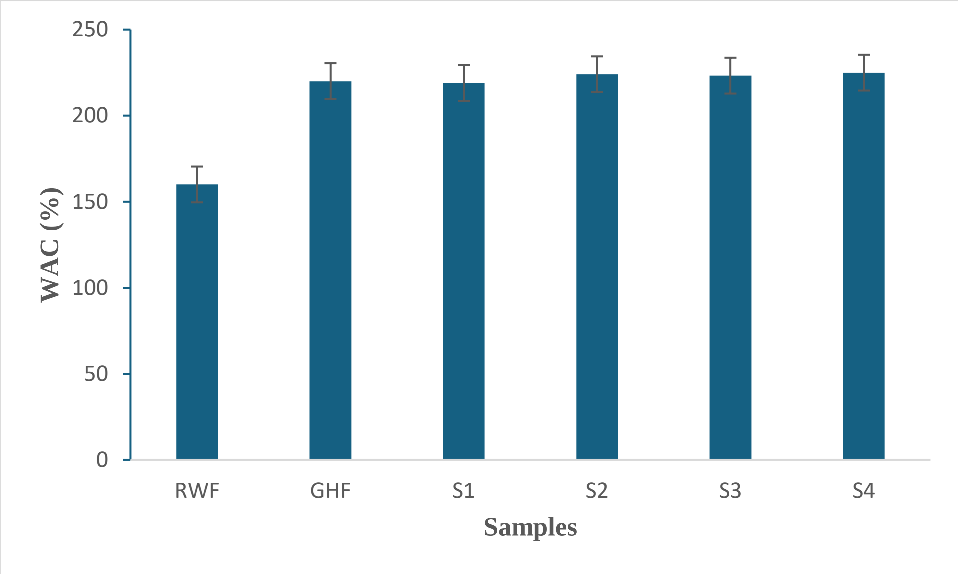

Figure 1. Water absorption capacity of different samples

The superior WAC in S_4 blend (40% GHF:60% RWF) may be due to its higher protein content. High WAC is particularly beneficial in the development of ready-to-eat products, where it contributes to product cohesion and texture.

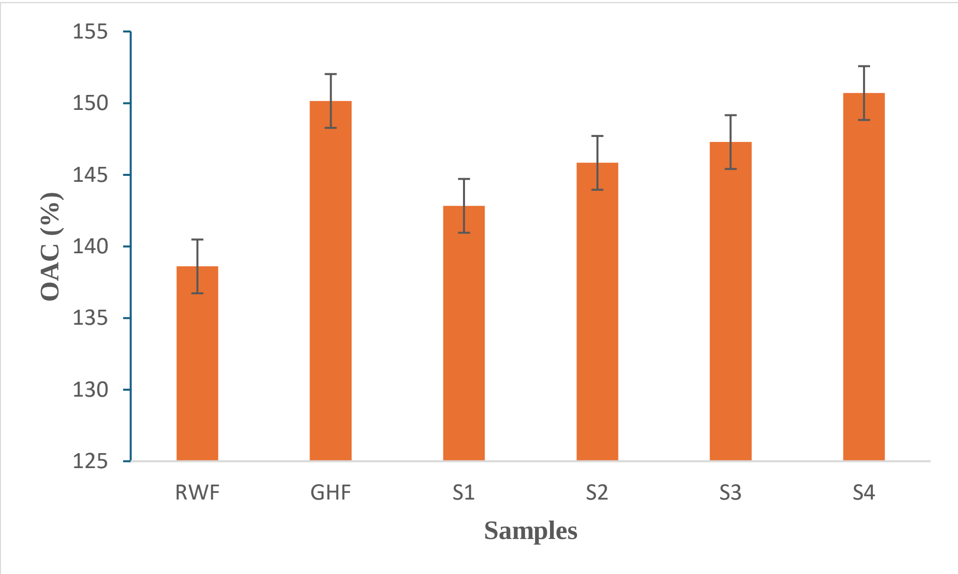

Figure 2. Oil absorption capacity of different samples

OAC measures the interaction between oil and the nonpolar side chains of proteins. Among the samples, OAC ranged between 138.60 to 150.70%, with S_4 blend (40% GHF:60% RWF) again demonstrating the highest value (150.70%), significantly exceeding the values for GHF and RWF ($p < 0.05$). According to Subagio (2006), elevated OAC values are often associated with the presence of hydrophobic amino acid groups in proteins. A higher OAC can improve the sensory qualities of food, enhancing both flavor retention and mouthfeel, thereby increasing consumer acceptability.

3.2 Physical parameters of cookies

Cookies prepared using various flour combinations showed significant variation in their physical properties, as presented in Table 2. The diameter of the cookies ranged between 55.08 to 61.07 mm, with the highest value observed in the S_4 formulation (40% GHF:60% RWF), which was significantly ($p < 0.05$) higher than that of the control cookies (100% RWF). Similarly, cookie thickness varied from 5.75 to 6.03 mm, with S_4 also reflecting the maximum thickness (6.03 mm). The results revealed a noticeable increase in both diameter and thickness as the proportion of GHF increased in the blend.

Table 2. Physical characteristics of cookies

Sample	Diameter (mm)	Thickness (mm)	Spread ratio	Weight (g)
RWF	$58.90{\pm}0.03^{b}$	$6.02{\pm}0.01^{c}$	$9.64{\pm}0.04^{c}$	$10.45{\pm}0.01^{b}$
GHF	$55.08{\pm}0.01^{a}$	$5.75{\pm}0.03^{b}$	$9.57{\pm}0.02^{b}$	$10.55{\pm}0.02^{c}$
S_1	$55.10{\pm}0.02^{a}$	$5.83{\pm}0.02^{a}$	$9.45{\pm}0.03^{a}$	$11.39{\pm}0.01^{e}$
S_2	$55.21{\pm}0.03^{a}$	$5.83{\pm}0.01^{a}$	$9.46{\pm}0.01^{a}$	$10.27{\pm}0.01^{a}$
S_3	$60.25{\pm}0.01^{c}$	$6.01{\pm}0.01^{c}$	$10.02{\pm}0.02^{d}$	$11.01{\pm}0.02^{d}$
S_4	$61.07{\pm}0.01^{d}$	$6.03{\pm}0.01^{c}$	$10.12{\pm}0.02^{e}$	$11.00{\pm}0.02^{d}$

Results are presented as mean ± SD (n=3).
Different superscripts within the same column denote significant differences (p < 0.05).
S_1 = 10 GHF:90 RWF; S_2 = 20 GHF:80 RWF; S_3 = 30 GHF:70 RWF; S_2 = 40 GHF:60 RF

According to Narwal et al. (2024), factors such as flour particle size, protein content, and functional properties like water and oil absorption capacities significantly influence the physical dimensions of cookies. The weight of the cookies ranged between 10.27 and 11.39 grams, with the highest weight recorded for S_1 cookies and the lowest for S_2 cookies. The spread ratio (SR), an important indicator of cookie quality, varied from 9.45 to 10.12 across the samples. Cookies made 10% GHF (S_1) exhibited the lowest spread ratio, whereas those prepared with a 40% GHF:60% RWF blend (S_4) showed the highest values. Differences in spread ratio were primarily linked to variations in cookie diameter and thickness, which are themselves affected by factors like protein concentration and the extent of starch damage.

3.3 Color parameters of cookies

Table 3 presents the color parameters of cookies prepared from RWF, GHF, and their various blends. The color attributes are influenced by factors such as testa pigmentation, protein levels, flavonoids, and other pigments.

Table 3. Color parameters of cookies

Sample	L*	a*	b*
RWF	$65.86{\pm}0.03^{f}$	$5.73{\pm}0.01^{a}$	$20.59{\pm}0.04^{f}$
GHF	$61.85{\pm}0.01^{a}$	$7.15{\pm}0.03^{d}$	$25.00{\pm}0.02^{e}$
S_1	$64.45{\pm}0.02^{e}$	$6.83{\pm}0.02^{c}$	$23.97{\pm}0.03^{b}$
S_2	$64.23{\pm}0.03^{d}$	$6.83{\pm}0.01^{c}$	$24.09{\pm}0.01^{d}$
S_3	$63.26{\pm}0.01^{c}$	$6.28{\pm}0.01^{b}$	$24.05{\pm}0.02^{c}$
S_4	$63.00{\pm}0.01^{b}$	$7.70{\pm}0.01^{e}$	$25.11{\pm}0.02^{a}$

Results are presented as mean ± SD (n=3).
Different superscripts within the same column denote significant differences (p < 0.05).
S_1 = 10 GHF:90 RWF; S_2 = 20 GHF:80 RWF; S_3 = 30 GHF:70 RWF; S_2 = 40 GHF:60 RF

The lightness value (L*) among the samples ranged from 61.85 to 65.86, with a significant difference ($p < 0.05$) noted between GHF and RWF. The L* value tends to be affected by the protein content and shows a negative correlation with the ash content in the flour. GHF appeared darker than RWF, likely due to pigments present in the seed coat. Among the blends, blend S_1 (containing 10% GHF) exhibited the highest L* value (64.45), indicating a lighter shade compared to the other blends (S_2, S_3, S_4). The redness parameter (+a*) for GHF, RWF, and blends varied between 5.73 and 7.70, with the blends showing statistically significant differences ($p < 0.05$) compared to RWF. The yellowness (+b*) values ranged from 20.59 to 25.11, with the lowest value observed for control cookies (100% RWF) and the highest for S_4 cookies. An increasing trend in both +a* and +b* values was observed with higher proportions of GHF in the blends, while L* values decreased correspondingly as the GHF content increased.

3.4 Sensorial properties of cookies

The sensory characteristics play a vital role in determining a product's overall quality, as they are often the first attributes noticed by consumers and greatly influence their preference. Cookies made from various blends of RWF and GHF were assessed for sensory attributes including appearance, color, texture, taste, and overall acceptability (Figure 3).

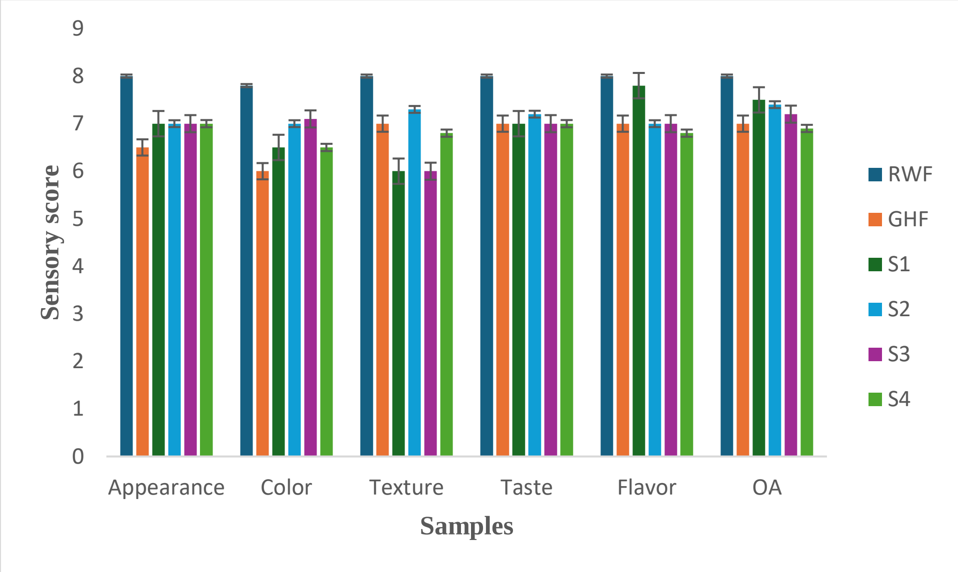

Figure 3. Sensory scores of cookies prepared from RWF, GHF, and GHF-RWF blends

Incorporation of GHF had a significant negative effect ($p < 0.05$) on the sensory qualities of these cookies, leading to lower ratings for all evaluated parameters compared to the control (100% RWF) cookies. This outcome aligns with the findings of Levent et al. (2017), who also observed reduced sensory scores in gluten-free noodles when chia flour was added. Appearance scores ranged from 6.5 to 8, with the highest rating given to control cookies (100% RWF) and the lowest to cookies of 100% GHF. The darker color imparted by GHF contributed to the lower appearance scores. Taste evaluations varied between 7 and 8.00, with highest rating given to control cookies RWF and the lowest and S_4 the lowest. The inclusion of GHF also negatively influenced texture, flavor, and overall acceptability. Similar trends were reported by Narwal and Yadav (2022), who noted decreased sensory scores for GHF fortified noodles. The overall acceptability score was lowest for S_4 cookies (6.90), while S_1 cookies achieved the highest score among the blends (7.57), after the control (8.0).

IV.Conclusion

The fortification of germinated horse gram flour into cookies significantly enhanced the nutritional and functional qualities of the product, particularly in terms of water and oil absorption capacities. The S_4 blend (40% GHF) demonstrated superior physicochemical and physical characteristics; however, sensory acceptability declined at higher substitution levels due to changes in color, flavor, and texture. Among all formulations, the S_1 cookies (10% GHF) offered the most favorable balance between nutritional improvement and sensory quality, closely followed by S_2 (20% GHF). Therefore, up to 20% substitution of RWF with GHF is recommended for producing nutritionally enriched cookies with acceptable sensory characteristics. This research supports the use of germinated horse gram as a valuable functional ingredient in developing health-oriented bakery products.

References

[1]. Bravo L, Siddhuraju P, and Saura-Calixto F, Composition of underexploited Indian pulses. Comparison with common legumes. *Food chemistry* 1999; 64(2):185-192.

[2]. Deshpande, S. S., Sathe, S. K., Salunkhe, D. K., & Cornforth, D. P. (1982). Effects of dehulling on phytic acid, polyphenols, and enzyme inhibitors of dry beans (Phaseolus vulgaris L.). *Journal of Food Science*, *47*(6), 1846-1850.

[3]. Kadam, S. S., Salunkhe, D. K., & Maga, J. A. (1985). Nutritional composition, processing, and utilization of horse gram and moth bean. *Critical Reviews in Food Science & Nutrition*, *22*(1), 1-26.

[4]. Levent, H. (2017). Effect of partial substitution of gluten-free flour mixtures with chia (Salvia hispanica L.) flour on quality of gluten-free noodles. *Journal of food science and technology*, *54*, 1971-1978.

[5]. Moktan, K., & Ojha, P. (2016). Quality evaluation of physical properties, antinutritional factors, and antioxidant activity of bread fortified with germinated horse gram (Dolichus uniflorus) flour. *Food science & nutrition*, *4*(5), 766-771.

[6]. Narwal, J., & Yadav, R. (2022). Development and quality evaluation of noodles supplemented with germinated horse gram flour. *Current Research in Nutrition and Food Science*, *10*(1), 276.

[7]. Narwal, J., Yadav, R. B., & Yadav, B. S. (2024). Characterization of selected wheat (Triticum aestivum) cultivars for their physicochemical and cookies making quality characteristics. *Cereal Research Communications*, *52*(2), 789-801.

[8]. Parmar, N., Singh, N., Kaur, A., & Thakur, S. (2017). Comparison of color, anti-nutritional factors, minerals, phenolic profile and protein digestibility between hard-to-cook and easy-to-cook grains from different kidney bean (Phaseolus vulgaris) accessions. *Journal of Food Science and Technology*, *54*, 1023-1034.

[9]. Sosulski, F., Humbert, E. S., Bui, K., & Jones, J. D. (1976). Functional properties of rapeseed flour, concentrates and isolate. *Journal of Food science*, *41*(6), 1349-1352.

[10]. Subagio, A. (2006). Characterization of hyacinth bean (Lablab purpureus (L.) sweet) seeds from Indonesia and their protein isolate. *Food chemistry*, *95*(1), 65-70.