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Nutritional Characteristics of Horsegram *(Macrotyloma uniflorum)* and its Value-Added Food Products: A Review

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Abstract

Horsegram (*Macrotyloma uniflorum)* belongs to the family fabaceae. It is an underutilized drought tolerant crops which can combat natural calamity and play a significant role in global nutritional management making it a potential food source for the future. The grain can be consumed in different ways; as ready-to-eat food products or as different snacks along with fortification with other millets, pulses, or vegetables. As a result, consumers can choose the many value-added horsegram products as a healthier alternative to other grains on the market. The nutritional benefits of the value-added products that may be made from horsegram have been explored in this review study in order to assist the nutritional need of the global population and combat malnutruition.

Keywords: Horsegram, nutrition, value-added products, underutilized crops, therapeutic

Introduction

Taxonomical Classification and vernacular names of the *Macrotyloma uniflorum*

Kingdom	Order	Family	Genus	Species
•Plantae	•Fabales	•Fabaceae	•*Macrotyloma*	•*uniflorum*

Macrotyloma uniflorum is commonly known as horsegram (English), Dolico cavallino (Italian), Faveira (Portuguese), Dolic biflore (French), Frojol verde (Spanish), Kerderkorn (German), Gahot (Uttarakhand), Kulattha (Sanskrit), Kollu (Tamil), Kurti-kalai (Bengali), Muthira (Malyalam), Ullavallu (Telgu), Kolatha (Oriya) (Agnihotri & Rana, 2021)

Morphological description, distribution, and production

Horsegram (Figure 1(a), (b) and (c)) is a short day and day-neutral plant, maturing 120-180 days after planting which requires an annual temperature starting from 18-27°C and low to moderate annual rainfall of 200 to 1000mm. The crop can be grown in a wide range of soil i.e., from black cotton soil,

deep red loam, to clay loam paddy soils. Although it is drought tolerant crop, does not tolerate flooding or waterlogging. The crop has a high nitrogen fixation ability and also helps in soil conservation (Prasad & Singh, 2015).

It is grown as food, forage, and green manure crop in temperate and sub-tropical regions of the world including the countries such as Angola, Ethiopia, Kenya, Namibia, Somalia, South Africa, Tanzania, India, China, Nepal, Taiwan, Philippines, Bhutan, Pakistan, Sri Lanka, and Australia (A Bhartiya et al., 2015; Ranasinghe & Ediriweera, 2017; Siddhuraju & Manian, 2007; Sreerama et al., 2012). In India, it is most extensively grown from the Himalayan region in the North to Tamil Nadu in the South and Gujarat in West to Bengal in the East, with the maximum area being in Andhra Pradesh, Karnataka, and Tamil Nadu (Anuradha Bhartiya et al., 2014; Patil & Kasturiba, 2018).

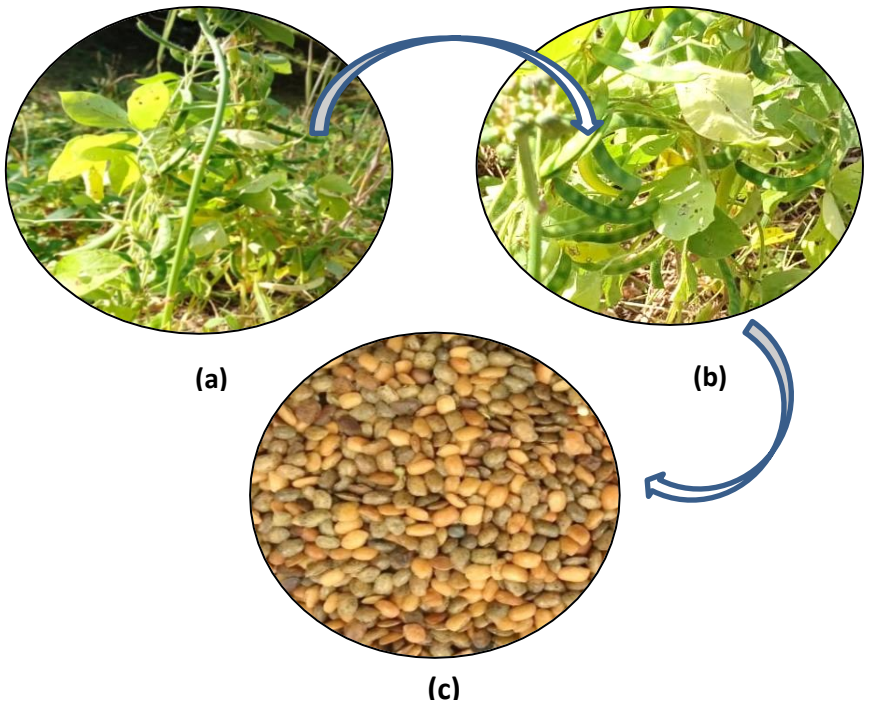

Figure 1 (a) Horsegram (*Macrotyloma uniflorum)* plant (b) Pods of Horsegram (c) Raw seeds of Horsegram

In India, horsegram cultivation occurs in around 3.25 lakh hectares and during 2016-17, 1.16 lakh tons production of horsegram was reported (https://www.indiastat.com/, n.d.), where Uttarakhand state had contributed about 10.45 thousand tons from 12.78 thousand hectare cultivation area. The average productivity of horsegram in Uttarakhand (8.17 q/ha) is significantly higher than the yield level in major growing states suggesting better suitability of horsegram to the agro-ecosystem of this region and a vast potential exists for enhancing the area and production of horsegram in Uttarakhand hill (Anuradha Bhartiya et al., 2014). The district-wise production details of horsegram in Uttarakhand are represented in Figure 2.

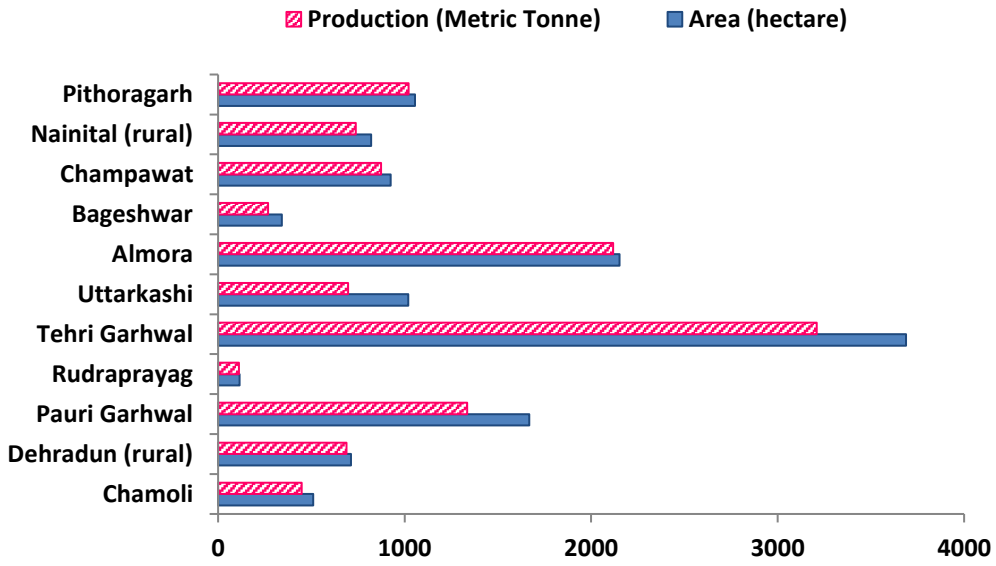

Fig.2 Production details of horsegram in Uttarakhand (2018-19)
Source: https://agriculture.uk.gov.in, n.d.

Nutritional properties of Horsegram

Horsegram being highly nutritive is not only used as food but can also be used as fodder for cattle and horses (Marimuthu & Krishnamoorthi, 2013; J B Morris, 2008). Its nutritional value is superior in every way to that of other widely produced cereal crops (Agnihotri & Rana, 2021). Horsegram seeds can be consumed as a whole seed or as well as in dehulled form. It contains 28.8% total dietary fibres, mainly 27.82% insoluble dietary fibre (IDF) and 1.13% soluble dietary fibre (SDF) whereas its flour contains 16.3% total dietary fibre (14.9% insoluble and 1.4% soluble and 2.2% resistant starch). The insoluble dietary fiber is essential for normal functioning lower intestinal in humans. The horsegram seeds are a good source of protein and contain approximately 21.73% of protein. The dehulled seeds exhibit higher protein content (18.4–25.5%) than the whole (17.9–25.3%) (Bravo et al., 1999; Sudha et al., 1995). The fat content of horsegram seeds ranges from 0.6–2.6%. The whole horsegram seeds (0.70–2.06%) seeds contain lower crude fat content than dehulled (0.81–2.11%) seeds. They are also a good source of essential fatty acids and contain 27.5% saturated fatty acids (i.e. 21.97% palmitic, 2.85% arachidic, 2.32% stearic acid, and 0.36% myristic) and 72.49% unsaturated fatty acids (i.e. 42.78% linoleic, 16.15% oleic and 13.56% linolenic acid) (Mishra & Pathan, 2011; Sudha et al., 1995).

Carbohydrate content varied in both forms; whole seed contains 51.9-60.9% while dehulled seed contains 56.8-66.4% carbohydrate. The raw horsegram seeds contains 36±1.17g starch per 100g dry matter wherein about 85% is digestible starch, 14.47% is resistant starch whereas 3.38% is resistant starch which is associated with insoluble dietary fibers (Bravo et al., 1999; Sudha et al., 1995). The main amino acid found in horsegram seed are leucine, arginine, valine, lysine, histidine, etc. followed by methionine and tryptophan in limited quantity (Thirumaran & Kanchana, 2000). The mineral content in horsegram, micro minerals (Fe, Ni, Cu, Zn, and Mn), macro minerals (Mg, S, P, K, and Ca) ranges from 1.0–95.0 µg and 1.3–14 mg per gram dry weight respectively. It is a rich source of calcium and iron content ranging from 244-312 mg with the value of 238 and 223 mg/100g of calcium in whole seed and dehulled seed respectively. Horsegram contains several antinutritional factors that reduce the

bioavailability of nutrients. Its flour contains trypsin inhibitor activity (9246±18 TIU/g), phytic acid (10.2±0.4mg/g), oligosaccharides (26.8mg/g) and polyphenols (14.3±0.4mgGA/g) (John Bradley Morris et al., 2013; Sreerama et al., 2012). It also contains phytochemicals, such as anthocyanins (Cyanidin, Delphinidin, Malvidin, Petunidin), phenolics (Gallic acid, Protocatechuic acid, 4 Hydroxybenzoic acid, 3,4 dihydroxy benzoic acid, Syringic acid, Vanillic acid, Caffeic acid, p-Coumaric acid, Ferulic acid, Sinapic acid) and flavonoids (Daidzein, Genistein, Kaempferol, Myricetin, Quercitine) which serve as a good source of natural antioxidants (Ranasinghe & Ediriweera, 2017).

Therapeutic attributes of Horsegram

The consumption of sprouted horsegram seeds has steadily increased in popularity due to its outstanding ability to lower the risk of certain diseases and exert health-promoting effects, in addition to its nutritional content (Pasko et al., 2009). As per Charak Samhita, the seeds of *Macrotyloma uniflorum* are helpful to cure piles, hiccup, abdominal lump, respiratory disorder, and in regulating perspiration. Within the Sushruta Samhita, it's mentioned that the seed powder is beneficial in stopping excessive perspiration. Horsegram seeds additionally as extracts has glorious hypolipidaemic, hypoglycaemic (Senthil, 2009), therapeutic properties and traditionally used to cure kidney stones, piles, urinary troubles, acid peptic disorder (gastritis), constipation, heat-stroke, rheumatoid arthritis, bleeding disorder, intestinal worms, bronchitis, leucoderma, asthma, inflamed joints, perspiration therapy, fever, musculoskeletal disorder, breast milk purifier, sinus wounds, tumours, pathology, localized gastric tumour and various feminine problems such as leucorrhoea, menstrual troubles, hemorrhage throughout maternity, post-partum excessive discharges (Thirumaran & Kanchana, 2000).

Besides, it conjointly possesses high tolerance against salinity, drought, and heavy metals. Horsegram species possess different medicinal properties like anti-diabetic, antiulcer, antimicrobial, antioxidant activity. It also helps in the dietary management of obesity because of the presence of helpful bioactive compounds. It is advised for those who have jaundice, iron deficiency, water retention, as part of a diet to lose weight, and is also helpful for maintaining body temperature in the cold (Ramesh et al., 2011). Horsegram seeds contain linoleic acid, which makes them useful for treating diabetes and cardiovascular diseases. Horsegram lipids have anti-ulcer activity because of the presence of phytosterol organic compounds that imparts protecting and healing impact on acute gastric ulceration produced by alcohol (Mishra & Pathan, 2011; Sudha et al., 1995). Furthermore, extract of the legume seeds with spices is taken into account to be a possible remedy for the respiratory illness, sore throat, fever and also the soup said to come up with produce heat (Thirumaran & Kanchana, 2000) and horsegram powder or liquid act as a medicament to remove mucus from the body (Agnihotri & Rana, 2021; Siddhuraju & Manian, 2007).

Value Added food Products of Horsegram

With time various products from horsegram has been prepared with wider food application in food industries consumed in the form of bread, cookies, noodles, nachos, instant dosa mix and ladoo etc. The food products are made with the combination of wheat flour and other legumes flour with horsegram flour to enhance the sensory profile.

1. **Bread:** Mokhtan and Ojha 2016 prepared bread fortified with germinated horsegram flour and evaluated it for its physical, nutritional, antinutritional properties and antioxidant activities (Table 1).

The bread was formulated in different ratios i.e. 100:0, 98:2, 96:4, 94:6, and 92:8 of wheat flour and germinated horsegram flour. As a result of sensory evaluation, the bread with 6 % GHF was most acceptable; therefore this ratio was further used to evaluate the other nutritional parameters. The bread with 6% GHF was also reported to enhance protein, fat and fibre content, polyphenol content and antioxidant properties and mineral like calcium and iron content (Moktan & Ojha, 2016).

2. **Cookies:** Kukade 2017 conducted research to create and evaluate the organoleptic and microbiological quality of composite flour cookies with guar gum. For making cookies, different ratios of horsegram and pearl millet flour were used in place of wheat flour, i.e. Horsegram: Pearl millet was used for T_0 (100:0:0), T_1 50:30:20 and 0.1% guar gum, T_2 50:30:20 and 0.2% guar gum, T_3 50:30:20 and 0.3% guar gum, T_4 50:30:20 and 0.4% guar gum respectively. As a result of sensory evaluation sample T_3 was found organoleptically superior over other samples as well as these cookies were found to be most acceptable with good microbial quality. Through the nutritional assessment its can be evaluated that these cookies are highly nutritious and horsegram, pearl millet is an effective substitute for refined wheat flour for bakery products (Kukade et al., 2017) (Table 1).
Ghumre 2019 prepared cookies with the incorporation of horsegram flour in different percentages i.e. 0, 10, 15, 20, 25 %. Among all, the cookie with 20% of horsegram flour was found to be organoleptically superior with a score of 4.8 over other cookies which were further analyzed for their nutritional parameters (Ghumre, 2019). The result reveals that the value-added cookies are more nutritious than the basic cookies and are rich source of protein, carbohydrate, fat, fibre, calcium, iron, zinc, copper, manganese (Table 1).
Ishwarya 2019, prepared cookies with the incorporation of refined wheat flour and germinated horsegram flour (GHF) in different ratio i.e. 100:0, 80:20, and 70:30. In sensory evaluation, the cookies with 20% GHF were found to be superior to other samples (Ishwarya & Swarnalatha, 2020). The nutritive value of the developed products was evaluated, it contains good quality of nutrients such as carbohydrate, fat, protein, fiber and calcium, and iron (Table 1).

3. **Malt Powder:** An experiment was conducted to determine the sensory characteristics, nutrient composition, and shelf life quality of protein-rich malt powder made from soya bean, cowpea, horsegram, samai, Italian millet, jowar, ragi, bajra, almonds, cashew nuts, and cardamom. The nutritional composition of the malt powder shows that it is highly nutritious containing a good amount of protein, carbohydrate, fat, fibre, and minerals like iron and calcium (Table 1). From the above study, it is evident that unconventional legumes like soy beans, horse gram, and cowpea can be effectively used in the preparation of protein rich malt powder by properly processing legumes and optimizing the levels of other ingredients in appropriate proportions (Reddy & Sree, 2018).

4. **Kaulath (a fermented food):** Dwivedi 2015 developed a new fungal fermented food i.e. Kaulath from horsegram using *Penicillium camemberti*. The nutritional analysis of Kaulath showed the reduction in antinutrients such as trypsin inhibitor and phytic acid whereas it is reported to be a rich source of protein, carbohydrate, fat content and minerals such as calcium, iron, zinc, potassium, phosphorus, copper and manganese (Dwivedi et al., 2015) (Table 1).

5. **Horsegram Adai:** Ishwarya 2019 carried out a study to assess the nutritional and sensory evaluation of developed horsegram adai. The roasted horse gram flour (RHF) was replaced with ragi flour to develop Adai. In sensory evaluation, the adai with 60% RHF was found to be superior to other samples (Ishwarya & Swarnalatha, 2020). The nutritional analysis of the developed product shows higher content of carbohydrate, protein, fat, fibre, and minerals such as iron and calcium (Table 1).

6. **Noodles:** Thilagavathi 2015 prepared noodles from composite flour of whole wheat flour, modified millet flour (kodo millet, pearl millet), and pulse flour (horse gram and soybean). These noodles were analyzed for their rheological, cooking, nutritional and organoleptic characteristics. The incorporation of millet and pulse flour increased the cooking characteristics such as cooked volume, water uptake, cooked weight and decreased gruel loss. The protein, fat, fibre, calcium, phosphorous, iron, copper, and zinc content of the millet and pulse incorporated noodles were increased whereas carbohydrate, starch, amylose contents were decreased than the whole wheat flour noodles (Thilagavathi et al., 2015) (Table 1).

7. **Horse gram enriched ready to eat product (nachos):** Kawale 2020 took an initiative for the exploration of horse gram lead to the development of cost-effective product (nacho). The ingredients used for preparing nachos were horse gram, corn flour, wheat flour, rice flour, cumin, black pepper, red chilli powder, and zero trans-fat sunflower oil (Kawale et al., 2020). The product comes out with excellent nutritional properties having more protein, carbohydrate, fat, fibre, calcium and iron content (Table 1).

8. **Ready to Cook Idly Mix:** A study on the creation, evaluation, and standardisation of a ready-to-cook horsegram idly mix powder was carried out by Sudarsan and Santhanam in 2017. The idly mix was prepared using the combination of rice, black gram dhal, horsegram in four different compositions (75:25:0, 50:25:20, 40:25:30, and 40:25:35). The formulated product with 30 % horsegram gained a higher score than the other two formulations in organoleptic evaluation hence is used for carrying out further analysis. The study indicates that horse gram idly mix powder is rich in protein, fibre, calcium, iron, vitamin-C, antioxidant, and phytochemicals (Sudarsan & Santhanam, 2017) (Table 1).

9. **Biscuits:** Ghumre 2019, prepared salty biscuits with the incorporation of horsegram flour in different percentages i.e. 0, 10, 15, 20, 25%. Based on sensory evaluation the 20% of horsegram flour incorporated biscuits are highly acceptable with a score (5.0) (Ghumre, 2019). The same sample was further analyzed for their nutritional parameters. The result reveals that the incorporation of horsegram flour enhances the nutritional value of biscuits with an excellent source of protein, carbohydrate, fat, fibre and minerals calcium, iron, zinc, copper and manganese (Table 1).
   The horsegram based biscuit was prepared by Jain 2012 with horsegram flour and wheat flour used in the proportion of 50:50. The prepared biscuits were assessed their physicochemical and, nutritional properties. Biscuits provided 369 kcal energy, 74.83 % carbohydrate, and 13.37 % protein with an overall acceptability score of 7.5 based on sensory evaluation (Jain et al., 2012) (Table 1).

10. **Mathri:** Another horsegram based product prepared by Jain 2012 was mathri with horsegram flour and wheat flour in the ratio of 50:50. The prepared mathri i.e. a deep-fried snack product, was further analyzed for their physicochemical and, nutritional properties. The nutritional analysis provided 554 kcal energy, 75.53 % carbohydrate, 21.87% fat, and 13.48 % protein with an overall acceptability score of 7.6 based on sensory evaluation (Jain et al., 2012) (Table 1).

11. **Kasar:** The horsegram based kasar prepared by Jain 2012 were assessed for their physicochemical and, nutritional properties. The product was prepared using horsegram flour and wheat flour in the proportion of 30:20 with ghee and sugar as other major ingredients. Through sensory evaluation, it obtained an overall acceptability score of 7.70. Kasar is highly enriched with 6.95% protein and 20.88% fat content (Jain et al., 2012) (Table 1).

12. **Laddoo:** Joshi and Dubey 2018 carried out a study to determine the "utilization of Horse Gram in the preparation of laddoo". The product was prepared by the incorporation of gram flour and horsegram in different compositions (100:0, 90:10, 80:20, and 70:30). As a result of sensory evaluation, the laddoo prepared by the incorporation of gram flour and horsegram in the ratio of 80:20 was found most acceptable. Nutritionally, it was found that the nutrients content of laddoo (prepared by 80:20 composition) was significantly higher in terms of protein, fibre, energy, calcium, iron, phosphorus, carbohydrate, and fat content as compared to the control (100:0 ratio) (Joshi & Dubey, 2018) (Table 1).

    The horsegram based laddoo was also prepared by Jain 2012 and was further assessed for their physicochemical and, nutritional properties. For the preparation of laddoo horsegram flour and wheat flour were used in the proportion of 30:20 with ghee and sugar as other major ingredients. The overall acceptability score of ladoo was 7.40 as evaluated through the sensory test. The nutritional analysis provided 957 kcal energy, 72.14 % carbohydrate, 41.75% fat, and 13.60 % protein (Jain et al., 2012) (Table 1).

    Yuvrani and Anitha (2016) create the multigrain ladoo, a new traditional healthy product, in order to assess consumer acceptance as well as the product's nutritional value and antioxidant content. The main ingredients used for the study were finger millet, foxtail millet, wheat flour, sprouted horse gram, sprouted green gram, jaggery, and ghee and cardamom powder. With an overall acceptance score of 9, consumers found the product to be very favourable (Yuvarani & Anitha, 2016). The product multigrain ladoo has a very high nutritious content, particularly in terms of proteins, carbohydrates, fat, calcium, iron, and phosphorus. It also has good antioxidant potential (Table 1).

13. **Instant Dosa-Mix:** Haripriya and Lidiya 2017 formulated horse gram based instant dosa mix. The study focuses on the effect of processing steps such as germination and autoclaving process used during preparation of dosa-mix in nutritional and antinutritional parameters. The pre-treated horsegram dosa mix showed an excellent nutritional profile with a rise in carbohydrate, protein, and calcium content; however, the processing processes caused a decrease in the iron content and antinutrients (Table 1). On the basis of sensory evaluation, the overall acceptability score of germinated horse gram dosa mix (3.86) was found to be high for all parameters followed by germinated and autoclaved horse gram dosa mix (3.4) and untreated horse gram dosa mix (2.93) (Haripriya & Lidiya, 2017).

14. **Shakkarpara:** Ghumre 2019, prepared shakkarpara with the incorporation of refined wheat flour and horsegram in different ratio i.e. 60:0, 50:10, 45:15, 40:20, and 35:25. On the basis of sensory evaluation shakkarpara prepared with 15% of horsegram flour ranked higher with a score (4.6). The sample prepared with 15% of horsegram flour was further analyzed for their nutritional parameters (Ghumre, 2019). The nutritional analysis reveals that the incorporation of horsegram flour enhances the nutritional value of shakkarpara with a high amount of protein, fibre, calcium, and iron (Table 1).

15. **Kharapara:** Ghumre 2019, prepared kharapara with the incorporation of refined wheat flour and horsegram in different ratio i.e. 60:0, 50:10, 45:15, 40:20, and 35:25. Organoleptically kharapara prepared with 15% of horsegram flour ranked higher among other samples with an overall acceptability score (4.6). The sample prepared with 15% of horsegram flour was further analyzed for their nutritional parameters (Ghumre, 2019). The nutritional analysis reveals that value addition with horsegram flour enhances the nutritional value of kharapara with a rich source of protein, fat fibre, calcium, iron and zinc (Table 1).

16. **Semolina Burfi:** Semolina burfi, a sweet dish was prepared by Ghumre 2019, with the incorporation of refined wheat flour and horsegram in different ratio i.e. 60:0, 50:10, 45:15, 40:20, and 35:25. The product prepared with 20% of horsegram flour proved to be better in terms of sensory evaluation with an overall acceptability score (4.6). On the basis of the results of nutritional analysis, it has been concluded that there was an increase in the nutrient content in value-added semolina burfi when compared to the control sample. The study indicates that semolina burfi is rich in protein, carbohydrate, fat, fibre, calcium, iron, zinc, manganese, and copper(Ghumre, 2019) (Table 1).

17. **Roti:** Thirukkumar and Sindhumathi 2014 prepared chapati/roti with the incorporation of wheat flour along with the processed horsegram flour (soaked, dried; and roasted) in different ratio (100:0, 95:5, 90:10, 85:15, 80:20). The products were studied for their sensory and nutritional evaluation. Their research findings indicated that among the various compositions, the soaked and dried horsegram floor processed chapati with the ratio of 90:10 was highly acceptable with a score of 8.7 whereas roasted horsegram floor processed chapati with the ration 85:15 were highly acceptable after organoleptic evaluation with a score 8.8 (Thirukkumar & Sindumathi, 2014). As a result of the nutritional analysis of processed horsegram flour, it has been evaluated that processing reduces antinutrient content whereas no such changes were observed in protein, calcium, iron, and phosphorus (Table 1). The study also indicates that as horse gram flour is rich in protein, calcium, and dietary fibre thus processed horse gram flour could be used in the preparation of various food products.

    Ghumre and Arya 2020 analyzed sensory and nutritional parameters of roti prepared by incorporating horsegram flour along with jowar flour in different compositions i.e. 0:100, 10:90, 15:85, 20:80, and 25:75. Through sensory evaluation, it was noticed that the sample prepared with 20% of horsegram flour ranked higher among other samples with an overall acceptability score (4.8) (Ghumre & Arya, 2020). The nutritional analysis reveals that the increase in the nutrient content was significant in value-added product flour enhances the nutritional value of roti. The value addition results increase in protein, fibre, calcium, iron, and copper whereas a reduction in fat and carbohydrate content (Table 1).

18. Paratha: Thirukkumar and Gurumeenakshi 2015 studied the effect of utilization of horse gram flour by simple processing methods for the preparation of Chappathi. The wheat flour was incorporated with processed horse gram flour (soaked, dried; and roasted) to standardize chappathi mix in different compositions (100:0, 95:5, 90:10, 85:15, 80:20), the soaked and dried horsegram floor processed chapati with the ratio of 90:10 was highly acceptable with a score 8.7 whereas roasted horsegram floor processed chapati with the ratio 85:15 had received highly acceptable score 8.8 after organoleptic evaluation (Thirukkumar & Gurumeenakshi, 2015) (Table 1).

Ghumre and Arya 2020 analyzed sensory and nutritional parameters of chapati prepared by incorporating horsegram flour along with wheat flour in different compositions i.e. 0:100, 10:90, 15:85, 20:80, and 25:75. Through sensory evaluation, it was noticed that the sample prepared with 20% of horsegram flour is highly acceptable with a score (4.6) (Ghumre & Arya, 2020). The value-added products reveals that the value added products are highly nutritious being a rich source of calcium, iron, copper, and manganese, and other proximate nutrients would be a better source of nutrients than basic one (Table 1).

Table 1: Nutritional profiling of horsegram based food products

S.No.	Name of the Product		Protein (%)	Carbohydrate (%)	Fat (%)	Fibre (%)	Moisture (%)	Ash (%)	Calcium (mg $100g^{-1}$)	Iron (mg $100g^{-1}$)	Zinc (mg $100g^{-1}$)	Phosphorus (mg $100g^{-1}$)	Copper (mg $100g^{-1}$)	Manganese (mg g^{-1})	Phytic Acid (mg g^{-1})	Tannin (µg $100g^{-1}$)	Reference
1.	Chappathi /Roti	Soaked and dried	15.20	-	-	-	11.30	3.10	230	14.20	-	312	-	-	4.38	1.49	
		Roasted	20.60	-	-	-	6.40	3.40	234	15.60	-	318	-	-	10.30	8.38	(Thirukkumar & Sindumathi, 2014)
		Normal (without Processing)	12.25	74.06	1.69	1.91	8.2	-	60	4.4	1.21	-	0.46	0.92	-	-	(Ghumre & Arya, 2020)
2.	Kaulath (fermented food)		19.6	73.4	2.9	-	36.05	4.1	107.2	6.11	2.43	261	0.77	1.85	0.104	0.026	(Dwivedi et al., 2015)
3.	Malt Powder		16.25	50.83	8.46	4.6	-	-	102.02	6.677	-	-	-	-	-	-	(Reddy & Sree, 2018)
4.	Bread fortified with germinated horsegram flour		9.8	-	3.74	1.23	-	1.36	128	4.07	-	-	-	-	2.46	2.06	(Moktan & Ojha, 2016)

5.	Cookies	15.28	52.65	22.74	2.51	4.32	2.50	-	-	-	-	-	-	-	-	(Kukade et al., 2017)
		9.8	62.16	17.01	1.26	7.06	-	82.16	2.3	0.8	-	2.16	0.69	-	-	(Ghumre, 2019)
		12.50	62.02	22.34	8.53	-	-	2.44	4.67	-	-	-	-	-	-	(Ishwarya & Swarnalatha, 2020)
6.	Adai	10.79	60.16	19.51	4.38	-	-	1.47	5.57	-	-	-	-	-	-	(Ishwarya & Swarnalatha, 2020)
7.	Horsegram incorporated ready to cook Idly Mix	18			6.5	7	3.4	290	8	-	355	-	-	-	-	(Sudarsan & Santhanam, 2017)
8.	Noodles	17.61	53.20	1.07	4.93	6.73	2.86	180.65	6.65	5.85	347.17	2.38	-	-	-	(Thilagavathi et al., 2015)
9.	Kharapara	10.92	66.48	12.47	2.33	6.4	-	189.5	3.65	1.35	-	0.64	0.85	-	-	(Ghumre, 2019)
10.	Shakkarpara	8.39	73.14	10.33	1.05	5.66	-	61.33	2.51	0.72	-	0.65	0.79	-	-	(Ghumre, 2019)

11.	Semolina Burfi		11.37	68.32	9.01	1.23	8.46	-	216.16	2.33	0.62	-	0.70	0.42	-	-	(Ghumre, 2019)
12.	Instant dosa mix	Untreated	12.12	31.33	-	3.09	3.98	-	123	2.5	-	-	-	-	1.40	-	(Haripriya & Lidiya, 2017)
		Germinated	12.12	39.11	-	3.12	3.11	-	135	1.2	-	-	-	-	1.10	-	
		Germinated and autoclaved	15.33	39.12	-	3.12	4.12	-	146	1.8	-	-	-	-	0.80	-	
13.	Chapati	Normal (without Processing)	10.5	74.67	1.07	2.21	8.8	-	97	5.09	1.38	-	0.44	0.8	-	-	(Ghumre & Arya, 2020)
		Soaked and dried horsegram flour	12.41	69.92	2.03	2.24	-	2.65	66.20	5.83	-	350.70	-	-	-	-	(Thirukkumar & Gurumeenakshi, 2015)
		Roasted horsegram flour	13.37	69.36	1.51	2.41	-	2.72	75	6.50	-	349.45	-	-	-	-	(Thirukkumar & Gurumeenakshi, 2015)
14.	Salty Biscuits		10.23	62.85	16.17	1.83	7.06	-	134	2.63	1.05	-	0.48	0.61	-	-	(Ghumre, 2019)

			13.37	74.83	41.76	2.72	-	1.92	-	5.9	-	-	-	-	-	-	(Jain et al., 2012)
15	Laddoo	Plain	22.40	57.92	34.2	1.86	-	-	103.8	8.95	-	334.2	-	-	-	-	(Joshi & Dubey, 2018)
			13.6	72.14	41.75	3.52	-	2.89	-	7.03	-	-	-	-	-	-	(Jain et al., 2012)
		Multigrain	9.22	73.17	6.56	-	8.82	-	14.8	4.21	1.72	885	0.3	3.51	-	-	(Yuvarani & Anitha, 2016)
16	Kasar		6.95	36.34	20.88	1.92	-	1.46	-	3.72	-	-	-	-	-	-	(Jain et al., 2012)
17	Mathri		13.48	75.53	21.87	3.50	-	2.07	-	6.24	-	-	-	-	-	-	(Jain et al., 2012)
18	Chutney Powder	Dry Roasted	20.98	50.21	-	7.6	3.12	-	288.5	5.9	-	-	-	-	-	-	
		Germinated	26.78	44.56	-	4.98	3.22	-	291.5	6.0	-	-	-	-	-	-	(Haripriya & Lidiya, 2017)

		Germinated and Autoclaved	26.78	39.11	-	5.11	2.25	-	296	5.95	-	-	-	-	-	-	
19	Horsegram enriched ready to eat product (nachos)		17.80	51.91	22.40	6.82	4.95	2.94	221	80	-	-	-	-	-	39.6	(Kawale et al., 2020)
20.	Rasam Mix	Dry Roasted	20.24	54.41	-	5.46	2.11	-	255	6.44	-	-	-	-	1	5.89	(Haripriya & Lidiya, 2017)
		Germinated	28.34	46.7	-	5.89	5.89	-	256	6.44	-	-	-	-	3	3.3	
		Germinated and Autoclaved	26.12	39.4	-	5.44	2.11	-	248	5.33	-	-	-	-	1.5	1.7	

Conclusion

Horsegram is a significant legume for the food industry due to their nutritional profile and health advantages. It is a cheap source of protein, dietary fibre, and a number of bioactive substances. It can be used for the development of numerous value-added goods that can be beneficial for those with protein-energy deficiency and for those with sufferning from kidney stone. It can be used to prepare weaning foods in malted or extruded form and is useful as a nutritional food for infants. It is still important to to create awareness about the food products especially created from horsegram to encourage its use and consumption so that they can be more widely known.

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