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CHEMICAL AND PHYSICOCHEMICAL PROPERTIES, OF HORSE GRAM (*MACROTYLOMA UNIFLORUM*) AND ITS PRODUCT FORMULATION

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ABSTRACT

Horse gram *(Macrotyloma uniflorum)* is a minor, under-exploited legume of tropics and subtropics grown mostly under dry land agriculture. The seeds of two varieties of horsegram 'AK-21' and 'AK-42' were assessed for their physicochemical and, nutritional properties using five common indigenous products *kasar, laddoo, mathri*, biscuits and *khakra*. The hydration capacity at 6hr for both varieties was 0.03g /seed and at 12,18 and 24 hr similar i.e. 0.04g/seed. The seed count, seed weight and density were higher of 'AK-21' variety as compared to 'AK-42'. The cooking time of 'AK-42' after 18hr. of soaking in plain water was recorded as 50 min, while that of 'AK-21' 60 min. The protein content of 'AK – 21' and 'AK-42' were 15.10 and 15.32 g% (DMB), respectively. The fat content of 'AK-21' was higher (1.8g %) as compared to 'AK-42' (1.29g %). Fibre content of both varieties ranged between 4.57-5.15g%. The energy content ranged from 376.12 to 377.21 kcal /100g and 2.77 to 3.08g% respectively on dry matter basis. The amount of iron was 8.71-9.16mg% (DMB). The mean scores for all the sensory parameters of *kasar*, *laddoo,* biscuits, *mathri* and *khakra* were within the 7.00-7.90 scale indicating their acceptibility.

Keywords : *Macrotyloma uniflorum*, Horsegram, Physicochemical characteristics, Chemical components, Product formulation.

INTRODUCTION

Horse gram (*Macrotyloma uniflorum,* previously *Dolichos biflorus*) is a minor, under-exploited legume of tropics and subtropics grown mostly under dry land agriculture. It is an important source of protein, iron and molybdenum. It is extensively grown in India, mainly for animal feed. The use of dry seeds of horse gram as human food is limited due to its poor cooking quality, presence of high levels of enzyme inhibitors and heamagglutinin activities (Ray, 1969). The seed is reported to be high in tannins and polyphenols compared to other legumes (Kadam and Salunkhe, 1985). Horse gram is however, consumed as sprouts in many parts of India (Ghorpade *et al.* 1986). Horsegram has been reported to have a lot of medicinal value. The rich fibre content of horsegram helps in reducing the body fat in fast mode. It is believed that eating horsegram makes our body strong and is also good in treating stones, menstrual problems, obesity, curing cough and cold (Kamala, 2009). Poor functional properties of horse gram are major limitations to use its flour in legume composite flours. Utilization of horse gram can be maximized through an understanding of its physical and chemical components and by the implementation of diverse processing strategies to facilitate the development of economically viable alternative products. Nutritional value and consumption of horse gram could be improved by processing it into a new product or ingredient that can be used in food processing. The aim of this research is to assess the physicochemical properties and nutritive value of horse gram and its product formulation.

MATERIALS AND METHODS

Two varieties of horse gram 'AK-21' and 'AK-42' were procured from Agricultural Research Station, Bhilwara of Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan) in a single lot. The seeds were cleaned of extraneous matter and kept in a cool and dry place prior to use.

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Physicochemical Quality: Size of the seeds (length and thickness) was determined with an electronic digital caliper. Seeds were randomly selected and the results were registered as the average of 10 seeds of each variety. Seed count per 10g and seed weight (g/100 seeds) were determined with an analytical balance in ten lots. Density, hydration and swelling capacities, hydration and swelling indexes and cooking time were determined by the techniques used by Bishnoi and Khetarpaul (1993).

Density: Raw whole grain sample weighing 100g were transferred to a measuring cylinder, where 100ml distilledled water was added. Seed volume was obtained after subtracting 100ml from the total volume (ml). Density was recorded as g/ml.

Hydration capacity: Raw whole grain sample weighing 100g were counted and transferred to a measuring cylinder and 100ml water was added. The cylinders were covered with aluminum foil and left overnight at room temperature. Next day seeds were drained, superfluous water removed with filter paper and swollen seeds reweighed. Hydration capacity per seed was determined by using the following formula:

$$\text{Hydration capacity} = \frac{\text{Weight of soaked seed-weight of seed before soaking}}{\text{No. of seeds}}$$

Hydration index - Hydration index was calculated using the formula

$$\text{Hydration index} = \frac{\text{Hydration capacity per seed}}{\text{Weight of one seed (g)}}$$

Swelling capacity - Raw whole grain sample weighing 100g were counted, their volume noted and soaked overnight. The volume of the soaked seeds was noted in a graduated cylinder. Swelling capacity per seed was calculated as:

$$\text{Swelling capacity} = \frac{\text{Volume after soaking-volume before soaking}}{\text{No. of seeds}}$$

Swelling index -

The swelling index was calculated as below:

$$\text{Swelling index} = \frac{\text{Swelling capacity per seed}}{\text{Volume of one seed (ml)}}$$

Cooking time - Raw whole grain sample weighing 100g were soaked in water for 18hr. The soak water was discarded and seeds were transferred to beakers fitted with condensers to avoid evaporation during boiling. Water was added in the ratio of 1:4 (w/v). Sample was stirred at 2 min intervals. After 25 min, one seed was withdrawn without interrupting the boiling. Pressing the seed between index finger and thumb tested "Degree" of cooking.

If seeds remained 'uncooked', one seed was again tested after 5 min. This procedure continued until five seeds were found as cooked. At this time, total cooking time (minutes) was recorded. All the analyses were done in five replicates.

Nutritional Analyses: Raw grains of both varieties 'AK-21' and AK- 42 were ground into flour using an electric grinder and packed in air tight containers for further analysis. Moisture, crude protein, crude fat, crude fibre, ash and energy were determined by AOAC (1990) methods. For conversion of nitrogen to crude protein a factor of 6.25 was used. Total carbohydrate was determined by different method, i.e. sum of moisture, protein, crude fibre, fat and ash, subtracted from 100. The iron content of samples was estimated in wet ash on atomic absorption spectrophotometer. Wet ash was prepared by digesting moisture free sample in diacid mixture as suggested by Jain and Mogra (2006). To the weighed sample 5 ml nitric acid was added and left overnight. Next day 5 ml perchloric acid was added and kept over digestion unit at 15-20°C till the particles were completely digested and cleaned. When cooled, the volume was made up to 100 ml with double distilled water. An aliquot of this mineral solution was used for determination of iron on the atomic absorption spectrophotometer. The analytical values were from the mean of three determinations for each sample.

Product formulation : Horse gram seeds were subjected to milling to obtain flour. The flour so obtained was used for development of two sweets (*kasar* and *laddoo*) and three savoury (biscuits, *mathri* and *khakra*) products for improving their nutritional quality using horsegram pulse flour for supplementation. These five products were chosen

because they were quiet common, easy to prepare, handle and store.

RESULTS AND DISCUSSION

Physicochemical Analyses : The length and thickness of horse gram seeds variety AK – 21 and 'AK-42' are shown in Table -1. The small size and thickness of the seeds might be attributed to drought resistant grain crops being hardy in nature, have a thick endosperm as observed in other millets and legumes like pearl millet, foxtail millet, barnyard millet etc.

The hydration and swelling capacities are given in Table 2. The hydration capacity at 6 hr. was comparable with that of velvet bean as reported by (Gurumoorthri and Janardhanan, 2008) and other conventional pulses (Singh *et al.* 2004). Swelling capacity of horse gram was lower as compared to velvet bean germplasms (0.29-1.14ml/seed) as reported by Gurumoorthri and Janardhanan (2008). Lower values for swelling capacity reflected that the seeds possessed very hard and impermeable seed coat and they were not hydrated easily. The seed count, seed weight and density were more of 'AK-21' variety as compared to 'AK-42' (Table - 3). The values obtained for these parameters correspond to the values reported by for conventional pulses reported by Singh *et al.* (2004) and for khesari dhal by Kokhar *et al.* (1996). The seed volume of 'AK-42' was more 14.70g/ml in comparison to 6.60g /ml of 'AK-21' variety. The lower density of 'AK-42' may be attributed to its lighter weight of seeds and hence more seed volume.

TABLE L: Length and thickness of horse gram seeds.

Parameter	Variety	
Mean ± SD	AK – 21	AK- 42
Length mm (N=10)	5.66 ± 0.512	5.59 ±0.366
Thickness mm (N=10)	2.16 ± 0.205	2.09 ±0.224

The hydration index of 'AK-21' was higher while its swelling index was lower as compared to 'AK-42' indicating correlation with its higher seed weight and density (Table 4). Both hydration and swelling indexes increased in a linear manner upto 12h and decreased slightly at 18 and 24h (Table 4). These results indicate that the maximum hydration and swelling of horse gram seeds had occurred at 12hr. The cooking time of 'AK-42' after 18hr. of soaking in plain water was recorded as 50 min. While that of 'AK-21' 60 min. (Table 3). The cooking time of 'AK-42' was lower as its swelling capacity was higher. Similar correlations have been reported in faba beans and chickpea (Sharman, 1989) and khesari dhal (Khokhar *et al.* 1996). Moreover, the beans which absorb more water are highly preferred by the consumers as well as processors (Ahmad and Shehata, 1982). The lower hydration and swelling capacity of horse gram seeds as compared to other beans and peas clearly indicated their hard to cook defect and hence not preferred by food processors.

TABLE 2: Functional properties: Hydration and Swelling capacity

(N=5)

HoursMean ± SD	Hydration capacity (g/seed)		Swelling capacity (ml/seed)	
	AK – 21	AK- 42	AK – 21	AK- 42
6	0.038 ±0.003	0.03 ±0.002	0.03 ±0.001	0.04 ±0.013
12	0.04 ±0.004	0.04 ±0.004	0.07 ±0.001	0.07 ±0.003
18	0.04 ±0.003	0.04 ±0.004	0.05 ±0.006	0.06 ±0.002
24	0.04 ±0.003	0.04 ±0.002	0.04 ±0.009	0.05 ±0.012

TABLE 3: Seed count, seed weight, seed volume and density

Parameter	Variety	
Mean ± SD	AK – 21	AK- 42
Seed count N=20 (per 10g)	299.35 ±13.58	296.60 ±4.71
Seed wt. N=10 (g/100 seeds)	3.397 ±0.61	3.33 ±0.68
Seed volume N=5	6.60 ±0.54	14.70 ±0.70
Density (g/ml)	0.51	0.47
Cooking time (min.)	60	50

TABLE 4: Hydration and Swelling Indices

Index	Hrs.	AK -21	'AK-42'
Hydration	6	1.143	1.017
	12	1.408	1.357
	18	1.249	1.338
	24	1.262	1.292
Swelling	6	0.938	1.292
	12	2.028	1.878
	18	1.639	1.834
	24	1.717	1.550

Nutritional Value:

The proximate composition and iron estimation values of horse gram varieties are expressed on dry weight, as is and per serving basis (Table- 5). The protein content of 'AK – 21' and 'AK-42' were 15.10 and 15.32 g% (DMB), slightly lower than the reported values of 17.9 – 25.3 g% (Sudha *et al.* 1995) and 22.0 g% (Gopalan *et al.* 1989) for horse gram cultivars. ICMR has recommended 30g as one serving of pulses for Indians. One serving of whole raw horse gram under this study would be providing 4.80-4.86 g protein which is quiet sufficient. The lower amount of protein estimated in the present study might be attributed to the higher amount of anti nutritional factors like TIA, saponins, heamagglutinins in these varieties of horse gram. The fat content of 'AK-21' was higher (1.8g %) as compared to 'AK-42' (1.29g %) and was comparable to reported values by Sudha *et al.* (1995) and Gopalan *et al.* (1989). Fibre content of raw seeds of horse gram was ranging between 4.57-5.15, which is similar to the reported values of Sudha *et al.* (1995) and Gopalan *et al.* (1989). Fibre regulates digestion, detoxifies and normalizes bowel function, reduces blood cholesterol and prevents colon cancer. Carbohydrates of raw seeds of horse gram were 74.88-76.06g%, higher than the reported values of 51.9-60.9g% by Sudha *et al.* (1995) and 57.2g % by Gopalan *et al.* (1989). The carbohydrates of horse gram can easily provide the energy required for oxidative metabolism. In addition, carbohydrate-rich food maintains glycemic homeostatic, gastro intestinal integrity and also serves as the vehicle for important micronutrients and phyto chemicals. Unlike fats and proteins, high level of carbohydrate intake is not associated with adverse health effects. The energy of raw seeds of horse gram varieties under study ranged from 376.12 to 377.21 kcal /100g which is slightly higher than that reported by Gopalan *et al.* (1989).

The iron content was higher 8.71-9.16mg% as compared to the reported values of 6.77mg% by Gopalan *et al.* (1989). This may be due to

TABLE 5: Nutrient composition of horse gram

Parameter	Dry wt. basis (per 100g)		As is basis (per 100g)		One Serving 30g	
	AK – 21	AK- 42	AK – 21	AK- 42	AK – 21	AK- 42
Moisture g	6.14	5.97	-	-	-	-
Protein g	15.10	15.32	16.02	16.23	4.80	4.86
Fat g	1.8	1.29	1.91	1.36	0.57	0.40
Ash g	3.08	2.77	3.26	2.93	0.97	0.87
Fibre g	5.15	4.57	5.46	4.84	1.63	1.45
CHO g	74.88	76.06	79.47	80.60	23.84	24.18
Energy kcal	376.12	377.21	399.25	399.72	119.76	119.91
Iron mg	9.16	8.71	9.72	9.22	2.91	2.76

TABLE 6 : Acceptability and nutritive value of *Kasar*

Ingredients	Amount	Acceptability	Mean ± (SD)	Nutritive value (calculated values)	
Horsegram flour	30g	Colour	7.40 ± (0.97)	Protein (g)	6.95
Wheat flour	20g	Taste	7.40 ± (0.97)	Fat (g)	20.88
Powdered sugar	35g	Flavour	7.10 ± (0.74)	Ash (g)	1.46
Ghee	20g	Texture	7.60 ± (0.52)	Fibre (g)	1.92
Cooked wt. 95g.		Appearance	7.40 ± (0.70)	CHO (g)	36.34
		Doneness	7.50 ± (0.71)	Energy (kcal)	500
		Overall Acceptability	7.70 ± (0.67)	Iron (mg)	3.72

TABLE 7: Acceptability and nutritive value of *Laddoo*

Ingredients	Amount	Acceptability	Mean ± (SD)	Nutritive value (calculated values)	
Horsegram flour	50g	Colour	7.50 ± (1.35)	Protein (g)	13.6
Wheat flour	50g	Taste	7.40 ± (0.97)	Fat (g)	41.75
Powdered sugar	60g	Flavour	7.30 ± (0.95)	Ash (g)	2.89
Ghee	40g	Texture	7.30 ± (0.95)	Fibre (g)	3.52
Cooked wt.193g.		Appearance	7.10 ± (0.88)	CHO (g)	72.14
		Doneness	7.40 ± (0.84)	Energy (kcal)	957
		Overall Acceptability	7.40 ± (0.84)	Iron (mg)	7.03

TABLE 8: Acceptability and nutritive value of biscuits

Ingredients	Amount	Acceptability	Mean ± (SD)	Nutritive value (calculated values)	
Horsegram flour	50g	Colour	7.90 ± (0.88)	Protein (g)	13.37
Wheat flour (refined)	50g	Taste	7.20 ± (1.32)	Fat (g)	41.76
Ghee	40g	Flavour	7.20 ± (0.92)	Ash (g)	1.92
Salt	A pinch	Texture	7.00 ± (1.05)	Fibre (g)	2.72
Baking powder	2.5g	Appearance	7.70 ± (0.82)	CHO (g)	74.83
Baking soda	A pinch	Doneness	7.70 ± (0.67)	Energy (kcal)	369
Milk	10 ml	Overall Acceptability	7.50 ± (0.85)	Iron (mg)	5.9
		Cooked wt.135g.			

TABLE 9: Acceptability and nutritive value of *Khakra*

Ingredients	Amount	Acceptability	Mean ± (SD)	Nutritive value (calculated values)	
Horsegram flour	50g	Colour	7.90 ± (0.57)	Protein (g)	27.29
Wheat flour (refined)	50g	Taste	7.90 ± (0.57)	Fat (g)	28.39
Oil	25g	Flavour	7.50 ± (0.71)	Ash (g)	4.09
Salt	6 g	Texture	7.80 ± (0.79)	Fibre (g)	7.01
Red chilli powder	4 g	Appearance	7.60 ± (0.52)	CHO (g)	151.13
Cumin seeds	3g	Doneness	7.40 ± (0.52)	Energy (kcal)	970
Water	125 ml	Overall Acceptability	7.70 ± (0.48)	Iron (mg)	12.30
		Cooked wt. 226g.			

geographical locations. Incorporating horse gram (one serving) in the daily diet would provide 2.76 to 2.91 mg iron (Table 5). The iron content of horse gram was much higher than that of many commonly cultivated pulses (Sidhuraju *et al.* 2000, Seena and Sridhar 2006). The high content of iron in horse gram can be utilized beneficially in the diets of people who suffer from anemia. Products formulated out of it in combination with other food groups can be introduced in supplementary feeding programmes of ICDS and Mid day meal programme.

Product formulation:

Looking to the excellent nutritional composition of horse gram, it was used for development of five common products viz *kasar*, *laddoo*, biscuits, *mathri* and *khakra* which are usually wheat based, The data so obtained are summarized in Table (6 to 10). *Kasar* is a sweet product prepared by roasting the flour in ghee and addition of powdered sugar. It obtained mean overall acceptability score of 7.70 indicating that it was liked by the judges. *Kasar* was providing 500 kcal energy, and 20.88 g of fat which indicated its suitability as a supplementary snack food for preschool children, pregnant and lactating women. The mean scores for all the sensory parameters of *laddoo* were in 7.00-7.50 scale indicating their acceptibility by the panel of judges (Table 7). *Laddoo*s were providing 13.6g%

Table 10: Acceptability and Nutritive value of *Mathri*

Ingredients	Amount	Acceptability	Mean ± (SD)	Nutritive value (calculated values)	
Horsegram flour	50g	Colour	7.30 ± (0.82)	Protein (g)	13.48
Wheat flour (refined)	50g	Taste	7.50 ± (0.85)	Fat (g)	21.87
Salt	1.25 g	Flavour	7.40 ± (0.70)	Ash (g)	2.07
Carom seeds	1.25g	Texture	7.30 ± (0.67)	Fibre (g)	3.50
Cumin seeds	1.25g	Appearance	7.30 ± (0.67)	CHO (g)	75.53
Red chilly powder	1.25g	Doneness	7.40 ± (0.70)	Energy (kcal)	554
Oil	For deep frying	Overall Acceptability	7.60 ± (0.70)	Iron (mg)	6.24
Water	For dough				
		Cooked wt. 137g.			

protein and 7.03 mg% iron indicating their suitability for use in supplementary feeding programmes, emergencies like drought, floods, earthquakes, etc. because of their ease of handling.

Three savory products biscuits, *mathri* and *khakra* were formulated using horse gram flour and refined flour in 1:1 ratio. Biscuits provided 369kcal energy, 74.83g% carbohydrate and 13.37g% protein (Table 8). *Mathri* is a deep fried snack item. Iron content was 12.30mg%, protein 27.29g%, carbohydrate 151.13g% and energy 970 kcal /100g (Table 10).

Looking at the mean scores obtained or sensory parameters of the formulated products, their ease of preparation, handling and nutritional value they all can very easily be introduced as supplementary foods in the Integrated Child Development Scheme, an initiative of Government of India, mid day meal programmes being run in all the primary schools throughout the country, emergency ration at the time of natural calamities like drought, floods, earthquakes, etc.

Horse gram can be used easily in formulating different type of products. Looking to its beneficial properties as an adjunct flour and medicinal value it is suggested that it be included in daily diet as a source of various nutrients.

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