



Nutritional status of recently developed Makhana (Gorgon Nut) variety - Swarna Vaidehi

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ABSTRACT

Makhana is an important aquatic, annual and seed propagated crop with gigantic floating leaves. It is known as Gorgon nut (*Euryale ferox* Salisb) belongs to family Nymphaeaceae. Swarna Vaidehi has been released as an ever first variety of makhana originated from selection-6. Nutritional profiling was undertaken for popped seeds of Swarna Vaidehi and local cultivar along with raw seeds of "Swarna Vaidehi". Standard procedure was applied for nutritional profiling of the Makhana samples. Results revealed that maximum moisture content (34.7%) was recorded in case of raw seeds of swarna vaidehi. Maximum ash content (0.4%) was recorded in case popped seeds of both tested samples i.e. swarna vaidehi, lowest value (0.3%). Maximum seed protein (8.7%) was obtained by the swarna vaidehi. Maximum crude fiber (0.5%) was obtained in the raw seeds of swarna vaidehi as compare to popped one. Maximum total carbohydrate (79.8%) was recorded in popped seeds of swarna vaidehi; however the lowest value (57.0%) was also noticed in raw seeds of swarna vaidehi. It worth to notice that maximum calorific value (358) was recorded in popped seeds of swarna vaidehi. Maximum (18.5mg) calcium content was recorded in case of popped seeds of swarna vaidehi. Likewise maximum (1.3) manganese content was recorded in case of popped seeds of swarna vaidehi. It was worth to mention that maximum (1.1) zinc content was recorded in case of popped seeds of swarna vaidehi.

ARTICLE INFO	
Received on	: 25.10.2016
Accepted on	: 20.11.2016
Published online	: 14.12.2016

Keywords: Makhana, Gorgon nut (*Euryale ferox* Salisb) nutritional quality, phytochemicals, Swarna Vaidehi

INTRODUCTION

Gorgon nut or Fox nut (*Euryale ferox* Salisb) is an important aquatic crop, belonging to family Nymphaeaceae and commonly known as Makhana. Makhana plant is considered as a native of South-East Asia and China, but distributed to almost every parts of the world. Its distribution is extremely limited to tropical and sub tropical regions of South-East and East Asia and known to exist in Japan, Korea, Russia, North America, Nepal, Bangladesh and some parts of India. In India, it is distributed in West Bengal, Bihar, Manipur, Tripura, Assam, Jammu and Kashmir, Eastern Odisha, Madhya Pradesh, Rajasthan and Uttar Pradesh (Kumar *et al.*, 2011 and Mishra *et al.*, 2003). However, its commercial cultivation is limited to North Bihar, Manipur, parts of West Bengal and Madhya Pradesh. In the state of Bihar, major Makhana producing districts include Darbhanga, Sitamarhi, Madhubani, Saharsa, Supaul, Araria, Kishanganj, Purnia and Katihar.

Approximately, 80% of total production of processed Makhana comes from Darbhanga, Madhubani, Purnia and Katihar districts alone. Area under makhana cultivation is about 13,000 ha. Makhana cultivation provides livelihood to thousands of resource poor farmers, particularly in Bihar and Manipur. It is a cash crop (dry fruits) and marketed in the form of popped makhana commonly known as *Makhanalawa*, grown in stagnant perennial water bodies like ponds, land

depressions, oxbow lakes, swamps and ditches. Makhana seeds are also called as Black Diamond (Jha and Prasad, 2003). It is a plant of tropical and subtropical climate. For its proper growth and development, the conducive range of air temperature is 20°C-35°C, relative humidity 50-90% and annual rainfall 100-250cm (Mishra *et al.*, 2003 and Mandal *et al.*, 2010).

The popping process is highly skilled, tedious, time consuming and pains taking. Most of the experts of this technology belong to the women population of a specific community of 'Mallah' of north Bihar. In general, the post-harvest technology involves sun drying, size grading, pre-heating & tempering, roasting & popping, polishing, and grading & packaging (Jha and Prasad, 2003). Perhaps this is the only reason, that the processing of Makhana is restricted to Bihar only. Popped Makhana are used in the preparation of a number of delicious and rich sweet dishes like Makhanakheer, Makhana vermicelli and Makhana halva etc (Jha and Prasad, 2003 and Kumar *et al.*, 2011). It is used in pudding and milk based sweets. Dal makhani and vegetable curries become delicious when Makhana is mixed for taste and thickening object. Makhanaraita is also tastier and digestive in nature. The medicinal properties of Makhana are well documented in Indian and Chinese ancient literature. According to these literatures, all the plant parts have tonic, astringent and de-obstruent properties (Dragendorff, 1898). The seed is analgesic and aphrodisiac. It is taken internally in the treatment of chronic diarrhoea, vaginal discharge, impotence,

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premature and involuntary ejaculation, nocturnal emissions and kidney weakness associated with frequent urination. Das *et al.* (2006) demonstrated that Makhana has the cardio-protective properties and suggested that these properties may be linked with the ability of Makhana to induce TRB-32 and Trx-1 proteins and to scavenge ROS. The leaves are effective against rheumatism which may be attributed to the presence of an alkaloid “drummine” (Sokolov, 1952) and infusion of leaves was found to be effective against difficult parturition. Leaf ash cooked with fermented rice was found to have the capacity to restrain seminal gleets. In every religion, Makhana is considered as the pious and divine food item. In Hindu religion, it is used in all the worshiping ceremonies, Hawan, Pooja etc. In addition to this, due to its heavenly nature, it is considered as the best offering to god and goddesses in temples. Being the non-cereal food, Makhana is a ideal staple food of devotees during their religious fast (Mishra *et al.*, 2003 and Kumar *et al.*, 2011).

Suitability of any crop and their variety is solely depends upon the purpose for they are developed and should be equally accommodative with the location specific agroclimatic conditions (Singh *et al.*, 2008). Ecologically, *Euryale ferox* Salisb has been classified as an annual aquatic herb with gigantic floating leaves, emergent macrophyte of monotypic genus, growing in the littoral parts of the flood plain wetlands of stagnated shallow water (4-6 ft) which are of perennial in nature. *Euryale ferox* is an absolutely seed propagated plant and its new plants arise upon the germination of its fully matured seeds (CSIR, 1952 and Kumar *et al.*, 2011). The germination of Makhana seed is of “hypogeal” type. Upon the germination, the cotyledons and hypocotyls of seeds remain in the soil. It has the cluster roots. The roots are thick, long (40-50 cm), fleshy and fibrous in nature and also having a number of air pockets. Each plant has about 3 – 5 clusters of roots and each of these cluster is consisting of about 10-15 rootlets.

The Makhana plant has rhizomatous stem. The rhizome is short thick and erect, leaf buds are folded up in involucre. Leaves are alternate, round, large (1 -2m) and floating in nature. These are born on a 3-5 feet long petiole. The colour of upper surface appears to be green while the lower one looks deep purple. Both surfaces are covered by numerous thorns. The flowers are complete, big, solitary, bright purple in colour with long pedicel. The thalamus is fleshy and goblet-shaped. The number of sepals is four. They are persistent, green and thorny which gradually merge into the petals. The petals are of purple colour (Verma *et al.*, 2003). They are numerous (> 40). The inner ones are lobate while the outer ones are obovate. They gradually merge into the stamens. The stamens are numerous, free and adnate to the fleshy thalamus that envelops the carpels. The stigma is sessile and the ovary is inferior, multicarpellary, syncarpous and multilocular (7-12 loculates). Makhana is an exclusively self polinated plant. The flowering and fruiting starts from the month of May and it continued up to the month of October-November. In the flowers of makhana, fertilization (seed setting) takes place at an extremely early stage of their development. After 35-40

days of flowering, the fruits become fully developed and matured. It is berry, large (5-8 cm diameter), spongy, spiny and crowned with persistent sepals. Each fruit has about 20 to 200 seeds. The fresh seeds are lumpy, and surrounded by a streaked bright red arils. After some time (3-4 days), the aril of fresh seeds gets decomposed and they turned into black colour. Seeds are enough bold and having a hard outer covering. The diameter varies from 0.5 to 1.5 cm. The edible part of seed is its perisperm, which is white and starchy in nature. *Euryale* is a monotypic genus. Hence, there is no other species under this genus. Makhana is a diploid plant and the chromosome constitution of this plant is $2n=2x=58$ (Kumar *et al.*, 2011 and Singh *et al.*, 2014b).

The flowers of Makhana are large in size, purple in colour and of bisexual type. Makhana is an exclusively self pollinated plant and the fertilization in flowers takes place at a very early (hermetically sealed) stage under the surface water. Makhana is a monotypic genus and the available genetic variability is limited (Verma *et al.*, 2010). In the absence of genetic diversity, no improvement could be made in crop plants. Keeping this fact in view, studies on genetic diversity in Makhana, using 36 germplasm (collected from different places of Bihar and Manipur) was conducted and the range of different quantitative traits is depicted as: Days to germination (28-35); Days to initiation of flowering (112-126); Days to fruit bursting (146-156); No. of effective fruits per plant (8-15); Fruit diameter (4-8 inch); No. of seeds per fruit (20-200); Seed yield per fruit (15-150g); Diameter of seed (0.4-1.5cm); 100-seed weight (40-130g); Seed yield per plant (150-1600g) Owing to peculiar characteristics of Makhana buds, the artificial hybridization is not possible through conventional means in this crop. Therefore, artificial selection is the only possible way for genetic improvement in Makhana. Keeping this fact in view, pure line selection is being practiced and many promising lines (Sel-1, Sel-5, Sel-6, Sel-13 and Sel-14) have been developed and identified so as to increase the productivity (Mishra *et al.*, 2003 and Kumar *et al.*, 2011).

MATERIALS AND METHODS

Makhana variety –Swarna Vaidehi

Keeping in view its commercial importance of Makhana, a regional centre was set-up to conduct research on various aspects of Makhana in Darbhanga district of Bihar under the administrative control of ICAR Research Complex for Eastern Region. On the basis of three years multilocation testing, the Selection-6 strain of Makhana has been released as an ever first variety of Makhana under the name of Swarna Vaidehi by institute variety release committee of ICAR-RCER, Patna (Singh *et al.*, 2014b and Singh *et al.*, 2012b). The seeds of Swarna Vaidehi are bold and its average productivity is 28-30 q/ha which is near about 45% higher to the seed yield of local check. In addition to high yield potential, this variety is resistant to common insects-pests and disease of Makhana. The cumulative data of seed yield of Swarna Vaidehi and local checks are presented in table 1 and fig. 1 (a-d).

Table 1: Comparative performance of Swarna Vaidehi (Sel-6) along with local checks

Year	No. of location	Seed yield (q/ha)		% increase over Local check
		Swarna Vaidehi	Local check	
2010-11	6	30.7	19.9	56.3
2011-12	8	31.1	20.8	47.7
2012-13	19	28.8	21.1	36.9
Average	11	30.2	20.6	46.7

Source: Annual Report (2013-14) ICAR Research Complex for eastern Region Patna

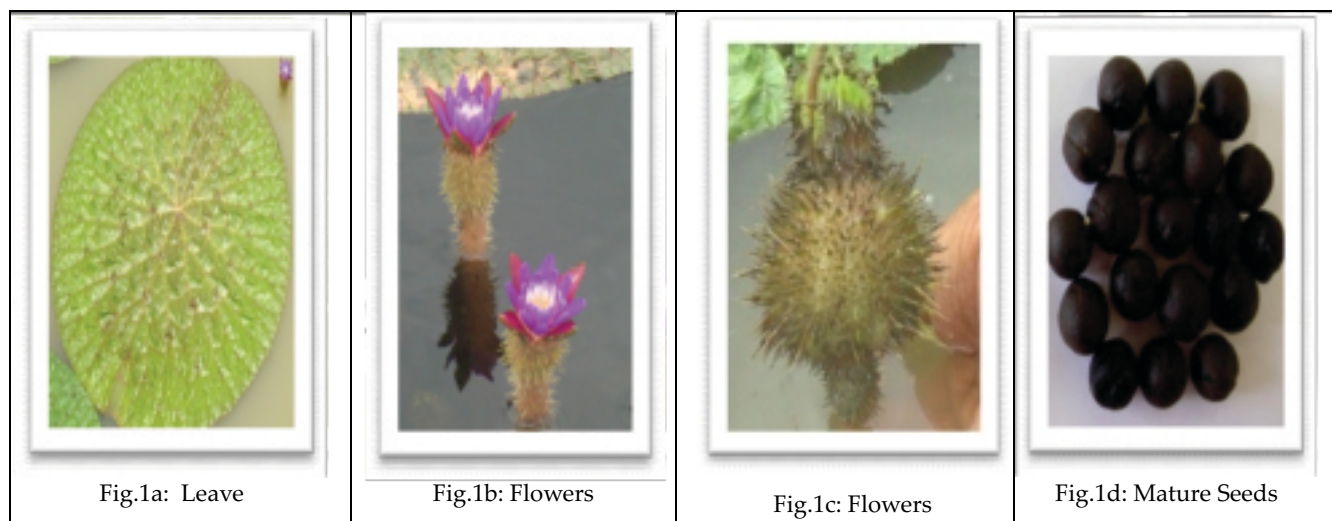


Fig.1 : Leaf; flowers, fruit and mature seeds of newly released Makhana variety Swarna Vaidehi

Premium attributes of developed Swarna Vaidehi (Sel-6) variety of Makhana

Major characteristic feature of recently developed Makhana variety Swarna Vaidehi (Sel-6) are depicted in table 2. Most important features are high seedling vigour, large size flowers, days to 50% flowering 120-125 days, colour of petals are Bright Purple, fruit shape Spheroid, fruit colour is whitish brown, deep black seed coat colour, Seed shape is spherical, 100-seed weight is 28-30g, popped seeds (*Lawa*) shape is oblate and colour is sparkly white (Anonymous, 2014; Kumar *et al.*, 2011 and Singh *et al.*, 2012a).

Makhana Samples

Popped seeds of newly developed makhana variety Swarna Vaidehi and local cultivar along with raw seeds of Swarna Vaidehi have been taken as sample to analysis biochemically to know the presence of some important parameters. Single plant selection (SPS) are the one of the best way to identify and purify the desirable traits. Swarna vaidehi i.e. Selection 06 line was screened and purified adopting the same technique. This variety was found suitable for Bihar and Assam as well. The major characteristic features of swarna vaidehi have been given in table 1 and 2 (Anonymous, 2014). The developed variety has been deposited to National Gene Bank, National Bureau of Plant Genetic Resources (NBPGR) New Delhi and an IC Number has been allocated for this variety (Singh *et al.*, 2012a). Further one set of above mentioned seeds a sample of swarna vaidehi was supplied to Central Food Technological Research Institute, Mysore for its biochemical analysis.

Accordingly swarna vaidehi seeds samples were analysed following protocol as mentioned below

Sample Preparation

The seeds of recently released variety "swarna vaidehi" and local cultivar of makhana were first grounded into powdered flour and stored in a closed container at room temperature for research purposes (Singh *et al.*, 2012a and Singh *et al.*, 2014a). 50 g of the makhana flour was then mixed with 200 ml of methanol. The mixture was incubated for 24h and then filtered. The solvent was evaporated under vacuum and resulting extracts were stored at 4°C.

Biochemical analysis

Moisture content

The samples were dried at 65°C in a hot-air oven for 72 h until constant dry weight (DW) was achieved. Moisture content was determined as $100 \times [(FW-DW) / FW]$ and expressed in per cent.

Ash determination

For the determination of ash content, 5g of dried ground sample taken in silica crucible and initially charred at 250°C for 1 h and then temperature was raised gradually to 550°C and maintained for 4 hr. Ash content was expressed as g per 100 fresh weights.

Estimation of crude fat

10 g of dried and homogenized sample was extracted with

Table 2: Premium attributes of developed Swarna Vaidehi (Sel-6) variety of Makhana

Name of attributes	Magnitude
Seedling attributes	
Seedling vigor	High
Shape of juvenile leaves	Sinuate followed by sagittate
Leaf attributes (Fully developed)	
Shape	
Diameter	Orbicular 110-
Dorsal surface colour	140 cm
Ventral surface colour	Deep green
Orientation	Deep purple
Venation	Horizontally floating on water
Ventral rib appearance	Reticulate type
Ventral rib colour	Thick and prominent
Shape of dorsal prickles	Yellowish
Orientation of dorsal prickles	Hooked Periphery facing
Flower attributes	
Size	Large
Colour of sepals	Outer side green and inner light purple
Colour of petals	Bright Purple
Status of prickles	Dense
Size of prickles	1.2-2.0 cm
Days to 50% flowering	120-125 days
Fruit attributes	
Shape	Spheroid
Colour	Whitish brown
Appearance	Protuberant
Status of prickles	Dense
Size of prickles	1.2-2.0 cm
Fruit diameter	7.0 - 8.6 cm
Seeds/fruit	65 - 110
Fruits/plant	12-16
Seeds weight (g /fruit)	62-106
Seed attributes	
Seed coat colour	Deep black
Seed shape	Spherical
100-seed weight(g)	92-98
Seed diameter (mm)	9.5-10.2
Yield attributes	
Seed yield /plant(g)	750-980
Seed yield /ha (q)	28-30
Quality attributes of popped seeds (lawa)	
Shape	Oblate
Size	2.0 - 2.5 cm
Colour	Sparkly white

Source: Annual Report (2013-14) ICAR Research Complex for eastern Region Patna

petroleum ether 40-60°C AR grade as solvent as per AOAC official method 920.39. Samples were extracted for 24 hours and dried overnight before and after extraction.

Estimation of total protein

Total protein was estimated as per AOAC official method 976.05 with some modifications in digestion of samples. One hundred mg of dried and homogenized sample was digested with sulphuric acid – selenium– anhydrous sodium sulphate – hydrogen peroxide digestion mixture in glass digestion tubes at 350°C for 45 min as per the standard method Nitrogen percentage in digest was estimated by Kjeltach (FOSS tecator) nitrogen autoanalyser.

Estimation of total crude fibre

Total dietary fiber was estimated by enzymatic-gravimetric method as per AOAC Official Method 985.29. Total dietary fiber assay kit (K-TDFR) and total dietary fiber control kit (K-TDFC) was obtained from Megazyme, Ireland were used in analysis.

Estimation of total carbohydrates

Total carbohydrates were calculated using formulae:

Available carbohydrates (% fresh weight) = 100 - moisture (%) - protein content (% fresh weight) - crude fat (% fresh weight) - ash (% fresh weight) and reported as total carbohydrates in %.

Extraction of Amylose

100 mg sample was extracted with 5.0 ml of 80% ethanol in ultrasonic bath at 70°C for 60 min. Contents were centrifuged at 5000 g for 20 min and supernatants were collected. Residue was re-extracted in 5 ml of 80% ethanol thrice, supernatants were pooled and volume was made up to 25 ml. This supernatant was stored in -20°C in the dark until analysis. Residue left from centrifugation after extraction used for starch estimation.

Estimation of caloric value

The caloric value was calculated according to the system of Atwater, namely: kcal = (3.36 × % protein fresh weight) + (3.60 × % total carbohydrate fresh weight) + (8.37 × % fat).

RESULTS AND DISCUSSION

1. Moisture content

Moisture content was determined and expressed in per cent (% by wt). Perusal of data presented in table 3, revealed that maximum moisture content (34.7%) was recorded in case of raw seeds of swarna vaidehi, corresponding lowest value (10.4%) was noticed in case of popped seeds of swarna vaidehi. It was worth to mention here that all the popped seeds of newly developed variety i.e. swarna vaidehi has retained less moisture as compared to local cultivar used as check (Jha *et al.*, 1991 and Singh *et al.*, 2014a).

1. Total Ash content

Data presented in table 3, revealed that maximum ash content (0.4%) was recorded in case of popped seeds of both tested samples i.e. swarna vaidehi and local cultivar however corresponding lowest value (0.3%) was noticed in case of raw

seeds of swarna vaidehi. Makhana raw seeds contain less ash as compare to popped one. Most of popped seeds contain higher ash as compare to raw seeds (Table 3). This might be due to more moisture retaining capacity in raw seeds as compared to the popped seeds (Jha *et al.*, 1991 and Mishra *et al.*, 2003).

2. Fat content

Makhana contains least fat and is good for the health point of view. Seed were also analysed for fat estimation purposes (% by wt.). Results summarized in table 3 clearly indicate that no seed samples contains fat > 0.5%. Maximum (0.5%) fat was reported in the popped seeds samples of swarna vaidehi a newly developed makhana variety, corresponding lowest (0.2%) was noticed in Local check cultivar. Raw seeds of swarna vaidehi contain more fat (0.3%) than local cultivar (Singh *et al.*, 2014a and Mishra *et al.*, 2003).

1. Protein content

Makhana contains high quality easily digestible protein. The crude protein content of the seeds varies widely depending on many factors, for example variety, fertilizer application, and location of growth. The seed coat contains less protein and more carbohydrate in comparison to cotyledons and whole seeds. Perusal of data presented in table 3 revealed that among the samples maximum seed protein (8.7%) was obtained by the swarna vaidehi a newly developed makhana variety, similarly minimum seed protein (7.2 %) was obtained by the raw seeds of swarna vaidehi. Among the tested local check cultivar recorded maximum seed protein (8.6%) (Mishra *et al.*, 2003).

2. Crude Fiber

Makhana is not a very good source of dietary fiber and it lowers the blood cholesterol levels (Singh *et al.*, 2014a). It is a good source of both soluble and insoluble crude fiber. Results presented in table 3 confirm that raw seeds contain more crude fiber as compare to popped seeds. Maximum crude

fiber (0.5%) was obtained in the raw seeds of swarna vaidehi. Corresponding minimum crude fiber (0.2%) was found in popped seeds of swarna vaidehi.

Carbohydrate

Makhana is an excellent source of quality carbohydrate. Phytochemical analysis was also done with respect to total carbohydrate (% by wt). Maximum total carbohydrate (79.8%) was recorded in popped seeds of swarna vaidehi, however the lowest value (57.0%) was also noticed in raw seeds of swarna vaidehi (Mishra *et al.*, 2003).

3. Amylose

Similarly in case of Amylose (%) Maximum and minimum (19.5% and 18.2%) was recorded in raw seeds of swarna vaidehi and popped seeds of swarna vaidehi. It is worth to mention that the popped seeds of local check also recorded 18.5% Amylose (Mishra *et al.*, 2003 and Singh *et al.*, 2014a).

4. Calorific value (K. cal/100g)

Makhana is also an excellent source of energy. Analysis was also done with respect to total calorific value (K. cal/100g). Maximum calorific value (358) was recorded in popped seeds of swarna vaidehi; however the lowest value (259) was also noticed in raw seeds of swarna vaidehi. It is worth to mention that the popped seeds of local check also recorded 354 K. cal/100g (Mishra *et al.*, 2003 and Jha *et al.*, 1991).

Mineral composition

To know the nutritive value of the developed faba bean lines seed samples were also analysed for its mineral constituents.

Phosphorus (mg/100g)

Data presented in table 4 revealed that maximum (79.1mg) phosphorus was recorded in case of popped seeds of local check cultivar, corresponding minimum (53.2mg) was noticed in case of popped seeds of swarna

Table 3: Comparative study of nutritional profile of Swarna Vaidehi variety of and local cultivar of Makhana

Parameters	Popped seeds of Swarna Vaidehi	Popped seeds of Local check	Raw Seeds of Swarna Vaidehi
Moisture (% by wt.)	10.4	11.1	34.7
Total ash (% by wt.)	0.4	0.4	0.3
Fat (% by wt.)	0.5	0.2	0.3
Protein (% by wt.) (N x 6.25)	8.7	8.6	7.2
Crude fiber (% by wt.)	0.2	0.3	0.5
Carbohydrate (% by wt.)	79.8	79.4	57.0
Amylose %	18.2	18.5	19.0
Calorific value (K. cal/100g)	358	354	259

vaidehi. Raw/whole seeds contain more phosphorus as it was recorded with swarna vaidehi (66.1mg) (Mishra *et al.*, 2003).

Potassium (mg/100g)

Perusal of data presented in table 4 that maximum (56.0 mg) potassium was recorded in case of popped seeds of local check cultivar, corresponding minimum (35.6 mg) was noticed in case of raw seeds of swarna vaidehi. Raw/whole seeds contain less potassium it was recorded with swarna vaidehi (35.6 mg). Popped seeds of swarna vaidehi contain (42.0 mg) (Mishra *et al.*, 2003 and Jha *et al.*, 1991).

Iron (mg/100g)

Iron helps in respiration at the cellular level by synthesizing haemoglobin that helps to carry oxygen to cells. Results obtained for the iron contents in the seed samples were depicted in table 4. Maximum (1.9 mg) iron content was recorded in case of popped seeds of local cultivar used as check; whereas corresponding minimum (0.8 mg) was noticed in case of raw seeds of swarna vaidehi. Popped seeds of swarna vaidehi contain (1.4mg) iron (Mishra *et al.*, 2003 and Jha *et al.*, 1991).

Calcium (mg/100g)

Calcium content was estimate and the results obtained for raw and popped seed samples were depicted in table 4. Maximum (18.5mg) calcium content was recorded in case of popped seeds of swarna vaidehi; whereas corresponding minimum (9.5 mg) was noticed in case of raw seeds of swarna vaidehi. Popped seeds of local cultivar used as check contain (13.0 mg) (Mishra *et al.*, 2003 and Singhet *et al.*, 2014a).

Magnesium (mg/100g)

Magnesium content was estimate and the results obtained for

raw and popped seed samples were depicted in table 4. Perusal of data presented in table 4 revealed that maximum (13.9 mg) magnesium content was recorded in case of popped seeds of swarna vaidehi; whereas corresponding minimum (11.3 mg) was noticed in case of raw seeds of swarna vaidehi. Popped seeds of local cultivar used as check contain (11.9 mg) (Singh *et al.*, 2014a).

Sodium (mg/100g)

Makhana is one of the good sources of sodium. Results revealed that there that maximum (71.0 mg) sodium content was recorded in case of popped seeds of swarna vaidehi; whereas corresponding minimum (48.2 mg) was noticed in case of raw seeds of swarna vaidehi. Sodium contents of popped seeds of local cultivar used as check contain (65.2 mg) (Mishra *et al.*, 2003 and Jha *et al.*, 1991).

Copper (Cu) (mg/kg)

Like other minerals makhana is one of the good sources of copper. It reduces the risk of inflammatory diseases like rheumatoid arthritis, and enhances the activity of enzymes that are needed to maintain the elasticity of blood vessels, ligaments and joints. Results revealed that there was not much difference in the copper among the tested makhana developed variety as well as local check varieties under the test. Copper contents varied from 0.3 to 0.5 (Mishra *et al.*, 2003 and Singh *et al.*, 2014a).

Manganese (mg/100g)

Makhana is one of the good sources of manganese. It functions as a cofactor in various metabolic reactions involved in the efficient production of energy and enhancing the activity of antioxidant enzymes. Data presented in table 4 revealed that maximum (1.3) manganese content was recorded in case of popped seeds of swarna vaidehi and local check

Table 4: Comparative study of mineral composition of Swarna Vaidehi variety of and local cultivar of Makhana

Parameters	Popped seeds of Swarna Vaidehi	Popped seeds of Local check	Raw Seeds of Swarna Vaidehi
Phosphorus (mg/100g)	53.2	79.1	66.1
Potassium (mg/100g)	42.0	56.0	35.6
Iron (mg/100g)	1.4	1.9	0.8
Calcium (mg/100g)	18.5	13.0	9.5
Magnesium (mg/100g)	13.9	11.9	11.3
Sodium (mg/100g)	71.0	65.2	48.2
Copper (mg/100g)	0.5	0.4	0.3
Manganese (mg/100g)	1.3	1.3	0.9
Zinc (mg/100g)	1.1	0.7	0.9

however corresponding minimum (0.9) was noticed in case of raw seeds of swarna vaidehi (Mishra *et al.*, 2003 and Jha *et al.*, 1991).

Zinc (mg/100g)

Makhana is the good sources of zinc. Data presented in table 4 revealed that maximum (1.1) zinc content was recorded in case of popped seeds of swarna vaidehi, however corresponding minimum (0.7) was noticed in case of local check variety. Raw seeds of swarna vaidehi contain (0.9 mg/100g) zinc. It was noticed that popped seed contains more zinc as compare raw one (Mishra *et al.*, 2003 and Singh *et al.*, 2014a).

CONCLUSION

Popped and raw seeds of newly developed "swarna vaidehi" variety of Makhana has been evaluated for its nutritional

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quality along with local check. Maximum ash content (0.4%) was recorded in case popped seeds of both tested samples i.e. swarna vaidehi, lowest value (0.3%) was noticed in case of raw seeds of swarna vaidehi. Maximum crude fiber (0.5%) was obtained in the raw seeds of swarna vaidehi as compare to popped one. Maximum calorific value (358) was recorded in popped seeds of swarna vaidehi. In case of mineral composition, maximum (79.1mg) phosphorus was recorded in case of popped seeds of local check cultivar, similarly in case of potassium maximum (56.0 mg) was recorded with popped seeds of local check cultivar. Maximum (1.9 mg) iron content was recorded in case of popped seeds of local cultivar. Maximum (18.5mg) calcium content was recorded in case of popped seeds of swarna vaidehi. It was worth to mention that maximum (1.1) zinc content was recorded in case of popped seeds of swarna vaidehi.

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Citation:

Kumar L, Singh AK and Bhatt BP.2016.Nutritional status of recently developed Makhana (Gorgon Nut) variety - Swarna Vaidehi. *Journal of AgriSearch* **3**(4): 199-205