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STUDIES ON THE SCOPE OF IMPROVEMENT FOR QUALITY PARAMETERS IN POTATO (solanum *tuberosum* L)

VIVEKANANDA MANDI, SUDESHNA PANJA, C. BHATTACHARYA & K.K. SARKAR

Department of Genetics & Plant Breeding, BCKV, Mohanpur, Nadia, West Bengal, India

ABSTRACT

In the present investigation, twenty three potato genotypes were collected from AICRP on Potato, BCKV centre evaluated in winter season for two consecutive years (2009-2010, 2010-2011) at seed production farm Adisaptagram, Govt of West Bengal situated in district Hooghly, West Bengal. The quality traits on seed shape, seed size, colour, eye depth, tuber flesh, time taken for cooking, easiness for peeling of cooked tuber, softness and dryness of cooked tuber, colour of cooked tuber, protein and starch content, processing qualities like chip colour, dry matter content of tuber and reducing sugar content of tuber were considered in evaluation trial through field and laboratory experiment. Highest dry matter content in tuber was found in K. Sutlej followed by K. Chipsona-1 and MS-1/4906. Cooked flesh of K. Sutlej had found to be mealy. Tubers were useful for processing purpose for preparation of 'French Fries'. The variety K.Chipsona-2 showed highest protein content. The lowest protein content was recorded in the variety K. Jawahar. Regarding starch content, the variety K.chipsona-2 had the highest value followed by K.chipsona-1. The low reducing sugar content and and low total sugar content in the varieties were K.Chipsona-1, and K.Chipsona-2 which are desirable for chip and crisp production in potato. The flavor of K. Chipsona-1 and K. Chipsona-2 were found to be very good and are suitable for cooking in steamed water and favored by consumer for the fragrance. The other genotypes like K. Jyoti, K. Puskar, K. Sadabahar, K. Jawahar and K. Bahar might be considered as promising for processing as well as cooking purposes as it had oval round tubers with medium depth eyes. Accepted chip colour and consistency were recorded in J-99/243, J-95/227,K. Chandramukhi, K. Chipsona-1, K. Chipsona-2, K. Jyoti observed significant variation from these quality characters potato genotypes. The early maturing varieties as identified in the evaluation were K. J-99/243, K. Khyati, K. Chipsona-1, K. Chipsona-2, K. K22, K. Ashoka, MS-1/4906 and these can be cultivated to obtain good tuber yield at the earliest of the cropping season.

KEYWORDS: Potato, Total Sugar Content, Reducing Sugar Content, Protein Content

INTRODUCTION

Potato (*Solanum tuberosum* L.) is the world`s third most important food crop after wheat and rice with 325 million tonnes fresh weight production in 2007 (Bradshaw, 2009) of which over half of the production obtained from Asia, Africa, Latin America. At present China is number one potato producer while India ranked third. Average fresh weight yield vary from 2 to 50 tonne ha^{-1} with a global average of 16.8 tonne ha^{-1} whereas average production of China was 14.4 tonne ha^{-1}. There has been a phenomenal increase in area, production and per capita availability of potatoes in India in the last 50 years. The average production of potato in India is 20 t/ha of marketable tubers and per capita availability of potato has gone up to 23.5 kg/ year (Pandey *et al*., 2007). From a meagre 1.285 million tonnes (t) and 205,000 hectares (ha) in 1949 (Srivastava, 1980), potato production in India now has passed 34 million t (FAO, 2011a) with projections forecasting

50 million t by 2020 (CPRI, 1997). Potato is an energy rich crop producing twice as many calories per hectare as rice or wheat and also acclaimed as highly nutritious for presence of significant concentrations of vitamin-C and the amino acids in its tube. Although potatoes are traditionally used as food after baking, boiling or roasting, their commercial value is increased considerably when they are processed into edible products that appeal to consumers due to flavour, texture and appearance. Moreover, extension of potato processing industries will protect the growers from distress sale which many occur occasionally due to over production of potato. Potato processing has grown into a global industry since 1950s and is still expanding. In our country potato growers had an objective to avail high fresh weight yields of tubers but their mind set should be changed to enhance total dry matter yield with reduced reducing sugar instead of high reducing sugar with low dry matter content which generally are present in table purpose potatoes as this approach will make them compatible and competitive in global commercial potato processing industries where high dry matter content is desirable for Crisps because it is associated with an increased yield of product and lower the oil consumption.

Potato processing industry is highly developed in USA, Canada, and Europe where potato varieties have been specifically bred for processing. About 30-67% of the total potato production in the developed European countries and North America is utilized for the production of processed products like French fries and crisps. Although India is the third largest producer in the world, potato processing was at a slow pace till 1997 due to the non-availability of suitable potato varieties. In India, there are only four or five French fry industries, but even these are either working under-capacity or not producing fries meeting international standards. All the released varieties were meant for table purpose only. These varieties generally had low dry matter (17-19%) and high reducing sugars content (>250 mg/100 g fresh tuber weight.) which are undesirable traits for processing. The potato processing industries had no other alternative and were compelled to utilize these table varieties even for processing into crisps and French fries. The availability of processing quality potatoes was a major bottleneck for growth of potato processing industry in India. In total, 43 potato varieties have been released up to 2009 in India and about 12 varieties including both the table and processing varieties are in commercial cultivation. However, information regarding cultivation of processing potato cultivars is very scanty resultantly, despite huge demand for processed potato products (Rana, 2011), the state West Bengal is lagging behind in setting up of potato processing units. It is reported that desirable processing attributes (high tuber dry matter, low reducing sugar, sucrose and free amino acids) greatly varied with location (Kumar *et al.*, 2003), time of sowing (Kumar *et al.*, 2007), cultivars, time of dehaulming (Marwaha, 1998; Marwaha *et al.*, 2005) and prevailing temperature during crop season (Pandey *et al.*, 2008). Therefore, it is highly desirable to evaluate available indigenous and exotic processing cultivars at Kalyani (West Bengal, India) having lowest minimum temperature with the hypothesis that if a variety performs well here, it can be rated as most ideal for producing processing quality potatoes throughout West Bengal. In perspective of these advantages in potato production for various purposes the present investigation will attempt to identify varieties either good cooking quality or uniform tubers with good processing quality or tubers for dual purposes.

MATERIALS AND METHODS

The field experiments were conducted during Rabi season at two consecutive years (2009-2010 and 2010-2011) at seed production farm Adisaptagram, Govt of West Bengal situated in the district of Hooghly, West Bengal. The area under the experimental site comes under subtropical humid climate and is situated just south of tropic of cancer. Normally mean temperatures range from greater than 10^{o}C in December to less than 40^{o}C during April - May. The sunshine hours during

the cropping season varies generally from ten to twelve hours. Annual rainfall varies from 1200-1500 mm. The relative humidity remains as high as 95% or even more during Kharif season and 65-85% during Rabi season. The experiment was done in Randomized Block Design (RBD) with 3 replications with plot size of 2m x 2m with spacing of 25cm. Twenty three genotypes were supplied and collected from All India Co-Ordinated Project on Potatoes, Simla through the Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, and Nadia centre for the investigation. The twenty three genotypes are K. Jyoti, MS-1/4906, MS-1/1871, MS-1/3708, MS-1/4053, K. Sadabahar, K. Pukhraj, K. Anand, K. Chipsona-1, K. Chipsona-2, K. Puskar, K. Khyati, G4, K22, K. Jawahar, K. Ashoka, K. Chandramukhi, K. Bahar, J-95/22, J-99/48, J-99/243, K. Surya and K. Sutlej.

The land was thoroughly ploughed, levelled subsequently and drainage cum irrigation channel was made. Standard fertilizer doses were applied during the land preparation i.e., FYM @ 20-30 tonnes/ha, N @ 120 kg/ha, P_2O_5 @80 kg/ha K_2O @ 150kg/ha. Irrigation was given in three to four different stages. First after sowing, second at 21 days after sowing and third during branching and tuber development stage. First, weeding was done at 35 days after sowing and second 45 days after sowing during the growth stages. Spraying of Thiodan @ 1.5ml/lt of water was applied 2 times during tuber initiation stage.

Data were recorded on thirteen different characters for quality traits, *viz*., gradation of tubers according to seed shape, seed size, colour, eye depth, quality of tuber flesh; tubers for table purposes through time taken for cooking, easiness of peeling of cooked tuber, softness and dryness of cooked tuber, colour of cooked tuber, protein (Lowry *et al*.,1951) and starch content (Anthron reagent); tubers for processing purposes chip colour, dry matter content, reducing sugar content in tuber (following Nelson, 1944).

RESULTS AND DISCUSSIONS

The quality traits of potato tubers were assessed by using various scales. The mean for different quality traits of thirteen cultivars for dry matter content (%), starch content, sugar content, protein content and reducing sugar content is presented in Table 1.

Dry matter is one of the most important constituents with regard to the texture of potatoes (Warren and Woodman 1974). Results showed that the highest dry matter content was obtained in K. Sutlej (20.90%) followed by G4 (19.78%), K. Chipsona-1 (19.22%) and MS-1/4906 (18.36 %) respectively. K. Sutlej had rather mealy type of cooking quality. Potatoes of this type are soft type and the surface of the potato may disintegrate to some extent. They may be rather soft in consistency and rather coarse in structure. Increase in dry matter content, increases the potato chips production efficiency and produces good chips with less fat, better taste than potatoes with less dry matter (Talburt, 1987). Therefore, the K. Sutlej may be recommended for tuber production for eating and boiling purposes and for French-fry and starch production. J-99/243 had lowest dry matter content (15.36%); its texture firmness is rather mealy type of cooking. Its surface is pale white and does not disintegrate or only to some extent. The potatoes of this genotype are rather firm, slightly humid and rather dry and must be fine to rather fine. This type is suitable for eating by boiling, mashing, as fresh and conserves potato consumption. The variety K.chipsona-2 had the highest protein content (1525 mg/100 g fresh weight) and starch content (16.41 mg/100 g fresh weight) followed by K.chipsona-1 (1495 mg/100 g fresh weight and 15.30 mg/100 g fresh weight) over other varieties and K. Jawahar had the lowest protein content (1272 mg/100 g fresh weight). The other varieties were intermediate of these two varieties. K. Ashoka (285.5 mg/100 g fresh weight) and G4 (175.50 mg/100 g fresh weight) had

the highest and lowest reducing sugar content respectively. Regarding total sugar content K. Pukhraj (535.45 mg/g) and K. Chipsona-1 (336.45 mg/g) was the highest and lowest performer respectively. The low reducing sugar content and low total sugar content was seen in the varieties K. Chipsona-1 and K. Chipsona-2 which are desirable for chip and crisp production in potato. Suitability of these two varieties for chips production purpose and crisp production are also reported by other authors (Pandey *et al*., 2009). The varieties with lower magnitude of reducing sugar content are desirable in processing industries, as it is one of the determining for production of acceptable chips or fries as being observed by Hendrickx and Vleeschouwer (2006).

The flavour of K.Chipsona-2 and K.Chipsona-1 were good to very good. They are suitable for cooking with water and steam. The medium to high color change of raw tuber flesh after 24h were observed in the varieties, J-99/48, K. Jyoti, K. Chandramukhi, MS-1/4906, K 22, J-95/227 (Table 2). Regarding cooking time for 20 minutes the variety G4 was found completely soft in respect to the rest cultivars studied (Table 2). The cultivar of K. J-95/227 showed strongly mealy type of tuber flesh after cooking of 20 min time for this trait. The genotypes J-95/227, J-99/243, K. Chipsona-1, K. Chipsona-2, K. Sadabahar, K. Anand showed rather strong texture after cooking (Table 2). Very soft to soft cooked potatoes may be used for salad purpose; rather soft structure is suitable for mashing and mealy structure for French fries. Blackening of potato after cooking was found almost negligible in MS-1/1871, MS 1/3708, K. Sadabahar, G4, K. Jawahar, J-99/48 (Table 2). Good flavour of cooked potato was presen in K. Chandramukhi, K. Khyati, K. Chipsona-1, K. Chipsona-2 and K. Sadabahar among other cultivars.

Least colour change was observed after 24hrs of peeling in K. Chipsona-1, K. Chipsona-2, K. Chandramukhi, J-95/227, J-99/243, MS-1/3708, K. Puskar, among the genotypes under the experiment (Table 4). Hassanpanah *et al*., (2011) observed lowest to medium colour change of raw tuber flesh after 24hrs among different potato varieties. Accepted chip colour and consistency were recorded in J-99/243, J-95/227, K. Chandramukhi, K. Chipsona-1, K. Chipsona-2, K. Jyoti (Table 4). The genotypes K. Chipsona-1, K. Chipsona-2, K. Chandramukhi, J-95/227, J-99/243, MS-1/3708, K. Puskar were such genotypes which were acceptable due to non blackening of cooked potatoes after 20 minutes of cooking among the cultivars studied (Table 4). Hassanpanah *et al*., (2011) observed significant variation from these quality characters potato genotypes. Increase in dry matter production increased the potato chips production efficiency and produced good chips with less fat, better taste than potatoes with less dry matter (Talburt, 1987).

Among the genotypes K. Jyoti, K. Puskar, K. Sadabahar, K. Jawahar and K. Bahar may be considered as promising one in processing and cooking purpose as it had round to short oval tubers with medium eye depth with comparatively high tuber yield (Table 6). Genotype K. Sadabahar could be considered as promising one as it had round to short oval tubers with shallow eye depth with comparatively high tuber yield for processing and cooked food and these genotypes can be favourably improved if their dry matter content can be increased like K. Khyati, MS-1/1871 J-95/227 and J-99/243 (Harris, 1978). Round shaped tuber is preferable by the consumer (Herman *et al.,* 1994**).** Harris (1978) reported that round oval tubers weighing 150-200 g as best to determine quality potato. Among the varieties studied the early maturity varieties were J-99/243, K. Khyati, K. Chipsona-1, K. Chipsona-2, K. K22, and K. Ashoka, MS-1/4906 (Table 6). These results are in conformity with the finding of Beukema and Zaag (1990), who reported that soil conditions had great effect on plant growth. Potato crop was planted in dry and less fertile soil not only produced small number of stems but also showed retarded growth and early maturity.

CONCLUSIONS

Selection or identification of promising parents for good quality parameters is one of the most important jobs to be done from this experiment. From the above experiment highest dry matter percent was obtained in K. Sutlej (20.90%) followed by K. Chipsona-1 and MS-1/4906. Therefore K. Sutlej may be recommended for tuber production for eating and boiling purposes and for French-fry and starch production. This type is suitable for eating by boiling, mashing, as fresh and conserves potato consumption. The flavour of K.Chipsona-2 and K.Chipsona-1 were good to very good. They are suitable for cooking with water and steam. The variety K.chipsona-2 had the highest protein content and starch content followed by K.chipsona-1. The low reducing sugar content and low total sugar content in the varieties were K.Chipsona-1 and K.Chipsona-2 which are desirable for chip and crisp production in potato. Among the genotypes K. Jyoti, K. Puskar, K. Sadabahar, K. Jawahar and K. Bahar may be considered as promising one in processing and cooking purpose as it had oval round tubers with medium depth eyes with comparatively high tuber yield.

From the present experiment K. Chipsona-1 and K. Chipsona-2 may be regarded as the best performer for good quality parameters, for value added products as well as for table purpose.

Table 1: Mean of Quality Traits in Twenty Three Genotypes of Potato

Genotypes	Dry Matter Content (%)	Protein Content Mg/ 100 g Fresh wt (soluble)	Starch Content Mg/ 100 g fresh wt	Reducing Sugar Content Mg/ 100 g fresh wt	Total Sugar Content Mg/gm
K.Jyoti	15.46	1421	12.10	**189.95**	441.10
MS-1/4906	**18.36**	1373	14.12	224.74	395.50
MS-1/1871	15.44	1387	13.41	185.50	415.25
MS-1/3708	16.78	1481	10.00	192.50	386.72
MS-1/4053	16.48	1411	12.11	223.50	462.30
K.Sadabahar	17.82	1395	14.50	230.15	386.50
K.Pukhraj	17.32	1461	12.45	245.25	**535.45**
K. Anand	17.90	1431	11.21	204.40	400.45
K.Chipsona-1	**19.22**	**1495**	**15.30**	**180**	**336.45**
K.Chipsona-2	18.17	**1525**	**16.41**	**192.40**	**345.20**
K.Puskar	16.72	1432	13.40	232.25	485.32
K.Khyati	16.00	1416	**9.45**	215	524.12
G4	**19.78**	1422	11.24	**175.50**	402.50
K22	17.80	1288	10.34	245.25	395.45
K.Jawahar	16.70	**1272**	10.01	255	515.12
K. Ashoka	16.74	1305	10.40	**285.50**	525.24
K.Chandramukhi	18.11	1376	13.35	275.15	497.23
K.Bahar	18.26	1477	12.13	235.45	476.45
J-95/227	16.94	1413	14.11	198.75	541.23
J-99/48	15.49	1434	11.32	210.25	486.46
J-99/243	15.36	1413	10.50	**178**	387.50
K.Surya	18.28	1463	13.15	231.5	524.50
K.Sutlej	**20.90**	1333	11.27	266.45	520.15
SEm	**0.538**	**13.377**	**0.736**	**5.392**	**8.774**
CD	**1.533**	**38.127**	**2.098**	**15.368**	**25.007**

Table 2: Assessment of Cooking Quality Characters in Twenty Three Genotypes of Potato

Genotypes	Flesh Colour Change (24 hrs)	Cooking Time 20 mins	Texture Firmness	After Cooking Blackening	Flavour	Raw Tuber Flesh Colour
K.Jyoti	**7**	2	3	4	5	White Flesh
MS-1/4906	**6**	2	3	7	6	Dull White
MS-1/1871	5	2	3	**9**	5	Dull White
MS-1/3708	4	2	3	**8**	4	Light Yellow
MS-1/4053	5	3	3	4	6	Dull White
K.Sadabahar	5	2	**2**	8	**7**	Dull White
K.Pukhraj	4	3	3	4	5	Yellow
K. Anand	4	2	**2**	7	6	White
K.Chipsona-1	5	**2**	**2**	6	**8**	Dull White
K.Chipsona-2	5	**2**	**2**	5	**8**	Dull White
K.Puskar	5	2	3	6	5	Light Yellow
K.Khyati	3	3	2	6	7	Light Yellow
G4	5	**1**	4	**9**	5	Dull White
K22	**6**	3	3	8	6	Light Yellow
K.Jawahar	3	3	2	8	3	Pale Yellow
K. Ashoka	4	3	3	6	4	Light Yellow
K.Chandramukhi	**7**	2	**2**	7	**7**	Dull White
K.Bahar	5	3	3	4	6	White
J-95/227	**6**	**4**	**2**	7	5	Dull White
J-99/48	**7**	2	3	8	3	Pale White
J-99/243	5	3	**2**	4	4	Pale White
K.Surya	4	2	3	7	4	Pale Yellow
K.Sutlej	5	2	3	4	5	White

Table 3: Using Different Scale for Assessment of Quality in Twenty Three Genotypes of Potato

Score	Colour Change of Raw Tuber after 24 Hrs	Cooking Time 20 Min	Texture Firmness	After Cooking Blackening	Flavour
1	very low	very soft	strong	severe	very poor
2	very low to low	soft	rather strong	some to severe	very poor to poor
3	low	rather soft	rather mealy	some	poor
4	low to medium	mealy	mealy	little to some	poor to moderate
5	medium to high	very mealy		some	moderate
6	medium			trace to little	moderate to good
7	high			trace	good
8	very high to high			none to trace	good to very good
9	very high			none	very good

Source: Hassanpanah, Hassanabadi and Chakherchaman, 2011

Table 4: Difference in Chips Appearance of Twenty Three Genotypes of Potato

Genotypes	Chip Colour	Consistency	Overall Acceptance
K.Jyoti	6	7	7
MS-1/4906	5	5	4
MS-1/1871	5	3	3
MS-1/3708	6	4	5
MS-1/4053	5	3	4
K.Sadabahar	5	3	5

Table 4: Cond.,			
K.Pukhraj	3	5	6
K. Anand	5	3	3
K.Chipsona-1	**7**	**8**	**9**
K.Chipsona-2	**8**	**8**	**9**
K.Puskar	**7**	6	6
K.Khyati	5	3	5
G4	1	6	3
K22	5	4	4
K.Jawahar	3	4	5
K. Ashoka	7	5	6
K.Chandramukhi	**7**	**8**	**8**
K.Bahar	5	4	5
J-95/227	**7**	7	**8**
J-99/48	7	5	6
J-99/243	**7**	7	7
K.Surya	3	3	3
K.Sutlej	6	6	4

Table 5: Using Different Scale for Quality Assessment

Scale	Colour	Consistency	Aceptibility
1	Very dark brown	Dislike very much	Non- accepted
3	Dark brown	Dislike moderately	Non- accepted
5	Brown	Dislike slightly	non -accepted
6	Pale yellow	Neither like nor dislike	Non- accepted
7	Very pale yellow	Like slightly	Accepted rather
8	Cream	Like moderately	Accepted
9	Pale cream to till white	Like very much	completely accepted

Source: Wooster and Farooq, 1995

Table 6: Difference in Tuber Appearance of Twenty Three Genotypes of Potato

Genotypes	Eyes depth	Crop maturity	Tuber shape
K.Jyoti	5	3	**1**
MS-1/4906	5	2	3
MS-1/1871	**6**	3	5
MS-1/3708	5	3	6
MS-1/4053	**6**	3	3
K.Sadabahar	**7**	3	**2**
K.Pukhraj	4	4	5
K. Anand	**7**	6	6
K.Chipsona-1	**6**	**1**	5
K.Chipsona-2	5	**2**	5
K.Puskar	**8**	3	**2**
K.Khyati	**6**	**1**	5
G4	4	2	5
K22	4	**1**	7
K.Jawahar	**6**	2	**2**
K. Ashoka	4	**2**	6
K.Chandramukhi	6	3	5
K.Bahar	5	3	**2**

J-95/227	6	3	5

Table 6: Cond.,

J-99/48	1	4	3
J-99/243	2	**1**	5
K.Surya	**7**	4	7
K.Sutlej	**7**	4	5

Table 7: Using Different Scale for Quality Assessment of Potato Cultivars

Scale	Eye depth	Crop maturity	Tuber shape
1	Very depth	Crop still green	Round
2	Very depth to deep	Starting to senescent	Round to short oval
3	Deep	Clearly senescent	Short oval
4	Deep to medium	Mostly senescent	Short oval to oval
5	Medium	Foliage completely dead	Oval
6	Medium to shallow		Oval to long oval
7	Shallow		Long oval
8	Shallow to very shallow		Long oval to very long oval
9	Very shallow		Very long oval

Source: Wooster and Farooq, 1995

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