Journal of Crop and Weed, 12(3):05-09(2016)

Genetic variability in potato for cooking quality

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Received :10.12.2016 ; Revised : 24.12.2016 ; 30.12.2016

ABSTRACT

The experiment was taken up to evaluate potato germplasm to identify genotypes being excellent for nutritional and cooking properties. Yellow colour raw tuber flesh was found to be most frequent as compared to white colour flesh and the peeled potato tubers of K.Pukhraj, K. Anand and K. Khyati had restricted colour change in flesh upon exposure to air for 24 hours. Cooked potato tubers were soft in MS-1/1871, MS-1/3708, K. Sadabahar, K.Pukhraj, K. Khyati, G-4, K. Chandramukhi, J-95/227, J-99/243, K. Surya and K. Sutlej and these genotypes can be used as culinary purposes. The mealy tubers for processing purpose were observed in K.Chipsona-1, K.Chipsona-2, MS-1/4053 and K.Anand. Textures of the cooked tubers were found superior in MS-1/4053, K. Khyati and J-99/243. The cooked tubers free from blackening were observed in K.Chipsona-2, K.Chipsona-1, K. Khyati, K-22, K. Jawahar, K. Bahar. Starch content was highest in K.Chipsona-2 followed by K.Chipsona-1 and dry matter content in K. Sutlej followed by G-4. Lowest concentration of reducing sugar was found in G-4 followed by J-99/243.

Keywords : Cooking, dry matter, potato, quality, starch

Potato is a *Rabi* season crop that grows mainly in the climate with cool temperature, bright sunlight, moderate day temperature and cool night. Quality influences consumer preference and its trade potentiality. Good quality potatoes are clean, uniform in shape and size, with unblemished skin and firm flesh and shallow eyes. Consumers select potatoes by visual characteristics such as tuber size, shape, color and skin brightness in the market. However, presently the consumers of both developed and developing countries are showing increasingly greater interest for nutrient-rich potato, having potential antidote against diseases due to malnutrition, cancers and cardiovascular problems (Andre *et al.,* 2007). Freshly harvested potato contains about 80 percent water and 20 percent dry matter and 60 to 80 percent component of dry matter is starch. On dry weight basis, the protein content of potato is similar to that of cereals and very high as compared to other root and tuber crops. Potato is low in fat and rich in several micronutrients, (Lutaladio and Castaldi, 2009); especially vitamin C when eaten with its skin. It's a good source of vitamins B_1, B_3 and B_6 and minerals. Potatoes also contain dietary antioxidants, which helps in preventing diseases related to ageing. Potato tubers also contains high concentrations of other organic compounds like protein cysteine, various organic and amino acids that stimulate the absorption of micronutrients by human, accompanied by lower concentration of compounds like phytate (0.11 to 0.27% of dry matter) and oxalate (0.03% of dry matter) that limit absorption of micronutrients, as a result of which the bioavailability of mineral elements in potatoes is potentially high (Karenlampi and White, 2009). In contrast to most vegetable crops it has high-energy value. High yield with good quality is the most important objective in potato breeding. It was evident that yield and quality cannot be improved simultaneously rather independent selection for both may be beneficial (Datta *et al.,* 2014).

There are two important classes of tuber quality: Physical and chemical or external and after-cooking quality (Storey and Davies, 1992). Physical quality aspects were determined with regard to physical characteristics like tuber size, shape and appearance of wounds and other defects, (Högy and Fangmeier 2009). Chemical quality analyses comprised of concentration of proteins, mineral elements, starch, reducing carbohydrates, organic acids, amino acids, glycoalkaloids and anions (Storey and Davies, 1992) which determine acceptance of potato for culinary purpose (Cacace *et al.,* 1994). The physical qualities of potato like tuber shape, size, colour of flesh, depth of eye, etc determine the factors to standardize cooking quality. Styszko *et al.* (2003) found positive and significant relationship between cooking quality and starch content in tubers. A potato is judged being cooked to an acceptable stage by the experience of cook or consumer or by forcing a pointed knife or fork inside cooked potato. Softening of the tubers is the result of the changes in the cell walls induced by higher temperature. The texture of cooked potato has often been associated with starch content, but Linehan and Huges (1969) observed that starch content is partially associated with texture of cooked tuber. Sterling and Bettelheim (1955), have demonstrated that there are at least two essentially independent features to determine

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texture of cooked potatoes. These are referred to as "mealiness" or "mouthfeel" and "breakdown" or "sloughing" (disintegration of potato in cooking water).

The texture of a cooked potato is directly related to dry matter content. Potatoes are described as mealy and dry if they have a high dry matter content, or moist to wet with a low dry matter. White-fieshed potatoes are expected to have a creamy white colour when boiled or baked. Yellow-fleshed varieties should retain their characteristic yellow colour during cooking. White or yellow-fleshed potatoes should exhibit minimum after-cooking darkening. This darkening, which is often more prevalent at the stem end of the tuber, is caused by an accumulation of a dark pigment created by the reaction between chlorogenic acid and iron, both naturally occurring compounds in potatoes. In the commercial potato processing industry sodium acid pyrophosphate is used to reduce darkening after cooking. Cooked potatoes are expected to have "normal" potato flavour and aroma, without off-flavours or odours. Considering the importance of potato on these aspects the present investigation was taken up to evaluate potato germplasm to identify genotypes being excellent for nutritional and cooking properties.

MATERIALS AND METHODS

The experiment was conducted at the Instructional Farm and laboratory of Dept. of Genetics and Plant Breeding, BCKV, Nadia, West Bengal. The Geographical location of instructional farm is situated at 22.87^{o}N latitude, 88.59^{o}E longitudes and 7.8 m altitude above mean sea level and the ecosystem is medium land. During the investigation period the maximum mean monthly temperature was 34.82^{o}C in the month of March and the minimum mean monthly temperature was 5.60^{o}C in the month of January. Very low rainfall occurred during the investigation period of potato but at the end time of storage there was plenty of rainfall. Twenty three potato genotypes namely 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. Khyati, K. Puskar, G4, K-22, K. Jawahar, K. Ashoka, K. Chandramukhi, K. Bahar, J-95/227, J-99/48, J-99/243, K. Surya, K. Sutlej were collected from AICRP as sent through Central Potato Research Institute (CPRI, Shimla). The experiment was laid following randomized block design with 3 replication. For cooking quality some of the characters were measured such as raw tuber flesh colour, colour change after 24 hrs, cooking type, texture firmness, blackening after cooking, starch content, reducing sugar content and dry matter.

Character attributable to quality : Color change of raw tuber flesh after 24 hour: One tuber each cultivar selected and cut longitudinally from centre of tuber. The pieces are exposed to the air for 24 h before being examined. The color change of raw tuber flesh after 24 h is assessed on a 1-9 scale.

Cooking type: The cooking type of different genotypes were assessed on the basis of 5 scale such as very soft (1), soft (2), rather soft (3), mealy (4) and very mealy (5).

Texture firmness: The firmness or softness of the cooked flesh is assessed by slowly pushing a knife down into the centre of the tuber. Texture firmness is assessed on a 1-4 scale: strong (1), rather strong (2), rather mealy (3) and mealy (4). The potato is assessed by mouth feel for dryness and noted as moist or dry. If there is variation in the sample the majority characteristic is noted.

After cooking blackening: Tubers are cooked and peeled. The color change assessed after 24 h. 1-9 assessment is used: severe (1), some to severe (2), some (3), little to some (4), some (5), trace to little (6), trace (7), none to trace and (8), none (9).

Starch content and reducing Sugar: Estimation of starch was done by anthrone reagent by Hudge and Hofreiter (1962).

Dry matter content: First of all 2-3 tubers were cleaned with water and then chipped. From that 100 g sample was taken out and kept for drying upto 9-10 days. After drying the dry matter weight was measured.

Statistical analysis: The experimental data were analyzed statistically following the method of analysis of variance for single factor (Gomez and Gomez, 1987). The significance of the calculated variance was determined by 'F' value.

RESULTS AND DISCUSION

Among the 23 genotypes, seven genotypes like K.Jyoti, MS-1/4053, K.Sadabahar, K.Ashoka, K-22, K.Chandramukhi, K.Bahar had white flesh colour of the raw tuber while rest of the genotypes had yellow flesh colour. Colour change was minimum after twenty hours of peeling in K. Khyati and K. Pukhraj and K.Anand; all these varieties originally had yellow flesh colour. While other yellow fleshed colour genotypes like MS-1/4906, MS-1/1871, MS-1/3708, K.Chipsona-1, K. Jawahar, K. Bahar, J-95/227, J-99/48 and J-99/243 showed change in flesh colour from medium to higher extent. Genotypes shows medium change in flesh colour ware K. Jyoti, MS-1/4053, K.Chipsona-2 and K-22. K. Ashoka was the only variety which showed little change in flesh colour. While K. Sadabahar, K. Pushkar, K. Chandramukhi, K.Surya and K. Sutlej showed low to medium change in flesh colour. (Table 1). Hassanpana *et al.* (2011) observed lowest to medium colour change of raw tuber flesh after 24 hours among different potato.

Genotypes K.22, K. Jawahar, K. Ashoka, J-95/227 where grades as very soft while MS-1/3708, K. Sadabahar, K. Chandramukhi, K.Pukhraj, K. Khyati, G-4, J-99/243, K. Surya and K. Sutlej were graded soft and these could be used for salad purpose. Boiled potatoes were found to be rather soft in Ms-1/4906, K. Bahar and J-99/48 and this are suitable for meshing purpose. Ms-1/4053, K.Anand, K.chipsona-1 and K.Chipsona-2 were identified as mealy genotypes and can be used for processing of French fries. No very mealy category was found among the 23 genotypes. The genotypes J-99/243, MS-1/4053, K. Khyati and K. Bahar were promising with respect to total production of tubers of which MS-1/4053, also accompanied by a number of superior yield related characters (Tripura *et al.* 2016).

Firmness in texture of cooked potatoes was strong in MS-1/4053, K. Anand. and rather strong in MS-1/4906.Texture firmness of cooked potatoes were rather mealy in K. Jyoti, MS-1/1871, MS-1/3708, K. Sadabahar, K. Pukhraj, K.Chipsona-1, K.Chipsona-2, K. Puskar, K. Khyati, G-4, J-95/227, J-99/48, K. Sutlej and rest of the genotypes were categorized as mealy. Gravoueille *et al.* (1992) explained the texture of cooked potato as cooking characteristic of different varieties and their utilization for different purpose. Freeman *et al.* (1992) observed variation among potato genotypes with respect to softness and dryness which is found to be variably increase with increased in length of cooking period.

After cooking blackening had been standardized in nine different grades from severe blackening to no blackening (Hassanpana *et al.* 2011). Only one genotype MS-1/4906 showed severe blackening. Some too severe blackening was found in J-99/243, K. Surya. Some blackening was found in K. Jyoti and K.Anand. Little to some blackening was evident in MS-1/3708, G4, while blackening was traced in K. Puskar and J-99/48 and blackening was almost negligible in K.Chipsona-1, K. Chipsona-2, K. Khyati, K.Pukhraj, K. Jawahar, K-22 and K. Bahar. Wang-Pruski and Nowak (2004) examined the potato after-cooking darkening (ACD) is one of the most widespread, undesirable characteristics of cultivated potato and it is caused by the oxidation of ferri-chlorogenic acid in boiled or fried potatoes.

Analysis of variance showed that significant differences between starch content tuber of the tuber, reducing sugar and dry matter content among these genotypes. Amomg the 23 genotypes, starch content in potato tuber ranged from 9.45% to 16.41% (Table 2). The highest starch content was observed in K.Chipsona-2 (16.41%), followed by K.Chipsona-1(15.29%) and K.Sadabahar and lowest starch content was shown by K. Khyati and MS-1/3708. Styszko *et al.* 2003 observed significant and positive relationship with cooking quality and starch content in tuber and varieties with high starch content also have importance in brewing industry as reported by NIVA, (2002) and Harris (1978). Reducing sugar content is comprised of total amount of glucose and fructose in potato tubers. Highest reducing sugar content was observed in K.Ashoka followed by K.Sutlej and K.Chandramukhi and lowest reducing sugar content was found in G-4. Amrein *et al.* (2003) also observed variation within potato genotypes for accumulation of reducing sugar during storage. Varieties with lower concentration of reducing sugar content are desirable in processing industries, as it is one of the determining factors for production of acceptable chips or fries as suggested by Hendricks and Vleeschouwer, (2006). Dry matter content of potato tuber ranged from 15.36 to 20.90. Highest dry matter content was observed in Sutlej followed by G4 and K.Chipsona-1 and lowest dry matter content is found in J-99/243.The increase dry matter production, increase the potato chip production efficiency and produced good chips with less fat, better taste than potatoes with less dry matter (Talburt, 1987).

It could be concluded that yellow colour raw tuber flesh was found to be most frequent as compared to white colour flesh and the peeled potato tubers of K.Pukhraj, K.Anand and K. Khyati had restricted colour change in flesh upon exposure to air for 24 hours. Cooked potato tubers were soft in MS-1/1871, MS-1/3708, K. Sadabahar, K.Pukhraj, K. Khyati, G-4, K. Chandramukhi, J-95/227, J-99/243, K. Surya and K. Sutlej and these genotypes can be used as culinary purposes. The mealy tubers for processing purpose were observed in K.Chipsona-1, K.Chipsona-2, MS-1/4053 and K.Anand. Textures of the cooked tubers were found superior in MS-1/4053, K. Khyati and J-99/243. The cooked tubers free from blackening were observed in K.Chipsona-2, K.Chipsona-1, K. Khyati, K-22, K. Jawahar, K. Bahar. Starch content was highest in K.Chipsona-2 followed by K.Chipsona-1 and dry matter content in K. Sutlej followed by G-4. Lowest concentration of reducing sugar was found in G-4 followed by J-99/243.

Table 1: Cooking quality of potato genotypes

Genotype	Raw tuber flesh colour	Colour change raw tuber after 24 hrs	Cooking type (20 min after boiling)	Texture firmness	After cooking blackening
K.Jyoti	White	6 (medium)	4 (Mealy)	3 (rather mealy)	3 (some)
MS-1/4906	Yellow	5 (medium to high)	3 (Rather soft)	2 (rather strong)	1 (severe)
MS-1/1871	yellow	5 (medium to high)	2 (Soft)	3 (rather mealy)	5 (some)
MS-1/3708	yellow	5 (medium to high)	2 (Soft)	3 (rather mealy)	4 (little to some)
MS-1/4053	white	6 (medium)	4 (Mealy)	1 (strong)	6 (trace to little)
K.Sadabahar	white	4 (low to medium)	2 (Soft)	3 (rather mealy)	6 (trace to little)
K.Pukhraj	yellow	2 (very low to low)	2 (Soft)	3 (rather mealy)	9 (none)
K.Anand	yellow	2 (very low to low)	4 (Mealy)	1 (strong)	3 (some)
K.Chipsona-1	yellow	5 (medium to high)	4 (Mealy)	3 (rather mealy)	8 (none to trace)
K.Chipsona-2	yellow	6 (medium)	4 (Mealy)	3 (rather mealy)	9 (none)
K.Puskar	yellow	4 (low to medium)	1 (Very Soft)	3 (rather mealy)	7 (trace)
K.Khyati	yellow	2 (very low to low)	2 (Soft)	3 (rather mealy)	9 (none)
G4	white	5 (medium to high)	2 (Soft)	3 (rather mealy)	4 (little to some)
K22	yellow	6 (medium)	1 (Very Soft)	4 (mealy)	8 (none to trace)
K.Jawahar	yellow	5 (medium to high)	1 (Very Soft)	4 (mealy)	9 (none)
K.Ashoka	yellow	3 (low)	1 (Very Soft)	4 (mealy)	6 (trace to little)
K.Chandramukhi	White	4 (low to medium)	2 (Soft)	4 (mealy)	5 (some)
K.Bahar	White	5 (medium to high)	3 (Rather soft)	4 (mealy)	9 (none)
J-95/227	yellow	5 (medium to high)	1 (Very Soft)	3 (rather mealy)	5 (some)
J-99/48	yellow	5 (medium to high)	3 (Rather soft)	3 (rather mealy)	7 (trace)
J-99/243	yellow	5 (medium to high)	2 (Soft)	4 (mealy)	2 (some to severe)
K.Surya	yellow	4 (low to medium)	2 (Soft)	2 (rather strong)	2 (some to severe)
K.Sutlej	yellow	4 (low to medium)	2 (Soft)	3(rather) mealy	5 (some)

Table 2: Quality parameters of potato genotypes

Genotype	Starch content (%)	Reducing sugar content (mg 100g^{-1})	Dry matter content (%)
K.Jyoti	12.10^{gh}	189.95^{m}	15.46^{ij}
MS-1/4906	14.12^{cd}	224.73^{h}	18.36^{cd}
MS-1/1871	13.40^{de}	185.50^{n}	15.44^{ij}
MS-1/3708	9.99^{kl}	192.50^{m}	16.78^{e-j}
MS-1/4053	12.11^{gh}	223.50^{h}	16.48^{g-j}
K.Sadabahar	14.49^{bc}	230.15^{j}	17.82^{c-g}
K.Pukhraj	12.45^{fg}	245.25^{e}	17.32^{d-h}
K.Anand	11.21^{hij}	204.39^{k}	17.90^{c-g}
K.Chipsona-1	15.29^{b}	179.99^{o}	19.22^{bc}
K.Chipsona-2	16.41^{a}	192.39^{m}	18.17^{e-f}
K.Puskar	13.40^{de}	232.24^{fg}	16.72^{e-j}
K.Khyati	9.45^{l}	214.99^{i}	16.00^{j-j}
G4	11.24^{hij}	175.50^{p}	19.78^{ab}
K-22	10.34^{jkl}	245.25^{e}	17.80^{c-g}
K.Jawahar	10.00^{kl}	254.99^{d}	16.70^{f-j}
K.Ashoka	10.40^{ijk}	285.50^{a}	16.74^{e-j}
K.Chandramukhi	13.35^{de}	275.14^{b}	18.11^{c-f}
K.Bahar	12.13^{gh}	235.45^{f}	18.26^{c-f}
J-95/227	14.10^{cd}	198.74^{l}	16.94^{d-i}
J-99/48	11.31^{hi}	210.25^{j}	15.49^{ij}
J-99/243	10.49^{ijk}	178.00^{op}	15.36^{j}
K.Surya	13.15^{ef}	231.49^{fg}	18.28^{cde}
K.Sutlej	11.27^{hi}	266.45^{c}	20.90^{a}

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