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Evaluation of processing type of potato (*Solanum tuberosum* L.) for yield and quality attributes

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Abstract
The present experiment was carried out for the evaluation of processing type of potato (*Solanum tuberosum* L.) for yield and quality attributes among 12 potato genotypes with respect to morphological and physiological traits and the association of different characters with process grade tuber yield. The genotype AICRP P-24 (MP/6-39) (74.70 cm) recorded the highest plant height. AICRP P-58 (4.40) recorded the maximum shoots/plant while Kufri Frysona (394000/ha) recorded the maximum numbers of Process grade tuber. Genotype Kufri Frysona (17.2 t/ha) estimated the maximum process grade tuber yield and AICRP P-25 (HT/7-620) (478) recorded the maximum tuber yield. Genotype AICRP P-25 (HT/7-620) (20.71 t/ha) recorded the maximum total tuber yield beside the quantitative analysis, Kufri Chipsona-3 (21.46 mg/100g) recorded maximum ascorbic acid while the maximum starch content was found in the Atlantic (16.41%),the genotype AICRP P-60 (Sagitta) (1.122) recorded maximum specific gravity, AICRP P-25 (HT/7-620) (132mg/100g) having the maximum reducing sugar, genotype Kufri Chipsona 1 (17.54 mg/kg) recorded maximum Zinc content in tuber, The genotype AICRP P-58 (455.5 mg/100g) recorded maximum Potassium content in tuber, genotype AICRP P-58 (63.47 mg/100g) recorded maximum Potassium content in tuber, Genotype Kufri Frysona (22.13%) recorded the maximum Dry matter %. Perusal of the data from the experiment with 12 genotypes it was found that the genotype AICRP P-25 (HT/7-620), Kufri Frysona and AICRP P-58 were identified as best genotypes for yield and yield attributing traits and also for processing.

Keywords: *Solanum tuberosum* L., DAP, morphological, physiological

Introduction
Potato (*Solanum tuberosum* L.) belonging to family Solanaceae (2n=4x=48) is originated in South America was introduced to India in 17th century by Portuguese. Potato is popularly known as “King of Vegetables" is grown in nearly 150 countries in the world. Potato is the 4th important food crop in the world after wheat, rice and maize. It is a short duration crop which produces large amount of dry matter, protein, starch and energy. It is used for both table and processed forms nearly all over the world. India is the second largest producer of the potato after China. In India potato is cultivated in 2.2 million hectare area with production of 51.33 MT (FAOSTAT, 2020). In the world potato is cultivated in 19.302 million hectares with the production of 359 million tons (FAOSTAT, 2020). Potato has very high biological and nutritive value. It provides protection against colon cancer, lower plasma cholesterol and triglyceride concentration, improves glucose tolerance and insulin sensitivity and reduces fat storage. Varieties, soil, ecology, crop management, cultivation practices and storage condition affect their tuber quality and quantity (Karenlampi and White, 2009) [11]. Potato is having diversified use as vegetable, processed food, livestock feed and raw material for many industrial products. Potato is a wholesome food and produces more food per unit time and area and has high nutritional value to sustain burgeoning population. It is one of the most popular vegetables, which is available throughout the year in vegetable market due to its long-term storability. Now-a-days, many dehydrated products like chips, French fries, flakes, slices, potato crisps, used in starch industry, alcohol industry etc. are prepared from potato. Potato is an excellent source of vitamins, minerals and nutrients which is very easy to digest. Gopalan *et al.*, (1972) [9] found that potato contains 79.3% of water, carbohydrates (22.6 g), proteins (1.6 g), calcium (10 mg), minerals (0.60 g), carotene (24 mg), iron (0.70 mg), fibre (0.40 g), phosphorus (40 mg), thiamine (0.10 mg), riboflavin (0.01mg), niacin (1.20 mg), Vitamin-C (17 mg) with little quantity of fat (0.1 g) from one hundred gram of fresh potato tubers. It is also an excellent source of lysine and also 20 minerals which are very important for the

nutritional point of view and includes phosphorus, potassium, iron, calcium and magnesium and some other phytochemicals (Burlingame *et al*., 2009) [6].

All the cultivated varieties are not suitable for processing purposes. Dry matter and reducing sugar are two important components that determine the quality of processed potato products. Higher content of reducing sugar in processing potatoes results in the brown colouration of fried products. Processing type of potatoes should have dry matter in the range of 21-23% and reducing sugar of less than 150 mg per 100 g of fresh weight of tubers. The demand for processed potato products like chips, french fries, flakes, etc. are increasing continuously in the present liberalized economy mainly due to improved living standard, increased urbanization, preference for fast foods, rise in per capita income, increase in the number of working women preferring ready cooked food and expanding tourist trade. To increase the supply of processing-grade potatoes for the industry, ICAR- Central Potato Research Institute (CPRI) in India is constantly working to develop new cultivars. In 2005, 'Kufri Chipsona-3' was released, which had a higher tuber yield and better processing quality than the previously released processing cultivars 'Kufri Chipsona-1' and 'Kufri Chipsona-2'. According to trials conducted across the India, these processing cultivars provide greater yields (>30t/ha), have higher dry matter content (21– 24%), lower reducing sugar content (0.1%). Dry matter content, specific gravity and reducing sugar concentration (glucose and fructose) are all well-known quality characteristics for potatoes. Tuber dry matter is the most essential feature since it determines product recovery and oil content in chips. Tuber maturity, growth conditions, water and nutrient uptake were the additional elements that influenced potato tuber dry matter and reducing sugars. Kufri Jyoti, Kufri Chandramukhi, Kufri Lauvkar, Kufri Chipsona-1, Kufri Chipsona-2, Kufri Chipsona-3, Kufri Chipsona-4, Kufri Frysona and Kufri Himsona are some of the processing varieties which were released by CPRI and meet the morphological and biochemical requirement for processing. The good quality processing potatoes can be grown in the states of Bihar, West Bengal and Assam which can supply suitable raw material to the industries located in the Eastern states (Marwaha *et al*., 2007a, 2007c) [13, 14].

There is a huge scope of processing of potato in India. Processed value-added products have the huge market demand with enhanced market value as compared to fresh potatoes used for table purpose which can improve the income of the farmer and uplift the living standard and can will an important milestone in the endeavor of doubling the farmer's income. There is huge potential for the development of the processing industry for potato processing in India for internal consumption and also for export.

Materials and Methods

The present investigation was carried out at the Research Farm of All India Coordinated Research Project on Potato, OUAT, Bhubaneswar during rabi, 2021-2022 (from November 2021 to March 2022). The experiment was carried out in randomized complete block design with four replications. The mean temperature during the crop growth period was 15.01-35.65°C; with an average rainfall of 35mm. Data were recorded for nine qualitative and nine quantitative characters. Plant characters like height and number of shoots per plant of five tagged plants was measured from the base of the plant and their mean values were calculated for analysis. After that at the time of final harvest number of tubers and number of processed grade tubers per hectare was calculated. At the time of final harvest, the tubers were graded into big (>75g), medium (25-75g) and small sized (0-25g) in each treatment. Then the total number of tubers and number of tubers in three different grades per plot were counted and recorded and then total number of big tubers was calculated. As per procedure described by Birhman *et al*. (1998) [5] to determine the tuber dry matter content 100 g of tuber tissues were chopped and dried at 105℃ for 48 hours to ensure complete drying. Electric balance was used to weigh the dried matter. Total weight of healthy tubers produced from each plot was recorded at 90 DAP and their mean was recorded and then yield/ha was calculated. The ascorbic acid content of potato tubers has been determined by the method described by Rangananan (1985) [18]. Phosphorous was calculated by Digestion with di acid (HNO3: HClO4: 3:2) followed by spectrophotometric determination and Potassium and zinc by Di acid digestion followed by Flame photometric determination.

Results and Discussion

Significantly wide variation was observed for plant height from 46.95 cm to 74.70 cm, with an average of 63.54 cm. The genotype AICRP P-24 (MP/6-39) (74.70 cm) recorded the highest plant height followed by Kufri Frysona (73.00 cm), the lowest plant height was observed in Atlantic (47.00 cm) followed by AICRP P-60 (Sagitta) (52.00 cm). Genotypes such as AICRP P-24 (MP/6-39) (74.70 cm), Kufri Frysona (73.00 cm) and AICRP P-58 (69.70 cm) were found at par for this character. Number of shoots/plant ranged between 3.30 to 4.40 with a mean of 3.80. The genotype AICRP P-58 (4.40) recorded the maximum shoots/plant. The lowest shoots/plant was observed in AICRP P-24 (MP/6-39) (3.30). Genotypes such as AICRP P-58 (4.40), AICRP P-4 (Kufri FryoM) (4.20), Chipsona-3 (4.10), Kufri Jyoti (4.00) and AICRP PH-3 (Kufri Chipsona-4) (3.90) were found at par for this character. Foliage senescence at 75 days after planting ranges between 3.80-83.80% with a mean of 25.78%. The genotype AICRP P-60 (Sagitta) (83.80%) recorded the maximum Foliage senescence at 75 days after planting. The lowest Foliage senescence at 75 days after planting was observed in AICRP P-4 (Kufri FryoM) and AICRP P-24 (MP/6-39) (3.80%) followed by Kufri Chipsona-3 and Kufri Frysona (8.50%), Kufri Jyoti (9.30%), Kufri Surya (9.8%), AICRP PH-3 (Kufri Chipsona-4) (13.80%). number of processing grade tuber ranged between 295.5-393.98 with a mean of 347.43. The genotype Kufri Frysona (394) recorded the maximum numbers of process grade tuber followed by Kufri Chipsona-1 (387), AICRP P-4 (Kufri FryoM) (375.4). The lowest number of process grade tuber was observed in Atlantic (295.5) followed by AICRP P-60 (Sagitta) (296.4), AICRP PH-3 (Kufri Chipsona-4 (296.9). Genotype Kufri Frysona (394) was found at par for this character. Process grade tuber yield (t/ha) ranges between 12.8-17.2 t/ha with a mean of 15.09 t/ha.

Table 1: Mean performance for quantitative traits in 12 genotypes of processing type potato

Sl. No.	Genotypes	Plant height (cm)	Shoots per plant	Foliage senescence at 75 DAP (%)	Foliage senescence at 90 DAP (%)	Process grade tuber (No.s/ha) (000/ha)	Process grade tuber yield (t/ha)	Total tuber yield (No.s/ha) (000/ha)	Peel in %of boiled whole tuber	Total tuber yield (t/ha)
1	AICRP P-58	69.7	4.4	46.0	90.3	353.9	15.3	439.2	1.535	19.05
2	AICRP P-4 (Kufri FryoM)	61.5	4.2	3.8	37.0	375.4	16.3	423.0	1.577	18.32
3	AICRP P-24 (MP/6-39)	74.7	3.3	3.8	17.0	359.9	15.6	421.1	1.133	18.24
4	AICRP PH-3 (Kufri Chipsona-4)	68.0	3.9	13.8	63.0	296.9	12.9	339.2	1.378	14.68
5	Atlantic	47.0	3.4	50.0	98.5	295.5	12.8	327.0	1.364	14.23
6	Kufri Chipsona-1	64.7	3.7	35.3	51.3	387.0	16.7	426.3	1.953	18.49
7	Kufri Chipsona-3	64.6	4.1	8.5	51.3	355.0	15.4	427.7	1.597	18.57
8	Kufri Frysona	73.0	3.5	8.5	37.3	394.0	17.2	473.9	1.537	20.67
9	AICRP P-60 (Sagitta)	52.0	3.8	83.8	100.0	296.4	12.9	311.4	1.343	13.54
10	AICRP P-25 (HT/7-620)	62.3	3.6	36.8	100.0	359.6	15.6	478.0	0.985	20.71
11	Kufri Surya	63.2	3.7	9.8	61.3	346.9	15.1	421.0	1.282	18.19
12	Kufri Jyoti	62.1	4.0	9.3	52.8	348.7	15.2	424.9	1.294	18.39
13	Mean	63.54	3.78	25.76	63.29	347.43	15.09	409.39	1.410	17.76
14	Minimum	46.95	3.330	3.750	17.000	295.530	12.820	311.4	0.9846	13.540
15	Maximum	74.70	4.400	83.750	100.000	393.980	17.240	478.0	1.953	20.710
16	CV (%)	6.716	11.794	10.259	3.06	0.658	0.175	0.489	0.927	0.144
17	SE(+m)	2.134	0.223	1.321	0.968	1.143	0.013	1	0.007	0.013
18	CD at 5%	6.166	0.644	3.818	2.798	3.302	0.038	2.89	0.019	0.037

Table 2: Mean performance for qualitative traits in 12 genotypes of processing type potato

Sl. No.	Genotypes	Ascorbic acid (mg/100g)	Starch content (%)	Specific gravity	Reducing sugar content (mg/100g)	Zn content in (mg/kg)	K content in tuber (mg/100g)	P content in tuber (mg/100g)	Dry matter % at 75 DAP (%)	Dry matter % at 90 DAP (%)
1	AICRP P-58	16.36	13.74	1.086	106.25	15.69	455.50	63.47	19.86	20.78
2	AICRP P-4 (Kufri FryoM)	18.49	13.90	1.069	84.00	16.34	364.42	41.24	20.21	21.09
3	AICRP P-24 (MP/6-39)	15.96	14.58	1.072	103.25	16.87	413.70	45.65	19.24	20.75
4	AICRP PH-3 (Kufri Chipsona- 4)	18.49	13.25	1.056	129.25	16.58	402.30	51.34	21.49	22.20
5	Atlantic	13.57	16.41	1.065	80.25	17.12	422.85	47.08	20.39	21.52
6	Kufri Chipsona-1	15.81	13.45	1.052	69.25	17.54	387.51	43.58	21.56	22.11
7	Kufri Chipsona-3	21.46	13.63	1.05	57.25	16.40	406.47	53.14	21.59	22.22
8	Kufri Frysona	12.71	15.21	1.051	41.25	14.51	394.34	54.85	22.13	22.40
9	AICRP P-60 (Sagitta)	16.52	12.57	1.122	95.25	16.36	407.45	45.26	19.29	21.42
10	AICRP P-25 (HT/7-620)	14.89	13.62	1.054	132.00	15.49	397.62	47.60	17.49	19.79
11	Kufri Surya	21.46	13.92	1.046	104.75	14.99	388.57	48.74	19.82	20.69
12	Kufri Jyoti	15.61	13.02	1.058	128.50	17.03	375.47	50.15	18.40	19.68
13	Mean	16.78	13.94	1.07	94.27	16.24	401.35	49.34	20.12	21.22
14	Minimum	12.71	12.57	1.05	41.25	14.51	364.42	41.24	17.49	19.68
15	Maximum	21.46	16.41	1.12	132.00	17.54	455.50	63.47	22.13	22.40
16	CV (%)	4.71	0.41	2.32	10.37	0.13	1.17	2.94	0.19	0.07
17	SE(+m)	0.40	0.03	0.01	4.57	0.01	2.36	0.72	0.02	0.01
18	CD at 5%	1.14	0.08	0.04	13.19	0.03	6.81	2.09	0.06	0.02

The genotype Kufri Frysona (17.2 t/ha) recorded the maximum process grade tuber yield followed by Kufri Chipsona-1 (16.7 t/ha), AICRP P-4 (Kufri FryoM) (16.3 t/ha). The lowest process grade tuber yield was observed in Atlantic

(12.8 t/ha) followed by AICRP P-60 (Sagitta) and AICRP PH-3 (Kufri Chipsona-4) (12.9 t/ha).

Peel in % of boiled whole tuber ranges between 0.985-1.953% with a mean of 1.415%. The genotype Kufri Chipsona-1 (1.953%) recorded the maximum Peel in % of boiled whole tuber and the lowest Peel in % of boiled whole tuber was observed in AICRP P-25 (HT/7- 620) (0.985%) followed by AICRP P-24 (MP/6-39) (1.133%), Kufri Surya (1.282%). Total tuber yield ranges between 13.54-20.71t/ha with a mean of 17.76 t/ha. The genotype AICRP P-25 (HT/7-620) (20.71 t/ha) recorded the maximum total tuber yield and the lowest tuber yield was observed in AICRP P-60 (Sagitta) (13.54 t/ha) followed by Atlantic (14.23 t/ha). Ascorbic acid among potato genotypes ranges between 12.71-21.46 mg/100g with a mean of 16.78 mg/100g. Genotype Kufri Chipsona-3 (21.46 mg/100g) recorded maximum ascorbic acid and lowest was observed in Kufri Frysona (12.71 mg/100g). Similar results on ascorbic acid also reported by Luthra *et al*. (2018) [12]. Starch content ranges between 12.57-16.41% with a mean of 13.942%. Genotype Atlantic (16.41%) recorded the maximum starch content followed by Kufri Frysona (15.21%) and lowest Starch content was observed in AICRP P-60 (Sagitta) (12.57%). Similar results were also found by Ali *et al*. (2020) [4], Choi *et al*. (2020), Aggarwal *et al*. (2017) [3], Abbasi *et al*. (2011) [1], Ekin (2011) [7]. Specific gravity ranges between 1.046-1.122 with a mean of 1.065. The genotype AICRP P-60 (Sagitta) (1.122) recorded maximum specific gravity followed by AICRP P- 58 (1.086). and the lowest specific gravity was observed in Kufri Surya (1.046) followed by Kufri Chipsona-3 (1.05). similar results were reported by the Ali *et al*. (2020) [4], Solaiman *et al*. (2015) [20], Abbasi *et al*. (2011) [1], Ekin (2011) [7], Abong *et al*. (2009) [2] and Minhas *et al*. (2006) [15]. AICRP P-25 (HT/7-620) (132mg/100g) have the maximum reducing sugar. Similar results were found by Luthra *et al*. (2018) [12], Singh *et al*. (2009) [19], Pandey *et al*. (2005) [17] and Marwaha *et al*. (1999). The maximum zinc content in tuber was found in the genotype Kufri Chipsona-1 (17.54 mg/kg) and lowest zinc content in tuber was observed in Kufri Frysona (14.51 mg/kg). Similar results were found by the Ekin (2011) [7] and Burgos *et al*. (2007). Potassium content in tuber ranges between 364.42-455.5 mg/100g with a mean of 401.35 mg/100g. The genotype AICRP P-58 (455.5 mg/100g) recorded maximum Potassium content in tuber and the lowest Potassium content in tuber were observed in AICRP P-4 (Kufri FryoM) (364.42 mg/100g). Similar results were found by Ngobese *et al*. (2017) [16] and Abbasi *et al*. (2011) [1]. Phosphorus content in tuber ranges between 41.24-63.47 mg/100g with a mean of (49.34 mg/100g). The genotype AICRP P-58 (63.47 mg/100g) recorded maximum phosphorus content in tuber followed by Kufri Frysona (54.85 mg/100g). The lowest phosphorus content in tuber was observed in AICRP P-4 (Kufri FryoM) (41.24 mg/100g). Similar results were also observed by the Ngobese *et al.* (2017) [16] and Abbasi *et al*. (2011) [1]. Dry matter % at 90 DAP ranges between 19.68-22.40% with a mean of 21.22%. Genotype Kufri Frysona (22.40%) recorded maximum Dry matter % and the lowest dry matter % was observed in Kufri Jyoti (19.68%). Similar results were reported by the Ali *et al*. (2020) [4], Luthra *et al*. (2018) [12], Gupta *et al*. (2015), Solaiman *et al*. (2015) [20], Abong *et al*. (2009) [2] Singh *et al*. (2009) [19].

Conclusion

Perusal of the data from the experiment with 12 genotypes it was found that the genotype AICRP P-25 (HT/7-620), Kufri Frysona and AICRP P-58 were identified as best genotypes for yield and yield attributing traits and also for processing. The genotype Kufri Frysona (22.13%) recorded the maximum dry matter % followed by Kufri Chipsona-3 (21.59%), Kufri Chipsona-1 (21.56%) and lowest dry matter % was observed in AICRP P-25 (HT/7-620) (17.49%). Highest phosphorus content in tuber was found in the genotype AICRP P-58(63.47 mg/100g). Genotype AICRP P-58 (455.5 mg/100g) recorded the maximum potassium content in tuber followed by Atlantic (422.85 mg/100g), AICRP P-24 (MP/6-39) (413.7 mg/100g) and lowest potassium content in tuber was observed in AICRPP-4 (Kufri FryoM) (364.42 mg/100g). Regarding biochemical parameters the genotype Kufri Chipsona-3 (21.46mg/100g) recorded the maximum ascorbic acid. Significantly maximum tuber yield was recorded in genotype AICRP P-25 (HT/7-620) (20.71 t/ha). Significantly maximum processed grade tuber yield was recorded in genotype Kufri Frysona (17.2 t/ha).

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