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Evaluation of Cooking Quality Characteristics of Advanced Clones and Potato Cultivars

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ABSTRACT

For determination of cooking quality characteristics of advanced clones and potato cultivars, this experiment was conducted to determine the quality characteristics on the three advanced clones (397009-3, 397082-2 and 396156-6) and three potato cultivars (Agria, Marfona and Savalan) under *in vitro* condition in Ardabil, Iran in 2009. Experimental design was completely randomized with three replications. In the study some of characters were measured such as dry matter and starch percent, specific gravity, french-fry and chips color and quality, cooking type, texture firmness and flavor. Analysis of variance showed that significant differences between cultivars and clones for tuber yield, dry matter and starch percent, specific gravity, french-fry and chips color and quality and reducing sugars amount. The 397082-2, 396156-6, 397009-3 clones and Savalan cultivar had the highest yield. The highest dry matter, starch and specific gravity belonged to 396156-6 and 397009-3 clones and Savalan cultivar. These cultivars had C cooking type. Therefore, the 396156-6 clone and Savalan cultivar are recommended for chips production, 397009-3 clone for french-fry, chips and starch production. The Marfona cultivar had a lower dry matter and B cooking type. Potatoes of this type are suitable for eating boiled, mashing and fresh and conserve potato consumption.

Key words: Chips, dry matter, texture, flavor, cooking, potato

INTRODUCTION

Potato (*Solanum tuberosum* L.) is grown and eaten in greater countries more than some other crops (Stephen, 1999). It is a crop that grows mainly in climates with cool temperate with full sunlight, moderate daily temperatures and cool nights. Short days generally induce tubers in potatoes, although many modern cultivars can initiate tuberization in the long days of north regions temperate (Tarn *et al*., 1992). Among the most important crops in the world (Fernie and Willmitzer, 2001) and Iran (FAO, 2008), potato is ranked in fourth grade in annual production after the cereal species rice, wheat and barley. Iran is the world's 12th potato producer and the third biggest producer in Asia, after China and India's mentioned above (FAO, 2008).

More potatoes are being consumed after processing. Although, there are more than one hundred cultivars in the USA and Canada, only some cultivars are suitable for processing. Processed potatoes may be consumed as chips, french-fry or utilized for producing of starch and alcohol. Product efficiency depends on fresh potato quality (Harris, 1978; Marangoni and Yada,

1994). Potato cultivars have differences in tuber yield capacity, tuber appearance and resistance to pests and diseases, baking quality, maturity and storage characteristics and chemical composition. Some desirable attributes for potato tubers are high storage capacity, mid size, good shape, adequate color, no scars or cracking, smooth eyes and a smooth skin (Fallahi, 1997; NIVA, 2002).

Until 1984, the most breeding work on potatoes was concerned primarily with increasing yield, resistance to diseases, pests and environmental stresses (Marangoni and Yada, 1994). However, since then, research has focused on fresh consumption and processing tuber quality. The most important quality attributes are tuber shape and size, injury and diseases, dry matter and starch content and reduced sugars. In most cases, the best size and shape for a good quality tuber is round-oval and 150-200 g (Harris, 1978; NIVA, 2002). Long oval shaped tubers with more than 50 mm are required for French-fry production and round tubers between 40-60 mm are required for chips production (Beukema and van Der Zaag, 1990; Burton, 1989; NIVA, 2002). Dry matter percent varies between 13.1 to 36.8% (mean = 24%) and its amounts is important for quality. If dry matter be low, chips will be soft and extra energy needs for reduction of water content. However, if the dry matter content be too high, the french-fry will be too hard and chips will be too brittle. Dry matter percent also affects oil consumption. Dry matter must be 20-24% for french-fry, 22-24% for chips and more than 21% for flake industry (NIVA, 2002).

Color is one of the most important criteria in chips quality. High sugars are not suitable for frying because it makes the chips colorless. The sugars reducing rate determines the color of products. This rate must be no more than 0.3% of the fresh weight. For french-fry production, the standard is less than 0.5% of the fresh weight. For flake and granule to use in snack production, the reducing sugar content should not be exceeding 0.3% of the fresh weight. Increasing sugars reducing will lead to dark and brackish chips. For producing alcohol, high starch content is necessary (NIVA, 2002; Harris, 1978).

The objective of this study is tuber yield, dry matter percent, specific gravity, starch percent, french-fry and chips color, cooking type, texture firmness and flavors of the cultivars tubers determination.

MATERIALS AND METHODS

This experiment was conducted to determine the quality characteristics on the three advanced clones (397009-3, 397082-2 and 396156-6) with three potato cultivars as controls (Agria for French fries, Marfona for salad and mashing and Savalan for chips) under *in vitro* condition in Ardabil, Iran in 2009. Experimental design was completely randomized with three replications. In the study some of characters were measured such as dry matter percent, starch percent, specific gravity, reducing sugars, french-fry and chips color and quality, color change of raw tuber flesh after 24 h, cooking type, baking assessment (disintegration, after cooking blackening, texture firmness and flavors).

Determine qualitative characteristics

Dry matter percent: The 1.5 kg of tubers (60-80 mm diameter) were peeled and put into oven at 100°C for 48 h. After cooling, the dry matter percent was calculated (Hassanabadi and Hassanpanah, 2003).

Specific gravity: Specific gravity was measured by weighting 5 kg of tubers in air and water. It calculated by use of below equation (NIVA, 2002):

Specific gravity = a/(a-b)

where, a is weight in air and b is weight in water.

There is a relation between specific gravity, dry matter and starch percent, where the dry matter percent = 24.182+211.04×(Specific gravity-1.0988) and starch percent = 17.546+119.07×(Specific gravity-1.0988).

French-fry color: Ten tubers (60-80 mm diameter) from each cultivar were cut into 10-13 mm slices and washed in tap water for 2 min. The slices were then fried in oil at 180°C for three minutes and compared using a 1-9 scale (1 for very dark and 9 for very bright) (Hassanabadi and Hassanpanah, 2003) (Table 1).

Chips color: Ten potato tubers (60-80 mm diameter) from each cultivar were cut into 1.25 mm slices after peeling and washed in tap water for 2 min. Then they dried and fried. After 2-3 min in oil at 180°C, the color was compared using a 1-9 scale (1 for very dark and 9 for very bright) (Hassanabadi and Hassanpanah, 2003) (Table 2).

Crisps and french-fries quality: For determining of crisps and french-fries quality selected ten person for randomly. Then cultivars ranked after eating of crisps and french-fries.

Color change of raw tuber flesh after 24 h: One tubers each cultivar selected and cutted 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 (Table 3):

Cooking type: The cultivars and clones grouped for cooking type in four groups A, B, C and D (Table 4).

Table 1: Ranking french-fry color

Color	Scale	Status
Pale cream till white	9	Accepted completely
Cream	8	Accepted
Very pale yellow	7	Accepted rather
Pale yellow	6	Non accepted
Brown	5	Non accepted
Dark brown	3	Non accepted
Very dark brown	1	Non accepted

Table 2: Ranking chips color

Color	Scale	Status
Pale cream till white	9	Accepted completely
Cream	8	Accepted
Very pale yellow	7	Accepted rather
Pale yellow	6	Non accepted
Brown	5	Non accepted
Dark brown	3	Non accepted
Very dark brown	1	Non accepted

Baking assessment: Tubers are washed and baked until cooked. They are assessed while still hot by a trained panel (not less than 4 persons) in the following sequence:

Disintegration: The backed tuber is cut in half and the presence or absence of after cooking blackening is noted. 1-4 assessment is used: severer (1), moderate (2), slight (3) and none (4).

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).

Texture firmness: The firmness or softness of the cooked flesh is assessed by slowly pushing a fork 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.

Flavor: Each tuber is tasted and each person assesses potato flavor, expressed as (Table 5):

Table 3: Ranking color change of raw tuber flesh after 24 h

Color	Scale	Status
Very low	1	Accepted completely
Very low to low	2	Accepted
Low	3	Accepted
Low to medium	4	Accepted rather
Medium	5	Accepted rather
Medium to high	6	Non accepted
High	7	Non accepted
Very high to high	8	Non accepted
Very high	9	Non accepted

Table 4: Classification of cooking type

Cooking type	Suitable for	Structure	Dry matter percent
A	Salad	Very soft	<16
A	Salad	Soft	16-18
B	Mashing	Rather soft	18-20
C	French-fries	Mealy	20-22
D	Chips	Very mealy	>22

Table 5: Ranking flavor

+Scale	Status
1	Very poor
2	Very poor to poor
3	Poor
4	Poor to moderate
5	Moderate
6	Moderate to good
7	Good
8	Good to very good
9	Very good

Reducing sugars amount: Reducing sugars amount measured with 2, 4-Nitro-Phenol method. This method, first a homogeneous sample putted in 50 mL conical tube and it added 50 mL distilled and 45 sec moved strongly, then 10 min centrifuged 200 rpm. After centrifugation transferred 1 mL of front solution to the 16 cm test tube and added 2 mL 2, 4-Nitro-Phenol solution and we strongly shake for 10 sec and heated 6 min in boiling water bath. Than cooled in cold water and sample absorption measured in the 600 nm wave length with using spectrophotometers the maximum distance of 20 min. To reset to zero of Spectrophotometers used distilled water. Draw a standard curve for glucose, 1 mL glucose standard solution with concentrations of 0, 0.2, 0.5 and 1 mg mL^{-1} removed and measured as potato samples. Finally, the amount of absorption measured with using Spectrophotometers. The based on results calculated and estimated regression equation and regeneration sugar amount of potatoes (Gorji *et al.*, 2005).

RESULTS AND DISCUSSION

Analysis of variance showed that significant differences between cultivars and clones for tuber yield, dry matter and starch percent, specific gravity, french-fry and chips color and quality and reducing sugars amount.

The 397082-2, 396156-6, 397009-3 clones and Savalan cultivar had the highest yield, while the lowest yield were related to Agria and Marfona cultivars. Farmers are more interested in the cultivars produce consistent yields under their growing conditions and breeders want to meet these needs (Mulema *et al.*, 2008).

Results qualitative characteristics showed that the highest dry matter percent, starch percent and specific gravity belonged to 396156-6 and 397009-3 clones and Savalan cultivar. These cultivars had C cooking type (Table 6). Potatoes of this type are mealy and rather dry. The surface of the potato may disintegrate to some extent. They may be rather soft in consistency and rather coarse in structure. Therefore, the 396156-6 clone and Savalan cultivar are recommended for chips production, 397009-3 clone for french-fry, chips and starch production.

The Marfona cultivar had a lower dry matter and B cooking type (Table 6). Potatoes of this type are slightly mealy. Their surface is dull and does not disintegrate or only to some extent. The potatoes are rather firm, slightly humid or rather dry and must be fine to rather fine. Potatoes of this type are suitable for eating boiled, mashing, fresh and conserve potato consumption.

The Agria cultivar and 397009-3 clone had high dry matter (21.5-22 %) (Table 6). They are suitable for french-fry potato consumption. The Marfona cultivar and 397082-2 clone had moderate dry matter (19.5-21.5 %) and rather strong (Table 6). They are suitable for eating boiled, frying, mashing and fresh and conserve potato consumption. The Agria and Savalan cultivars and 396156-6 and 397009-3 clones had yellow tuber fresh and Marfona cultivar and 397082-2 clone white tuber fresh (Table 6).

Increased 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).

The flavor of Agria and Savalan cultivars and 396156-6 and 397009-3 clones were very good. They are suitable for cooking with water and steam. The lowest color change of raw tuber flesh after 24 h belonged to Marfona cultivar and other cultivars were medium (Table 6).

The highest reducing sugars belonged to Agria cultivar and 396156-6 clone and the lowest reducing sugars belonged to 397009-3 clone and Marfona cultivar. However, reducing sugars of 397009-3 clone and Marfona cultivar were lower than Agria cultivar and 396156-6 clone.

Table 6: Mean of quality traits in potato cultivars

Cultivars	Total tuber yield (t ha^{-1})	Dry matter (%)	Specific gravity	Starch percent	Flesh color	Color change of raw tuber flesh after 24 h	
Agria	37.93 c	21.53 c	1.086 b	16.02 b	Yellow	5 (Medium)	Accepted rather
Marfona	38.27 c	19.67 d	1.077 c	14.95 c	White	3 (Low)	Accepted
Savalan	57.38 a	22.52 b	1.091 b	16.62 b	Yellow	5 (Medium)	Accepted rather
396156-6	49.11 b	24.41 a	1.100 a	17.69 a	Yellow	5 (Medium)	Accepted rather
397082-2	54.84 a	21.68 c	1.087 b	16.14 b	White	5 (Medium)	Accepted rather
397009-3	49.00 b	22.04 b	1.089 b	16.38 b	Yellow	5 (Medium)	Accepted rather

			French-fry		Chips	
Cultivars	Cooking with water (scald)	Cooking with steam	Color	Quality (acceptance ability)	Color	Quality (acceptance ability)
Agria	7 (Accepted)	7 (Accepted)	7 (Very pale yellow)	Accepted rather	8 (Cream)	Accepted rather
Marfona	5 (Accepted rather)	5 (Accepted rather)	8 (Cream)	Non accepted	8 (Cream)	Non accepted
Savalan	7 (Accepted)	7 (Accepted)	7 (Very pale yellow)	Accepted rather	8 (Cream)	Accepted
396156-6	7 (Accepted)	7 (Accepted)	7 (Very pale yellow)	Accepted rather	8 (Cream)	Accepted
397082-2	3 (Non accepted)	5 (Accepted rather)	8 (Cream)	Non accepted	8 (Cream)	Non accepted
397009-3	7 (Accepted)	7 (Accepted)	8 (Cream)	Accepted	8 (Cream)	Accepted

	Baking assessment						
Cultivars	Disintegration	After cooking blackening	Texture firmness	Flavor	Reducing sugars amount (mg kg^{-1} of dry matter)	Cooking type	Suitable for
Agria	None	None to trace	Mealy	Very good	135	C (Mealy)	French-fry
Marfona	None	Trace	Rather strong	Moderate to good	90	B (Fairly firm)	Fresh consumption
Savalan	None	None to trace	Mealy	Very good	118	C (Mealy)	Chips
396156-6	None	None to trace	Mealy	Very good	130	C (Mealy)	Chips
397082-2	Moderate	Some	Rather strong	Poor to Moderate	110	B (Fairly firm)	Fresh consumption
397009-3	None	None to trace	Mealy	Very good	90	C (Mealy)	Starch, chips, french-fry

This study had not potatoes cultivars A and D type. Potatoes of A type are not mealy. Their surface is smooth and shiny transparent. They have a firm consistency. The potatoes may be above all not wet and soft and the structure must be fine. Potatoes of this type are suitable for using as potato salad and eating boiled. Potatoes of "D" type are very mealy and usually dry. The surface may disintegrate entirely and sometimes potatoes of this type may completely disintegrate be very soft in consistency and have a fibrous structure. Potatoes of this type are suitable for chips.

Hassanpanah *et al.* (2006) Picasso, Romano, Aozonia, Cosima, Draga and Ilona were selected for conserve. Agria, Aula, Herta, Aziza and Sante were selected for chips, granule and french-fry. So Kuras and Elles were suitable for the starch industry.

Since 2005, extensive studies have been done on amount of acryl-amide reduction in the food products of acryl-amide processing (Millard reaction), particularly potato chips. Effective actions were reducing of acryl-amide potential in the chips, reducing the amount of regenerative sugars. El-Ziney *et al.* (2009) reported the results of the survey study on acryl-amide levels in selected traditional foods and infant powder milk and cereal based foods obtained from the Saudi market. Also, Tawfik and El-Ziney (2008) used acryl-amide levels in selected foods in Saudi Arabia.

Potato storage conditions of the most important factors in controlling the amount of reducer sugar in potatoes. Acryl-amide reduction is factor determining in the amount of reducer sugars in the potato chips (Ohara-Takada *et al.*, 2005; Becalski *et al.*, 2004; Williams, 2005; Amrein *et al.*, 2003).

As one of the important factors determining reducer sugars is cultivars (Hendrickx and Vleeschouwer, 2005). Between the reducer sugars of potato different cultivars has been in a number of cultivar, even under conditions of climate, agriculture and the storage (Amrein *et al.*, 2003; Becalski *et al.*, 2004). The results of this study's matched with Ohara-Takada *et al.* (2005), Amrein *et al.* (2003) and Aliabadi *et al.* (2008) findings. Aliabadi *et al.* (2008) showed that the samples of reducer sugars of potato different cultivars chips were significant difference. Maximum amount of reducer sugar were in the Sante cultivar (with 3513 mg kg^{-1}) and minimum amount of reducer sugar in Agria cultivar (with 2111 mg kg^{-1}) and Savalan cultivar (with 1622 mg kg^{-1}).

CONCLUSION

The 397082-2, 396156-6, 397009-3 clones and Savalan cultivar had the highest yield. The highest dry matter, starch and specific gravity belonged to 396156-6 and 397009-3 clones and Savalan cultivar. These cultivars had "C" cooking type. Therefore, the 396156-6 clone and Savalan cultivar are recommended for chips production, 397009-3 clone for french-fry, chips and starch production. The Marfona cultivar had a lower dry matter and "B" cooking type. Potatoes of this type are suitable for eating boiled, mashing, fresh and conserve potato consumption. The reducing sugars of 397009-3 clone and Marfona cultivar were lower than Agria cultivar and 396156-6 clone.

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REFERENCES

Aliabadi, S.S., H. Nekopour, F. Kebarfard and M.M. Parsapour, 2008. Effect of potato varieties on the amount of acrylamide processing in the potato chips. J. Nutr. Food Sci., 3: 65-72.

Amrein, T., S. Bachman, A. Noti, M. Biedermann, M. Barbosa and S. Biedermann, 2003. Potential of acrylamide formation, sugars and free asparagine in potatoes: A comparison of cultivars and farming systems. J. Agric. Food Chem., 51: 5556-5560.

Becalski, A., A. Lau and D. Lewis, 2004. Acrylamide in French-fries: Influence of free amino acids and sugars. J. Agric. Food Chem., 52: 3801-3806.

Beukema, H.P. and D.E. van Der Zaag, 1990. Introduction to potato production. Am. J. Potato Res., 67: 810-810.

Burton, W.G., 1989. The potato. Potato Res., 32: 483-484.

El-Ziney, M.G., A.A. Al-Turki and M.S. Tawfik, 2009. Acrylamide status in selected traditional Saudi foods and infant milk and foods with estimation of daily exposure. Am. J. Food Technol., 4: 177-191.

Fallahi, M., 1997. Potato Knowledge and Technology. Barsava Publishing Co., Mashhad, Iran.

FAO, 2008. International year of the potato 2008. http://www.potato2008.org/.

Fernie, A.R. and L. Willmitzer, 2001. Molecular and biochemical triggers of tuber development. Plant Physiol., 127: 1459-1465.

Gorji, M.A., F. Shavakhi, D. Hassanpanah, A.M. Back, S. Hassanzadeh and K.H. Parvizi, 2005. Evaluation of qualitative and quality potato new cultivars in spring cultivation. Final Report No, 84/867 Seed and Plant Improvement Institute. Karaj. Iran.

Harris, P.M., 1978. The Potato Crop. Chapman and Hall Ltd., London, pp: 81-82.

Hassanabadi, H. and D. Hassanpanah, 2003. Ireland breeding technical course report. Seed and Plant Improvement Institute, Karaj, Iran.

Hassanpanah, D., R. Shahriari and M.B. Khorshidi, 2006. evaluation of qualitative characteristics of potato cultivars suitable for processing. Acta. Hort., 699: 213-218.

Hendrickx, E. and K. Vleeschouwer, 2005. Quantifying the formation of carcinogens during food processing acrylamide. Trends Food Sci. Tech., 16: 181-193.

Marangoni, A.G. and R.Y. Yada, 1994. Building a better potato chips. Agric. Food Res., 17: 7-11.

Mulema, J.M.K., E. Adipala, O.M. Olanya and W. Wagoire, 2008. Yield stability analysis of late blight resistant potato selections. Exp. Agric., 44: 145-155.

NIVA, 2002. On the road to potato processing. The Netherlands. http://www.potato.nl/uk/about_potatoes/agronomy/on_the_road_to_potato_processing.

Ohara-Takada, A., C. Matsuura-Endo, Y. Chuda, H. Ono and H. Yada *et al.*, 2005. Change in content of sugars and free amino acids in potato tuber under short-term storage at low temperature and the effect on acrylamide level after frying. Biosci. Biotech. Biochem., 69: 1232-1238.

Stephen, D.J., 1999. Multiple signaling pathways control tuber induction in potato. Plant Physiol., 119: 1-8.

Talburt, W.F., 1987. Potato Processing. AVI Publisher Co., USA., pp: 19-37.

Tarn, R.T., G.C.C. Tai, H. De Jong, A.M. Murphy and J.E.A. Seabrook, 1992. Breeding potatoes for long-day, temperate climates. Plant Breed. Rev., 9: 217-332.

Tawfik, M.S. and M.G. El-Ziney, 2008. Acryl-amide levels in selected foods in Saudi Arabia with reference to health-risk assessment of dietary acryl-amide intake. Am. J. Food Technol., 3: 347-353.

Williams, J.S.E., 2005. Influence of variety and processing conditions on acrylamide levels in potato crisps. Food Chem., 90: 875-881.