SUITABILITY OF POTATO VARIETIES GROWN FROM TRUE SEED AND SEED TUBERS FOR CHIPS MAKING USING A MICROWAVE OVEN

T. TAUFIQUE1,2, T.S. ROY2, R. CHAKRABORTY2, M. MOSTOFA3, B.C. KUNDU4, H.K.M. DELOWAR5 and F. NOWROZ2

1Department of Bioproduction, Faculty of Agriculture, Yamagata University, 1-23 Wakaba Machi, Tsuruoka 997-8555, Yamagata, Japan
2Department of Agronomy, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh
3Institute of Seed Technology, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh
4Tuber Crops Research Centre, Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh
5Department of Environmental Science and Technology, Jashore University of Science and Technology, Jashore-7408, Bangladesh

Corresponding author: marufsau@hotmail.com

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ABSTRACT

One of the basic concepts of microwave drying of potato (Solanum tuberosum) chips is to achieve desired chip colour and texture, within a short period. In this study, chips (1 mm thickness) of true potato seed (TPS) (‘BARI TPS-1’) and seed potato (‘Asterix’) varieties were heated for 0, 10, 20, 30, 60, 90, 120, 180 and 300 s by a microwave oven, and the changes in chips were analysed physiologically and histologically to investigate the suitability of TPS tubers as processing potato. Although potato chip crispiness of both potato varieties increased continuously throughout the heating treatment, crispiness of ‘BARI TPS-1’, increased more slowly than that of ‘Asterix’, indicating that TPS chips became less rigid and fluffy after microwave heating than that of ‘Asterix’ chips. SEM images of starch granules showed slower swelling and deformed structure in TPS than in ‘Asterix’, suggesting that TPS can retain crisp texture longer than ‘Asterix’. Although there was no substantial increase of a* and b* value in both potato chips, a lower value of L* and crispiness in TPS, suggests TPS chips lose crispiness and colour within a shorter period of microwave heating than ‘Asterix’.

Key Words: Colour, crispiness, Solanum tuberosum, TPS

RÉSUMÉ

L’un des concepts de base du séchage par micro-ondes des frites de pomme de terre (Solanum tuberosum) consiste à obtenir la couleur et la texture souhaitées, en très peu de temps. Dans cette étude, des frites (1 mm d’épaisseur) de variétés des vraies graines de pomme de terre (TPS) (‘BARI
TPS-1) et des graines de pommes de terre («Astérix») ont été chauffés pendant 0, 10, 20, 30, 60, 90, 120, 180 et 300 s par un four à micro-ondes, et les changements dans les frites ont été analysés physiologiquement et histologiquement pour examiner la pertinence des tubercules TPS en tant que le processus de transformation de pomme de terre. Bien que le croustillant de frites de pomme de terre des deux variétés de pomme de terre ait augmenté de façon continue tout au long du traitement de chauffage, celui de ‘BARI TPS-1’ a augmenté plus lentement que celui de ‘Asterix’, indiquant que les frites de TPS sont devenues moins rigides et moelleuses que les chips d’Astérix après le chauffage par micro-ondes. Les images de SEM pour les granules d’amidon ont montré un gonflement plus lent et une structure déformée dans TPS qu’à Astérix, ce qui suggère que TPS peut conserver une texture croustillante plus longtemps qu’Astérix. Bien qu’il n’y ait pas eu d’augmentation substantielle des valeurs a * et b * dans les deux croustilles, une valeur inférieure de L * et de croustillant dans TPS, suggère que les frites TPS perdent leur croustillant et leur couleur en moins de temps que «Astérix».

Mots Clés: Couleur, croustillant, Solanum tuberosum, TPS

**INTRODUCTION**

The properties and composition of potato (Solanum tuberosum) tuber affect the technological processing, yield and quality of the finished product. A large number of potato tubers is processed to make chips, french fries and similar products. An important quality requirement for these tubers is the ability to produce light-coloured, flavourful fried products that are acceptable to consumers. The textural and colour features are the major determinants for suitability of potato to chips (Mendoza et al., 2007), and can be evaluated by sensory and instrumental methodologies.

A conventional drying method involves their prolonged exposure to elevated drying temperatures, which causes substantial deterioration of such quality attributes like colour, nutrient concentration, flavour and texture of food material (Maskan, 2000; Askari et al., 2008). To prevent this quality deterioration, as well as achieve fast and effective thermal processing, a microwave application for food drying has been widely used in recent decades (Cerretani et al., 2009).

One of the most important quality attributes of potato chips is the crispy texture, which is referred as the crispiness (Salvador et al., 2009). During microwave heating, the air pressure rapidly converts the water in potato slices to steam, which expands the tissue and produces the puffy and crispy texture of the chips (Sham et al., 2001).

Another basic concept of microwave drying of potato chips was to achieve the desired chip colour. It permits a shorter drying time and a substantial improvement in the quality of dried materials. Conventional heating causes surface gelatinisation, but microwave heating disrupts the granules due to evaporation of water molecules present in the crystalline region (Karkkainen et al., 2011). Xie et al. (2013) reported heavy deformation, fracturing and collapse of potato starch granule after 20 s treating of microwave heating at 95 °C. Colour is another important attribute for potato chips.

Microwave drying has the inability to induce browning as it inhibits enzymatic action responsible for browning (Chavan and Chavan, 2010). Joshi et al. (2016) observed that potato chips of ‘Kufri Chipsona-2’ did not show any sign of enzymatic browning during the whole drying process in the microwave.

Suitable varieties with high-quality seed potatoes are essential for profitable and sustainable potato cultivation (NIVAP, 2011), as well as potato products. As a solution for long storage and low-cost transportation, True Potato Seed or the actual ‘Botanical potato seed’ (TPS) were piloted to produce good quality seeds or edible tubers. However, there are few studies on the properties of tubers
Suitability of potato varieties grown from true seed and seed tubers produced from TPS as processed potato compares to common potato. The objective of the present study was to evaluate the colour change of potato slice and histological changes of starch granule due to microwave heating at different time variation observed between seed and TPS tubers.

MATERIALS AND METHODS

Potato tubers from ‘BARI TPS-1’ (TPS) and from ‘Asterix’ (seed potato) were obtained from Bangladesh (Fig. 1). Potato samples were of 1 month (25-35 days) after harvest, and non-stored tubers. Fresh weight, volume and specific gravity of all the tubers were measured. Ten tubers per each cultivar were taken for the experiment. Each potato was sliced at 1 mm thickness using a potato slicer, and used for microwave heating.

Five to six sliced tubers were taken from each cultivar and the slices were heated in a microwave oven for 0, 10, 20, 30, 60, 90, 120, 180 and 300 s using one slice for each heating time. The weight of the potato slices was measured following the heating treatment. The potato samples were placed in the same position (center) within the microwave to ensure uniform heating on every potato slice. Tests were conducted to select the conditions required for each treatment. Potato sample weight was taken after microwave treatment.

Potato tuber slices were weighed before and after heat treatments for determination of water loss. Potato chips crispiness was also measured before and after the heat treatments using a Fource Gauge and AD equipped with a 5 mm triangle plunger.

Instrumental measurement of chip colour before and after drying was performed using a colour meter (NF333, Nippon Denshoku, Saitama, Japan) on the CIELAB scale. The colour of potatoes was measured on 30 slices, selected randomly, and was described by three coordinates in the colour space: L* (lightness), a* (redness), b* (yellowness).

Three to five sample pieces of approx 5 x 5 mm were taken from the middle portion (not central) of each treated and untreated potato slice and dipped into 5 ml FAA solution in micro tubes, and kept at ambient temperature at the laboratory of Bioproduction department, Yamagata University, Japan. Then all the sample pieces were prepared for SEM studies after coating Pt by ion coater.

Data collected were subjected to analysis of variance and the differences between cultivars was compared with student’s t-test using SPSS software.

RESULTS AND DISCUSSION

In ‘Asterix’ potato chips, the moisture loss increased from 3.54, 8.56 to 12.47% after 10, 20 and 30 s of microwave heating, respectively, and continued to increase thereafter. Moisture loss of ‘BARI TPS-1’ showed a similar tendency, but the values after 10, 20 and 30 s of microwave heating (5.58, 15.14 and 16.84%, respectively) were higher.

![Figure 1. Potato varieties used for microwave heating; BARI TPS-1 (left), Asterix (right).](image-url)
than those of ‘Asterix’ (Fig. 2). Similar increase in moisture loss in potato chips was observed by (Singh et al., 2013) (potato) and (Bai-Ngew et al., 2011) (durian chips). Chua and Chou (2005) reported that the rapid energy absorption by microwaving caused, fast evaporation of water, which results in higher rates of moisture loss. They also observed shortening of drying time by 42% of carrot chips after 60 to 120 s of microwave drying at 40°C temperature. Comparatively, the higher moisture loss percentage of ‘BARI TPS-1’ than that of ‘Asterix’ after 10, 20 and 30 s of heating, indicates higher evaporation rate in TPS (Fig. 2).

In ‘Asterix’, the crispiness increased to 24 after 10 s of heating, then gradually increased continuously thereafter. The crispiness of ‘BARI TPS-1’ also showed similar tendency, but the value (16.3) after 10 s of heating was less than that of ‘Asterix’ (Fig. 3). Therefore, crispiness of ‘Asterix’ was significantly higher than that of ‘BARI TPS-1’ during 0 to 180 s of heating. The texture of potato chips depends upon the temperature gradient, and the hardness of the tissue or cellular structure (Taiwo et al., 2001; Lewicki and Porzecka-Pawlak, 2005). Relatively lower crispiness of ‘BARI TPS-1’ chips than that of ‘Asterix’ chips (Fig. 3), indicated a higher requirement of microwave energy to penetrate the tissue during microwaving for the different time period (Yam and Lai, 2004). The changes in thickness, length and width of potato samples during drying, increases linearly with decreasing moisture content (Singh and Kaur, 2009). Rapid water loss may have directly made the deformation and damage of cells and the form of porous structure (Isik et al., 2016). This may explain the increased crispiness of ‘Asterix’ chips (Contreras et al., 2005).

Representative potato chips from each variety after microwave treatment for the different time periods (0, 10, 20, 30, 60, 90, 120, 180 and 300 s) are shown in Figs. 5 - 7. The changes in potato chips from each variety after microwave treatment are summarised in Table 1. Microwave treated potato chips

![Figure 2](image_url)

**Figure 2.** Effect of moisture loss on potato chips as influenced by microwave heating (n = 10 ± SE). * shows significant difference and n.s. shows non-significant difference at P<0.05 by student’s t-test.
Suitability of potato varieties grown from true seed and seed tubers showed crisped structure and colour change from whitish to brown colour in both varieties.

The cross-sectioned portions of representative potato chips from each variety after microwave treatments for the different time period (0, 10, 20, 30, 60, 90, 120, 180 and 300s) are shown in Figures 8 and 9. The changes in potato chip structures from each variety after microwave treatments are summarised in Table 2. ‘BARI TPS-1’ showed faster swelling and deformed structure than ‘Asterix’. Asterix’ potato chips showed visible browning earlier than TPS, after 180 s of microwaving (Fig. 7), suggesting high temperature accumulation in the sample (Bondaruk et al., 2007).

Microwave treated potato chips of both varieties showed disintegrated cell wall and shrinkage of starch granules (Figs. 8 and 9) (Liu et al., 2012). Longer microwave heating might have resulted this feature due to the increased compactness of granules, caused by the gelatinisation and retrogradation of starch (Sadeghi and Shawrang, 2008; Karkkainen et al., 2011). There was evidence of compact and dense granules in both varieties and ‘BARI TPS-1’ showed comparatively more compact structure after 90 s of microwaving (Fig. 9). This might explain the fact that starch granules of TPS may hydrate more rapidly than the local potato starch. This occurred because steam or vapour could not escape quickly enough, leading to internal pressure rise, which ruptured the starch granules and damaged the texture (Wang and Xi, 2005). Under increasing duration of microwaving, microwave energy vibrates the water molecules present in the crystalline regions of the starch granules, thereby destroying the lamellar arrangement which destroys granular surfaces (Palav and Seetharaman, 2006).

In ‘Asterix’, L* started to increase after 10 s of microwave heating, and continued thereafter in the range of 71 to 77 (Fig. 4). L* of ‘BARI TPS-1’ showed no significant changes after microwave heating, resulting in

![Figure 3. Effect of crispiness on potato chips as influenced by microwave heating (n = 10 ± SE). * shows significant difference and n.s. shows non-significant difference at P<0.05 by student’s t-test.](image-url)
Figure 4. Effect of colour indices on potato chips as influenced by microwave heating (n = 10 ± SE).
* shows significant difference and n.s. shows non-significant difference at P<0.05 by student’s t-test.
Suitability of potato varieties grown from true seed and seed tubers

Figure 5. Microwave heated potato chips for 0, 10 and 20 sec of two potato varieties.

Figure 6. Microwave heated potato chips for 30, 60 and 90 sec of two potato varieties.

Figure 7. Microwave heated potato chips for 120, 180 and 300 sec of two potato varieties.
| Variety          | Heating time (sec) | 0       | 10      | 20      | 30      | 60   | 90   | 120       | 180          | 300          |
|------------------|--------------------|---------|---------|---------|---------|------|------|-----------|--------------|--------------|
|      BARITPS-1   | Uniform sized slices | No visible colour change | Slightly dried texture at edge, whitish | Some chips are yellowish | Yellowish slices | Yellowish, dried texture | Crispness not visible | Fluffy, porous structure, less browning than Asterix | Mostly browning appeared |
| Asterix          | Uniform sized slices | No visible colour change | Whitish appearance | Whitish appearance | Dried texture at edge, whitish | Fluffy, porous structure visible | Fluffy, porous structure visible | Browning visible | Less browning than TPS |
TABLE 2. Changes of potato chip structures after microwave treatment of two potato varieties

| Variety   | Heating time (sec) |
|-----------|--------------------|
|           | 0  | 10 | 20 | 30 | 60 | 90 | 120 | 180 | 300 |
| BARI TPS-1| 0  | 10 | 20 | 30 | 60 | 90 | 120 | 180 | 300 |
| Small individual granules | Granules started to swell | Small to medium swollen granules | Cell wall ruptured, swollen, medium to large clumped granules | Cell wall ruptured, swollen, small to medium swollen granules | Swollen clustered granules | Cell wall ruptured, clumped region | Irregular, swollen granule visible | Ruptured from side, center depression, mostly deformed |
| Asterix   | 0  | 10 | 20 | 30 | 60 | 90 | 120 | 180 | 300 |
| Small individual granules | Mostly individual small granules | Mostly individual small granules | Medium to large swollen granules | Cell wall ruptured, small to medium swollen granules | Large, swollen, cell cluster | Ruptured, clumped region | Ruptured, clumped region | Gelatinised, small intercellular space |
a significant difference between the varieties during 20 to 90 s of heating. Although the b* of ‘BARI TPS-1’ did not show significant changes after microwave heating, the values decreased (20) after 120 s of heating (Fig. 4). b* of ‘Asterix’ showed the same tendency, but the value after 120 s of microwave heating was higher (25) than that of ‘BARI TPS-1’. Therefore, b* of ‘Asterix’ was significantly higher than that of ‘BARI TPS-1’ after 120 s of microwave heating. In ‘BARI TPS-1’ chips, a* reached to the highest value of 1.80 after 10 s of heating then decreased continuously thereafter (Fig. 4). a* of ‘Asterix’ after 10 s of heating was much lower (~0.04) than that of ‘BARI TPS-1’ and decreased rapidly, thereafter, resulting in a significant difference between the two varieties during 10, 20, 30 and 60 s of heating.

No substantial increase of a* and b* up to 120 s of microwaving indicates no enzymatic browning reaction occurred during heating in both varieties (Figs. 4). This can be explained by fast inactivation of enzymes due to the sharp rise in temperature of samples, and by the relatively low temperature of the samples
Suitability of potato varieties grown from true seed and seed tubers during microwaving which was not high enough to initiate the Maillard reactions (Bondaruk et al., 2007). The results also showed that a higher drying rate may cause comparatively higher lightless (L*) in Asterix’ than TPS chips (Fig. 4).

**CONCLUSION**

True Potato Seed (TPS) chips can retain the crispiness and colour longer than that of ‘Asterix’ after microwave heating. Although the crispiness and lightness were comparatively lower than seed potato ‘Asterix’, ‘BARI TPS-1’ chips have the advantage of slower Maillard reaction and longer crisp structure. Therefore, TPS potato can also be used for chip production. Although the crispiness and lightness of TPS chips was not as high as the seed potato chips, they were still acceptable as potato chips.

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