Flavouring compounds in Indian potato snacks

Pinky Raigond¹ · Brajesh Singh¹ · Akshita Dhulia¹ ·
Shelly Chopra¹ · Som Dutt¹

Revised: 18 May 2015 / Accepted: 25 May 2015 / Published online: 5 June 2015
© Association of Food Scientists & Technologists (India) 2015

Abstract Market for processed potato products is rising day by day. Flavour plays important role in decision making by consumers due to their preferences for better tasting food. In potato and potato products, glutamic acid, aspartic acid, guanosine 5'-monophosphate (GMP) and adenosine 5'-monophosphate (AMP) are the major umami compounds which contribute towards flavour. Therefore, umami 5' nucleotides (AMP+GMP) were estimated from local potato products available as common fried products in the Indian markets and processed potato products being sold by the retailers. The analysis was also carried in raw, microwaved and pressure cooked tubers of forty seven Indian potato cultivars. Umami 5' nucleotide content ranged from 2.63 (Aloo seekh) to 8.26 µg/g FW (fried lachcha) in local potato products. In processed potato products, the content ranged from 2.72 µg/g FW (Smiles) to 14.75 µg/g FW (Aloo Bhujia). Along with aloo bhujia, umami 5'

nucleotides were also high in dehydrated aloo lachcha (11.14 µg/g FW) and dehydrated potato chips (10.13 µg/g FW) and low in Smiles (2.72 µg/g FW) and Potato Shortz (3.40 µg/g FW). The study suggests that the potato products prepared solely from potato contained higher levels of umami 5' nucleotides compared to other products prepared by mixing potato with other cereals and vegetables. In Indian potato cultivars overall there was 14 % increase on microwave cooking and 31 % increase in flavouring compounds on pressure cooking. This type of study enabled in identifying better tasting cultivars for further product development and also to develop products with less addition of salt.

Keywords Potato · Potato products · Adenosine 5' monophosphate · Guanosine 5' monophosphate · Microwave cooking · Pressure cooking

Introduction

Potato is the fourth most important vegetable crop in the world and is a wholesome food. Potatoes have been utilized largely for consumption as fresh potatoes and the major part of potato harvest (approx. 68.5 %) goes to domestic table consumption in India. Whereas, in the developed countries, table potato utilization is merely 31 %, rest being frozen French fries (30 %), chips and shoestrings (12 %) and dehydrated products (12 %) (Miranda and Aguilera 2006). Due to more sophistication in eating habits of the today's consumers, high attention has been given to the quality of fried as well as dehydrated products in terms of processes involved during preparation of product, storability, taste

✉ Pinky Raigond
jariapink@gmail.com

Brajesh Singh
birju16@gmail.com

Akshita Dhulia
dhulia88@gmail.com

Shelly Chopra
shellyrtc@rediffmail.com

Som Dutt
sd_bio@yahoo.com

¹ Division of Crop Physiology, Biochemistry and Post Harvest Technology, Central Potato Research Institute, Shimla, Himachal Pradesh, India

as well as texture of the final product. Lots of potato products are available in market in large number that are ready to cook, ready to eat and heat and eat. Potatoes have potential for diversification into various products such as chips, fries, dehydrated products viz. dehydrated chips, dice or cubes, *waris*, papads, flakes, granules and flour and also in form of potato starch. With increasing popularity among all the sections of the society, potato chips alone comprise 85 % of the Rs. 2500 crore salty snack business in India. The sector is still increasing with the production of potato chips from 0.38 mt in 2006–2007 to 0.61 mt in 2010–2011 and is expected to increase further to 3.55 mt by the year 2050 (Singh et al. 2014).

People are attracted more towards fast food not only due to its good taste but also because it is inexpensive and convenient to eat. Taste of a food determines its fate and continuous purchase of same food is generally due to its good taste. Frying medium i.e., hot oil is the secret behind the quality of fried products in terms of texture and taste. Different methods of processing provide different flavour and texture to potato products which overall affect the product acceptability. Potato flavour is due to both volatile and non-volatile compounds. Major non-volatile compounds that contribute towards flavour are umami compounds. Umami is the fifth basic taste, along with sweet, saltiness, bitterness and sour. Major umami compounds are amino acids viz. glutamate and aspartate and 5' nucleotides viz. adenosine 5' monophosphate (AMP) and guanosine 5' monophosphate (GMP). Potato product flavour majorly depends upon cultivar used and processing method. Umami compounds provide a meaty and savory sensation (Del Valle et al. 2006). Flavour precursors in raw potatoes are sugars, amino acids, RNA and lipids and these compounds react to produce the Maillard reaction compounds and the sugar, lipid and RNA degradation products that contribute to final flavour of the product (Duckham et al. 2001). Among the umami compounds, glutamate and GMP are significant contributor to flavour (Yamaguchi et al. 1971). Flavour is strongly influenced by the processes involved in preparation of products as well as to some extent on storage of product also. The intensity of umami compounds is enhanced by some salts such as sodium, potassium and magnesium (Ugawa and Kurihara 1994). Food technologists are using the synergistic effect of GMP and inosine 5' monophosphate along with monosodium glutamate to prepare food products with enhanced flavour.

Umami compounds enhance or highlight the saltiness in salty foods (Marcus 2005). Concentration of 5'-ribonucleotides are higher in potato tubers compared to other plant food (Solms and Wyler 1979). As the

tubers are heated during cooking, 5'-ribonucleotides are liberated by enzymatic hydrolysis of RNA (Halpern 2000). A large number of processed potato products are available in the market. Considering the importance of potato flavour to consumers, it should be given a high priority in potato breeding programmes. However, flavour assessment in breeding programmes is a difficult task due to unavailability of high throughput reliable methodology, variable impact of flavouring compounds (volatiles as well as non-volatile) and different perception of consumers towards flavour i.e., some may like bland flavour and others may like more complex flavour profile. Most of the potato breeders are working on development of low sugar potatoes to avoid product darkening, varieties resistant to biotic and abiotic stresses and antioxidant rich potato varieties. No information is available on levels of umami compounds in local and processed potato products. Work has been done on the level of umami compounds in Indian potato cultivars, but the effect of cooking method such as pressure cooking and microwaving is not known. Therefore, the present study was initiated to determine the level of umami 5'-ribonucleotides in raw, boiled and microwave cooked potato tubers along with their detection in local and processed potato products using high performance liquid chromatography (HPLC).

Materials and methods

Sample collection and preparation

The experiments were conducted at Central Potato Research Institute, Shimla. For estimation of umami 5' nucleotides (AMP+GMP), common fried potato products available in the Indian markets i.e., local potato products and processed potato products being sold by retailers were purchased. Six local potato products viz. samosa (fried), aloo tikki, lachcha fried, lachcha whole tokri, lachcha tokri outer layer and aloo seekh and sixteen processed products viz. Chips fried, branded chips-1, branded chips-2, branded chips-3, branded chips-4, branded chips-5, potato shortz, masala fries, French fries, potato chilli bites, smiles, dehydrated chips branded, dehydrated chips, dehydrated lachcha, Aloo bhujia, Samosa (baked) were used under the study. The frozen and dehydrated products were fried before sampling.

For estimating the effect of cooking on flavour, potatoes from the crop raised at CPRIC, Modipuram, India (29° 4' N, 77° 46' E, 237 masl) using standard package of practices were used and tubers of forty seven potato

Fig. 1 Standard curve of AMP+GMP standard mixture

cultivars varying widely in keeping and processing quality were microwaved and pressure cooked as per the method described by Raigond et al. (2014a). Microwave cooking was carried out by cooking potatoes in a microwave oven for 8 min at 900 W without water. Pressure cooking was done by cooking 1 kg of intact washed and unpeeled tubers in 400 ml of water under 15 psi for 10 min. Raw and cooked tubers were sampled for estimation of flavouring compounds (AMP+GMP) using HPLC. All the samples were analyzed in triplicates.

Reagents Standards of high purity viz. AMP and GMP, perchloric acid, potassium dihydrogen phosphate, dipotassium hydrogen phosphate were procured from Sigma Chemical Co (USA). All the reagents were dissolved in deionized water (MilliQ) and filtered through 0.45 µm filter.

Extraction of 5'-nucleotides (AMP+GMP) 5'-nucleotides were extracted with the method described by Raigond

et al. (2014b). Sample (0.5 g) was rapidly frozen in liquid Nitrogen and homogenized into powder. For extraction of 5'-nucleotides, chilled 5 % perchloric acid (10 ml) was added to the powder and the sample was incubated in ice bath for 1 min. The extraction mixture was centrifuged at 4 °C for 10 min at 15,000 rpm. Supernatant (8 ml) was quickly neutralized to pH 6.5 to 6.8 with the drop wise addition of 5 mol/L potassium carbonate. Neutralized supernatant was collected after centrifugation at 15,000 rpm for 10 min. Supernatant was filtered through 0.45 µm filter and out of the filtrate, 6 ml supernatant was stored at −20 °C for HPLC analysis.

HPLC analysis

Mobile phases Mobile phase 'A' was prepared by dissolving 0.06 mol/L dipotassium hydrogen phosphate and 0.04 mol/L potassium dihydrogen phosphate in deionized water and pH adjusted to 7.0 with 0.1 mol/L potassium hydroxide. Mobile phase 'B' was 100 % acetonitrile (HPLC grade, Merck, India).

HPLC conditions A reverse phase column (125×4 mm Purospher RP-18e, Merck, Germany) was used on the LaChrom HPLC system (Merck-Hitachi Darmstadt, Germany). Isocratic system was used for estimation of AMP+GMP using Mobile phase 'A' and 'B' in the ratio of 80: 20. Flow rate of the mobile phase was 1.2 ml/ min and injection volume was 20 µl. The retention time was about 1 min for AMP + GMP. AMP + GMP concentration in the samples was identified and quantified using ESTD method and the standard curve was prepared using AMP: GMP mixture in 1:1 ratio (Fig. 1).

Fig. 2 Concentration of AMP+GMP (µg/g FW) in local and processed potato products {One way ANOVA followed by Tukey's HSD multiple-rank test was performed. Mean values that are not significantly different are represented by same letter ($P < 0.05$)}

Fig. 3 HPLC chromatogram of AMP+GMP of Aloo Seekh and Fried Samosa

Statistical analysis

All the analysis was performed in three replications using complete randomization block design (CRBD) and the data was subjected to statistical analysis. The ANOVA was performed at 5 % level of significance and the significance of means was compared using the Tukey's HSD test ($p < 0.05$). The dendrogram of flavouring compounds were analysed using XLSTAT software (XLSTAT version 2014.4.05).

Results and discussion

Flavouring compounds in potato products

Consumers have preferences for better tasting food, therefore, flavour of a food is of utmost importance. The mean AMP+GMP content were 5.01 $\mu\text{g/g}$ FW and 7.03 $\mu\text{g/g}$ FW in local and processed potato products, respectively (Fig. 2). Out of the local potato products AMP+GMP content was the maximum in fried lachcha (8.26 $\mu\text{g/g}$ FW) and the minimum in Aloo seekh (2.63 $\mu\text{g/g}$ FW) (Fig. 3). The 5' nucleotides are

higher in potato compared other vegetables (Solms and Wyler 1979). Fried lachcha is a product prepared solely from potato, whereas aloo seekh is prepared from aloo mixed with some other vegetables and gram flour. Hence the concentration of flavouring compounds is higher in fried lachcha compared to aloo seekh. Along with aloo seekh, fried samosa also contained low level of umami 5' nucleotides i.e., 4.42 $\mu\text{g/g}$ FW. Umami 5' nucleotides ranged from 2.72 $\mu\text{g/g}$ FW to 14.75 $\mu\text{g/g}$ FW in processed potato products (Figs. 2 and 4). Its content was the maximum in aloo bhujia (14.75 $\mu\text{g/g}$ FW) followed by dehydrated aloo lachcha (11.14 $\mu\text{g/g}$ FW) and dehydrated potato chips (10.13 $\mu\text{g/g}$ FW). Processed potato products such as Smiles (2.72 $\mu\text{g/g}$ FW), Potato Shortz (3.40 $\mu\text{g/g}$ FW), dehydrated potato crax (3.51 $\mu\text{g/g}$ FW) contained low levels of these compounds. More than 250 volatile compounds have been identified in cooked potatoes but their role in flavour is still not clear (Morris et al. 2010). Among non-volatile compounds, umami are the major compounds that contribute to cooked and processed potato flavour. Umami compounds are known to enhance or highlight the saltiness in salty foods.

Fig. 4 HPLC chromatogram of AMP+GMP of Aloo Bhujia and Masala Fries

Flavouring compounds in raw and cooked potatoes

The AMP+GMP content in raw and cooked potatoes ranged from 2.04 $\mu\text{g/g}$ FW (Kufri Dewa) to 7.69 $\mu\text{g/g}$ FW (Kufri Chipsona-1) with the mean value of 4.60 $\mu\text{g/g}$ FW (Fig. 5). In accordance with published literature (Morris et al. 2007; Raigond et al. 2014b), raw tubers contain low concentration of these compounds. Among raw tubers the concentration was the highest in Kufri Chipsona-1 followed by Kufri Girdhari (7.53 $\mu\text{g/g}$ FW), Kufri Neela (7.43 $\mu\text{g/g}$ FW), Kufri Gaurav (6.41 $\mu\text{g/g}$ FW) Kufri Chamatkar (6.30 $\mu\text{g/g}$ FW) and Kufri Arun (6.13 $\mu\text{g/g}$ FW). Cooking for 5–10 min is optimal for release of 5' nucleotides (Morris et al. 2007). After pressure cooking the content ranged from 1.47 $\mu\text{g/g}$ FW (Kufri Chamatkar) to 12.75 $\mu\text{g/g}$ FW (Kufri Frysona).

The average content of AMP+GMP in forty seven potato cultivars was 5.92 $\mu\text{g/g}$ FW after pressure cooking. Pressure cooked tubers of varieties such as Kufri Jawahar (9.11 $\mu\text{g/g}$ FW), Kufri Kuber (8.90 $\mu\text{g/g}$ FW), Kufri Jyoti (8.85 $\mu\text{g/g}$ FW), Kufri Khasigaro (8.76 $\mu\text{g/g}$ FW), Kufri Ashoka (8.70 $\mu\text{g/g}$ FW) also exhibited high levels of AMP+GMP (Fig. 5). The AMP+GMP content increased to 143.4 % in Kufri Frysona and in Kufri Jyoti, Kufri Khasigaro, Kufri Ashoka, Kufri Jawahar and Kufri Kuber, the increase after pressure cooking was 180, 170, 115, 77 and 33 %, respectively. The products of interactions between amino acids and 5'-ribonucleotides are considered to be mainly responsible for boiled potato flavour (Halpern 2000). Microwaved potatoes contained 2.67 to 8.87 $\mu\text{g/g}$ FW umami 5'-nucleotides, with average content of 5.17 $\mu\text{g/g}$ FW (Fig. 5). Its content was the

Fig. 5 Flavouring compounds in raw and cooked tubers of forty seven potato cultivars (Standard error bars represents standard error of interaction between cooking method and variety)

Fig. 6 Clustering of cultivars based on flavouring compounds

maximum in microwaved tubers of Kufri Jawahar (8.87 $\mu\text{g/g}$ FW) followed by Kufri Khasigaro (8.59 $\mu\text{g/g}$ FW), Kufri Gaurav (8.11 $\mu\text{g/g}$ FW) and Kufri Ashoka (8.00 $\mu\text{g/g}$ FW) and increase was 73, 165, 27 and 98 %, respectively after microwaving. Raigond et al. (2014b) observed more increase in umami 5' nucleotides after microwave cooking which could be due to the fact that flavour is not only influenced by variety, but factors like agronomic practices and storage environment also influence the potato flavour (Jansky 2010). The literature has shown that the trend of decrease or increase of umami 5' nucleotides concentration changes w.r.t variety, processing technique, time for cooking and storage (Morris et al. 2007, 2010; Raigond et al. 2014b, c). Therefore, it is likely that all varieties shall not perform in the similar manner towards processing w.r.t flavouring compounds. Hence, some aberrations have been observed, though the mean trend shows a clear picture of increase in the flavours due to processing. The correlation between pressure cooked and microwaved tubers was positive (r^2 0.446). AMP+GMP content of raw tubers was positively correlated with AMP+GMP content of pressure cooked tubers (r^2 0.184) and microwaved tubers (r^2 0.363).

Cluster analysis of AMP+GMP of pressure cooked and microwaved potatoes grouped the varieties into 3

clusters (Fig. 6). Mean performance of varieties in each cluster is depicted in Table 1. Pressure cooked tubers of highest AMP+GMP content containing varieties were grouped in cluster 3 that is constituted by ten cultivars viz. Kufri Shailja, Kufri Kanchan, Kufri Khyati, Kufri Jyoti, Kufri Alankar, Kufri Chipsona-4, MS-18-1565, Kufri Megha, Kufri Sadabahar and Kufri Frysona. Cluster 1 comprised of thirteen cultivars viz. Kufri Swarna, Kufri Bahar, Kufri Sherpa, Kufri Badshah, Kufri Chipsona-1, Kufri Kundan, Kufri Chandramukhi, Kufri Girdhari, Kufri Gaurav, Kufri Khasigari, Kufri Jawahar, Kufri Ashoka and Kufri Kuber which contained highest content of AMP+GMP in microwaved tubers. Maximum cultivars came under cluster 2 (24

Table 1 Means of flavouring compounds in 3 groups formed by cluster analysis of 46 Indian potato cultivars

Cluster number	Number of cultivars	AMP+GMP content of pressure cooked tubers	AMP+GMP content of microwaved tubers
1	13	7.444	7.210
2	24	4.284	4.379
3	10	7.849	4.408

cultivars) that contained average content of AMP+GMP in both pressure cooked as well as microwaved tubers.

Conclusion

The study revealed that the potato and potato products contain different concentrations of umami 5' nucleotides. On an average, overall there was 14 % increase on microwave cooking and 31 % increase in flavouring compounds (AMP+GMP) on pressure cooking. Different products contained different concentration of umami 5' nucleotides which could be due to the difference in variety (Raigond et al. 2014b) and processing technique (Morris et al. 2007; Raigond et al. 2014b, c). Umami compounds increase the saltiness of a product, therefore, identification and utilization of potato cultivars containing high concentration of umami 5' nucleotides for product development can help in reduction of salt intake through less addition of salt in a product. This type of study will enable in identifying better tasting cultivars for further product development and also to develop products with less addition of salt.

References

- Del Valle M, Camara M, Torija ME (2006) Chemical characterization of tomato pomace. *J Sci Food Agric* 86:1232–1236
- Duckham SC, Dodson AT, Bakker J, Ames JM (2001) Volatile flavour components of baked potato flesh: a comparison of eleven potato cultivars. *Food Nahrung* 45:317–323
- Halpern BP (2000) Glutamate and the flavor of foods. *J Nutr* 130:910–914
- Jansky SH (2010) Potato flavour. In: Hui YH (ed) *Handbook of fruits and vegetable flavours*. Wiley, Hoboken, pp 935–946
- Marcus JB (2005) Culinary applications of umami. *Food Technol* 59(5): 24–30
- Miranda M, Aguilera JM (2006) Structure and texture properties of fried potato products. *Food Rev Int* 22:173–201
- Morris WL, Ross HA, Ducreux LJM, Bradshaw JE, Bryan GJ, Taylor MA (2007) Umami compounds are a determinant of the flavour of potato (*Solanum tuberosum* L.). *J Agric Food Chem* 55:9627–9633
- Morris WL, Shepherd T, Verrall SR, McNicol JW, Taylor MA (2010) Relationship between volatile and non-volatile metabolites and attributes of processed potato flavour. *Phytochemistry* 71:1765–1773
- Raigond P, Ezekiel R, Kaundal B (2014a) Starch fractions of cooked potatoes at low temperature. *Potato J* 41(1):58–67
- Raigond P, Singh B, Dhulia A, Bandana DS, Singh BP (2014b) Losses in flavour of Indian potatoes: influence of storage temperature. *Int J Innov Hort* 3(1):34–40
- Raigond P, Singh B, Gupta VK, Singh BP (2014c) Potato flavour: profiling of umami 5'-nucleotides from Indian potato cultivars. *Ind J Plant Physiol* 19(4):338–344
- Singh BP, Rana RK, Govindkrishnan PM (2014) Vision 2050. Central Potato research Institute, Shimla, pp 16–17
- Solms J, Wyler R (1979) Taste components of potatoes. In: Boudreau JC (ed) *Food taste chemistry*. American Chemical Society, Washington, pp 175–184
- Ugawa T, Kurihara K (1994) Enhancement of canine taste responses to umami substances by salts. *Am J Physiol* 266:944–949
- Yamaguchi S, Yoshikawa T, Ikeda S, Ninomiya T (1971) Measurement of the relative taste intensity of some L-amino acids and 50 nucleotides. *J Food Sci* 36:846–849