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Research Article

Partial Replacement of Salt by Maillard Reaction Product and its Effect on Sensory Property of Roasted Peanut

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Abstract

Snack consumptions increases salt intake more than 60% and the excess intake of NaCl might be associated with cardiovascular disease and the incidence of stroke. The main objective of the present study was to partially replace salt by Maillard Reaction Product in roasted peanuts and investigate its effect on sensory property. The addition of Maillard Reaction products improved sensory profile roasted peanut. Sensory evaluation results revealed that sample containing corn MRP had relatively the best sensory results. This finding coincides with the analysis by principal component Analysis (PCA) and DFA Discriminant Factor Analysis of Electronic nose. PLSR was successfully able to detect significant, positive and negative correlations between sensory analysis and key eleven peanut volatile compositions identified by GC–MS. Roasting peanut increase peanuts volatile components. This study investigated the sensory impact associated with partial replacement of normally added NaCl using Maillard Reaction Product as flavor enhancer.

Keywords: Snack consumption, Maillard reaction, roasted peanuts, sensory results, flavor enhancer.

Introduction

Sodium chloride is widely used as an additive in the food processing and its major functions include preservation, flavor enhancement and control of texture. Findings reported that more than 70% of dietary salt intake arises from processed foods and savory snack such as roasted peanut. The recommended daily allowance for sodium chloride rise up to 5 g of salt (Syarifuddin *et al.,* 2016); which is approximately 2 g of Sodium. The average salt consumption among the world population has increased to 10–12 g per day which is twice the amount recommended by the World Health Organization (Busch *et al.,* 2013). However higher intake of salt were reported to cause long term negative health effect in humans, including high blood pressure, heart disease, stroke and kidney failure (Taylor *et al.,* 2018).

Peanuts (*Arachis hypogaea* L.) contains about 26% protein, 48% oil, 50% fat and 3% fiber, as well as high levels of calcium, thiamine and niacin (Valentine, 2016). The presence of fat might lead to lipid oxidation which might results in changes in their flavor, odor and color, thus affecting the overall acceptability and shelf-life (Wang *et al.,* 2016).

Roasted peanuts are popular food snack because of its unique flavor and abundant nutrients. Peanuts are readily acceptable as a cheap protein source and popular snack item that can be eaten alone or combined with other foods. They are the most shelf- life sensitive component due to their rich content of unsaturated oil, by which roasting is a key step in the process and directly impacts the quality (crispness, taste, and flavor) and shelf-life of the final product (Davis and Dean, 2016). Roasting can be defined as the heat treatment at temperatures above 125°C, at which non-enzymatic reactions occur to form pigments with specific yellow-brown color (Shi *et al.,* 2017). Among different methods employed for controlling lipid oxidation, the use of antioxidants is the most effective and convenient method (Comert and Gokmen, 2018). Antioxidants are substances that when present in food delay, control and prevent oxidative processes leading to food quality deterioration (Sun *et al.,* 2010; Sangatash *et al.,* 2016). Maillard Reaction Product has antioxidant proprieties and flavor enhancer propriety. Maillard reaction takes place between amine groups, usually from amino acids and proteins and carbonyl compounds, generally from reducing sugars, such as xylose, fructose, glucose at high temperature (Han *et al.,* 2013).

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In the present study, the partial replacement of salt by plant derived Maillard reaction product was evaluated. Because of their flavor-enhancing properties, Maillard reaction product may be used to enhance saltness perception and flavor improvement. In addition to flavor, color is also an important attribute in consumer preference of roasted peanuts .Given that color and flavor develop through similar pathways (Maillard and caramelization reactions), Roasted peanut color has also been investigated.

Materials and methods

Material: Raw peanut and salt were purchased at local supermarket (Wuxi city, China). The raw material sunflower, soybean and corn for Maillard reaction product preparation were obtained from Suntime International Seed co. Ltd. (Xinjiang, China). Alcalase 2.4 L FG and Flavourzyme 500 MG were purchased from Novo Co. Ltd. (Novozyme Nordisk, Bagsvaerd). All other chemicals and solvents used were of analytical grade and purchased from Shanghai Chemical Reagent Co. Ltd. (Shanghai, China).

Method

MRP Preparation: Maillard Reaction Product (MRP) were prepared according to the method previously reported by Karangwa with slight modifications (Eric *et al*., 2014). Thirty grams of each sample were dissolved in distilled water at a concentration ratio of 1:10 (w/v) (for sunflower, soybean and corn meal). The solution was pre-treated at 95°C for 30 min. After cooling, the pH of solution was adjusted to pH 8.0, using Sodium hydroxide solution (2M NaOH) at 58°C. The solution was hydrolyzed with alcalase enzyme/substrate ratio (E/S) of 1.0% (v/v) for 3 h. The sample was then subjected to a second hydrolysis for 2 h at pH 6.5 and 50°C with flavourzyme enzyme/substrate ratio (E/S) of 0.6% (w/v). The hydrolysates were heated at 95°C for 10 min to inactivate the enzymes; followed by centrifugation (Hitachi, RXII series, Japan) at 10000 rpm for 20 min at 4°C to remove the precipitate. The hydrolysate obtained was used for the preparation of MRPs. The MRPs were prepared by mixing the hydrolysate (60 mL), xylose and cysteine at pH 7.4 and then heated at 120°C for 2 h.

Peanut roasting: Raw peanuts were initially soaked in 2% salted Maillard reaction product derived from corn, soybean and sunflower with Total Soluble Solid equal to 20 at 60°C for 2 h in water bath (Shi *et al.,* 2017). Raw peanuts were soaked in salted water solution 2% at 60°C for 2 h and were used as control sample. Peanut were pre-roasted in oven at 110°C for 15 min in order to reduce moisture. Finally peanut were roasted in oven at 180°C for 12 min (Dimitrios Lykomitros 2016; Wang *et al.,* 2017; Djikeng *et al.,* 2018).

Peanut oil extraction: The oil was extracted from peanuts according to the method previously reported by Delfan-Hosseini (2017) using an electrical pressing machine (AOKEYA machine, China). The extracted oil was filtered and centrifuged at 4000 rpm for 20 min. The extracted oil were stored at –20°C for 2 d until further analysis (peroxide values, thiobarbituric acid values). Peroxide values and thiobarbituric acid values were analyzed using the AOCS official method.

Determination of volatile compounds (GC/MS): The volatile compounds were sampled with an SPME-fiber (75 µm, carboxen /poly-dimethyl siloxane) and assayed with a gas chromatograph-mass spectrometer (Finnigan Trace GC/MS, Finnigan, USA). GC/MS analysis were performed using a trace GC system equipped with a DB-WAX capillary column (30 m × 0.25 mm i.d., 0.25-µm film thickness) and with a trace mass spectrometer (Finnigan, San Jose, Calif., U.S.A.), operated in electron impact ionization mode (70 eV) scanning a mass range (m/z) from 32 to 402 amu. The analysis was carried out in the splitless mode, using helium as the carrier gas (0.8 mL/min flow rate). The injector and detector temperature were 250°C and 280°C, respectively. The column was maintained at an initial temperature of 40°C for 4 min and then programmed at 6◦C/min to the final temperature of 230◦C, where it was maintained for 10 min (Liu, 2010). Identification of compounds was based on both mass spectra data-base (NIST/EPA/NIH mass spectral library, Version 2.2, 2014) and Kovats indices (KI). KI was calculated based on the retention time of a series of n-alkanes (C7-C30). Semi-quantification was done for the identified compounds, and the relative concentration was reported based on the area of the 1,3 dichlorobezene, which was used as the internal standard (Wang *et al.,* 2017).

Volatiles analyzed with an electronic nose: GC–MS/O analysis was conducted using an Agilent gas chromatograph equipped with mass spectrometer and a sniffing port connected with a flow splitter after the column exit (Xiao, 2014). The effluent was respectively split 1:1 between the MS and sniffing port. The sniffing port consisted of a temperature controlled base with a source of purified and humidified air in order to maintain olfactory sensitivity. The DB-WAX column was also used for GC analysis. The chromatographical conditions used were identical to those of GC–MS analysis. The flavors of non-oxidized and oxidized oils were determined by E-nose. About 3 mL of the peanut oil were detected through Electronic nose .Each sample was replicated five times.

Sensory evaluation: The sensory evaluation was conducted with the trained panelists consisting of 16 people at the age of 20–39 who had experience in working on food products. Sensory analysis was conducted in a sensory laboratory Food Chemistry Lab.

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Table 1. Components of flavor profile of different roasted peanuts samples.

	Key compounds	Raw peanuts	Roasted peanuts	CN peanuts	SB peanuts	SF peanuts
F1	Pyrazine ethyl	0.0018	0.0024	0.0052	0.003846	0.00699
F2	Pyrazine 2,6 dimethyl	0.00139	0.0014	0.021	0.018	0.025
F3	Pyrazine2,5 dimethyl	0.00139	0.01926	0.0265	0.0221	0.020
F4	Pyrazine,3ethyl 2,5 dimethyl	0	0.00474	0.00925	0.007	0.005
F5	Pyrazine methyl	0	0.00803	0.028	0.021	0.03
F6	Pyrazine 2 ethyl 5 methyl	0	0.006572	0.0388	0.0111	0.0355
F7	Pyrazine 2 ethyl 6 methyl	0	0.00555	0.003	0.0024	0.0038
F8	Pyrazine 2,6 diethyl	0	0	0.03088	0.02743	0.035
F9	2Furanmethanol	0.0188	0.01495	0.0245	0.0211	0.0415
F10	3Furanmethanol	0.0024	0.0125	0.026	0.023	0.038
F11	Hexanal	0.0101	0.01274	0.01417	0.01135	0.018

Determination of color: Color development is generally used as a method of measuring the roasting degree as it is rapid and inexpensive. Color characteristics were determined by a colorimeter (CR-400, Konica Minolta, Inc. Japan). CIE-L*a*b* color coordinate system used for the analysis. L* value is a measure of lightness, ranging from blackness (0) to whiteness (100); a* value ranges from greenness (−60) to redness (+60) and b* value ranges from blueness (−60) to yellowness (+60) (Smith *et al.,* 2014). Color measurements of peanut were conducted during five weeks storage.

Statistical analysis: Statistical analysis was performed using Microsoft Excel 2010, Origin and SPSS (Microsoft, Redmond, WA, USA) and SPSS 19.0 (IBM, Armonk, NY, USA). ANOVA with Turkey multiple comparison tests for post hoc tests was performed to determine statistical differences among individual samples for each attribute. $P<0.05$ was considered as significant, the difference among individual sample for each sensory attribute. Partial least squares regression (PLSR) analysis was performed by the Unscrambler version 9.8 CAMO Software, Oslo, Norway. PLSR was performed with GC–MS as the X-matrix and sensory attributes as the Y-matrix. The correlation between individual sensory attributes and the volatiles of 5 essential oils were analyzed byPLS1. PLS2 was applied to illustrate correlations among the GC–MS data and sensory attribute datasets. Data reported in this work were means of triplicate experiments.

Results and discussion

Sensory evaluation of peanut: Sensory characteristics of five different roasted peanut samples were conducted by 16 well-trained sensory panelists. The hedonic scores for all five sensory attributes; saltness, flavor, aroma and overall acceptance of peanut were evaluated (Fig. 1). Saltness for peanut treated with different MRP were significantly different at $P=0.05$. Peanut treated with corn MRP had the best score while peanuts containing sunflower MRP were ranked last. Maillard reaction product derived from corn contains umami amino acid such as aspartate and glutamate, umami can increase salt perception however SF MRP were high in sulfur containing amino acid and it contains bitter amino acid (Methven, 2012).

Relationship between key characteristic volatile components and sensory profiles of peanut by PLSR analysis: The key compound responsible of peanut flavor are especially pyrazine such as pyrazine ethyl, pyrazine 2,6 dimethyl, pyrazine 2,5 dimethyl, pyrazine methyl, pyrazine 2ethyl 5 methyl, pyrazine 2,6 diethyl, 2Furanmethanol, pyrazine 3 ethyl 2,5 dimethyl, pyrazine 2 ethyl 6 methyl and Hexanal. Among all pyrazines 2,5-dimethylpyrazine is the compound with the single highest correlation with roasted peanut aroma, followed by 2,3,5-trimethylpyrazine and 2,3-dimethylpyrazine. It is in higher quantity in roasted Peanut with CN-MRP > peanut with SB-MRP > peanut with SF-MRP. This result is consistent with the findings of many researchers (Lykomitros *et al.*, 2016; Wang *et al.*, 2017). The volatile compounds of raw peanut, roasted peanut with or without Maillard reaction product were separated and detected on a DB-WAX column. The main flavor compounds are shown in Table 1. Pyrazines are a varied class of heterocyclic nitrogen-containing compounds derived from non-enzymatic protein–sugar interactions and these compounds have long been associated with flavor of roasted nutty foods including peanuts. Over 70 pyrazines have been isolated and identified in peanuts. Pyrazines are key volatiles compound that affect the stability of roasted peanut flavor (Liu, 2010). Peanut roasted with corn MRP present more pyrazine quantity base on high quantity of umami amino acid found in corn Maillard reaction product. This result is in accordance with the findings of Eric *et al.* (2014) which state that corn contains more umami amino acid.

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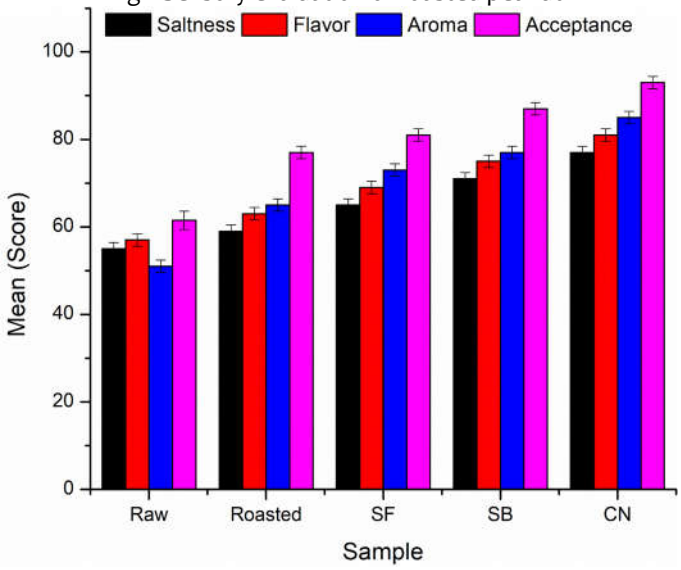
Fig.1.Sensory evaluation of roasted peanut.



Lipid oxidation is thought as a mechanism that raises the peanut content of aldehyde such as 2-methylpropanal, 3-methylbutanal, pentanal, octanal and hexanal during storage. They are often associated with offflavors. Hexanal is one of the aldehyde found in great quantity in peanut. It was positively correlated as seen on Fig. 2 and 3. However, pyrazine ethyl (F1) is significantly correlated. It is related to the sweet aroma attribute. This result is in accordance with the results of Lykomitros (2016).

Detection of peanut flavour by electronic nose: Electronic nose is used to determine aroma-active compounds in food and quality classification (Peris and Escuder-Gilabert, 2016). Different peanut samples gave significantly different response from electronic nose. Principal component (PCs) score distributions indicated the degree of similarities between different samples. PCA results give an overall picture of the distribution of the volatile compounds with the separation of the peanut samples. According to the spacing between each sample group, the samples were divided into five groups as shown in Fig. 4. The samples that got the same treatment form the cluster. The same peanut sample with its replications was located close to one another as cluster and the differences between groups distributed different locations on the two-dimensional plane was visualized by PCA plots more clearly as seen on Fig. 5. The distance between clusters predicted that there was significant difference among peanut samples (Xiao, 2014). Discriminant function analysis (DFA) is a statistical analysis to predict a categorical dependent variable (called a grouping variable) by one or more continuous or binary independent variables (called predictor variables). Discriminant analysis is used when groups are known a priori (unlike in cluster analysis) (Xiaoa and Zhua, 2014).

Fig. 2. PLS1 prediction models for the sensory attributes variables saltness.

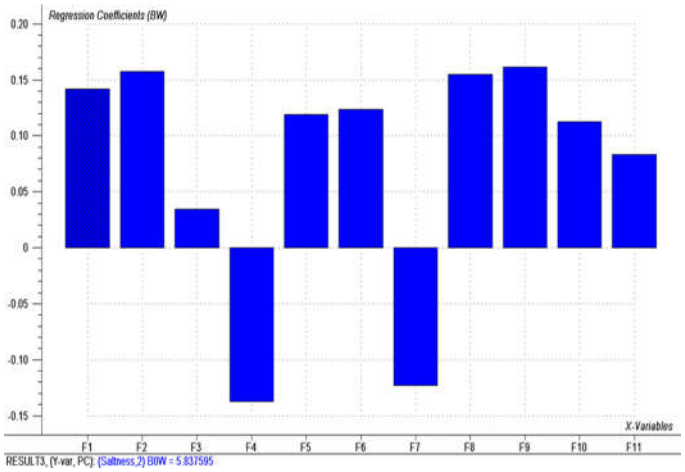


Fig. 3. PLS1 prediction models for the sensory attributes variables overall acceptance.

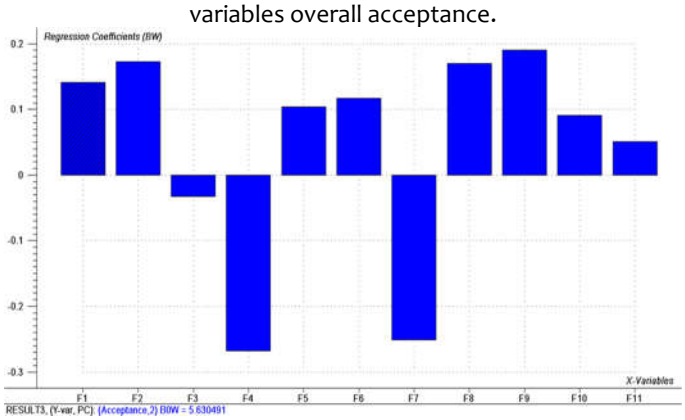


Fig. 4. Score of cluster plot for E-nose response data with the first two PCs for raw peanut, roasted peanut, corn MRP peanut, soybean MRP peanut and sunflower MRP peanut sample groups.

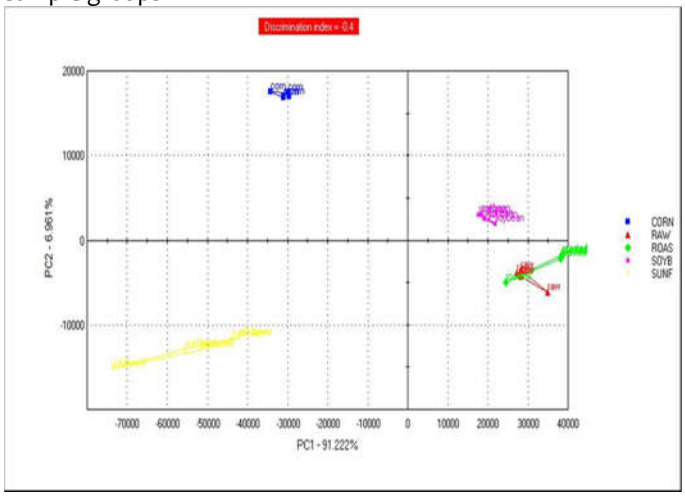


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Fig. 5. Discriminant function analysis for raw peanut, roasted peanut, corn MRP peanut, soybean MRP peanut and sunflower MRP peanut sample groups.

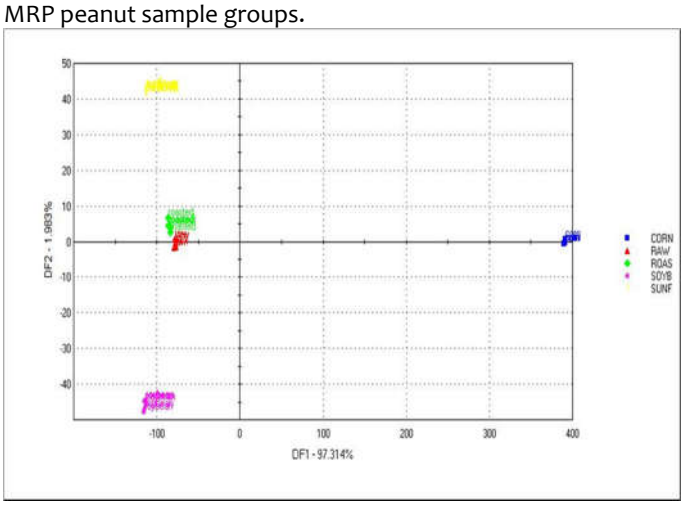
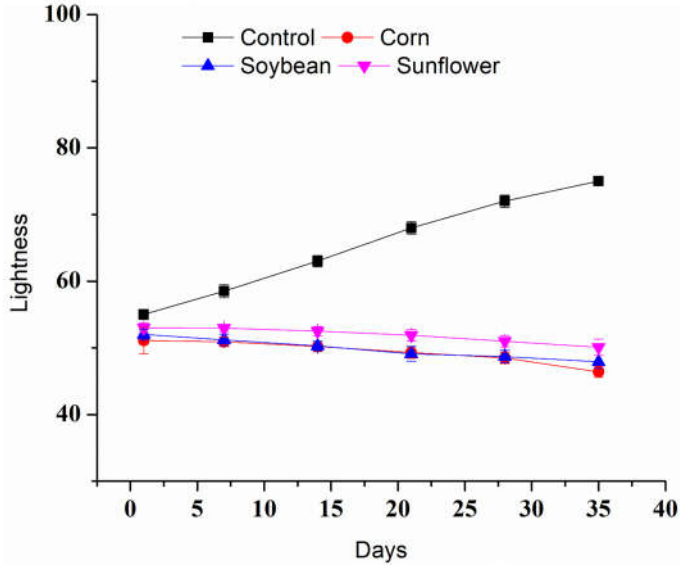


Fig. 6. Color degradation of peanuts samples stored at 55°C.



Each sample must have a score on one or more quantitative predictor measures, and a score on a group measure. Both PCA and DFA results indicated internal differences between samples as shown In Fig. 5.

Roasted peanut color measurement: Color is one of the parameters that are used for process control during roasting. Color development in peanut is mainly due to Maillard Reaction and partly to caramelization. It is an effective quality indicator because brown pigments increase as the browning and caramelization reaction increases (Shi *et al.*, 2017). The L* value indicates the degree of lightness of a sample. Lower L∗ values indicate a darker roast color, while higher values indicate a lighter roast color. The L* value of peanut kernels tended to decrease during the roasting process. However it increases during storage.

Control sample L value during storage was significantly different at p=0.05, L value for corn, soybean, sunflower Maillard Reaction product were not significantly different at p=0.05. L value were between 52 to 58, this finding is in accordance with the previous research results which state that CIELAB L∗ values of roasted peanut should be around 56 (Smith and Barringer, 2014). Roasting peanuts promotes the formation of melanoidin pigments formed from amino acids reacting with reducing sugars during the Maillard reaction, which give roasted peanuts a distinct color. During storage, color degrades as result of enzymatic and non-enzymatic reaction (Djikeng *et al.*, 2018). Maillard reaction product added to roasted peanut as food additive preserve the color of roasted peanut, Maillard reaction browning products intensify while roasting peanuts.

Conclusion

This study proposes salt reduction in roasted peanuts by partial replacement with Maillard Reaction Products. Descriptive sensory analysis were used in identification of the saltness of roasted peanut and other attribute such as flavor, aroma and acceptance were evaluated. Peanut roasted with CN-MRPs exhibited better sensory characteristics compared to other peanuts sample. Maillard Reaction product from corn, sunflower MRP and soybean MRP. Roasted peanut with corn Maillard Reaction product had the best score due to relatively higher number of umami amino acid such as aspartate and glutamate. Significant, Positive and negative correlations between sensory descriptors and volatile compounds were found when PLSR was applied. It is widely agreed that the reduction of dietary sodium intake in snacks can have a significant role in the control of blood pressure, which in turn is considered one the major modifiable factors in the development of cardiovascular and related diseases. The application of Maillard Reaction Product as partial salt replacement could be a proposed solution for salt reduction in snacks.

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