EFFECT OF ROASTING ON TEXTURE, COLOUR, NUTRIENT CONTENT AND ACCEPTABILITY OF SOYBEANS (*GLYCINE MAX*)

Pham Ngoc Hung*, Tran Quoc Tiep, Hoang Quoc Tuan

School of Biotechnology and Food Technology, Hanoi University of Science and Technology, 1 Dai Co Viet Road, Hanoi, Vietnam

*Email: *hung.phamngoc@hust.edu.vn*

Received: 15 August 2016; Accepted for publication: 6 October 2016

ABSTRACT

Effect of roasting on texture, colour, and nutrient content and sensory acceptability of soybean was studied at four temparture (160, 180, 200 and 220 ^{o}C) and time (10, 15, 20 and 25 minutes) combinations. In general, hardness and toughness decreased with increased in roasting temperature and time except at 200 and 220 ^{o}C for 20 minutes. L* values of roasted soybean decreased at increased temperatures while a* values increased with increasing roasting temperature and time that affected to hue and chroma values of soybean. The highest sensory evaluation including colour, appearance, roasted odour and overall quality were found for soybean roasted at 200 ^{o}C for 20 minutes. Lipid and ash content of the roasted soybean was found to have increased following the roasting time and temperature. While the protein content of the soybean roasted decreased as the roasting time and temperature increased.

Keywords: roasted soybean, roasting, nutritional composition, colour, sensory evaluation.

1. INTRODUCTION

Soybeans (*Glycine max*) are popular food which have been used by Asian people in traditional cooking such as tofu, soymilk and soybean roasted [1]. Soybeans are rich in protein, fiber and oil, in addition to being a main source of vitamins, mineral, phytosterols etc [2]. Soy protein has demonstrated hypocholesterolemic effects on total and LDL cholesterol levels, especially in individuals with elevated cholesterol levels. The amino acid ratios in soy protein are hypothesized to contribute to the cholesterol-lowering effects. Arginine tends to lower cholesterol levels while lysine and methionine tend to raise them. Compared to other protein sources, soy has a higher ratio of arginine to lysine and methionine. This ratio may lower insulin and glucagon secretion, inhibiting lipogenesis [3]. The lipids in soybeans are cholesterol-free, low in saturated fatty acids, and high in unsaturated fatty acids. One of the unsaturated fatty acids in soybean oil is α-linolenic acid, an omega-3 fatty acid. Recent epidemiological studies suggest that consumption of omega-3 fatty acids and α-linolenic acid results in a decrease in risk for cardiovascular disease (CVD) [2 - 4]. Phytosterols are found in plants such as soybeans. The three primary phytosterols in soybeans are campesterol, β-sitosterol, and stigmasterol.

Phytosterols are important because their consumption can significantly reduce blood cholesterol in humans [4, 5].

Processing methods not only affect changes in the physical characteristics and flavour, but also in chemical composition of soybeans. Some study results demonstrated that processing methods can preserve the health benefit effects by enhancing bioactive [3]. Anti-nutritional factors such as trypsin inhibitors and haemagglutinins are inactivated up to 95 and 100 % respectively during roasting. In addition to the desirable nutritional changes, desirable flavour compounds are also formed. However, roasting does decrease the availability of some essential amino acids, namely lysine, through Maillard browning. For optimal nutrition, the amount of heat treatment needed to inactivate most of the anti-nutritional factors must be balanced with the loss of essential amino acids [6]. Effects of roasting soybean fatty acids vary with the temperature and length of roasting. Higher roasting temperatures (150 ℃ and 170 ℃) tended to increase relative contents of saturated and monounsaturated fatty acids and decrease contents of polyunsaturated acids slightly compared to a roasting temperature of 130 ℃ [7]. Roasting is a heat processing method that uses a dry heat treatment and causes a Maillard reaction. The consequences of Maillard browning are both positive and negative. Because proteins are involved in the reaction, a loss of essential amino acids such as lysine and tryptophan can occur, as well as decreased protein digestibility. The roasting process produces desirable flavors via Maillard browning [8]. Various studies indicated the affect of roasted grain hardness on sensory characteristics as well as on particale size of milled grain and energy consumption in milling [1, 9]. Grain hardness is affected by size, direction of applied force, moisture content, chemical composition and heat treatment [10, 11]. The objective of this study was to determine the effect of roasting method on the nutrient content, texture, colour and sensory characteristics of roasted soybean.

2. MATERIAL AND METHOD

2.1. Soybean roasting

The soybeans were soaked in water (3:1 w/w, water:soybeans) for 20 hours at 4 ℃ prior to roasting with 1000 g (soaked weight) batches in a drum roaster (Daohang, China-Model DH-10) for 10, 15, 20 and 25 min (holding time), consenquently. The roaster was provided with temperature control adjustments. After roasting, the soybeans were allowed to cool on paper towels.

2.3. Nutrient analysis

Proximate analysis of the roasted soybean (including lipid, protein and ash) was determined using the AOAC standard method (2004) [12].

2.4. Colour Determination

Colour was measured before drying and at pre-specified time interval during drying period by Hunter-Lab Color, Colorlite SPH860 model colormeter. The measurements were displayed in L, a and b values which represents light-dark spectrum with a range from 0 (black) to 100 (white), the green – red spectrum with a range from -60 (green) to + 60 (red) and the blue-yellow spectrum with a range from -60 (blue) to + 60 (yellow) dimensions repestively [13].

$$\text{Chroma} = \left(a^2 + b^2\right)^{0.5} \quad (1)$$

$$\text{Hue Angle} = \tan^{-1}\left(\frac{b}{a}\right) \quad (2)$$

2.5. Textural proberties

Textural properties of roasted soybean such as hardness and toughness were measured using Texture Analyzer (TA) TA.XT Plus (Stable Microsystems, UK) with P/6 probe. The TA setting were: Mode in compression, pre test speed- 3 mm sec^{-1}, test speed- 1 mm sec^{-1}, post test speed-10 mm sec^{-1}, distance- 3 mm, and 10 kg load cell. Textural properties were measured for 10 representative grains under each roasting condition. The peak force is considered as hardness and the peak area was considered as toughness of the grain [14].

2.6. Sensory evaluation

Roasted soybean were evaluated for different sensory attributes included roasted odour, colour & appearance and overall acceptability by a panel of 10 person [15]. Hedonic scale was in the following sepuence-like extremely-9, like very much-8, like moderately-7, like slightly-6, neither like nor dislike-5, dislike slightly-4, dislike moderately-3, dislike very much-2 and dislike extremely-1

2.7. Statistical analysis

Statistical comparisons of the mean values for each experiment were performed by one-way analysis of variance (ANOVA) using SPSS 22 for Windows software. Significance was declared at $P \leq 0.05$.

3. RESULTS AND DISCUSSION

3.1 Effects of roasting on color of roasted soybean

The colour of food product is the first attribute that affects the decision of consumer for purchasing or consuming and food. The changes of color during roasting are shown in Fig. 1 and Table 1.

The results in Fig. 1 showed that, the L* value of roasted soybean decreased from 57.5 to 27 while a* values increased from 65 to 92 when roasting temperature and time increased. This resulted in the darkening of the grain at higher temperatures. Whereas, b* values was increased when roasting at 160, 180 and 200 ^oC in 15 and 20 minuste consequenlty, and then decreased while b* values of roasted soybean at 220 ^oC, in general, was decreased when time of roasting increased. Roasting, in general, affected the color of roasted soybean kernels.

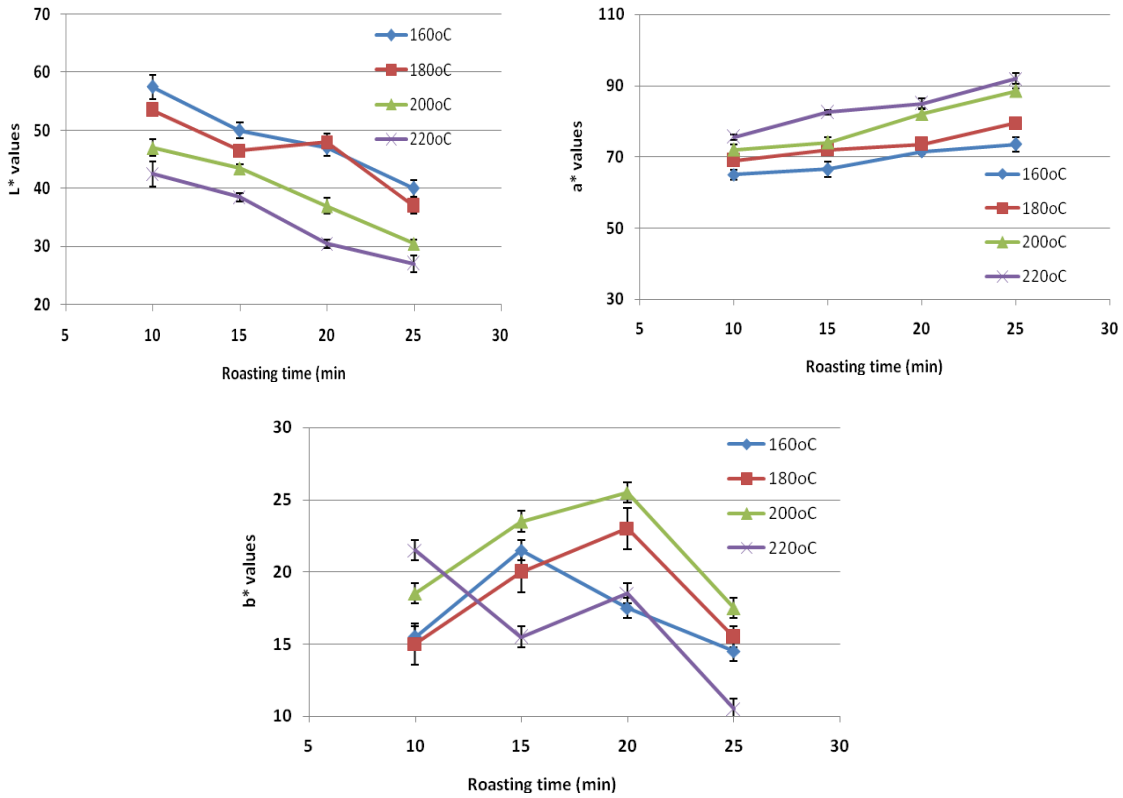

Figure 1. Effect of roasting on colour (L*, a* and b* values) of roasted soybean at 160, 180, 200 and 220 ^{o}C temparature for 10, 15, 20 and 25 min time.

The effects of temperature and time of roasting on Hue angle (h) and chroma (C*) values for roasted soybean were presented in Table 1. The value of chroma increased as a function of drying time and temperature (from 66.82 to 92.60), and vice versa was found for Hue angle values (from 42.14 to 20.45). Upon heating, the Hue angle decreased, shifting towards the darker region.

Table 1. Effect of roasting on Hue angle and Chroma values of roasted soybean at different temperature and time.

Time (min)	160^{o}C		180^{o}C		200^{o}C		220^{o}C	
	C*	Hue*	C*	Hue*	C*	Hue*	C*	Hue*
10	66.82	42.14	70.61	38.53	74.34	45.27	78.50	49.94
15	69.89	56.29	74.73	48.77	77.64	55.35	83.94	33.43
20	73.61	43.21	77.01	54.59	85.87	54.27	86.99	38.57
25	76.39	34.38	81.00	34.66	90.21	35.14	92.60	20.45

3.2. Effect of roasting on texture of roasted soybean

Texture properties of roasted soybean are very important because energy requirement for dehulling and grinding may be in proportion to the grain hardness [15]. Effect of roasting on

texture properties of roasted soybean were showed in Fig. 1. From Fig. 2, it was seen that in general, hardness of roasted soybean decreased with increase in roasting temperature and roasting time except at 200 and 220 ^{o}C for 20 minutes. The reason for the increase in hardness at 200 and 220 ^{o}C for 20 minutes may be due to the drastic reduction in moisture content of the soybean grain that made the grain harder as also observed in case of others roasted seed [14, 16]. The similar trend was observed in toughness of roasted soybean (Fig. 2).

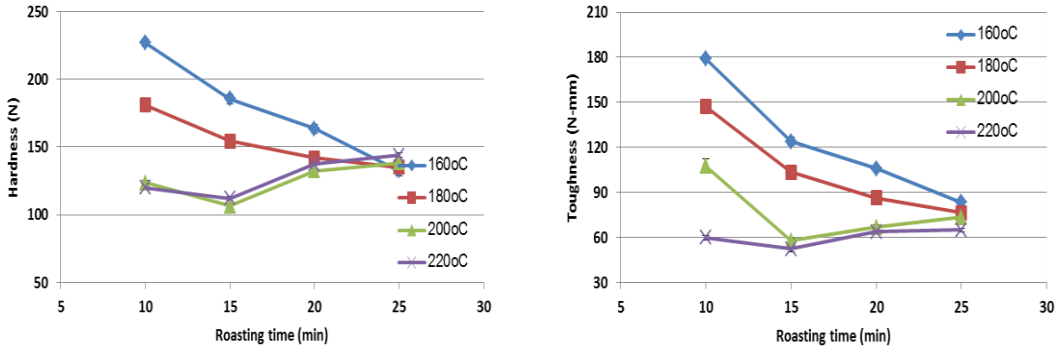

Figure 2. Effect of roasting on hardness and toughness of roasted soybean at 160, 180, 200 and 220 ^{o}C temparature for 10, 15, 20 and 25 minuste time. a) hardness, b) toughness.

3.3. Effects of roasting on nutrient ingredients in roasted soybean

Table 2. Nutrient content of roasted soybeans at different temperature and time.

Roasted temp	Time	Nutrient		
		Lipid (% DM)	Crude protein (% DM)	Ash (% DM)
160 ^{o}C	10	8.66 ± 0.30	37.98 ± 0.13	3.08 ± 0.42
	15	9.49 ± 0.25	35.66 ± 0.41	3.59 ± 0.77
	20	11.74 ± 0.42	33.08 ± 0.49	3.83 ± 0.71
	25	13.54 ± 0.47	31.80 ± 0.34	4.00 ± 0.28
180 ^{o}C	10	9.05 ± 0.45	37.43 ± 0.40	3.18 ± 0.42
	15	9.83 ± 0.77	34.76 ± 0.31	3.70 ± 0.56
	20	12.10 ± 0.21	32.45 ± 0.16	3.95 ± 0.28
	25	13.93 ± 0.63	31.32 ± 0.91	4.03 ± 0.42
200 ^{o}C	10	9.10 ± 0.35	36.71 ± 0.92	3.48 ± 0.63
	15	10.08 ± 0.84	33.94 ± 0.89	3.96 ± 0.56
	20	12.48 ± 0.71	31.84 ± 0.24	4.49 ± 0.27
	25	14.12 ± 0.42	30.72 ± 0.42	5.39 ± 0.74
220 ^{o}C	10	9.19 ± 0.28	34.97 ± 0.13	4.06 ± 0.14
	15	10.56 ± 0.15	32.99 ± 0.31	4.35 ± 0.12
	20	12.89 ± 0.17	29.98 ± 0.45	4.87 ± 0.11
	25	14.69 ± 0.24	29.22 ± 0.54	5.96 ± 0.15

Values expressed are means + S.D. of double replicate experiments

Table 2 shows the nutritional contents of roasted soybeans under different conditions of roasting. The fat content of roasted soybean was found to have increased following the roasting, which was related with the time and temperature increase. The highest fat content of roasted soybean was found to be 14.69 ± 0.24 % when roasted at 220 ^{o}C in 25 min. The protein content was higher in the soybean roasted at lower temperature and shorter time, and ranged from 29.22 ± 0.54 to 37.98 ± 0.13 %. As the roasting time and temperature increased, the protein decreased because roasting led to a degradation of polysaccharide sugars and amino acids, which resulted in the formation of Maillard reaction and condensation products [15, 17]. The roasted soybean's ash was analyzed and found to be significantly related to an increasing roasting time and temperature. This increase in lipid content in roasted soybean may be due to the fact that at high temperature there is disruption of cell structures and membranes partitions of the soybean leading to the release of more free fat molecules causing the fat to be easily extracted from the roasted soybean. This increase in the ash content of the roasted soybean might not be related with the reduced moisture content of roasted soybean. The report of Boge, E.L. et al. [17] also agreed with the findings of this study and it was reported that the ash content of raw soybeant increased as a result of roasting process.

3.4. Effects of roasting on sensory evaluation of roasted soybean

The effects of roasting on sensory evaluation of roasted soybean are presented in Table 3. Table 3 shows that roasting affected the sensory evaluation of resulted soybean. The highest mean sensory scores for all the attributes for soybean roasted at 200 ^{o}C for 20 min (mean score = 7.70) and follow by soybean roasted at 180 ^{o}C for 20 min (mean score = 7.30). The results thus indicated that these samples of roasted soybean were accepted by the panellist with highest sensory scores for roasted odour and overall quality (7.70) for the samples roasted at 200 ^{o}C in 20 min.

Table 3. Effect of roasting on mean sensory scores for different attributes of roasted soybean.

Roasting temperature	Time (minus)	Colour & Appearance	Roasted odour	Overall quality
160 ^{o}C	10	4.10	4.00	4.20
	15	5.10	4.90	5.20
	20	6.20	6.40	6.50
	25	6.80	6.90	6.70
180 ^{o}C	10	4.70	4.40	4.60
	15	6.10	6.20	5.80
	20	7.00	7.20	7.30
	25	5.80	5.50	5.50
200 ^{o}C	10	5.50	4.90	5.00
	15	6.50	6.60	6.30
	20	7.80	7.60	7.70
	25	5.30	5.40	5.20
220 ^{o}C	10	5.60	5.30	5.60
	15	7.20	7.10	7.10
	20	5.70	5.70	6.00
	25	4.00	3.30	3.40

4. CONCLUSION

Roasting of soybean at different temperature and time affected the physical properties, chemical composition and sensory evaluation of roasted soybean. In general, hardness of roasted soybean decreased with increase in roasting temperature and time of roasting except at 200 and 220 ^{o}C in 20 min. The lower hardness of roasted soybean was found at 200 ^{o}C for 150 min of roasting. The highest sensory scores for roasted soybean odour and overall quality (7.70) for the samples roasted was also found for soybean roasted at 200 ^{o}C but roasting time at 20 min. The results showed that the fat and ash content of roasted soybean increased as increased temperature and time of roasting and vice versa for protein content.

Acknowledgements. This research was financially supported by the Hanoi University of Science & Technology, project T2016-PC-030

REFERENCES

1. O'Toole D. K. - Soybean | Soymilk, Tofu, and Okara, in Reference Module in Food Science, Elsevier, 2016, pp. 185-195.
2. Miransari M. - 12 - Soybeans, Stress, and Nutrients, in Environmental Stresses in Soybean Production, Academic Press: San Diego, 2016, pp. 273-298.
3. Liu K. - Soybean: Overview, in Encyclopedia of Food Grains (Second Edition), Academic Press: Oxford, 2016, pp. 228-236.
4. Dijkstra A. J. - Soybean Oil, in Encyclopedia of Food and Health, Academic Press: Oxford, 2016, pp. 58-63.
5. Yang H. - Recovery of phytosterols from waste residue of soybean oil deodorizer distillate, Bioresource Technology **101** (5) (2010) 1471-1476.
6. Van V. C., Matser A. M., and Berg R. W. - Inactivation of soybean trypsin inhibitors and lipoxygenase by high-pressure processing, J Agric Food Chem **53** (4) (2005) 1087-92.
7. Jung M. Y. - Pyrazine contents and oxidative stabilities of roasted soybean oils, Food Chemistry **60** (1) (1997) 95-102.
8. Martins S. I. F. S., Jongen W. M. F., and Boekel M. A. J. S. - A review of Maillard reaction in food and implications to kinetic modelling, Trends in Food Science & Technology **11** (9–10) (2000) 364-373.
9. Rafiee-Yarandi H. - A comparison of the effect of soybeans roasted at different temperatures versus calcium salts of fatty acids on performance and milk fatty acid composition of mid-lactation Holstein cows, Journal of Dairy Science **99** (7) (2016) 5422-5435.
10. Ozkoc O. S., Sumnu G., and Sahin S. - Chapter 20 - Recent Developments in Microwave Heating A2 - Sun, Da-Wen, in Emerging Technologies for Food Processing (Second Edition) Academic Press: San Diego, 2014, 361-383.
11. Danielson D. M. and Crenshaw J. D. - Chapter 35- Raw and Processed Soybeans in Swine Diets, in Swine Nutrition, Butterworth-Heinemann, 1991, 573-584.
12. AOAC - Official method of analysis, 12 th Ed, Association of Official Agricultural Chemists, Washington, D. C. USA (2004).

13. Choudhury A. K. R. - 7 - Using instruments to quantify colour, in Principles of Colour and Appearance Measurement, A.K.R. Choudhury Editor, Woodhead Publishing, 2014, 270-317.
14. Mohammadi M. T. - Sensory and instrumental texture assessment of roasted pistachio nut/kernel by partial least square (PLS) regression analysis: effect of roasting conditions, Journal of Food Science and Technology **53** (1) (2016) 370-380.
15. Perren R. and Escher F. E. - 8 - Impact of roasting on nut quality A2 - Harris, Linda J, in Improving the Safety and Quality of Nuts, Woodhead Publishing, 2013, 173-197.
16. Ogunsina B. S. and Bamgboye A. I. - Effect of Moisture Content, Nut Size and Hot-Oil Roasting Time on the Whole Kernel "Out-Turn" of Cashew Nuts (Anacardium occidentale) During Shelling, Nigerian Food Journal **30** (2) (2012) 57-65.
17. Boge E. L., Boylston T. D., and Wilson L. A. - Effect of cultivar and roasting method on composition of roasted soybeans. Journal of the Science of Food and Agriculture **89** (5) (2009) 821-826.

TÓM TẮT

ẢNH HƯỞNG CỦA CHẾ ĐỘ RANG ĐẾN CẤU TRÚC, MÀU SẮC, THÀNH PHẦN DINH DƯỠNG VÀ TÍNH CHẤT CẢM QUAN CỦA HẠT ĐẬU NÀNH (*Glycine max)*

Phạm Ngọc Hưng*, Trần Quốc Tiệp, Hoàng Quốc Tuấn

Viện CN sinh học & CN thực phẩm, Đại học Bách khoa Hà Nội
Số 1 Đại Cồ Việt, Hà Nội

*Email: *hung.phamngoc@hust.edu.vn*

Ảnh hưởng của các chế độ rang lên cấu trúc, màu sắc, thành phần dinh dưỡng và tính chất cảm quan của hạt đậu nành được tiến hành nghiên cứu ở 04 mức nhiệt độ (160 ^{o}C, 180 ^{o}C, 200 ^{o}C và 220 ^{o}C) và thời gian rang (10, 15, 20 và 25 phút). Nhìn chung, độ cứng và độ dai của hạt đậu nành rang giảm khi nhiệt độ và thời gian rang tăng lên trừ trường hợp mẫu rang ở nhiệt độ 200 ^{o}C và 220 ^{o}C với thời gian rang là 20 phút. Giá trị L* của mẫu đậu nành giảm khi nhiệt độ và thời gian rang tăng trong khi đó giá trị a* lại tăng lên khi nhiệt độ và thời gian tăng, kết quả ảnh hưởng đến giá trị Chroma và Hue angle. Giá trị điểm cảm quan cao nhất là mẫu được tiến hành rang ở 200 ^{o}C trong 20 phút. Thành phần chất béo và tro tăng khi nhiệt độ và thời gian rang tăng lên, trong khi đó, thành phần sự biến đổi của thành phần protein là ngược lại.

Từ khóa: đậu nành rang, rang, thành phần dinh dưỡng, màu sắc, cảm quan.