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UTILIZATION OF CITRUS CROPS PROCESSING BY-PRODUCTS IN THE PREPARATION OF TARHANA

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ABSTRACT

After processing of citrus fruits (e.g. lemon, orange, grapefruit, mandarin) for juice and essential oils production, approximately 50% of the original fruit mass is left as waste material. Citrus crops processing by-products are valuable components as they contain nutrients such as pectins, saccharides, carotenoids, some vitamins, minerals, polyphenols and substances with antioxidant activity. Utilisation of these kind of side products in the recipe of various cereal product led to enhancement of final product nutritional value and better sensory attributes as well as improvement of product functional properties. In this work was studied the effect of orange and mandarin dietary fibre application at level 5 and 10% (w/w) in tarhana preparation and the influence on tarhana fermentation process. Chemical analysis showed, that dietary fibre preparations reached higher concentration of ash, fat and total dietary fibre compared to wheat flour. Wheat flour exhibited higher moisture content and protein concentration than citrus dietary fibre preparations. Orange and mandarin dietary fibre preparations showed higher values of water and oil absorption capacity, swelling capacity and least gellation concentration compared to wheat flour. Application of fruit dietary fibre preparations to tarhana recipe caused a rapid decrease in pH from 4.70 – 5.02 to values 4.31 – 4.51 during fermentation process. Reducing saccharides served as an available source of energy for fermenting microbiota and their concentration decreased from 24.5 – 32.8 to 2.2 – 0.2 g/kg after 144 h incubation. Fermentation also led to lactic acid (1.67 – 2.09 g/kg) and acetic acid (1.91 – 2.53 g/kg) production as a consequence of present microorganisms metabolic activity. Sensory evaluation of samples showed, that higher proportion of citrus dietary fibre preparations (10%) negatively affected taste, odour, consistency and sourness. Among all prepared tarhana samples with proportion of citrus dietary fibre preparation was the most acceptable tarhana with 5% of mandarin dietary fibre.

Keywords: fruit; dietary fibre; tarhana; fermentation

INTRODUCTION

Processing of citrus fruits (oranges, mandarins, etc.) in the production of juices and essential oils constitute approximately 50% of original whole fruit mass wastes. This remaining product is mainly used as feed, however, it also contains valuable nutritions such as pectins, saccharides, carotenoids, some vitamins, minerals, polyphenols and substances with antioxidant activity **(Braddock, 1995; Topuz et al., 2005)**. Fibre-rich by-products may be incorporated into food products as inexpensive, non-caloric ingredients for partial replacement of flour, fat or saccharides, as enhancers of water and oil retention and to improve emulsion or oxidative stabilities **(Elleuch et al., 2011)**.

Tarhana is cereal-based fermented product. It is prepared from wheat flour, yoghurt and other ingredients. After mixing of all ingredients the dough is formed, which ferment 1 – 7 days at temperature 25 – 30 ºC by using lactic acid bacteria from yoghurt culture (*Lactobacillus bulgaricus*, *Streptococcus thermophilus*) and yeasts *Saccharomyces cerevisiae*. Tarhana is usually reconstituted with water and served as a hot soup generally consumed at lunch and dinner **(Erbaş et al., 2006; Lar et al. 2012; Sengun et al., 2009)**. Tarhana has an acidic and sour taste with a strong yeasty flavor **(Kaya et al., 1999)**.

Tarhana is very nutritive food because of nutritional deficiency in wheat is mostly eliminated by yoghurt. Its nutritional value is incerased and digestion is faciliated by fermentation **(Dalgiç and Belibağh, 2008)**. The protein, polysaccharide and lipid components of tarhana are subjected to partial digestion and hydrolysis by lactic acid bacteria and yeasts during fermentation, resulting in a product with improved digestive properties **(Tamer et al., 2007)**. Fermentation of tarhana also results in significant increases of riboflavin, niacin, pantothenic acid and folic acid contents **(Bilgiçli, 2009)**. Tarhana is also a good source of calcium, iron, zinc as well as some other minerals **(Daglioğlu, 2000)**.

The objective of this work was to prepare dietary fibre preparations obtained from citrus crops (orange and mandarin) and perform the determination of chemical and functional properties of obtained dietary fibre preparations and subsequently evaluate the suitablility of fruit dietary fibre incorporation to the tarhana recipe and observe fermentation process by determination of pH, reducing saccharides, lactic and acetic acid concentrations as well as sensory evaluation of final products.

MATERIAL AND METHODOLOGY

Dietary fibre (DF) preparations were obtained from orange (cultivar *Valencia*) and mandarin (cultivar *Clemenville*) purchased from local markets. From the cleaned citrus crops were separated inner part of peels (albedo), which was subsequently dried for 6 days at 27 ºC. Finally the peels were milled and sieved to obtain 400 μm particle size **(Marín et al., 2007)**. The yoghurt was laboratory prepared from bovine UHT milk, 3.5% fat by using commercial yoghurt culture Lactoflora® and incubated at 40 °C for 6 h. Tarhana samples (control and samples with replaced a part of wheat flour with orange respectively mandarin DF preparation at level 5 and 10% w/w) were prepared according to recipe and method **Ibanoğlu et al. (1995)** and fermented for 144 h at 30 ºC.

Within the chemical analysis of citrus DF preparations and wheat flour was performed determination of moisture, ash, fat and protein content from the total nitrogen content determined by the Kjeldhal method and converted to protein using a factor 6.25 **(Kohajdová et al., 2014)**. Total dietary fibre (TDF) content was determined by enzymatic-gravimetric method according to **Sun-Waterhouse et al. (2010)**. Functional properties – water absorption capacity (WAC), oil absorption capacity (OAC), swelling capacity (SWC) and least gelation concentration (LGC) were determined according to **Hayta et al. (2002)** and **Raghavendra et al. (2004)**.

Fermentation process was observed by the determination of pH using inoLab pH Level 2 apparatus (WTW, Weilheim, Germany) **(Ibanoğlu et al., 1999)**. Reducing saccharides were determined according to Schoorl. The nonreacted Cu^{2+} was determined after formation of Cu_2O. The KI was oxidized by $CuSO_4$ to I_2 that was determined by titration with $Na_2S_2O_3$ **(Kohajdová and Karovičová, 2005)**. The concentrations of lactic and acetic acids were determined by capillary isotachophoresis method according to **Kohajdová et al. (2006)** by using ZKI 01 apparatus (Villa Labeco, Spišská Nová Ves, Slovakia) equipped with conductivity detector and two line recorder TZ 4200 (Laboratórní přístroje, Prague, Czech Republic). Used electrolytic system for lactic and acetic acid analysis had following composition: leading electrolyte 0.01 mol/L HCl, counter-ion 6-aminocapronic acid, additive 0.1% methylhydroxy-ethylcellulose, pH 4.25; terminating electrolyte 0.005 mol/L capronic acid. Applied driving current was 250 μA in the pre-separation column. Lactic and acetic acids were in the samples identified according to their RSH (relative step height) values and compared with the RSH of lactic and acetic acids in standard solutions. Quantitative analysis was performed by calibration of standard solutions.

Sensory analysis of final products – tarhana soups was carried out by 11 semi-trained panellists (between 22 and 25 years of age, 9 female, 2 male, all non-smokers), informed about the preparation of samples, used raw materials and with the methods of sensory evaluation. Sensory evaluation was performed by using 7 point hedonic scale (1=extremely unacceptable to 7=extremely acceptable) and evaluate parameters were taste, odour, consistency, acidity and overall acceptability **(Erbaş et al., 2005; Bilgiçli, 2009)**.

RESULTS AND DISCUSSION

Determination of chemical parameters (Table 1) showed, that citrus dietary fibre preparations reached higher concentration of ash, fat and total dietary fibre compared to wheat flour. Wheat flour exhibited higher moisture content and protein concentration than citrus dietary fibre preparations. Comparable concentration of proteins in fruit DF preparations also reported **Yasar et al. (2007)**. The content of TDF in both preparations exceeded 50%, what is according to **Figuerola et al. (2005)** minimal criterion for TDF concentration in DF preparations. Citrus dietary fibre preparations showed higher values of water and oil absorption capacity, swelling capacity and least gellation concentration compared to wheat flour.

During tarhana fermentation was observed a decrease in pH values (Figure 1a) from 4.70 – 5.02 to 4.31 – 4.51. **Ibanoğlu et al. (1999)** reported a decrease in pH values of tarhana samples (control, sample without salt addition, sample with double amount of added yoghurt and tarhana prepared from whole wheat flour) from initial values of 4.7 – 5.2 to 4.3 – 4.8 after 96 h fermentation at 30 ºC.

Table 1 Chemical and functional properties of wheat flour and citrus dietary fibre preparations.

Parameter	Fine wheat flour	Orange dietary fibre	Mandarin dietary fibre
Moisture (%)	11.39 ±0.25	9.19 ±0.08	9.11 ±0.70
Ash (%)	0.55 ±0.00	2.76 ±0.04	2.53 ±0.01
Protein (%)	10.48 ±0.15	3.66 ±0.11	4.35 ±0.17
Fat (%)	1.54 ±0.03	2.33 ±0.02	2.06 ±0.01
Total dietary fibre (%)	2.25 ±0.04	64.41 ±0.69	61.28 ±0.57
WAC ($g.g^{-1}$)	3.20 ±0.04	5.82 ±0.05	5.16 ±0.09
OAC ($g.g^{-1}$)	2.45 ±0.02	3.15 ±0.01	4.81 ±0.02
SWC ($cm^3.g^{-1}$)	2.51 ±0.07	10.87 ±0.16	7.52 ±0.10
LGC (%)	6.00 ±0.00	8.00 ±0.00	8.00 ±0.00

WAC/OAC – water/oil absorption capacity, SWC – swelling capacity, LGC – least gelation concentration

Table 2 Sensory properties of tarhana samples.

Sample	Taste	Odour	Consistency	Sourness	Overall acceptability
Control	7.0 ±0.0	6.9 ±0.1	7.0 ±0.0	6.8 ±0.1	99.2 ±0.5
ODFP 5 %	6.7 ±0.2	6.8 ±0.0	6.8 ±0.1	6.4 ±0.0	90.0 ±1.8
ODFP 10 %	6.3 ±0.3	5.7 ±0.2	5.1 ±0.3	5.4 ±0.1	87.2 ±1.1
MDFP 5 %	6.9 ±0.0	6.8 ±0.1	6.7 ±0.2	6.5 ±0.2	95.3 ±2.0
MDFP 10 %	5.9 ±0.1	5.5 ±0.1	5.3 ±0.2	5.9 ±0.2	84.5 ±0.8

ODFP – orange dietary fibre preparation, MDFP – mandarin dietary fibre preparation

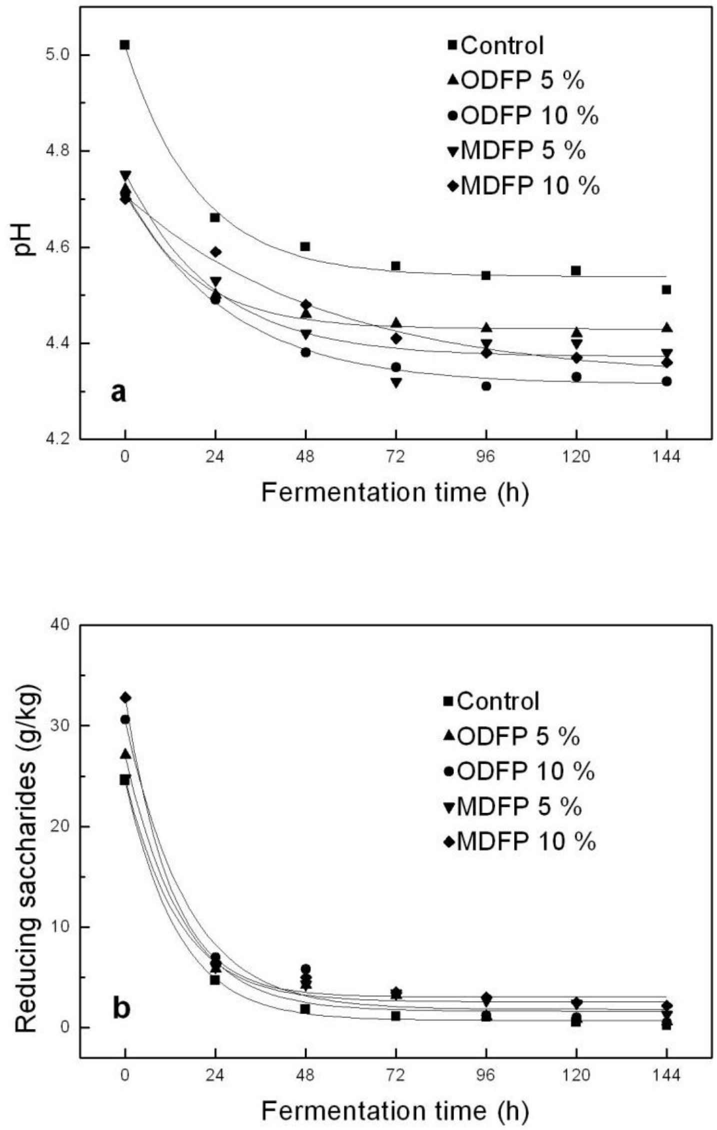

Figure 1 Changes in pH values (a) and concentration of reducing saccharides (b) during fermentation of tarhana, ODFP – orange dietary fibre preparation, MDFP – mandarin dietary fibre preparation.

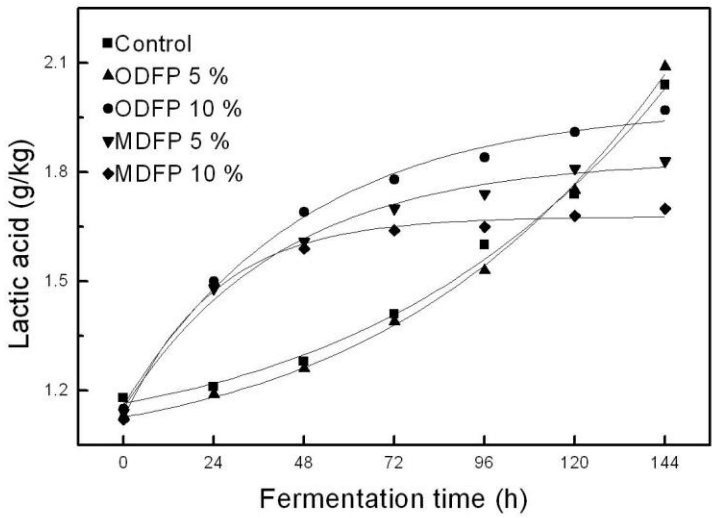

Figure 2 Changes in lactic acid concentration during fermentation of tarhana samples, ODFP – orange dietary fibre preparation, MDFP – mandarin dietary fibre preparation.

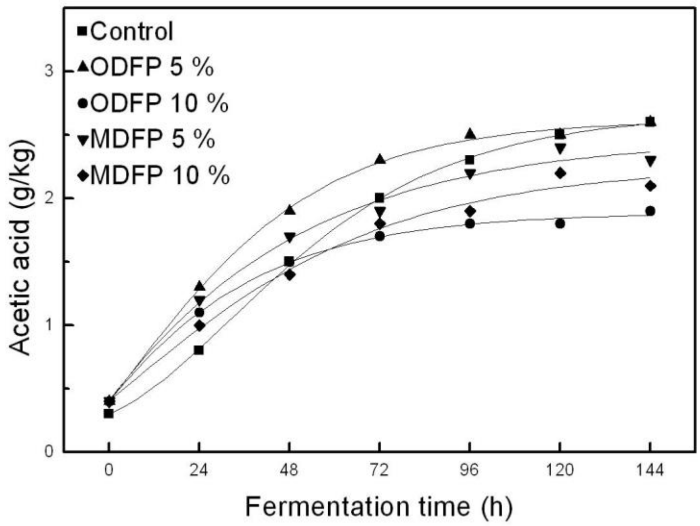

Figure 3 Determination of acetic acid during fermentation of tarhana, ODFP – orange dietary fibre preparation, MDFP – mandarin dietary fibre preparation.

Reducing saccharides are fermentable saccharides and their concentration decreased with increasing period of fermentation **(Singh et al., 2013)**. The concentration of reducing saccharides (Figure 1b) rapidly dropped in first 24 h of fermentation and in further process decreased slightly or remains constant.

Characteristic products of lactic acid fermentation by using lactic acid bacteria are lactic acid and acetic acid, which lower pH value and thus inhibit undesirable and pathogenic bacteria **(Kohajdová and Karovičová, 2008)**. The concentration of lactic acid (Figure 2) increased during tarhana fermentation and at the end of the process reached values in range 1.67 – 2.09 g/kg.

Determination of acetic acid (Figure 3) showed, that its concentration gradually increased with advancing time of fermentation and after 144 h reached values in range 1.91 – 2.53 g/kg. According to **Sroka and Tuszyński (2007)** the production of organic acids during fermentation depends on the concentration of available saccharides and nitrogen sources as well as on the pH value.

Sensory evaluation of tarhana samples (Table 2) showed, that higher amounts (10%) of added orange and mandarin dietary fibre preparations negatively affected taste, odour, consistency and sourness. Among all prepared tarhana samples with proportion of citrus dietary fibre preparation was the most acceptable tarhana with 5% of mandarin dietary fibre

CONCLUSION

Citrus dietary fibre preparations are valuable nutritive components of citrus crops. Prepared dietary fibre preparations obtained from orange and mandarin showed high content of total dietary fibre (64.41 and 61.28%) and higher concentration of ash and fat compared to wheat flour. Wheat flour exhibited higher moisture content and protein concentration than citrus dietary fibre preparations. Citrus dietary fibre preparations reached higher values of water and oil absorption capacity, swelling capacity and least gellation concentration compared to wheat flour.

Application of prepared orange and mandarin dietary fibre preparations to tarhana recipe led to significant decrease in pH values during fermentation. Concentration of reducing saccharides was reduced due to its utilization as an available source of energy for fermenting microorganisms. During fermentation was also observed lactic acid and acetic acid production. Sensory evaluation showed that higher amounts of added fruit preparations negatively affected taste, odour, consistency and sourness. The most acceptable among tarhana samples incorporated with citrus dietary fibre preparations was by panelists chosen tarhana with 5% proportion of mandarin dietary fibre.

REFERENCES

Bilgiçli, N. 2009. Effect of buckwheat flour on chemical and functional properties of tarhana. *LWT – Food Science and Technology*, vol. 42, no. 2, p. 514-518. http://dx.doi.org/10.1016/j.lwt.2008.09.006

Braddock, R. J. 1995. By-products of citrus fruits. *Food Technology*, vol. 49, p. 74-77.

Daglioğlu, O. 2000. Tarhana as a traditional Turkish fermented cereal food. Its recipe, production and composition. *Food/Nahrung*, vol. 44, no. 2, p. 85-88. http://dx.doi.org/10.1002/(SICI)1521-3803(20000301)44:2<85::AID-FOOD85>3.0.CO;2-H

Dalgiç, A. C., Belibağh, K. B. 2008. Hazard analysis critical control points implementation in traditional foods: a case study of Tarhana processing. *International Journal of Food Science & Technology*, vol. 43, no. 8, p. 1352-1360. http://dx.doi.org/10.1111/j.1365-2621.2007.01619.x

Elleuch, M., Bedigian, D., Roiseux, O., Besbes, S., Blecker, C., Attia, H. 2011. Dietary fibre and fibre-rich by-products of food processing: Characterization, technological functionality and commercial applications: A review. *Food Chemistry*, vol. 124, no. 2, p. 411-421. http://dx.doi.org/10.1016/j.foodchem.2010.06.077

Erbaş, M., Certel, M., Uslu, M. K. 2005. Microbiological and chemical properties of Tarhana during fermentation and storage as wet - sensorial properties of Tarhana soup. *LWT – Food Science and Technology*, vol. 38, no. 4, p. 409-416. http://dx.doi.org/10.1016/j.lwt.2004.06.009

Erbaş, M., Uslu, M. K., Erbaş, M. O., Certel, M. 2006. Effects of fermentation and storage on the organic and fatty acid contents of tarhana, a Turkish fermented cereal food. *Journal of Food Composition and Analysis*, vol. 19, no. 4, p. 294-301. http://dx.doi.org/10.1016/j.jfca.2004.12.002

Figuerola, I., Hurtado, M. L., Estévez, A. M., Chiffelle, I., Asenjo, F. 2005. Fibre concentrates from apple pomace and citrus peel as potential fibre sources for food enrichment. *Food Chemistry*, vol. 91, no. 3, p. 395-401. http://dx.doi.org/10.1016/j.foodchem.2004.04.036

Hayta, M., Alpaslan, M., Baysar, A. 2002. Effect of drying methods on functional properties of tarhana: A wheat flour-yoghurt mixture. *Journal of Food Science*, vol. 67, no. 2, p. 740-744. http://dx.doi.org/10.1111/j.1365-2621.2002.tb10669.x

Ibanoğlu, Ş., Ainsworth, P., Wilson, G., Hayes, G. D. 1995. The effect of fermentation conditions on the nutrients and acceptability of tarhana. *Food Chemistry*, vol. 53, no. 2, p. 143-147. http://dx.doi.org/10.1016/0308-8146(95)90779-7

Ibanoğlu, Ş., Ibanoğlu, E., Ainsworth, P. 1999. Effect of different ingredients on the fermentation activity in tarhana. *Food Chemistry*, vol. 64, no. 1, p. 103-106. http://dx.doi.org/10.1016/S0308-8146(98)00071-5

Kaya, S., Ibanoglu, S., Kaya, A. 1999. Moisture sorption chararcteristics of tarhana, a fermented turkish cereal food. *Journal of Food Quality*, vol. 22, no. 1, p. 95-100. http://dx.doi.org/10.1111/j.1745-4557.1999.tb00930.x

Kohajdová, Z., Karovičová, J. 2005. Sensory and chemical evaluation of lactic acid fermented cabbage-onion juices. *Chemical Papers*, vol. 59, no. 1, p. 55-61. ISSN 0366-6352.

Kohajdová, Z., Karovičová, J. 2008. Mliečne fermentované zeleninové šťavy. *Potravinárstvo*, vol. 2, no. 1, p. 50-59. ISSN 1338-0230.

Kohajdová, Z., Karovičová, J., Greifová, M. 2006. Lactic acid fermentation of some vegetable juices. *Journal of Food and Nutrition Research*, vol. 45, no. 3, 115-119. ISSN 1336-8672.

Kohajdová, Z., Karovičová, J., Magala, M., Kuchtová, V. 2014. Effect of apple pomace powder addition on farinographic properties of wheat dough and biscuits quality. *Chemical Papers*, vol. 68, no. 8, p. 1059-1065. http://dx.doi.org/10.2478/s11696-014-0567-1

Lar, A. Ç., Erol, N., Elgün, M. S. 2012. Effect of carob flour substitution on chemical and functional properties of tarhana. *Journal of Food Processing and Preservation*. http://dx.doi.org/10.1111/j.1745-4549.2012.00708.x

Marín, F. R., Soler-Rivas, C., Benavente-Garciá, B., Castillo, J., Pérez-Alvarez, J. A. 2007. By-products from different citrus processes as a source of customized functional fibres. *Food Chemistry*, vol. 100, no. 2, p. 736-741. http://dx.doi.org/10.1016/j.foodchem.2005.04.040

Raghavendra, S. N., Rastogi, N. K., Raghavaro, K. S. M. S., Tharanathan, R. N. 2004. Dietary fibre from coconut residue: effects of different treatments and particle size on the hydratation properties. *European Food Research and Technology*, vol. 218, no. 6, p. 563-567. http://dx.doi.org/10.1007/s00217-004-0889-2

Sengun, I. Y., Nielsen, D. S., Karapinar, M., Jakobsen, M. 2009. Identification of lactic acid bacteria isolated from Tarhana, a traditional Turkish fermented food. *International Journal of Food Microbiology*, vol. 135, no. 2, p. 105-111. http://dx.doi.org/10.1016/j.ijfoodmicro.2009.07.033

Singh, R., Mishra, B. K., Shukla, K. B., Jain, N. K., Sharma, K. C., Kumar, S., Kant, K., Ranjan, J. K. 2013. Fermentation process for alcoholic beverage production from mahua (*Madhuca indica* J. F. Mel) flowers. *Africal Journal of Biotechnology*, vol. 12, no. 39, p. 5771-5777. http://dx.doi.org/10.5897/AJB2013.12792

Sroka, P., Tuszyński, T. 2007. Changes in organic acid contents during mead wort fermentation. *Food Chemistry*, vol. 140, no. 3, p. 1250-1257. http://dx.doi.org/10.1016/j.foodchem.2007.01.046

Sun-Waterhouse, D., Teoh, A., Massarotto, C., Wibisono, R., Wadhwa, S. 2010. Comparative analysis of fruit-based functional snack bars. *Food Chemistry*, vol. 119, no. 4, p. 1369-1379. http://dx.doi.org/10.1016/j.foodchem.2009.09.016

Tamer, C. E., Kumral, A., Aşan, M., Şahin, I. 2007. Chemical compositions of traditional tarhana having different formulations. *Journal of Food Processing and Preservation*, vol. 31, no. 1, p. 116-126. http://dx.doi.org/10.1111/j.1745-4549.2007.00113.x

Topuz, A., Topacki, M., Çanakci, M., Akinci, I., Özdemir, F. 2005. Physical and nutritional properties of four orange varieties. *Journal of Food Engineering*, vol. 66, no. 4, p. 519-523. http://dx.doi.org/10.1016/j.jfoodeng.2004.04.024

Yasar, F., Togrul, H., Arslan, N. 2007. Flow properties of cellulose and carboxymethyl cellulose from orange peel. *Journal of Food Engineering*, vol. 81, no. 1, p. 187-199. http://dx.doi.org/10.1016/j.jfoodeng.2006.10.022

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