Annals. Food Science and Technology

2018

EFFECT OF FERMENTATION AND GERMINATION TREATMENTS ON PHYSICOCHEMICAL AND SENSORY PROPERTIES OF ENRICHED BISCUITS WITH ACORN FLOUR

Amina **Menasra**[1], Djamel **Fahloul**[1*]

[1]Food Sciences Laboratory (LSA), Department of Food Technology, Institute of Agriculture and Veterinary Sciences, University of Hadj Lakhdar Batna1, 05000 Batna, Algeria,

[*] E-mail: menasraamina@gmail.com, dfahloul2@yahoo.com

Abstract

Biscuits with a pleasant taste and accessible cost are widely consumed in the world. Over the years, a number of studies have been reported to improve nutritive value of biscuits. Many processes such as fermentation and germination are available to improve the nutritional quality of foods. The aim of this study was to estimate the potential incorporation of acorn as a dietary supplement and to determine the effect of fermentation and germination treatments on quality of enriched biscuits with acorn flour. Biscuits were prepared after incorporation of 10% of natural, fermented and germinated acorn flour of Quercus ilex variety. Physicochemical and sensory properties of enriched biscuits were characterized. Results showed that fermentation and germination treatments improve significantly nutritional properties of enriched biscuits (increases ash and decreases starch content). However, the above treatments decrease significantly physical dimensions (diameter and thickness) and sensory characteristics (color and appearance) of enriched biscuits. In addition, fermentation treatment decreases pH, increases titrable acidity and it has been effective in making enriched biscuits more acceptable (overall acceptance: 7.23). Thus, acorn flour could be used as a natural enrichment of gluten-free bakery product and fermentation treatment seems to be a natural method to improve sensory properties of enriched biscuits with acorn flour. Finally, all results indicate the possibility of the acorn flour as promising in the formulation of biscuits and open broad prospects in food industries.

Keywords: enriched biscuits, acorn flours, fermentation, germination, quality.

Received: 08.07.2018 Reviewed: 03.10.2018 Accepted: 24.10.2018

1. INTRODUCTION

Cereal products are consumed by the majority of populations (Heinio et al., 2016). Biscuits are favorite food mostly due to their pleasant taste, ready to eat nature, accessible cost, availability and longer shelf time (Vujic et al., 2015). For years, food industry has focused on increasing nutritional value of cereal products (Ktenioudaki and Gallagher, 2012). A number of studies have been reported to improve nutritive value of biscuits by incorporating bean, sesame seed, chickpea, barley, cowpea, lupine, soy protein and corn fiber (Serrem, 2010 ; Hyun-Jung et al., 2014). Acorn is an edible oval fruit of oak trees. This fruit is a rich source of carbohydrates, lipids, various sterols and vitamins (Ghaderi-Ghahfarrokhi et al., 2017). Plant proteins have been reported to have limiting amino acids and it is necessary to combine these plant proteins in proportions to improve protein intake of consumers. Many processes are available to improve the nutritional quality of plant foods. These methods include traditional processing such as cooking, soaking, dewatering, smoking, salting, fermentation, germination etc (Okpala and Okoli, 2012). Okpala and Okoli (2012) mentioned that fermentation improves amino acid composition and vitamin content, and lowers levels of antinutrients. Okpala et al. (2013) reported that germination induces an increase in free limiting amino acids with modified functional properties of seed components. Despite their botanical availability, acorns are not widely used, and more research should be carried out to boost its potential applications (Vinha et al., 2016). On the other hand, no work has been reported on the effect of fermentation and germination treatments on physicochemical and sensory properties of enriched biscuits with acorn flour. The current study was aimed to investigate the quality of enriched biscuits with natural, fermented and germinated acorn (*Quercus ilex* L.) flours.

2. MATERIAL AND METHODS

Material

All ingredients for biscuit preparation were purchased from local supermarket. Acorns (*Quercus ilex* L.) were collected during the month of October 2016 in Ichamoul region of Batna-northeast Algeria. Reagents and chemicals used in the experimental work were of analytical grade and were purchased from Sigma Co. (St. Louis, MO, USA). Materials were stored at 4 °C until testing (Correia et al., 2009).

Methods

Fermentation and germination treatments

Treated acorns nuts by fermentation and germination processes were prepared according to Khattab and Arntfield (2009) and Sangronis and Machado (2007), respectively as described in Figure 1.

Acorn flour production

Natural and treated acorns were dried at temperature of 50±5 °C for 16-18 hrs, ground in laboratory mill and sieved (1 mm) to obtain fine homogeneous flours.

Flours were stored at 4 °C until analysis (Sangronis and Machado, 2007).

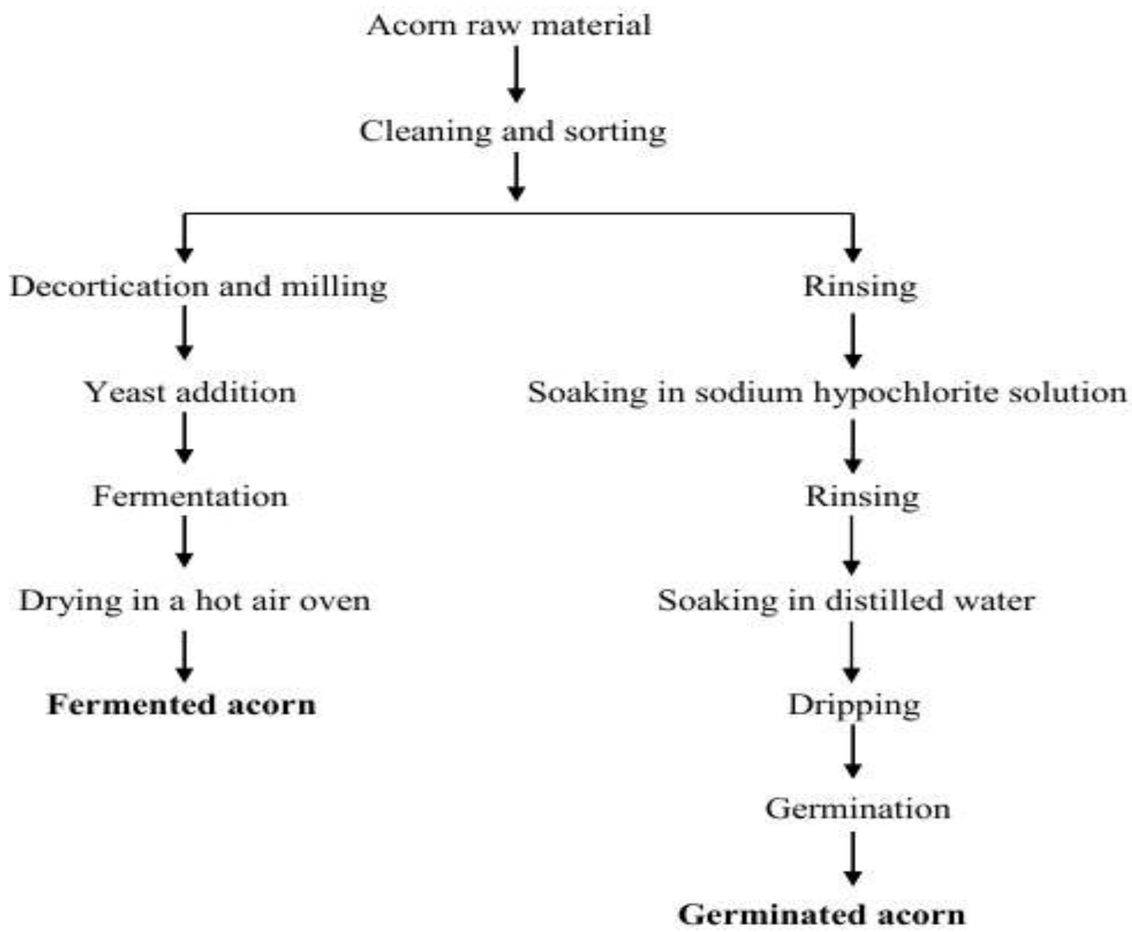

Fig. 1 : Fermentation and germination treatments of acorn

Biscuits preparation

Control and enriched biscuits with 10% supplementation level of natural, fermented and germinated acorn flours were prepared according to AACC (2000) (Method No. 10-50D) with slight modifications. The recipe contains 80.0±2 g standard wheat flour, 35.0±2 g grained sucrose, 20.0±2 g hydrogenated vegetable shortening, 1.0±2 g NaCl, 0.4±2 g NH_4HCO_3, 0.8±2 g N_aHCO_3 and 17.6±2 mL of water. Biscuits dough was sheeted and cut into circular shapes using a cutter (Reddy et al., 2005). Control and enriched biscuits were baked in an electrical baking oven (Teba High-01 Inox) under convection conditions at 180 °C for 15±2 min (Fels-Klerx et al., 2014).

Physicochemical properties of biscuits

Diameter and thickness of biscuits were determined according to AACC Method 10-53 (AACC, 2000). Spread ratio was calculated using the ratio of width to thickness according to Youssef and Mousa (2012). Weight loss was determined according to Agrahar-Murugkar et al. (2015). Volume of biscuit was calculated as a function of radius and biscuit density was determined and expressed as g per cm^3 (Serrem, 2010). Measurement of upper surface color of biscuits was determined using Minolta chroma meter. Color value is based on L* (lightness–darkness), a* (redness–greenness) and b* (yellowness–blueness) (Krystyjan et al., 2015). Results were used to calculate the browning index according to Sakin-Yilmazer et al. (2013). Control and enriched biscuits were analyzed for moisture and ash contents according to AACC Methods 44-19 and 40-70, by gravimetric method at 105 °C and incineration at 550 °C, respectively AACC (2000). pH was measured using a pH-meter Schott CG 843 with a combined electrode BlueLine 11 (Schott Geräte GmbH, Mainz, Germany) (Budryn et al., 2013). Starch content was determined by polarimetric method (Korus et al., 2015). Gluten was estimated by a Sodium hydroxide (NaOH) titration according to AACC Method 38-10 (AACC, 2000). Total titrable acidity was determined as described by Rizzello et al. (2010).

Sensory evaluation of biscuits

Sensory analysis of biscuits was carried out by 10 non-trained panelists from Food Sciences Laboratory in Food Technology Department. Evaluation attributes were appearance, color, texture, taste, odor and overall acceptability (Galla et al., 2017).

Statistical analy

Results were expressed as mean ± standard deviation. Statistical analysis was carried out with Duncan's multiple test ($P \leq 0.05$) (Hyun-Jung et al., 2014) using statistical software SPSS version 25.0 (SPSS Inc., Chicago, IL, USA) (Mogol and Gökmen, 2014).

3. RESULTS AND DISCUSSION

Physicochemical analysis of biscuits

Table 1 shows physical characteristics of biscuits. Substitution of wheat with acorn flour decreases significantly the weight of biscuits. Similarly, Serrem (2010) reported a reduction in weight of enriched biscuits with soy flour. Compared to enriched biscuits with natural acorn flour, weight and weight loss decreased in enriched biscuits with treated acorn flours. This may be explained by the high hydrophilicity of acorn proteins. This results in a reduction of total solids in dough and biscuits baked to lower weight (Serrem, 2010). Biscuits from wheat had the highest spread ratio (7.94). Difference in spread ratio depends on source of flours substitution (Hyun-Jung et al., 2014). It was observed that biscuits made with fermented acorn flour had the least diameter and spread ratio and the highest thickness than all prepared biscuits. Furthermore, an increase of biscuit volume was more pronounced when fermented acorn flour was added. Okpala et al. (2013) observed a similar trend in cookies made from fermented sorghum flour. This could be attributed to hydrophilic nature of fermented acorn flour, inducing a reduction in spread, thus leading to an increase in cookies thickness. It can be seen that biscuits density seemed to be affected by acorn flour addition (Table 1). Onacik-Gür et al. (2015) observed that usage of emulsifiers decreases the density of biscuits. Figure 2 shows colour data of control and enriched biscuits. Enriched biscuits lightness (L^*) decreased compared to control biscuit. Similarly, Korus et al. (2015) mentioned a decrease in lightness (L^*) values of enriched bread with acorn flour. It was observed a general increasing trend in browning index (BI) values of enriched biscuits with acorn flours. This may be ascribed to polyphenoloxidases activity as a result of biscuit baking (Jimoh et al., 2009). Increase in moisture content of enriched biscuit with fermented acorn flour compared to enriched biscuit with natural acorn flour could be attributed to water addition to acorn prior to fermentation (Ojokoh and Bello, 2014). Moisture content increased in enriched biscuit with germinated acorn flour (Table 2). Hyun-Jung et al. (2014) reported that moisture content in cookies increased when it was prepared with germinated brown rice flour. Activated enzymes during germination induced the degradation of starch and protein into smaller sugars and peptides, respectively. Thus, raising osmotic pressure, and made cookies retaining relatively higher amounts of water (Hyun-Jung et al., 2014). Enriched biscuits with acorn flour contain high values of ash (1.78-1.81%). Similarly, Hegazy et al. (2014) found an increase in ash content of enriched biscuits with chestnut (*Castanea sativa Mill.*) flour. This finding showed that addition of acorn flour in cereal products enhanced their nutritional values. pH decreased and total titrable acidity increased in enriched biscuits with fermented and germinated acorn flours due to the preliminary fermentation and germination of acorn flour. Rizzello et al. (2010) reported a decrease in pH and an increase in total titrable acidity of fermented wheat germ bread due to the presence of lactic and acetic acids. Enriched biscuits with acorn flours had lower starch content (Table 2). This decrease in starch content could be explained by the low carbohydrate content of flour. It could be seen that germination decreases significantly the carbohydrate content (Table 2). During germination, enzymes become active and α-amylase activity increases, catalyzing starch degradation, and consequently increasing the amount of small dextrin and fermentable sugars (Cornejo et al., 2015). Wet gluten content decreased significantly with acorn flour addition in biscuits (Table 2). This effect is a self-evident result from the substitution of wheat flour with acorn flour, reducing the amount of gluten in the composite flours. Korus et al. (2015) reported that acorn flour could be used to prepare gluten-free bakery products.

Table 1: Physical characteristics of biscuits.

Parameters	CB	BNAF	BFAF	BGAF
Weight (g)	9.77 ± 0.005^{a}	9.52 ± 0.01^{b}	9.37 ± 0.005^{c}	9.13 ± 0.01^{d}
Weight loss (%)	$20.79 \pm 0{,}01^{a}$	$20.24 \pm 0{,}04^{b}$	$19.93 \pm 0{,}03^{c}$	$19.41 \pm 0{,}006^{d}$
Diameter (cm)	4.21 ± 0.005^{a}	4.20 ± 0.02^{b}	4.16 ± 0.005^{c}	4.18 ± 0.005^{d}
Thickness (cm)	0.53 ± 0.005^{a}	0.56 ± 0.005^{b}	0.64 ± 0.01^{c}	0.55 ± 0.01^{d}
Spread ratio	7.94 ± 0.007^{a}	7.51 ± 0.008^{bd}	6.5 ± 0.009^{c}	7.6 ± 0.01^{db}
Volume (cm^3)	7.37 ± 0.009^{a}	7.79 ± 0.01^{b}	8.69 ± 0.015^{c}	7.54 ± 0.015^{d}
Density (g/cm^3)	1.32 ± 0.0012^{a}	1.22 ± 0.002^{bd}	1.07 ± 0.0013^{c}	1.21 ± 0.003^{db}

CB: control biscuit, BNAF, BFAF and BGAF: enriched biscuit with 10% of natural, fermented and germinated acorn flour, respectively. Superscript values with different letters in the same line indicate significant difference ($P \leq 0.05$) analyzed by Duncan's multiple range test.

Table 2: Physicochemical properties of biscuits.

Parameters	CB	BNAF	BFAF	BGAF
Moisture (%)	5.57±0.011[ad]	5.19±0.01[bc]	5.24±0.01[cb]	5.50±0.2[da]
DM (%)	94.43±0.011[ad]	94.81±0.01[bc]	94.76±0.01[cb]	94.50±0.2[da]
Ash (%)	1.61±0.01[a]	1.79±0.01[bd]	1.81±0.005[c]	1.78±0.01[db]
OM (%)	98.39±0.01[a]	98.21±0.01[bd]	98.19±0.005[c]	98.22±0.01[db]
pH	6.85±0.011[a]	6.88±0.01[b]	6.72±0.01[c]	6.79±0.005[d]
TTA (%)	0.136±0.001[ab]	0.133±0.005[ba]	0.148±0.0005[cd]	0.142±0.002[dc]
Starch (%)	68.08±0.015[a]	61.03±0.011[b]	59.4±0.2[c]	51.9±0.1[d]
WG (%)	37.13±0.015[a]	33.09±0.01[b]	33.18±0.015[c]	33.29±0.01[d]

DM: dry matter, OM: organic matter, TTA: totale titrable acidity, WG: wet gluten, CB: control biscuit, BNAF, BFAF and BGAF: enriched biscuit with 10% of natural, fermented and germinated acorn flour, respectively. Superscript values with different letters in the same line indicate significant difference ($P \leq 0.05$) analyzed by Duncan's multiple range test.

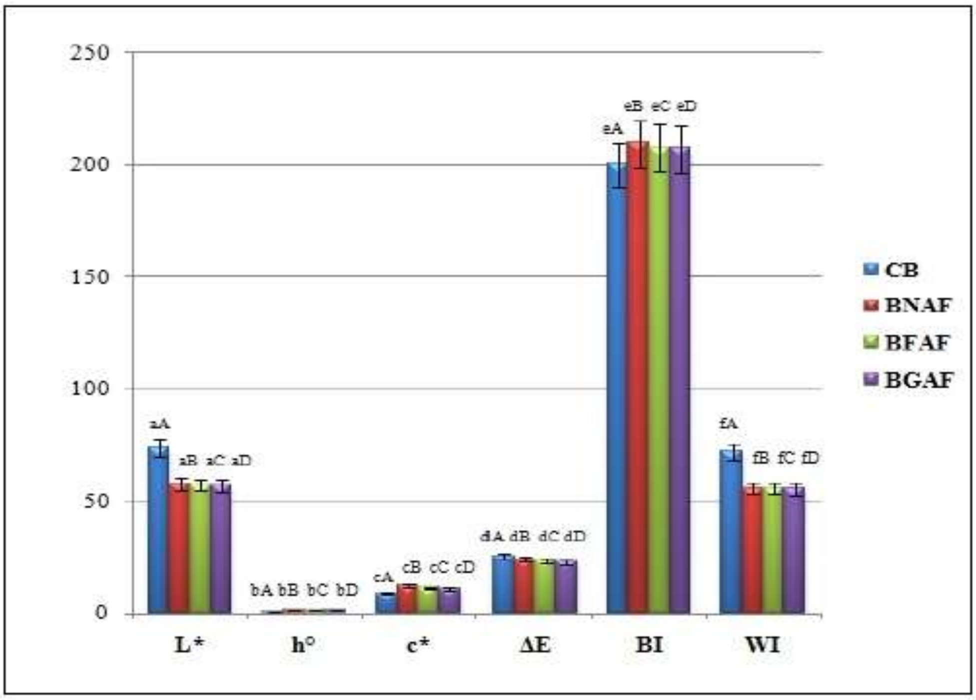

Fig 2: Colour of control and enriched biscuits

L^* : leightness, h° : hue angle, c^* : chromaticity, ΔE : total color change, BI : browning index, WI : wheitness index, CB : control biscuit, BNAF, BFAF an BGAF : enriched biscuit with natural, fermented and germinated acorn flour, respectively.

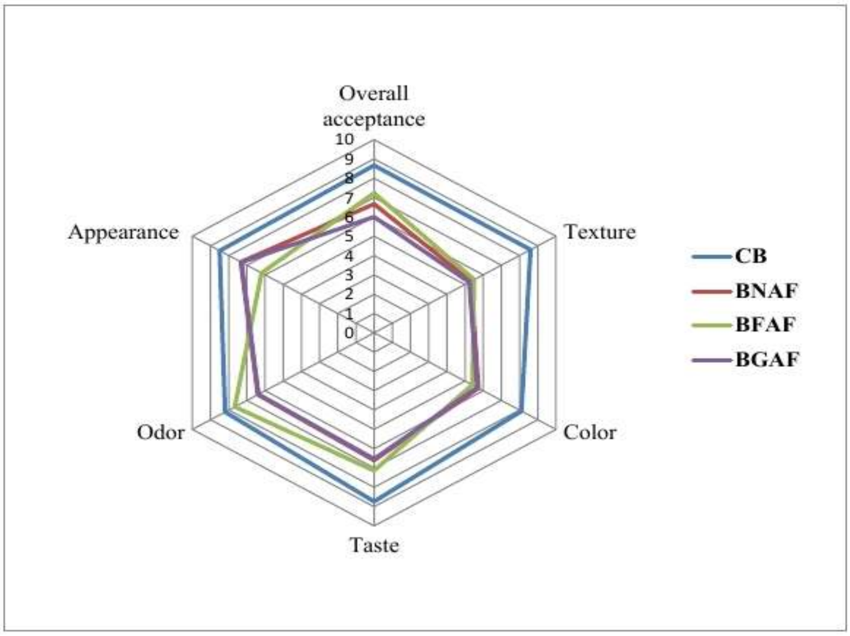

Fig 3: Spider diagram of sensory evaluation of biscuits

CB: control biscuit, BNAF, BFAF and BGAF: enriched biscuit with natural, fermented and germinated acorn flour, respectively. Scores are based on a 9-point hedonic scale with 1, dislike extremely; 5, neither like nor dislike; and 9, like extremely; number of panelists (n)=10.

Sensory evaluation of biscuits

The effect of adding acorn flour to wheat flour on sensory properties of biscuits was evaluated and presented in Figure 2. Biscuits made with wheat had the highest ratings for all tested sensory parameters. Hegazy et al. (2014) reported similar results. It was observed that replacement of wheat flour with germinated acorn flour affects significantly sensory properties of biscuit. Similarly, Okpala and Okoli (2012) found a decrease in sensory properties of enriched biscuits with germinated pigeon pea flour. Fermentation treatment may provide additional flavors to cookies which could enhance consumer's acceptability (Hyun-Jung et al., 2014). Ogunjobi and Ogunwolu (2010) reported that acidic pH of supplemented biscuits with cashew apple powder is associated with the development of a pleasant taste of biscuits.

3. CONCLUSION

Foods with healthy benefits need to have high sensory acceptance in order to be consumed. Acorn flour might be used to prepare gluten free biscuits characterized with high nutritive value. Fermentation treatment seems to be a natural and sustainable way to improve sensory properties of enriched biscuits with acorn flour.

Acknowledgement

Food Science Laboratory technicians are thanked for their assistance throughout the preparation of this work.

4. REFERENCES

[1] Heinio, R.L., Noort, M.W.J., Katina, K., Alam, S.A., Sozer, N., de Kock, H.L., Hersleth, M. and Poutanen, K. (2016). Sensory characteristics of wholegrain and bran-rich cereal foods e A review. *Trends in Food Science and Technology*, **47**: 25-38.

[2] Vujic, L., Cepo, D.V. and Dragojevic, I.V. (2015). Impact of dietetic tea biscuit formulation on starch digestibility and selected nutritional and sensory characteristics. *LWT - Food Science and Technology*, **62**: 647-653.

[3] Ktenioudaki, A. and Gallagher, E. (2012). Recent advances in the development of high-fibre baked products (review). *Trends in Food Science and Technology*, **28**: 4-14.

[4] Serrem, C.A. (2010). Development of soy fortified

sorghum and bread wheat biscuits as a supplementary food to combat protein energy malnutrition in young children. Doctoral thesis. Department of Food Science. Faculty of Natural and Agricultural Sciences, University of Pretoria, South Africa.
[5] Hyun-Jung, C., Ahra, C. and Seung-Taik, L. (2014). Utilization of germinated and heat-moisture treated brown rices in sugar-snap cookies, *LWT - Food Science and Technology*, **57**: 260-266.
[6] Ghaderi-Ghahfarrokhi, M., Sadeghi-Mahoonak, A.R., Alami, M. and Mousavi, K. (2017). Effect of processing treatments on polyphenol removal from kernel of two Iranian acorns varieties. *International Food Research Journal*, **24**(1): 86-93.
[7] Okpala, L.C. and Okoli, E.C. (2012). Development of cookies made with cocoyam, fermented sorghum and germinated pigeon pea flour blends using response surface methodology. *Journal of Food Sciences and Technology*, **51**(10): 2671-2677.
[8] Okpala, L., Okoli, E. and Udensi, E. (2013). Physico-chemical and sensory properties of cookies made from blends of germinated pigeon pea, fermented sorghum, and cocoyam flours. *Food Science and Nutrition*, **1**(1): 8-14.
[9] Vinha, A.F., Barreira, J.C.M., Costa, A.S.G. and Oliveira, M.B.P.P. (2016). ANewAge for *Quercus* spp. Fruits: Review on nutritional and phytochemical composition and related biological activities of acorns. *Comprehensive Reviews in Food Science and Food Safety*, **15**: 947-981.
[10] Correia, P.R., Leita˜o, A.E. and Beira˜o-da-Costa, M.L. (2009). Effect of drying temperatures on chemical and morphological properties of acorn flours. *International Journal of Food Science and Technology*, **44**: 1729-1736.
[11] Khattab, R.Y. and Arntfield, S.D. (2009). Nutritional quality of legume seeds as affected by some physical treatments 2. Antinutritional factors, *LWT - Food Science and Technology*, **42**: 1113-1118.
[12] Sangronis, E. and Machado, C.J. 2007. Influence of germination on the nutritional quality of Phaseolus vulgaris and Cajanus cajan. *LWT*, **40**: 116-120.
[13] A.A.C.C. (2000). Official Methods of Analysis. American Association of Cereal Chemistry. (9th edition), St. Paul., Minnesota, U.S.A.
[14] Reddy, V., Urooj, A. and Kumar, A. (2005). Evaluation of antioxidant activity of some plant extracts and their application in biscuits. *Food Chemistry*, **90**: 317-321.
[15] Fels-Klerx, V.D.H.J., Capuano, E., Nguyen, H.T., Mogol, A.B., Kocadağl, T., Taş, G.N., Hamzalıoğlu, A., Boekel, V.M.A.J.S. and Gökmen, V. (2014). Acrylamide and 5-hydroxymethylfurfural formation during baking of biscuits: NaCl and temperature–time profile effects and kinetics. *Food Research International*, **57**: 210-217.
[16] Youssef, H.M.K.E. and Mousa, R.M.A. (2012). Nutritional Assessment of Wheat Biscuits and Fortified Wheat Biscuits with Citrus Peels Powders. *Food and Public Health*, **2**(1): 55-60.
[17] Agrahar-Murugkar, D., Gulati, P., Kotwaliwale, N. and Gupta, C. (2015). Evaluation of nutritional, textural and particle size characteristics of dough and biscuits made from composite flours containing sprouted and malted ingredients. *Journal of Food Science and Technology*, **52**(8): 5129-5137.
[18] Krystyjan, M., Gumul, D., Ziobro, R. and Korus, A. (2015). The fortification of biscuits with bee pollen and its effect on physicochemical and antioxidant properties in biscuits. *LWT - Food Science and Technology*, **6**: 640-646.
[19] Sakin-Yilmazer, M., Kemerli, T., Isleroglu, H., Ozdestan, O., Guven, G., Uren, A. and Kaymak-Ertekin, F. (2013). Baking kinetics of muffins in convection and steam assisted hybrid ovens (baking kinetics of muffin. . .). *Journal of Food Engineering*, **119***:* 483-489.
[20] Budryn, G., Żyżelewicz, D., Nebesny, E., Oracz, J. and Krysiak, W. (2013). Influence of addition of green tea and green coffee extracts on the properties of fine yeast pastry fried products, *Food Research International*, **50**: 149-160.
[21] Korus, J., Witczak, M., Rafał, Z. and Juszczak, L. (2015). The influence of acorn flour on rheological properties of gluten‑free dough and physical characteristics of the bread. *European Food Research* and *Technology*, **240**: 1135-1143.
[22] Rizzello, C.G., Nionelli, L., Coda, R., Di Cagno, R. and Gobbetti, M. (2010). Use of sourdough fermented wheat germ for enhancing the nutritional, texture and sensory characteristics of the white bread. *European Food Research* and *Technology*, **230**: 645-654.
[23] Galla, N.R., Pamidighantam, P.R., Karakala, B., Gurusiddaiah, R.M. and Akula, S. (2007). Nutritional, textural and sensory quality of biscuits supplemented with spinach (*Spinacia oleracea* L.). *International Journal of Gastronomy and Food Science*, **7**: 20-26.
[24] Mogol, B.A. and Gökmen, V. (2014). Mitigation of acrylamide and hydroxymethylfurfural in biscuits using combined partial conventional baking and vacuum post-baking process: Preliminary study at the lab scale. *Innovative Food Science and Emerging Technologies*, **26**: 265-270.
[25] Onacik-Gür, S., Żbikowska, A. and Jaroszewska, A. (2015). Effect of high-oleic sunflower oil and other pro-health ingredients on physical and sensory properties of biscuits. *CyTA–Journal of Food*, **13**(4): 621-628.
[26] Jimoh, K.O., Olurin, T.O. and Aina, J.O. (2009). Effect of drying methods on the rheological

characteristics and colour of yam flours. *African Journal of Biotechnology*, **8**(10): 2325-2328.

[27] Ojokoh, A. and Bello, B. (2014). Effect of Fermentation on Nutrient and Anti-nutrient Composition of Millet (*Pennisetum glaucum*) and Soyabean (*Glycine max*) Blend Flours. *Journal of Life Sciences*, **8**(8): 668-675.

[28] Hegazy, N.A., Kamil, M.M., Hussein, A.M.S. and Bareh, G.F. (2014). Chemical and technological properties of improved biscuit by chestnut flour. *International Journal of Food and Nutritional Sciences*, **3**(6): 7-15.

[29] Cornejo, F., Caceres, P.J., Martinez-Villaluenga, C., Rosell, C.M. and Frias, J. (2015). Effects of germination on the nutritive value and bioactive compounds of brown rice breads. *Food Chemistry*, **173:** 298-304.

[30] Ogunjobi, M.A.K. and Ogunwola, S.O. (2010). Physicochemical and sensory properties of cassava flour biscuits supplemented with cashew apple powder. *Journal of Food Technology*, **8**(1): 24-29.