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Proceeding Paper

Properties of Oil Extracted from Oat Grains before and after the Roasting Process Conducted under Different Conditions †

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Abstract: Oat (*Avena sativa L.*) grains are important source of protein, minerals, and oil. They contain at least twice as much fat as other common cereals, such as wheat, barley or rye, and the fat contained in oat grains significantly contributes to their properties, including improved calorific value and nutritional quality. Heat treatment, particularly roasting, has long been considered the essential method of processing grains, as roasting effectively extends shelf life, provides a pleasant roasted flavor and improves taste. The paper covers the improving effect of roasting process of the whole oat grain on the quality of the oil contained in grains. A differential scanning calorimeter coupled with a high-pressure cell has been used to determine the oxidative stability of oil, calorimetric bomb was applied to determine whole grain calorific value and GC (Gas Chromatography) determined fatty acids composition of oil.

Keywords: oat; oat oil; fatty acid composition of oil; calorific value of oat grains

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1. Introduction

Oat (*Avena sativa L.*) is an ancient cereal crop which has been cultivated at least since the time of Theophrastus (371–286 BC) [1]. This seed is widely cultivated around the world. The global production of oat increased by around 11% from 2019 to 2020, reaching more than 25 million metric tons in 2020. It has always been considered a valuable crop due to its nutritional properties [2].

Oat grains consist mainly of starch (39–55%), proteins (9–16%), lipids (2–18%) and dietary fiber (20–39%). Oats were not used as a source of edible oil because its amount in the seeds is quite small compared to oilseeds, however it contains at least twice as much fat as other common cereals, such as wheat, barley or rye, and the fat contained in oat grains significantly contributes to its properties, including improved calorific value and nutritional quality. Therefore, the oil contained in oats have nutritional and technological potential [3].

Roasting is the process that causes substantial sensory improvement due to physical, chemical, structural changes occurring during seed processing Roasting changes the texture, color, flavor and appearance of the seeds, and the resulting product is of unique crunch and flavor characteristics compared to raw seeds. This process also modifies the phenolic compounds profile, and in some cases, it improves the health benefit effects by enhancing their antioxidant capacity [4].

Whole grains of Bingo oat variety, were roasted in a laboratory oven. Roasting was carried out at 100 °C and 130 °C for 20 and 40 min. Then the oil was extracted from the oats using the Soxhlet method.

The aim of current investigation is to establish and discuss the differences in the quality characteristics of oils obtained from oats before and after roasting in various conditions.

2. Methods

2.1. Fat Extraction from Oat

The oat was grounded before extraction. The fat was extracted according to the procedure depicted by Boselli et al. [5] and Dolatowska-Żebrowska et al. [6].

2.2. GC Analysis

The fatty acid composition of the fat extracted from the oat was determined as fatty acid methyl esters, according to the ISO method. The YL6100 (Young Lin Bldg., Anyang, Hogyedong, Republic of Korea) gas chromatograph equipped with a flame ionization detector and a BPX-70 capillary column (SGE Analytical Science, Milton Keynes, UK) was used. The determination was carried out according to the procedure described by Bryś et al. [7].

2.3. Oxidative Stability by Pressure Differential Scanning Calorimetry (PDSC) Method

PDSC instrument (DSC Q20 TA Instruments, Newcastle, WA, USA) was used to determine the oxidative stability of oils. The experiment was conducted at constant temperature of 120 °C under 1400 kPa pressure of oxygen. The procedure for determination of PDSC induction time was described by Symoniuk et al. [8].

2.4. Calorimetric Bomb Method

The calorific value of the whole grains has been determined by using the calorimetric bomb in correspondence with ISO standards 1928:2009.

2.5. Acid Value Determination

Acid value (AV) was determined by titration with 0.1 M ethanolic potassium hydroxide in correspondence with ISO standards 660: 2009.

2.6. Peroxide Value Determination

Peroxide values (PV) of oils were determined by the iodometric technique in correspondence with ISO standards 3960: 2007.

3. Results and Discussion

Although several methods have been used to analyze and monitor lipid oxidation [9], oxidation reactions cannot be controlled by a single method due to their complexity. One of the methods used to determine oxidative stability was the PDSC. This method allows determining the Oxidation Induction Time (OIT). The longer the OIT, the more oxidatively stable an oil sample is. Taking into account obtained results (Figure 1), it can be concluded that oil extracted from the oat that has been previously roasted is characterised by a higher OIT than the oil extracted from the unroastedoat grains. Oil extracted from oats roasted at lower temperatures and for a shorter time is more oxidatively stable than oil extracted from oats roasted at higher temperatures and for a longer time. This is graphiclly presned on Figure 1.

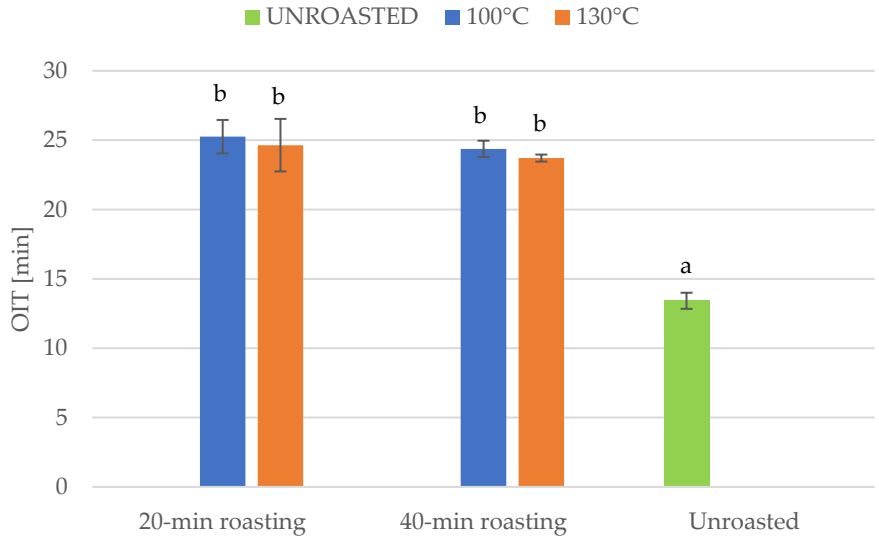

Figure 1. Oxidation Induction Time (OIT) of roasted and unroasted grain's oil. Different letters indicate that the samples are significantly different at $p < 0.05$.

Considering the results regarding the calorific value of oats (Figure 2), it is concluded that heat treatment does not result in statistically significant differences in the calorific value of oat grain. Slight increase in calorific value, however statistically insignificant, was observed only for samples roasted at a lower temperature. In the studies by Valendes at al. [10] microwave torrefaction of oat hull was conducted to change its physic-chemical properties. The results obtained showed that the heat treatment conducted in high temperature increased the calorific values, while decreased mass yield.

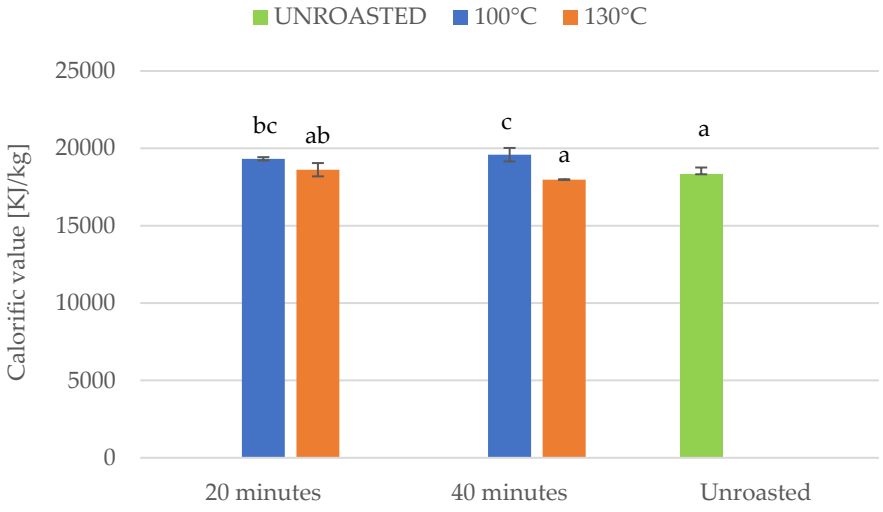

Figure 2. Calorific value of roasted and unroasted whole oat grains. Different letters indicate that the samples are significantly different at $p < 0.05$.

Considering the composition of fatty acids of the investigated samples (Table 1, Figure 3), it is concluded that unsaturated fatty acids dominate in the fatty acid composition of oat oil. Among the monounsaturated acids, oleic acid is the most abundant (range of 36-37%), while among the polyunsaturated acids, linoleic acid is the most abundant (range of 38-40%). Oat oil does not contain a lot of saturated fatty acids. Among the saturated acids, palmitic acid is the most abundant. Results obtained by other scientists agree that oat oil is considered to be a good source of polyunsaturated essential fatty acids and three

fatty acids dominate in oats—oleic, linoleic, and palmitic acids [11,12]. The proportion of unsaturated fatty acids (oleic, linoleic, and linolenic) in oats is about 75% of all fatty acids [13].

It was observed that the roasting process did not significantly affect the composition of fatty acids.

Table 1. Fatty acid composition present in both unroasted and roasted oat's oils.

Fatty Acid	Unroasted	100 °C/20 min	100 °C/40 min	130 °C/20 min	130 °C/40 min
C14:0	0.23 ± 0.14	0.35 ± 0.01	0.55 ± 0.30	0.35 ± 0.01	0.40 ± 0.08
C16:0	17.73 ± 0.35	16.26 ± 0.08	19.04 ± 4.99	16.12 ± 0.35	16.29 ± 0.25
C16:1	0.240 ± 0.001	0.32 ± 0.01	0.38 ± 0.09	0.32 ± 0.02	0.34 ± 0.01
C18:0	1.89 ± 0.14	1.380 ± 0.001	1.28 ± 0.17	1.35 ± 0.03	1.39 ± 0.10
C18:1 n-9	42.10 ± 0.18	37.00 ± 0.02	35.95 ± 2.40	37.02 ± 0.14	37.41 ± 0.46
C18:2 n-6	34.62 ± 0.13	40.090 ± 0.007	38.29 ± 2.28	39.99 ± 0.10	38.68 ± 1.56
C18:3 n-3	1.20 ± 0.01	2.03 ± 0.01	1.84 ± 0.22	2.06 ± 0.01	1.94 ± 0.08
C20:0	0.31 ± 0.01	0.19 ± 0.01	0.23 ± 0.04	0.19 ± 0.04	0.32 ± 0.14
C20:1	1.68 ± 0.04	1.16 ± 0.02	1.16 ± 0.23	1.18 ± 0.64	1.51 ± 0.52
others	1.080 ± 0.001	1.19 ± 0.07	1.26 ± 0.16	1.410 ± 0.001	1.70 ± 0.61

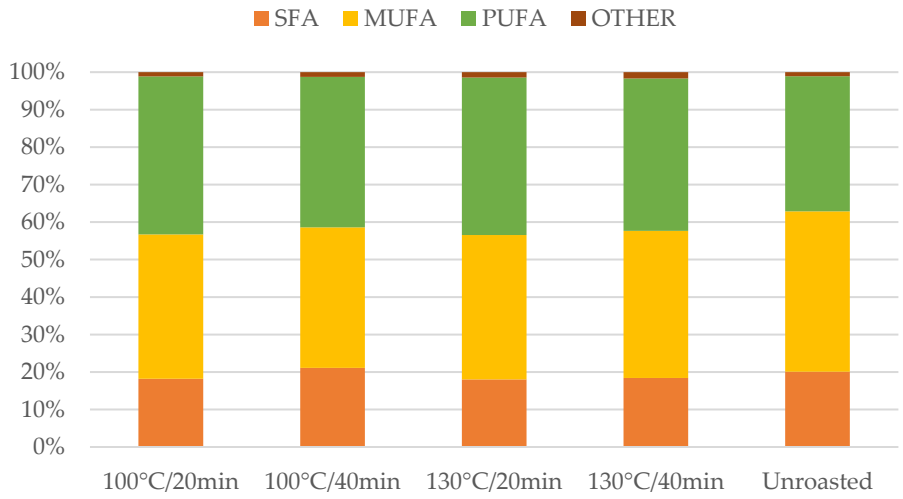

Figure 3. Percentage of fatty acids from the group: Saturated Fatty Acids (SFA), Monounsaturated Fatty Acids (MUFA), Polyunsaturated Fatty Acids (PUFA) and Other Fatty Acids.

The acid value (AV) is an indicator of the degree of oil hydrolysis. Considering the results obtained, it is concluded that in general the heat treatment causes increases in the acid value (Figure 4). The higher the roasting temperature, the higher the degree of hydrolysis of the oil from roasted oats. Other study have also reported a rise in AV of oil in the case of roasting process of walnut [14].

The peroxide value is an indicator of the content of primary oxidation products. Considering the obtained results (Figure 5), it is concluded that oil from grain processed at high temperature (130 °C) has a higher peroxide value compared to oil from oat seeds roasted at 100 °C. It has also been observed that heat treatment generally increases the peroxide value. Another study reported that increasing the roasting time increased the peroxide value of sesame seeds oil [15].

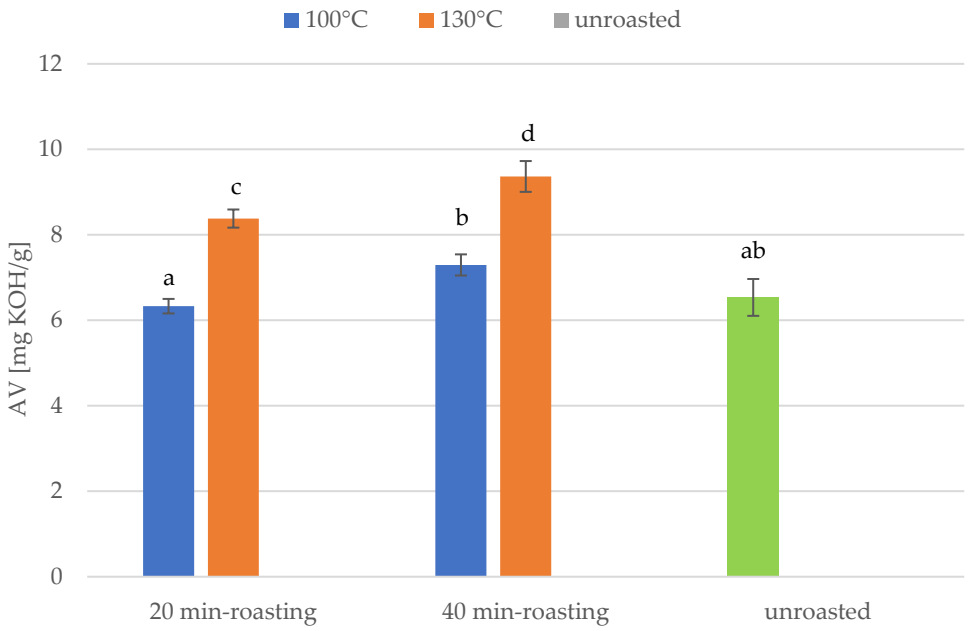

Figure 4. Acid value (AV) of roasted and unroasted oat's oil. Different letters indicate that the samples are significantly different at $p < 0.05$.

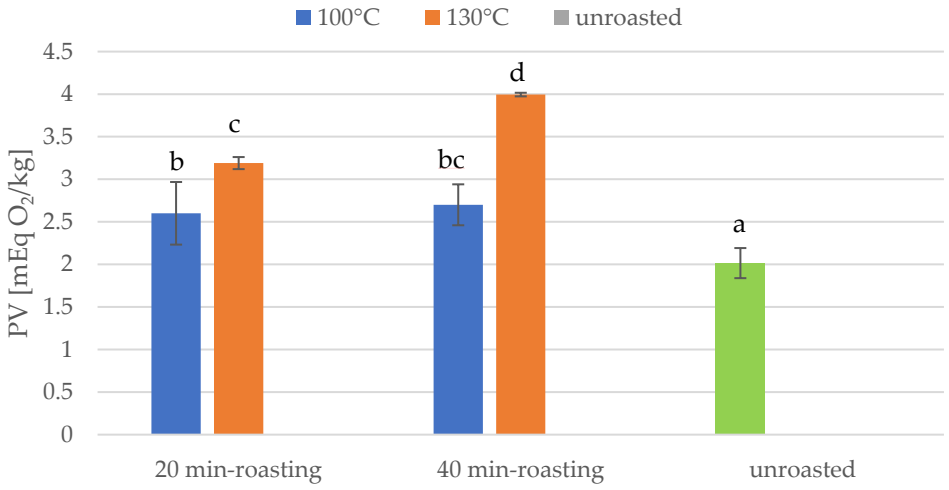

Figure 5. Peroxide value of roasted and unroasted oat's oil. Different letters indicate that the samples are significantly different at $p < 0.05$.

4. Conclusions

The conclusions drawn in current investigation based on determination of oxidative induction time using PDSC, acid values by titration, calorific value using calorimetric bomb and fatty acid compositions using Gas Chromatography. The oxidative stability of the oil increased after the roasting process of oat grains. Oil from roasted oat grains is characterized by a lower acid and peroxide value than oil from grains that have not been thermally treated. The higher the temperature and longer the roasting time, the worse the hydrolytic and oxidative quality of the oil. Roasting does not cause significant changes in the composition of fatty acids.

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preparation, B.K.P.; J.B., E.G.-S., A.B. and P.K.; writing—review and editing, E.G.-S., P.K.; supervision, P.K. All authors have read and agreed to the published version of the manuscript.

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