"Impact of Almonds Seed Geometrical Properties on the chemical properties of Extracted Almonds Oil"

Sheraz Zuher Karem1

Darwin Hawar Mohammed2

1,2Food Technology Department, Agricultural Engineering Sciences College, University of Salahaddin, Erbil, Kurdistan Region, IRAQ.

1https://orcid.org/0000-0002-6220-4880

2https://orcid.org/0009-0007-6790-6607

Abstract
The correlation between the morphological characteristics of almond seeds and the physical and chemical qualities of the oil that is extracted is the subject of this investigation. The tiny, medium, and large almond seeds were collected from the Bazar of Erbil in Iraq. A computerised Vernier calliper and an electronic balance were used to measure morphological characteristics, such as length, breadth, thickness, volume, surface area, and bulk density. Using petroleum ether as the solvent, the Soxhlet process was used at different temperatures to extract the oil. Acid value (AV), free fatty acid (FFA) content, iodine value (IV), peroxide value (PV), and saponification value (SP) were all tests that were run on the removed oil. According to the results, the oil output was much greater in the larger almond seeds (48.7% oil content vs. 35.4% in the smaller ones). Oil extracted from larger seeds exhibited greater levels of unsaturation, primary oxidation, and shorter average fatty acid chain lengths, as shown by higher AV, FFA, IV, PV, and SP values. These results point to the importance of seed size and related morphological characteristics in defining almond oil yield and quality. Results from this study corroborate those from other studies that have shown how important it is to carefully choose almond seeds in order to maximise oil extraction efficiency and quality.
keywords: Almond Seed, Almond seed oil, Extraction, Geometrical properties.

Introduction

The cultivated almond (*Prunus dulcis*) is a nutritionally important and valuable specialty crop grown in many temperate and sub-tropical regions in the world, both for domestic consumption and for trade. Almonds belong to the genus Prunus and the subgenus Amygdalus, within the Rosaceae family. They are the most extensively farmed nut crop in the Mediterranean region and have several positive effects on human health. Almonds come in two main varieties: bitter almonds (Prunus amygdalus "amara") and sweet almonds (Prunusamygdalus "dulcis"), the former of which is often used in cooking and the latter in the production of oils and flavourings (1). Worldwide, more than two million tonnes of almonds were produced, making them one of the most eaten nut varieties. This is particularly true in countries with high per capita income. According to FAOSTAT figures, in 2020 the United States was the leading nation in almond production, with an output of over one million tonnes. Almonds are low in moisture and contain a variety of minor beneficial substances; they also include lipids (about 50%), proteins (about 25%), and carbs (about 20%). Almonds' macro- and micronutrient composition is linked to their positive benefits (2).

Because of its high levels of protein, fat, minerals, fibre, and vitamin E, almonds are

considered a healthy and tasty fruit with an agreeable and desirable scent and flavour (3). Location, technical and cultural practices, and environmental factors all have a role on the almond's proximate composition. The many almond genotypes are characterised by several research (4).
While there is some seasonal variation in almond kernel size and weight, it is less pronounced in almonds than in other Prunus species. Certain business applications place a premium on the kernel's linear dimensions—its length, breadth, and thickness—along with its overall size (5). From a business perspective, kernel size matters, and bigger kernels are usually better (6). Many factors contribute to a variety's commercial success, including its kernel, shell, and hull qualities. Knowing the physical qualities of almond nuts is essential for optimal threshing performance, pneumatic conveying, storage, and other related activities. It is easy to measure the physical properties of several almond cultivars from California and Europe (7).
The high quantity of tocopherol in almonds has been shown to limit lipid oxidation during processing and storage, and almonds are a rich source of this vital vitamin. In addition to their usage in sugar-coated almonds and other processed foods, roasted almond kernels are an ingredient in many baked goods (8). To further prove its potential health advantages, knowledge of the bioactive components of almond kernels would be helpful. Many studies have shown that almond oil's unsaturated fatty acids—including oleic, linoleic, and linolenic—may reduce the risk of cardiovascular disease and cholesterol in people (9). In the medical, pharmaceutical, and beauty sectors, almond oil is a staple. Tocopherol, squalene, and sterol are just a few of the bioactive components found in vegetable seed oils that are extracted using the cold press technique (10). There are a few different ways to extract oil from seeds, the most popular of which is solvent extraction. Another option is cold press extraction, which uses less solvent and heat (11). The current research set out to determine how the geometrical properties effect the chemical properties, and the yield of oil.

2. Materials and Methods

2.1. Preparation of Sample The research used almond seeds sourced from Erbils Bazar in Iraq. It took a lot of hard work to get rid of any dirt, stones, or broken almond seeds. One hundred seeds were chosen at random.

2.2. Instrumentation

The length, width, and thickness of the Almond seed samples were measured using a Toolzone 150 mm Electronic Digital Vernier Caliper TC- 000899, X0005RMBUD. This caliper has a reading range of up to 150 mm and an accuracy of 150 mm. An electronic balance made in Switzerland by METTLER TOLEDO (SNR 1118151898, TDNR 26215122) was used to weigh the Almond seed samples.

2.3. Morphological characteristics of Determination Almond Seeds

Using length (in millimetres), weight (in millimetres), and thickness (in millimetres), we measured the almond seeds. Next, we measured 100 seeds for sample and computed their Morphological characteristics, which included (v, %), (ρ, kg/), (At,), (Af,), (Da, mm), (Dg, mm), and (S,). The geometrical parameters for samples of almond seeds are calculated using the following relationships (12)

$$D_g = (L\times W\times T)^{1/3} \text{ ---------------------------------- } (1)$$

$$D_a = \frac{(L+W+T)}{3} \text{ ------------------------------------- } (2)$$

$$S= \frac{(L\times W\times T)1/3}{L} \times 100\text{-------------------------}(3)$$

$$V= \frac{\pi}{6}(L\times W\times T), \text{ --------------------------------}(4)$$

the (A_t) and (A_f), is calculated in mm^2 (13).

$$A_t = \frac{\pi}{4}(W\times T), \text{ ---------------------------------}(5)$$

$$A_f = \frac{\pi}{4}(L\times W), \text{ ---------------------------------}(6)$$

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Density of seed (ρ_d):

$\rho_b = \frac{Wb}{Vb}$ ---------------------------------------(7)

2.4 Oil Extraction by Soxhlet

Almond oil was produced from almond seeds using a soxhlet method (14). After drying and powdering the seeds, 15 grammes of each sample was taken and placed in a thimble. Pour 300 ml of petroleum ether into the soxhlet apparatus's round bottom flask; this will serve as the solvent. Next, we proceeded to extract the substance by subjecting it to heats at 100, for a duration of four hours. Using a rotary evaporator set at 65 oC, the solvent was removed from the almond oil. The separated oil was heated to 40 ^{o}C and filtered under a vacuum to remove any remaining solvent. The resulting samples are mostly pale yellow in colour. Once the extract has been stored in a dark place for later analysis, we will go over it again (14).

% Yield = $W1{-}W2\ W1$ × 100

W1= W eight of Sample (g)

W2 = Weight of remaining sample (g).

2.5 *Chemical Analysis*

2.5.1 Acid Value

For each sample of almond oil, we determined its acidity using the (15) method. Before titrating with 2-3 drops of phenolphthalein indicator, a 0.1 N potassium hydroxide solution was made by dissolving 1g of almond oil sample in a 50:50 mixture of ethanol and ether. Here we may get the acid value and free fatty acid quantity using this equation. Where:Voltage of the potassium hydroxide titrant (ml), normality of the potassium hydroxide (N), molecular weight of potassium hydroxide (56 g/mol), and percent free fatty acid (%FFA) expressed as oleic acid per 100 g are all variables.

Acid Value = $\frac{V\ of\ KOH \times N \times 56}{weight\ of\ sample\ (g)}$

% Free fatty acid = Acid Value × 0.503

2.5.2 Iodine Value

The iodine value of the almond oil samples was determined according to the procedure described in reference (15). Add 18.2 grammes of iodine to 1 litre of glacial acetic acid and dissolve. Three millilitres of bromine water will increase the halogen level. To make the Hansus solution, mix 1 gramme of almond oil with half a millilitre of chloroform solvent. The next step is to add five millilitres of distilled water and half a millilitre of potassium iodide to the mixture. Just after that, after adding a few of drops of starch, the mixture is let half an hour to settle. Next, it is estimated by titrating with a sodium thiosulphate solution. The following equation was used to compute the iodine value: Iodine has a molecular weight of 126.9, and N is the solution's normalcy with respect to Na2S2O3. Millilitres of titrant sampled (S) and millilitres of titrant blank (B) are used here.

Iodine value = $\frac{[(B-S)\times N \times 126.9]}{sample\ wt.g}$

2.5.3 Peroxide Value

To determine the peroxide value of almond oil samples, the method outlined in (15) was used. To make a homogenous mixture, add 1 gramme of almond oil and stir for 1 minute in a dark place after adding 25 millilitres of glacial acetic acid (16.6 millilitres), chloroform (8.4 millilitres), and KI (1 gramme). 35% distilled water, 2-3 drops of starch for colour, and lastly, titratable sodium thiosulphate. The normality of sodium thiosulphate is denoted by N, and the volumes of the titrant with the sample and blank are denoted by S and B, respectively, in millilitres.

The measurement was given in milligrammes of peroxide oxygen equivalents per kilogramme of oil (meq/kg).

$$PV\ (meqO2/kg\ oil) = \frac{[\ (S-B)\ *\ N]\ x1000}{sample\ wt.\ g}$$

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2.5.4 Saponification

In accordance with (15), the number of saponification degrees detected in almond oil samples. Thirty grammes of potassium hydroxide in twenty millilitres of water will make the solution. Dilute the potassium hydroxide with 0.5 N alcoholic to 12.5 mL. As an indication, add two or three drops of phenolphthalein. Estimate the saponification number by titrating with hydrochloric acid. In what context: "B" stands for the millilitres of hydrochloric acid needed by the blank, "S" for the sample, and "N" for the hydrochloric acid normalcy.

$$\text{Saponification Number} = \frac{56.1\,(B-S)\times N\ of\ HCl}{Weight\ of\ sample\ (g)}$$

2.6 Statistical Analysis

The data from the Factorial in a Completely Randomised Design (FCRD) experiment was analysed statistically using the computer programme SPSS (SPSS software, version 26, 2019). We used Duncan's multiple range tests to compare the averages at a significance level of ($P \leq 0.05$).

3. Result and Discussion

3.1 Morphological characteristics of Almond Seed

Almond seeds were classified as tiny, medium, or big based on their geometrical features, which are summarised in Table 1. As the seeds grew larger, their length (L), width (W), and thickness (T) all increased. On average, the seeds were 18.5 ± 0.6 mm long, 22.5 ± 0.8 mm wide, and 26.0 ± 0.9 mm thick. Bigger seeds are noticeably larger in all dimensions, as seen by the considerable increases in both width and thickness. This rising tendency was also seen in the morphological characteristics mean diameter (Dg) and the arithmetic mean diameter (Da), with the largest values (16.5 ± 0.5 mm and 18.0 ± 0.6 mm, respectively) for large seeds, reflecting their overall higher size and volume. According to the sphericity (S) values, which varied from 56.5% for tiny seeds to 61.5% for large seeds, the processing characteristics of packing and flow may be affected by the sphericity of larger seeds.
The measurement of volume (V) increased significantly, almost doubling, from 600 ± 30 mm^3 in tiny seeds to 1900 ± 60 mm^3 in giant seeds, which is directly related to the rise in seed size. The seed size was shown to have a direct correlation with the increased projected area (At) and surface area (Af), suggesting that the seeds had a greater surface exposure. This, in turn, might impact the heat and mass transfer that occurs during extraction.
There was a minor drop in bulk density (ρb) as the size of the seeds increased, going from 0.60 ± 0.03 kg/m^3 for tiny seeds to 0.50 ± 0.02 kg/m^3 for large seeds. This reduction might be because bigger seeds have different interior structures or more porosity. There was a clear correlation between seed size and the mass of 100 seeds, indicating that larger seeds had a greater physical mass (10.5 ± 0.3 g) than smaller seeds (3.2 ± 0.1 g).
Because of their impact on oil extraction efficiency, these geometrical discrepancies are significant. Variations in bulk density and sphericity impact the processing and handling behaviour of seeds, although larger seeds with more volume and surface area may allow for a better oil output owing to more accessible oil-bearing tissue. In order to optimise almond oil extraction methods and forecast oil production, the findings indicate that seed size categorisation might be a valuable parameter.

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Table (1): SPSS-determined morphological characteristics of the Almond seeds sample according to seed size (small, medium, big)

Seed parameter of 100 seeds	Small seed size	Medium seed size	Big seed size
L, mm (Length)	18.5 ± 0.6b	22.5 ± 0.8a	26.0 ± 0.9a
W, mm (Width)	10.5 ± 0.3b	14.0 ± 0.5a	17.0 ± 0.6a
T, mm (Thickness)	5.5 ± 0.2b	7.5 ± 0.3a	9.0 ± 0.4a
Dg, mm (Geometric mean diameter)	10.5 ± 0.4c	13.5 ± 0.4b	16.5 ± 0.5a
Da, mm (Arithmetic mean diameter)	11.5 ± 0.5c	14.7 ± 0.5b	18.0 ± 0.6a
S, % (Sphericity)	56.5 ± 1.3b	60.0 ± 1.5a	61.5 ± 1.4a
V, mm^3 (Volume)	600 ± 30c	1200 ± 45b	1900 ± 60a
At, mm^2 (Projected area)	90 ± 5c	180 ± 7b	270 ± 8a
Af, mm^2 (Surface area)	320 ± 15c	650 ± 25b	1100 ± 40a
ρb, kg/m^3 (Bulk density)	0.60 ± 0.03b	0.55 ± 0.02b	0.50 ± 0.02a
Mass of 100 seeds, g	3.2 ± 0.1c	6.5 ± 0.2b	10.5 ± 0.3a

3.2 Oil Yield

Table 1 shows the findings of extracting almond oil from samples of small, medium, and large almond seeds, and Figure 1 shows the corresponding results. Petroleum ether was used as the solvent in a Soxhlet extractor to determine the oil content. Because seeds had different geometrical qualities, the oil output changed dramatically as seed size changed. Oil content varied across different seed sizes, with smaller seeds containing around 35.4% and larger seeds 48.7%. The oil content was around 42.3% in medium-sized seeds, which is considered intermediate. At room temperature, the extracted almond oil had a subtle, distinctive scent and was a transparent, pale yellow liquid. There was a significant link between seed size and oil content, as the category with the biggest seeds had the greatest oil output, largest volume (1900 ± 60 mm^3), and most mass (10.5 ± 0.3 g per 100 seeds). On the other hand, the oil output was lowest for the smallest seeds, measured at 600 ± 30 mm^3 and 3.2 ± 0.1 g per 100 seeds. Because of their larger kernels and oil-rich tissue, bigger almond seeds are likely to contain more oil, according to this trend. Compare to (16)

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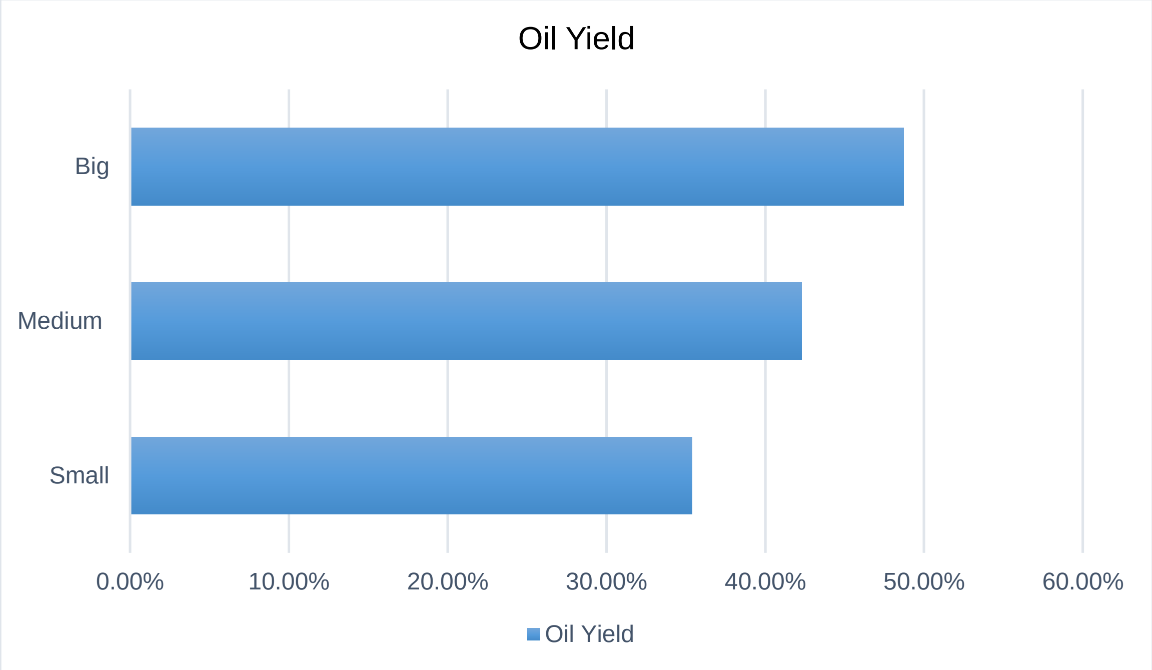

3.3 Chemical Analysis

3.2 Chemical properties of Almond oil parts

Table 3.2 Chemical properties of Almond Seed oil

Sample (Seed Size)	AV (mg KOH/g)	FFA (%)	IV (g I2/100g)	PV (meq O2/kg)	SP (mg KOH/g)
Small seed size	1.45 ± 0.12c	0.72 ± 0.08c	98.5 ± 1.2b	3.8 ± 0.10c	190.2 ± 1.5b
Medium seed size	1.85 ± 0.15b	0.95 ± 0.10b	105.3 ± 1.5a	4.5 ± 0.12b	195.6 ± 1.7a
Big seed size	2.30 ± 0.18a	1.20 ± 0.12a	110.7 ± 1.8a	5.2 ± 0.15a	198.9 ± 1.8a

3.3.1 Acid Value

To determine the concentration of fatty acid in the oil sample, the acid value is measured. Whether seed oil is safe for human consumption or not depends on its acidity value. One gramme of free fatty acid in one gramme of fat or oil is neutralised by milligrammes of potassium hydroxide (KOH), which are known as acid values. Acid readings measure the quantity of free fatty acid in oils and are often used as a general indication of the oil's quality and edibleness. Simply said, the more free fatty acids there are in the oil, the more acidic it will be. (17). A higher Acid Value and Free Fatty Acid content with rising sample levels may be a sign of oil degradation or impurities due to the increased concentrations of free fatty acids. Table 3.2 displays the relevant data. As seed size grew, the acid value also rose. For tiny seeds, it was 1.45 ± 0.12 mg KOH/g, for medium seeds, it was 1.85 ± 0.15 mg KOH/g, and for large seeds, it reached 2.30 ± 0.18 mg KOH/g, the same as in (18). It seems that bigger seeds produce oil with a higher concentration of free fatty acids. This might be because of the increased hydrolysis or enzymatic activity that occurs as seeds mature.

3.3.2 Free Fatty Acid

Similarly, the free fatty acid content showed an increasing pattern with seed size. Small

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seed oil had the lowest FFA at 0.72 ± 0.08%, medium seed oil had 0.95 ± 0.10%, and big seed oil had the highest FFA of 1.20 ± 0.12%. Higher FFA values in bigger seeds suggest a greater degree of lipid breakdown or degradation.

3.3.3 Iodine Value

One way to determine how much iodine a material may absorb is by looking at its "iodine value." This encompasses lipids and oil. To determine whether unsaturated fats are oxidisable, one may observe the reaction of iodine with their double bonds. If you want to know how stable the oil will be, you need to know its iodine value, which is often given as grammes of iodine per 100 grammes of sample (19). Details may be found in table 3.2. As the seed size grew, so did the iodine value, which is a measure of the oil's unsaturation level. The IV for small seed oil was 98.5 ± 1.2 g I_2/100g, for medium seed oil it was 105.3 ± 1.5 g I_2/100g, and for large seed oil it was 110.7 ± 1.8 g I_2/100g, the highest IV of the three (20). This provides additional evidence that unsaturated fatty acids are more abundant in oil extracted from bigger seeds.

3.3.4 *Peroxide Value*

The peroxide value is a useful indicator of oxidation or rancidity. In order to detect mild rancidity at an early stage, the peroxide value—a measurement of the primary products of lipid oxidation—is useful. While the p-anisidine test may determine the level of secondary oxidation in an oil sample, it also gives a measure of the degree of primary oxidation (21). All three types of seed oil showed a rising trend in peroxide values: small seed oil had 3.8 ± 0.10 meq O_2/kg, medium seed oil had 4.5 ± 0.12 meq O_2/kg, and large seed oil had 5.2 ± 0.15 meq O_2/kg. The higher amounts of unsaturation in oils extracted from larger seeds may explain why there is a correlation between PV and the degree of primary oxidation. It is same to (22)

3.3.5 *Saponification*

The amount of potassium or sodium hydroxide needed to saponify one gramme of oil is known as the saponification value or number. This evaluation is based on the mean molecular weight (or chain length) of triglycerides. On average, triglyceride weights are lower and fatty acid chains are shorter when the saponification score is high. Based on what is shown in Table 3.2, Starting at 190.2 ± 1.5 mg KOH/g in tiny seed oil, the saponification value climbed to 195.6 ± 1.7 mg KOH/g in medium seed oil, and finally reached 198.9 ± 1.8 mg KOH/g in large seed oil. This growth indicates that oils extracted from bigger seeds have a higher percentage of shorter-chain fatty acids or that the average length of fatty acid chains has been somewhat reduced.

Conclusion

The present study demonstrates a clear relationship between almond seed geometrical properties and the physicochemical characteristics of the extracted oil. Larger almond seeds exhibited significantly greater dimensions, volume, and mass, which corresponded to higher oil yields. The oil extracted from big seeds showed increased acid value, free fatty acid content, iodine value, peroxide value, and saponification value compared to oil from smaller seeds. This indicates that bigger seeds not only provide more oil but also contain oils with higher unsaturation levels and greater susceptibility to oxidation. These variations emphasize the importance of considering seed size during almond oil extraction to optimize yield and quality. Selecting larger almond seeds may enhance oil production efficiency; however, attention should be given to the potential for increased oxidation. Overall, the findings contribute valuable insights for the almond oil industry, supporting improved processing

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techniques and quality control measures based on seed size and physical characteristics.

References

(1) Karaat, F.E., 2019. Organic vs conventional almond: market quality, fatty acid composition and volatile aroma compounds. *Applied Ecology&Environmental Research*, *17*(4).

(2) Orhevba, B., Adebayo, S. E., & Salihu, A. (2016). Synthesis of Biodiesel from Tropical Almond (Terminalia Catappa) Seed Oil. Current Research in Agricultural Sciences, 3(4), pp. 57-63.

(3) Ouzir, M., Bernoussi, S.E., Tabyaoui, M. and Taghzouti, K., 2021. Almond oil: A comprehensive review of chemical composition, extraction methods, preservation conditions, potential health benefits, and safety. *Comprehensive reviews in food science and food safety*, *20*(4), pp.3344-3387.

(4) Tomishima, H., Luo, K. and Mitchell, A.E., 2022. The almond (Prunus dulcis): Chemical properties, utilization, and valorization of coproducts. *Annual Review of Food Science and Technology*, *13*(1), pp.145-166.

(5) Massantini, R. and Frangipane, M.T., 2022. Progress in almond quality and sensory assessment: an overview. *Agriculture*, *12*(5), pp.710.

(6) Özcan, M.M., 2023. A review on some properties of almond: ımpact of processing, fatty acids, polyphenols, nutrients, bioactive properties, and health aspects. Journal of Food Science and Technology, 60(5), pp.1493-1504.

(7) Freitas TR, Santos JA, Silva AP, Fraga H. Reviewing the adverse climate change impacts and adaptation measures on almond trees (Prunus dulcis). Agriculture. 2023 Jul 19;13(7):1423.

(8) Gaglio R, Tesoriere L, Maggio A, Viola E, Attanzio A, Frazzitta A, Badalamenti N, Bruno M, Franciosi E, Moschetti G, Sottile F. Reuse of almond by-products: Functionalization of traditional semolina sourdough bread with almond skin. International journal of food microbiology. 2023 Jun 16;395:110194.

(9) Garcia-Perez P, Xiao J, Munekata PE, Lorenzo JM, Barba FJ, Rajoka MS, Barros L, Mascoloti Sprea R, Amaral JS, Prieto MA, Simal-Gandara J. Revalorization of almond by-products for the design of novel functional foods: an updated review. Foods. 2021 Aug 6;10(8):1823.

(10) Sánchez, E., Zabaleta, R., Fabani, M.P., Rodriguez, R. and Mazza, G., 2022. Effects of the amendment with almond shell, bio-waste and almond shell-based biochar on the quality of saline-alkali soils. Journal of Environmental Management, 318, pp.115604.

(11) Shaikhiev, I.G., Kraysman, N.V. and Sverguzova, S.V., 2021. Review of almond (Prunus dulcis) shell use to remove pollutants from aquatic environments. Biointerface Research in Applied Chemistry, 11(6), pp.14866-14880.

(12) Hegazy, M., El Nagar, M.M., Mohamed, M.H., Elsagan, M.A.M. and Bader, L., 2024. Effect of Different Irrigation Treatments on Yield, and Quality of Potato under North Sinai Conditions. Scientific Journal of Agricultural Sciences, 6(1), pp.60-73.

(13) Paravar, A., Maleki Farahani, S. and Rezazadeh, A., 2023. Effect of nutrient and soil moisture of maternal environment on quality and biochemical characteristics of Dragon’s head (Lallemantia iberica) seed. *Iranian Journal of Seed Research*, *9*(2), pp.133-150.

ISSN 2072-3857

(14) Babatunde, O.A. and Umoru, P.E., 2022. Determination of the physicochemical parameters, saturation and unsaturation of some branded and unbranded vegetable oils sold in sabo market, kaduna state by fourier transformed infrared (ftir) analysis. *Fudma Journal of Sciences*, *6*(5), pp.140-145.

(15) AOAC (Association of Official Analytical Chemists). 2000. Official Methods of Analysis (17th ed.). AOAC International.

(16) Kumar, S.,&Singh, R. (2019). Effect of seed size on oil content and quality of almond (Prunus dulcis) kernels. Journal of Food Science and Technology, 56(5), 2664–2671.

(17) Özcan, M.M., 2023. A review on some properties of almond: ımpact of processing, fatty acids, polyphenols, nutrients, bioactive properties, and health aspects. Journal of Food Science and Technology, 60(5), pp.1493-1504.

(18) Singh, P.,&Kaur, A. (2020). Effect of seed size on the quality and chemical characteristics of almond oil. Journal of Food Chemistry and Technology, 58(3), 1452–1459.

(19) Akinola, A.O. and Adeyinka, T.F., 2022. Physicochemical characteristics study of oil extracted from almond seed. Saudi J Eng Technol, 7(6), pp.305-311.

(20) Ghazani, S. M.,&Rahimi, M. (2018). Influence of seed size on physicochemical properties and fatty acid composition of almond oil. Journal of Agricultural and Food Chemistry, 66(12), 3125–3132.

(21) Sidhu, A.R., Naz, S., Mahesar, S.A., Khaskheli, A.R., Shoaib, H., Khan, H., Samejo, M.Q., Siyal, F.J., Shar, Z.H., Pirzada, S. and Unar, A.A., 2021. Quality Assessment on the Oxidative Stability of Almond Kernels during Extensive Storage Time. Pakistan Journal of Analytical&Environmental Chemistry, 22(231).

(22) Melhaoui, R., Kodad, S., Houmy, N., Belhaj, K., Mansouri, F., Abid, M., Addi, M., Mihamou, A., Sindic, M., Serghini-Caid, H. and Elamrani, A., 2021. Characterization of sweet almond oil content of four european cultivars (ferragnes, ferraduel, fournat, and marcona) recently introduced in Morocco. Scientifica, 2021(1), p.9141695.

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