

Effects of Extraction Temperature and Particle Size on Quality of Edible Oil from Podocarpus Falcatus Seed by Aqueous Method, Ethiopia

*Daniel Alemu Goben
Department of Food Technology and Process Engineering, Haramaya University, Ethiopia

Solomon Abera
Department of Food Technology and Process Engineering, Haramaya University, Ethiopia

Anbesse Girma Shewa
Department of Food Science and Post-harvest Technology, Haramaya University, Ethiopia

Abstract
Introduction: The kernel from *Podocarpus falcatus* has potential for the production of edible oil**.** The oil is currently extracted using a traditional inefficient method for the purpose of house hold consumption. The objective of this study was to investigate the effects of particle size and extraction temperature on yield and quality of oil extracted from P. Falactus seeds by aqueous method. The experiment was carried out in a completely randomized design that comprised of three aqueous temperatures (70, 80 and 90^0C) and three particle sizes (0.25, 0.50, and 0.75mm). **Results:** The maximum oil yield in this study was obtained 22.29 and 22.38±2.10% at extraction temperature of 70^0C and at the particle size of 0.5mm respectively. Particle size and oil yield have correlation in that higher extraction was obtained (25%) as the particle size decreased. The particle size and temperature interaction had a positive effect on yield and maximum oil yield (25.25%) was obtained by the combination of 0.25mm particle size and 70^0C. The peroxide, iodine and saponification values were obtained with acceptable range by the combination of 0.25mm and within the acceptable limit of edible oil 70^0C. Yield and oil quality were influenced by extraction particle size and temperature.
Keywords: Edible oil, Physicochemical, Aqueous, extraction, temperature, particle size, *Podocarpus falcatus* seed
DOI: 10.7176/FSQM/114-01
Publication date: April 30^{th} 2022

Introduction

Podocarpus falcatus belongs to the family *podocarpceae and* is the coniferous species naturally growing up to 45 m high in Ethiopia. The seed of *Podocarpus falcatus* tree seed is greenish –blue ovoid in shape, about 1-1.85cm long and 1-1.25 cm in diameter and changes the color from yellowish to purplish as it gets ripe [1].

It is a multipurpose wild forest tree with wider range of socio economic and environmental importance. It is useful for fire wood, charcoal and paper pulp and various wild animals use it as part of their habitat. One of the most promising products is the oil extracted from the seeds [1], which is edible and used traditionally to treat gonorrhea.

The aqueous extraction method has advantage than solvent extraction in terms of cost, quality and environmental friend. During solvent extraction, the oil from the seed dissolved in solvent phase and needs extra separation techniques. While separation is done by conical flask or separator funnel for aqueous method. Oil is typically partitioned into the following fractions: solid residue, water and oil [2, 3].

A traditional method of oil extraction from seeds in the Chercher highlands of eastern Ethiopia is common. The local people prefer oil obtained from the *Podocarpus falcatus* seed to the ordinary edible oil they purchase from shops. The oil obtained from *Podocarpus falcatus* seed has potential to be used as edible oil as reported by [1]. *Podocarpus falcatus* seed oil is currently processed in traditional way with inefficient methods of oil extraction for house hold consumption. The extraction needs to be improved as its yield is very poor and inefficient. Thus, if improved, it could contribute to ensuring food security and increases the benefits of the product for many purposes. Insufficient study existed on *Podocarpus falcatus* seed oil effect extraction temperature and particle size on yield and quality.

Therefore, the aim of this study was to investigate the effect of particle size and extraction temperature on the yield and quality of edible oil from *Podocarpus falcatus* seed aqueous method

Main texts
Methods

Sample Collection and Preparation

Matured seeds, from different trees, of *Podocarpus falcatus* collected from Arsi zone, specifically, Tichoo area, Ethiopia. Seeds were sorted in the field to remove spoiled and rotten seeds. A total of 50 kilo grams of desirable seeds were transported to Haramaya University food science laboratory and stored in a dry condition. The epicarp (outer cover) and mesocarp (pulp) of the fruits were separated, milled and graded using 0.25, 0.50 and 0.75 mm size of sieves. The milled samples were heated at 88^0C for two hours by hot air oven. The conditioned samples were subjected to the aqueous extraction method.

Experimental design

The two experimental treatments, particle size (0.25, 0.5 and 0.75 mm) and extraction temperature (70, 80 and 90^{o}C) each with three levels, were considered for the study. Treatments were arranged in completely randomized design (CRD) with three replications.

Extraction

The oil extraction was done by aqueous method and separation was done by conical flask or separator funnel. Oil was typically partitioned into the following fractions: solid residue, water and oil.

Determination of Physicochemical Properties of the oil

The oil is extracted with aqueous extraction method (from each treatment combination) and% oil yield, peroxide value (PV), iodine value(IV), saponification value(SV), refractive index (RI), specific gravity (Sg), viscosity, color, were determined according to the method of [4].

Statistical Analysis

Two-way analysis of variance (ANOVA) for checking existence of variation (SAS Institute and Cary, NC) and least significant difference (LSD) for mean separation were use (P< 0.05). The results were expressed as mean ± SD of three replicate.

Results and Discussion

Main effect of temperature on physical properties and yield of the oil

Temperature, in aqueous extraction method, had shown significant (P<0.05) change on oil yield. The maximum oil yield was observed at 70°C and 80°C which were 22.29% and 20.67% respectively. The increase in temperature is believed to facilitate the rupturing of cell wall, creating a void serving as migratory space for oil bearing cells [5].

Temperature also lowers the oil viscosity and coagulates protein, facilitating the release of the oil from the cells into the inter-kernel void [6, 7]. But the result obtained in this experiment showed that temperature increment negatively influenced the yield and high extraction was obtained at low temperature. According to [8], at higher temperature of extraction, there is substantial loss of moisture leading to a hardening of samples and oil degradation which possibly is the reason why decreases in oil yield was observed with increased temperature.

Table 1.Main effect of extraction temperature and particle size on physical properties and yield of *P.falcatus* seed oil

Temp (°C)	Yield %	Sg	RI	Visc (CP)	Color (L,a*b*)		
					L	b*	a*
70	22.29±4.37^a	0.91±0.02^b	1.48±0.01^b	45.19±2.52^a	17.20±1.19^a	3.90±0.36^a	3.64±0.31^a
80	20.67±0.48^{ab}	0.94±0.03^a	1.47±0.01^a	42.01±1.39^b	14.78±3.34^b	3.93±0.38^a	3.61±0.34^a
90	19.82±1.07^b	0.92±0.01^{ab}	1.47±0.01^a	46.89±3.31^a	17.38±1.61^a	4.12±0.37^a	3.70±0.43^a
CV	8.92	2.27	0.01	4.35	9.89	9.45	9.46
LSD	1.82	0.02	0.01	1.90	0.37	0.37	0.34
Particle size (mm)							
0.25	22.00±2.45^a	0.92±0.01^a	1.48±0.01^a	43.16±2.44^b	17.35±1.48^a	4.08±0.45^a	3.79±0.37^a
0.5	22.38±2.10^a	0.93±0.03^a	1.47±0.01^a	46.93±3.74^a	14.31±3.08^a	3.99±0.30^a	3.45±0.37^b
0.75	18.40±1.65^b	0.92±0.02^a	1.47±0.01^a	43.99±2.06^b	17.70±0.76^a	3.89±0.36^a	3.71±0.25^{ab}
CV	8.92	2.27	0.01	4.35	9.89	9.45	9.46
LSD	1.82	0.02	0.01	1.90	0.37	0.37	0.34

All values are means ± standard deviations. Means followed by the same letters in a column are not different at P<0.05. CV= coefficient of variance; LSD=list significant difference .Sg= specific gravity, RI= refractive index and Visc =viscosity.

Extraction temperature had shown significant effect on specific gravity of the oil with highest value, 0.94, at 80°C. It is comparable with other vegetable oils such as soybean and sunflower reported in other studies [9].Most popular plant oils have specific gravity ranging from 0.9100 to 0.9400 and specific gravity of 0.92 is considered as good for any cooking oil [10].Some other authors have stated that the specific gravity suitable for edible oils range from 0.8800 to 0.9400 [11].According to those authors, in all extraction temperature, the specific gravity is within acceptable rage.

The refractive index (RI) values of *P.falcatus* seed oil were close to 1.47 as reported by [1].These values are similar to those of common seed oils such as Niger seed (1.46–1.48) and watermelon seeds (1.47) [12]. The RI of the oil was also within the range of some edible oils like cottonseeds and groundnut [13].

According to the work of [14], the oil viscosity has a direct relationship with some chemical characteristics of the lipids such as the degree of unsaturation and the chain length of the fatty acids that constitute the triacylglycerol. Consequently, the higher viscosity at 90°c could be due to oil degradation by the high extraction temperature.

Main effect of particle size on the physical properties and yield of oil

As presented in table 1; the particle size brought difference in oil yield with high yield at 0.25 and 0.5mm. [15], while investigating the extraction of oil from Jatropha seed stated that larger particles present smaller contact surface areas and were more resistant for oil to diffusion. Furthermore, oil globules in larger particle face longer distance to diffuse to the surface, thus, further reducing the yield.

Interaction Effect of Particle Size and Temperatures on the Physical Properties and yield of *P.Falcatus* Seed Oil

The highest values of the yield, 25.25 and 25.14% were obtained from 0.25 and 0.50 mm particles sizes with 70°C temperature. Accordingly to [15] the larger particles presents smaller contact surface area and more resistant for extraction providing less yield.

Table2. Interaction of Effect of Particle Size and Temperatures on the Physical Properties and yield

P*T	Yield%	Sg(g/ml)	RI	Vsc](CP)
P1*T1	25.25±0.23^{a}	0.93±0.00^{b}	1.47503±0.00^{d}	45.90±0.36^{d}
P1*T2	20.55±0.20^{cd}	0.90±0.00^{d}	1.47525±0.00^{abc}	40.33±0.37^{g}
P1*T3	20.20±0.26^{d}	0.91±0.00^{c}	1.47533±0.00^{a}	43.25±0.48^{e}
P2*T1	25.14±0.17^{a}	0.89±0.00^{e}	1.47519±0.00^{bc}	47.66±0.11^{b}
P2*T2	21.22±0.20^{b}	0.96±0.01^{a}	1.47533±0.00^{a}	42.30±0.36^{f}
P2*T3	20.77±0.40^{c}	0.93±0.00^{b}	1.47520±0.00^{bc}	50.83±0.20^{a}
P3*T1	16.50±0.17^{f}	0.89±0.00^{d}	1.47515±0.00^{c}	42.00±0.10^{f}
P3*T2	20.25±0.35^{d}	0.95±0.00^{a}	1.47528±0.00^{ab}	43.39±0.50^{e}
P3*T3	18.50±0.17^{e}	0.91±0.00^{c}	1.47517±0.00^{bc}	46.56±0.45^{c}
CV	1.19	0.43	0.0044	0.80
LSD	0.43	0.01	0.0001	0.61

All values are means ± standard deviations. Means followed by the same letters in a column are not different at P<0.05, CV= coefficient of variance; LSD=list significant difference,P1, P2, and P3 are 0.25mm, 0.50mm and 0.75mm, respectively. T1, T2, and T3 are 70°C, 80°C and 90°C respectively. Where Sg= specific gravity, RI= refractive index and Visc =viscosity.

Viscosity of the oils extracted by different treatment combinations as presented in Table 3, exhibited significant (P<0.05) differences with the highest viscosity (50.83±0.20) for the oil from particle of 0.5mm and at 90^0c. The lowest specific gravity, 0.89±0.00, was recorded for the oil extracted by combination of 70°C and 0.50mm. Most popular plant oils have specific gravity ranging from 0.9100 to 0.9400 and specific gravity of 0.92 is considered as good for any cooking oil [10]. Some authors have stated that the specific gravity suitable for edible oils range from 0.8800 to 0.9400 [16], a range within which this results fit.

Peroxide value is used as an indicator of deterioration of oils. Fresh oils have peroxide values of lower than10 MeqO_2/kg and the value must be between 20 and 40 Meq/kg [17]. Freshly extracted edible oil is expected to have an acceptable shelf life between 5 and 8 years which means its peroxide value should be less than 5 meq kg^-1. The temperature range used in the experiment has no effect on the quality of the oil that the peroxide value is below those most stated in literature.

Table 3.Effect of heating temperature and particle size on the chemical properties of *P. falcatus* seed oil

Temp (°C)	PV(Meq/kg)	IV(g/100g)	S.V(mlKOH/g)
70	11.46±1.78^{a}	127.26±1.02^{a}	169.30±31.09^{a}
80	10.81±1.47^{ab}	127.09±4.14^{a}	159.74±48.18^{b}
90	9.91±0.85^{b}	124.38±3.38^{b}	164.32±43.24^{ab}
CV	9.85	1.95	5.73
LSD	1.03	2.41	9.22
Particle size (mm)			
0.25	11.97±1.22^{a}	128.67±2.11^{a}	215.93±8.02^{a}
0.50	9.72±0.70^{b}	123.89±3.23^{b}	124.69±8.88^{c}
0.75	10.49±1.57^{b}	126.190±2.77^{b}	152.76±12.36^{b}
Acceptable limit (WHO)	15 Meq/kg	6-143 g/100g	189 – 199
CV	**9.85**	**1.95**	**5.73**
LSD	**1.03**	**2.41**	**9.22**

All values are means ± standard deviations. Means followed by the same letters in a column are not different at P<0.05. Where PV=peroxide value; IV=iodine value; S.V= saponification value; CV= coefficient of variance; LSD=list significant difference.

The highest iodine values, 127.26 and 127.09g/100g were obtained at extraction temperatures of 70 and 80°C, respectively. The values are comparable to IV values of other seed oils, such as soybean (124-139 g/100g) and sunflower (110-144g/100g) as reported by [9]. Similarly, the IV of oil extracted from Desert melon seed was 124.0g/100g as it is reported by [18].

Conclusions

The *Podocarpus falcatus* seed oil extraction yield and oil quality were influenced by the particle size and extraction temperature. Highest yield (22%) was obtained at an extraction temperature of 70°C and most of the physical and chemical qualities parameters were within the acceptable range though slight influences were observed. The particle size had minimal effect on the physic-chemical properties of the oil but relatively higher oil yield was obtained at 0.5 mm particle size. The result of interaction showed that the yield can be improved by combining 0.25mm particle size with extraction temperature of 70^{o}C. The oil qualities in most cases are within the acceptable range. Most households in rural areas are involved in low yield extraction and use primitive methods. So, the result obtained in this work shows the possibilities of improving extraction with simple aqueous method without a significant effect on the qualities of the oil. Improving extraction method of this oil will present a good quality, cheap, readily available and affordable. It holds promises in helping communities especially resources for poor people who don't afford the cost of commercial edible oils to tackle problems of malnutrition.

Limitation

Comparison with other extraction methods (mechanical and chemical extraction).

Abbreviations

AOAC : Association of Official Analytical Chemist; ANOVA: analysis of variance; PV: Peroxide value; I: iodine; KI: potassium iodine; KOH: potassium hydroxide; P.Falcatus : podocarpus falctus SD: standard deviation; WHO: World Health Organization.

Acknowledgements:

The authors thank the funding organization, Haramaya University, School of postgraduate study and Addis Abeba University for laboratory access. The authors also thank the editorial board and an anonymous reviewer for their assistance.

Funding

Haramaya University

Availability of materials and data

All data and materials are accessible upon request to the corresponding author.

Ethical approval and consent to participate

Not applicable

Consent for publication
Not applicable.

Conflicts of Interest
The team of authors declares that there is no conflict of interest.

Author's Contribution
All authors contributed to data gathering, laboratory analyzing, writing the manuscript and on final revision of the manuscript.

References

1. Feleke, S., Haile, F.E. and Alemu, A. (2012) Characteristics of seed kernel oil from Podocarpus falcatus CHARACTERISTICS OF SEED KERNEL OIL FROM PODOCARPUS. *J. Trop. For. Sci.*, 24, 512 516.
2. Lavenburg, V.M.; Rosentrater, K.A.; Jung, S. (2021) Extraction Methods of Oils and Phytochemicals from Seeds and Their Environmental and Economic Impacts. Processes 9, 1839. https://doi.org/10.3390/pr9101839
3. Fu, S.;Wu, W. (2019) Optimization of conditions for producing high-quality oil and de-oiled meal from almond seeds by water. J. Food Process. Preserv. 43, e14050.
4. AOAC. (2006) "Official Method of Analysis of AOAC International 18th edition. Association of Official Analytical Chemist *'Society Press" Washington D. C. p.801-805.*
5. Moghadas, H.C.; Rezaei, K. (2017) Laboratory-scale optimization of roasting conditions followed by aqueous extraction of oil from wild almond. J. Am. Oil Chem. Soc. 94, 867–876.
6. Ajibola, O.O., Owolarafe, O.K., Fasina, O.O. and Adeeko, K.A. (1993) Expression of oil from sesame seeds. *Can. Agric.* 35.
7. Nwithiga, G., &Moriasi, L. (2007) A Study of Yield Characteristics During Mechanical Oil Extraction of Preheated and Ground Soybeans. *Journal of Applied Sciences Research.*.
8. Alonge AF, Olaniyan AM, Oje K, Agbaje CO. (2003) Effects of dilution water temperature and pressing time on oil yield from groundnut oil expression. Journal of Food. Sci. Technol.
9. Goli SAH, Rahimmalek M, Tabatabaei B. (2008) Physicochemical characteristics and fatty acid profile of yarrow seed oil. *Int. J. Agric.Boil. 10(3): 355- 357.*
10. *Elert,* L.*,* Wong. (2005) The *Physics Factbook* . *Density of cooking oil*.*G Elert*.The *Physics Factbook*, *online*, http://hypertextbook.com/facts/*2000.*
11. Engineering Tool Box, (2017) *Density*. https://www. engineeringtoolbox.com/ density-gravity-t_64.html
12. Nkafamiya, I.I., Osemeahon, S.A., Dahiru, D. and Umaru, H.A. (2007) Studies on the chemical composition and physico- chemical properties of the seeds of baobab (Adasonia digitata). *African J. Biotechnol.*6, 756–759.
13. Ward, J.A. (1976) Processing High Oil Content Seeds in Continuous Screw Presses. *J. Am. OIL Chem. SOC.*, 53, 261–262.
14. Dutt, P., Mihov, I. and Zandt, T. Van. (2013) The effect of WTO on the extensive and the intensive margins of trade. *J. Int. Econ.*, 91, 204–219. Available at: http://dx.doi.org/10.1016/jinteco. 2013.08.001.
15. Sayyar, S., Abidin, Z.Z., Yunus, R. and Muhammad, A. (2009) Extraction of Oil from Jatropha Seeds Optimization and Kinetics Extraction of Oil from Jatropha Seeds-Optimization and Kinetics. *Am. J. Appl. Sci.*, 6 (7):, 1390–1395.
16. Sayed, A., Hossein, G. and Mehdi, Rahimmalek Badraldin, E.S. (2008) Physicochemical characteristics and Fatty Acid Profile of Yarrow (Achillea tenuifolia) Seed Oil. *Int. J. Agric. Biol.*, 10, 355–357.
17. Akubugwo IO, Ugbogu A. (2007) "Physicochemical studies on oils from five selected Nigerian plant seeds". *Pak. Journal of Nutrition, 6:75-78.*
18. Mabalaha, M. B., Mitei, Y.C. and Yoboah, S.O.(2007) A comparative study of the properties of selected melon seeds oils as potential candidates for development into commercial edible vegetable oil. *Journal of American Oil Chemistry Society. 84: 31-34.*