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Effect of microwave pretreatment in the extraction yield of garden cress seed oil

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Abstract
The present study was done to evaluate the effects of Microwave pretreatment parameters which includes irradiation time and power on the oil extraction yield and some selected physicochemical properties of the extracted oils including color, refractive index, specific gravity, saponification, iodine and peroxide values of the extracted oil of Garden cress seeds with the use of solvent extraction. The extraction method was optimized using different processing durations of 3, 5, and 7 minutes, as well as microwave strengths of 960, 1080, and 1200 W. Central Composite Design was used to undertake statistical analysis and process optimization. The optimization of process parameter was done based on higher extraction of Garden cress seed oil and process parameters were identified as microwave power 1200W and treatment time of 7 mins. According to the results it was found that enhancement in the microwave power and the treatment time increased the extraction of oil. The oil yield by Microwave pretreatment was considerably increased upto 10.3% as compared to oil sample without treatment. The quality evaluation of microwave pretreated extracted oil was found and compared with the control sample. The range of all physicochemical quality parameters were compatible within the acceptable limits as stated by international standard for edible oils. The quality of the oil obtained by microwave heating pretreatment was determined and is commensurate to the control sample. From this study it can be concluded that the Garden cress seed oil yield and quality can be improved by pretreatment of microwave prior to oil extraction.

Keywords: garden cress seeds, oil extraction, microwave pretreatment, oil yield

Introduction

Garden cress (*Lepidium sativum* L.) is an edible annually fast- growing herb belonging to the family Brassicaceae (Cruciferae), native to Egypt and west of Asia and presently it is commonly cultivated in the regions of India and Pakistan which is considerably temperate. The Garden cress (GC) is known as Chandrasur or Haliv/ Aliv in local language and it is considered to be medicinal crop in India. Garden cress seeds (*Lepidium sativum*) are extensively farmed in all parts of the world with hot and temperate climates, and are thought to have originated largely in highland locations (Singh R, 2017) [14]. Garden cress has the sustainability to grow in any aridity or altitude conditions upto a height of 50cm in a comparatively easy cultivation and tolerant to environmental predicaments (Maske Sachin, 2020) [10]. The *Lepidium sativum* seeds are bitter in taste and comprises of properties which makes them thermogenic, depurative, rubefacient, galactagogue, antiscorbutic, antihistaminic, tonic, aphrodisiac, ophthalmic and diuretic. The garden cress seeds are in the regimen to treat health conditions like asthma, coughs with expectoration, leprosy, skin disease, dysentery, diarrhea, poultices for sprains, splenomegaly, dyspepsia, leucorrhea, lumbago scurvy and seminal weakness. The seedlings have a very rich source of glucosinolates and is being consumed as spice. Seeds, leaves and roots of the Garden cress seeds have been economically useful too. The Garden cress seeds are majorly cultivated for its seeds in India. The Garden cress leaves have been used in the preparation of salads which have antibacterial, stimulant and diuretic properties (Diwakar, 2010) [6].

Garden cress seed oil is found to have very good source of both macro minerals and trace elements like calcium, copper, phosphorus, potassium, sodium, iron, magnesium, manganese, and zinc. Several fatty acids have been identified from the seed oil in which the primary fatty acids are oleic acid, α-linoleic acid, α-linolenic acid comprising a percentage of 18.5%–30.6%, 29.3%–30.1% and 32.1%–34.4% respectively. The several amino acid and fatty acid constituents present in the oil and other physicochemical properties seed makes the Garden cress seed oil a valuable source of these nutrients.

The varied bioactive profiles of *L. sativum* seed oils make the species an excellent choice for functional food and nutraceutical applications. The *L. sativum* seed oils incorporated diet will bring- forth the vital balance of omega-6: omega-3. The Garden cress seed oil has a linoleic acid: linolenic acid ratio in the range of 1:4 to 2:3 gives the seed oil to have a higher prospect of nutritional benefit when being compared to the linolenic acid-rich plant oils which already prevail in the market (Musara, 2020) [11].

Mechanical pressing and solvent extraction are the two major process for extraction of the oil from the oilseeds or the plant source bearing oil. Mechanical pressing is considered favorable only when oilseeds or the plant source having relatively higher oil content which exceeds 25% by weight and 4 to 5% residual oil content in the meal. Solvent extraction is beneficial for the oilseeds or plant materials having less oil content and the residual oil content particularly less than 1% by weight in the meal (Yusuf, 2018) [17]. The extraction process is the pivotal step in the production of oil from oilseeds. In the last two decades, some research groups have evaluated the potential of the application of novel seeds pre-treatment techniques to improve the oil recovery. Assisting the extraction, leads to enhanced yields and nutraceutical value of seed oils, reduced extraction time and energy consumption costs. Many publications have depicted that prior to extraction of oil different pretreatment methods of oilseeds can be done to increase the extraction of oil from important oilseeds, notably microwave radiation of seeds, which has been described as an outstanding technique for improving the efficiency of oil extraction from seeds (Azadmard-Damirchi, 2010) [3].

Considering literature review the objective of the research was to assess the effects of microwave pretreatment to the solvent extraction process of Garden cress seed oil. Based on research studies can presuppose the oil yield improved by microwave used as a pretreatment before oil extraction. Experiments were conducted to determine the effect of process parameters of microwave pretreatment namely time and power on oil recovery from Garden cress seed and compare the oil yield with the control sample.

Materials and Methods

Raw Materials

Fresh Garden cress seeds used in this research were bought from the local market. The purchased Garden cress seeds were dried in the shade and after they dried completely, they were placed in the plastic bags and firmly sealed. The sealed samples were shifted and preserved until the experiment day. Hot air oven method was used to found the moisture content of Garden cress seeds (Horwitz, 2000) [8].

Microwave Pretreatment

The Garden cress seeds were kept in the centre of the microwave oven on a Pyrex petri dish. The sample rotates within the oven as a result of the microwave radiation. This design allowed the samples to travel through the microwave oven's fixed electromagnetic field pattern, allowing for consistent energy absorption within the seeds. Microwave pretreatment was performed on the samples at a constant frequency of 2450 MHz. The selection of these microwave conditions (Power- 960W, 1080w, 1200W; Time- 3, 5 and 7 min) was done based on preliminary trials. When the seeds were inspected for a longer period of time and with a greater microwave power, they began to char and burn. As a control, Garden cress seed sample that had not been subjected to microwave pretreatment was used.

Oil Extraction

A high-speed mill was used to grind the microwave treated seeds. The ground seed powder was used to extract the oil. Soxhlet apparatus (Model SOCS PLUS SIX PLACE 6, Pelican equipment) was used to quantify the oil content in the Garden seeds using Hexane as solvent.

Determination of oil yield

The oil was extracted from tomato seed powder using hexane as a solvent in Soxhlet apparatus (Model SOCS PLUS SIX PLACE 6, Pelican equipment). The oil yield was calculated using the following formula. The ratio of weight of the obtained oil to that of the sample used for the extraction was the percentage of oil yield.

Oil yield = Weight of oil (g)/ Weight of sample (g) x 100 ………………. Eq (1)

Physicochemical evaluation of extracted oil

Hunter Lab Colorimeter (color Flex EZ color spectrophotometer, serial No CFEZ0925) was used to found the oil color. The refractive index (RI) was measured using an Abbe refractometer at 20 °C. The free fatty acid (FFA) (% of oleic acid) and peroxide values (PV) determined according to (Kumari, 2016) [9]. Saponification value (SV) and Iodine value (IV) was determined by (Horwitz, 2000) [8].

Statistical Analysis

Design- Expert (version 11.1.2.0) was utilized to analyze the variance for the optimization phase of this project. The experimental data were analyzed to see how well they fit into a statistical model. The experimental data were analyzed to see whether they could be fit into a statistical model (Linear, Quadratic, Cubic or 2FI). The model's coefficients were represented by the variables A and B. The model's adequacy was determined by the correlation coefficient (R2), adjusted determination coefficient (Adj-R2), and acceptable precision; the model was adequate when the P value, lack of fit P value, R2 > 0.7, and Adeq Precision > 4. Analysis of variance was used to determine the statistical significance of differences between means (ANOVA). $P<0.05$ was used as the statistical significance level.

Result and Discussion

Effect of Power and Time on extraction of Garden cress seed oil

According to the findings it was found that microwave pretreatment enhanced the extraction yield of Garden cress seed oil. It was also revealed that when the processing duration was increased extraction yield of the seed oil increased and the same applied when there was increase in the microwave power of the extraction process; 7 min pretreated Garden cress seeds at Microwave power of 1200W gave 24.5% oil yield prior to the solvent extraction when compared to the control seed oil without any pretreatment was 15.3%. It was believed that increasing tissue permeability would make the solvent or extraction medium more accessible to the oil inside the oil glands. This further enrich the rate of mass transfer and increases the leaching of cellular components into the solvent (Samavati, 2014) [12]. It was also observed that the treatment duration of the microwave radiation has repercussions more compared than the electric potential as it was observed that the seeds exposed to higher treatment time started to smoke and charred. The extraction yield of oil of the Garden cress seeds in the control sample without ant pretreatment is low since the undamaged cell wall brings about a major resistance to the oil extraction by solvent. Microwave treatment promotes cellular wall alteration and increased porosity, according to study. When irradiated with sufficient power, ruptures the cell wall of the plant material. This rupture enables oil to leach out, and the ruptured cell wall afford a high surface area for subsequent extraction of the oil. Consequently, penetration of the solvent into the seed cell membrane as well as enabling of oil to move across the permeable cell walls would be facilitated (Uquiche, 2008) [15].

Optimization of microwave extraction conditions

The conditions of microwave pretreated extraction of oil from Garden cress seeds were optimized for higher oil yield using Central Composite Design. Table 1. Shows the levels and factors (Microwave power and time) involved in this study along with the response variable (oil yield). The response surface linear model for yield is given below:

$$Y = +20.18 + 0.99 * A + 1.38 * B$$

Where, Y is the response variable; A and B are the factors microwave power and time respectively. The adequacy of the established model was estimated on the basis of correlation coefficient (R2). The R2 value was found to be 0.7809 which explains that, better compliance is existing between the model predicted and experimental value. Similarly, the significancy of the model was analyzed using ANOVA is given in Table. 3. The established model was found to be significant with F value of 59.07 and P-value < 0.0001 given in Table. 4.

The optimum conditions of extraction, as predicted from the model, were 1200W and 7min for Microwave power and time respectively. The maximum predicted yield of Garden cress seed oil was 22.54% under optimal conditions. The predicted optimum condition was analyzed for reliability with a number of experimental runs (N = 5) and average oil yield of 24.5% was obtained. Thus, the predicted model and optimum conditions were observed to be in accordance with laboratory trials.

Physicochemical property of extracted tomato seed oil

The physicochemical properties of extracted Garden cress seed oil were found. The extracted oil has RI of 1.2550 ± 0.04 and 1.2596 ± 0.01 for the control and microwave pretreated oil sample respectively. On comparison the RI of the oil remains the same with the control sample. The color value was color value (L*) was 5.193 ± 0.03 for untreated sample and 6.12 ± 0.02 for microwave treated oil sample respectively. This variation can be because of the damage of plant tissues during treatment given before extraction leading to more extraction of the pigments into the oil (Bakhshabadi, 2018) [4]. The specific gravity of extracted oil was 0.9035 ± 0.23 for untreated sample and for microwave pretreated oil sample was 0.9168 ± 0.02. This increased value might be the consequence of polymerization by the thermal pre-treatments making the oil denser (Anjum, 2006) [2]. The FFA value (Oleic acid %) of the extracted oil was 0.41± 0.23 for untreated sample and for 0.64 ± 0.12 microwave treated sample respectively. The increasing in the FFA is due to the Hydrolysis of triacylglycerol with higher temperature (Anjum, 2006) [2]. The Saponification values of extracted oil mg 182.5 ± 0.21mg KOH/g for untreated and 198± 1.63 mg KOH/g for microwave pretreated sample respectively. This may be due to the infringement of oil triglycerides into smaller fragments of FFA and carbonyl compounds with lesser molecular weight. The Peroxide values were relatively low 3.9 ± 0.02 meq/kg for untreated sample and 4.26 ± 0.05 meq/kg for microwave treated sample respectively. This reveals the action of low degree of oxidation during combined treatment. The Iodine value of Garden cress seed oil obtained are 125±1.34 g I/100 g oil for control sample and 120±1.21 I/100 g oil for microwave treated sample respectively. The reduction of iodine value in the treated sample was due to reduction in the number of unsaturation sites due to additive and subtractive chemical reactions (Anjum, 2006) [2]. The obtained values are within the range authorized by codex standard 210 (Shao, 2015) [13].

Table 1: Levels and Factors involved in the experimental design

Factor	Name	Units	Coded level	
			-1	+1
A	Microwave power	W	960	1200
B	Time	Min	3	7

Table 2: Experimental design with actual values for Garden cress seed oil yield

Run	Factor 1	Factor 2	Response 1
	A: Power	B: Time	Oil yield %
1	1080.00	2.17	18.3
2	1200.00	7.00	24.5
3	960.00	5.00	19.5
4	1080.00	5.00	20
5	1200.00	5.00	20.5
6	960.00	7.00	20
7	1080.00	5.00	20
8	960.00	3.00	18
9	1080.00	5.00	20
10	1200.00	3.00	20
11	1080.00	5.00	20
12	1080.00	7.83	21.5
13	1080.00	5.00	20

Table 3: ANOVA for Linear model testing the fitness of the regression equation

Source	Sum of Square	df	Mean Square	F- value	P- value	
Model	23.02	2	11.51	17.82	< 0.0001	significant
A- Microwave Power	7.83	1	7.83	12.12	< 0.0001	
B- Time	15.20	1	15.20	23.53	0.0007	
Residual	6.46	10	0.65			
Lack of Fit	6.46	6	1.08			
Pure Error	0.000	4	0.000			
Cor Total	29.48	12				

R^2: 0.7809 Adjusted R^2: 0.7371 Predicted R^2: 0.5219 Adeq Precision: 12.265

Table 4: Coefficients in Terms of Coded Factors

Factor	Coefficient Estimate	df	Standard Error	95% CI Low	95% CI High	VIF
Intercept	20.18	1	0.22	19.68	20.67	
A- Microwave Power	0.99	1	0.28	0.36	1.62	1.00
B- Time	1.38	1	0.28	0.75	2.01	1.00

Table 5: Predicted Values and Experimental Values

Power	Time	Predicted Yield%	Desirability	Experimental Yield
1200.00	7.00	22.5444	1.000	24.50
1200.00	6.90	22.4766	1.000	24.50
1200.00	6.80	22.4054	0.876	24.45

Conclusion

The effect of the process variables i.e., Microwave power and Treatment time involved in microwave pretreated extraction on the oil yield of Garden cress seed was scrutinized and the higher oil extraction yielding parameter were optimized using Central Composite Design. Microwave pretreatment significantly increases the oil yield by 10.3% compared with regards to the control sample. The extraction conditions providing the highest oil yield which was 24.5% were identified as Microwave power of 1200W treatment time of 7 min using the regression model. The model and the optimal conditions were verified by ANOVA for their efficacy. And the oil yield at the optimum conditions was affirmed to be 24.5% at the laboratory trials. The physicochemical properties of extracted tomato seed oil were analyzed and all the values were falls within the range. This study helps to explore the potential of novel thermal technique in magnifying the utilization of Garden cress seed oil in the food product.

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