Abstract—Microwave energy is a superior alternative to several other thermal treatments. Extraction techniques are widely employed for the isolation of bioactive compounds and vegetable oils from oil seeds. Among the different and new available techniques, microwave pretreatment of seeds is a simple and desirable method for production of high quality vegetable oils. Microwave pretreatment for oil extraction has many advantages as follow: improving oil extraction yield and quality, direct extraction capability, lower energy consumption, faster processing time and reduced solvent levels compared with conventional methods. It allows also for better retention and availability of desirable nutraceuticals, such as phytosterols and tocopherols, canolol and phenolic compounds in the extracted oil such as rapeseed oil. This can be a new step to produce nutritional vegetable oils with improved shelf life because of high antioxidant content.

Keywords—Microwave pretreatment, vegetable oil extraction, nutraceuticals, oil quality

I. INTRODUCTION

The use of microwave and dielectric heating in analytical researches began in the late 1970s and was first seized upon by the food industry. Microwave energy is a superior alternative to several thermal applications owing to its efficient volumetric heat production [1]. Microwave ovens use radio waves to convey energy and convert it to heat at a frequency which is approximately 300 MHz to 300 GHz [2]. Waves in this frequency range are mostly absorbed by water with a sufficiently polar oxygen group. In the food technology, microwave operation have been applied with increasing success in oil extraction, pasteurization, sterilization, baking, blanching, cooking, drying, and thawing of different food products [3]. Microwave penetration depths within a food sample are significantly determined by the electrical and physical properties, chemical composition, heating patterns, microbial inactivation and quality control [4]. Extraction techniques are widely employed for the isolation of bioactive compounds and vegetable oils from plant materials [5]. The technique used to extract oil determines the value of extracted oil which can be reported and there are discrepancies between the results of different extraction methods. Extraction of oils from oilseeds can be carried out by pressing or with solvent. Solvent oil extraction is usually applied to seeds with low content of oil (<20%), such as soybean. Prepressing method is applied for seeds with a high amount of oil, such as rapeseed, but this method is relatively inefficient and a large portion of the oil is left in the meal [6]. However, residual oil in the meal can be extracted afterwards by solvent. Solvent extraction method is the most efficient method with less oil remaining in the meal, but this method has some industrial disadvantages, such as plant security problems, emissions of volatile organic compounds into atmosphere, high operation costs, poor quality products caused by high processing temperatures, low extraction yield and a relatively high number of processing steps [7, 8]. Oil extraction by mechanical pressing is simpler, safer and contains fewer steps compared with oil extraction by solvent [9]. There are two types of oil pressing: cold press and hot press. Thermal treatment is not used in the cold press method, in contrast to hot press, where seeds are pretreated by heat, this is known as cooking [6]. Oil obtained from cold pressing of oilseeds has generally better preserved native properties. Therefore, there is a growing demand in the market for cold pressed oil, such as cold pressed rapeseed oil. However, cold pressing has a lower oil extraction yield compared to hot pressing. Among the different and new available methods, microwave pretreatment of seeds is a simple and desirable technique for production of high quality vegetable oil with coupled high nutritional aspects. The new pretreatment allows for better retention and availability of desirable nutraceuticals such as phytosterols and tocopherols in the extracted oil. Instead of thermal treatment, microwave radiation of seeds is receiving attention [10, 11]. Compared with conventional methods, microwave pretreatment for oil extraction has many advantages such as: improvement of extracted oil yield and quality, direct extraction capability, lower energy consumption, faster processing time and reduced solvent levels [1].

A. Effects of microwave pretreatment on oil extraction

Microwave pretreatment provides a potential to induce stress reactions in plant systems or oil seeds. By using microwave radiation in oil seeds, a higher extraction yield and an increase in mass transfer coefficients can be obtained because the cell membrane is ruptured. In addition, permanent pores are generated as a result, enabling the oil to move through the permeable cell walls [11]. According to Azadmard-Damirchi et al. [12] microwave pretreatment can increase oil extraction yield. In addition, they have been observed that increasing microwave treatment time can increase oil extraction yield. Uquiche et al. [11] have reported that pretreatment of hazelnuts with microwaves can increase...

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Microwave Pretreatment of Seeds to Extract High Quality Vegetable Oil

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the oil extraction yield and increasing the treatment time also
had a positive effect on the oil extraction yield. It has also
been shown that the time of exposure to microwave radiation
has a significant effect (p < 0.05) on oil extraction yield rather
than level of potency (400 W and 600 W). Moreno et al. [13]
used microwave pretreatment to the oil extraction from
avocado and found that extraction efficiency was 97% in
Soxhlet-hexane extraction coupled with microwave
pretreatment when compared (54%) to only the Soxhlet-
hexane extraction. This data concur with the previously
published data [14, 15, 16, 17].
A combined ultrasound and microwave pretreatment method for extraction of essential oil
from caraway seeds has been proposed by Chemat et al. [18]. They found that significant improvement in extraction was
obtained using simultaneous ultrasound and microwave
pretreatment.

B. Effects of microwave pretreatment on major compounds

Soxhlet extraction method would degrade the poly-
unsaturated fatty acids in vegetable oil and thus the resulting
profile would not be truly representative of the fatty acids in
the oil seeds. Cossignani et al. [19] reported that there is
significant decrease (p < 0.01) in the TAG fraction and
increase (p < 0.01) in the DAG and MAG fractions after
microwave pretreatment in olive oil. Many authors have
reported the results of the microwave pretreatment on fatty
acid compositions in vegetable oils. Kanitkar [20] reported
that the fatty acid compositions obtained for rice bran oil
extracted using microwaves differed slightly from previously
published data, but microwave extracted rice bran oil also
contained a considerable proportion of arachidic acid (C21:0)
in compared with conventional extracted rice bran oil.
Linoleic and palmitic acids are usually used as indicators of
the extent of oil deterioration. Tan et al. [3] found the
C18:2/C16:0 for microwave-radiated oil decreased with increased heating power settings. According to Anjum et al.
[21] the levels of oleic and linoleic acids were dramatically
affected by microwave pretreatment than palmitic and stearic
acids. The longer the pretreatment time, the lower was the
percentage of the linoleic acid and the higher was that of oleic
acid. Yoshida et al. [22] found a decrease in the amount of
PUFA in soybean oil during roasting time.

C. Effects of microwave pretreatment on minor compounds

Phospholipid, tocopherols, phenolic compounds and
phytosterols are minor components of vegetable oils. The
results revealed that microwave pretreatment has no
significantly effects (p > 0.05) on phospholipid content in
microwave extracted rice bran oil that can increase the overall
refining loss of the oil in compared with conventional
methods. Hence, the use of microwave pretreatment does not
have the deleterious effects on the oil quality from the
perspective of phospholipid composition [20]. The results also
showed that the phospholipids content in soybean oil is
directly dependent to the amount of oil extraction
[23]. Azadmar-Damirchi et al. [12] showed that pretreatment
of rapeseeds by microwave prior to oil extraction by press
increased the tocopherols significantly (p < 0.05) in oils.
These results suggested that damage to the oilseed cell
membrane by microwave pretreatment allow increased release
of tocopherols and enhance their amount in extracted oil.
According to Zigoneanu et al. [24] there is no significantly
difference (p > 0.05) in the vitamin E content or antioxidant
activity of rice bran oil obtained microwave pretreatment
when compared with conventional solvent extraction.

The results revealed that oil extracted from microwave-
treated rapeseed shows a markedly improved oxidative
stability, most likely due to the increase of phenolic
antioxidants [25].

The levels of α-, β- and γ-tocopherol in rice bran oil were
significantly (p < 0.05) increased when the rice bran was
subjected to microwave heating for up to 30 s [26]. This data
concur with the previously published data [27, 28]. Lee et al.
[29] reported that the levels of α-tocopherol in safflower oil
gradually increased with roasting temperature with increasing
up to 160°C but then decreased up to 180°C. According to
Yen [30], the contents of tocopherol in sesame oils prepared
by microwave pretreatment increased with processing
temperature up to 200 °C but decreased up to 260 °C.
However, it has been reported that the level of α-, β-, γ- and δ-
tocopherols reduced during microwave heating and α-
tocopherol showed the highest rate of loss due to unsaturation
of the TAG system under their conditions [21, 22].

Phytosterols in vegetable oils are important from a
nutritional point of view because they contribute to lowering
serum cholesterol levels and are also considered to have anti-
inflammatory, anti-bacterial, anti-ulcerative and antitumour
properties in humans [31, 32], as well as contributing to the
oxidative and thermal stability and shelf life of vegetable oils
[33]. The previously published results revealed that solvent
extraction is more efficient in extracting phytosterols of
rapeseed oil in compared with microwave pretreatment
extracted oil [12]. It has recently been reported that
microwave pretreatment of rapeseed could increase the
canolol content. However, higher temperatures (>160 °C)
can cause a reduction in the canolol content [34].

Martino et al. [35] found that employing 50% aqueous
ethanol either with microwave pretreatment or with ultrasound
pretreatment is the best method for extraction of
phytocomponents from flowering tops of Melilotus officinalis.

D. Effects of microwave pretreatment on physicochemical
properties

Changes in physicochemical composition and levels of
minor compounds affect the functional and nutritional aspects
of vegetable oils [22]. Anjum et al. [21] evaluated microwave
roasting effects on the physicochemical composition and
oxidative stability of sunflower seed oil. They found that with
increasing microwave roasting time the refractive index,
unsaponifiable matter and iodine value of the oils significantly
decreased. It also has been reported that high roasting time
increases saponification value, free fatty acid content of
sunflower oil and changes color of extracted oil from light
yellow (5 min of roasting) to yellow (10 min of roasting) to
brown. It has been addressed to Maillard-type nonenzymatic reactions, caramelization and phospholipid degradation and formation of browning substances [30, 36, 37]. Behera et al. [38] reported that there are no significant differences on refractive index between extracted oils from microwave pretreatment cumin seeds and conventional methods.

There is also an increased on anisidine, iodine, peroxide values and free fatty acid content in corn and soybean oil when applied to high-power setting. The results also revealed that high unsaturated oils are deteriorated higher than low unsaturated oils [3, 39]. The acid values of the microwave extracted soybean oil was the lower than rice bran oil. It may be due to the fact that the bran is not stabilized prior to oil extraction and the presence of native lipase broke down the triglyceride structure [20]. Terigar et al. [23] found that treatment time has higher effect on acid value in compared with temperature.

E. Effects of microwave pretreatment on extracted oil quality

Improvement of oil extracted quality depended on power, time and temperature of microwave pretreatment. So that longer microwave heating times, temperatures and high-power setting resulted in a greater degree of oil deterioration [3]. The chemical components of oils that are degraded during microwave radiation achieved at rates that vary with process temperature and time, as with other domestic processing methods. Therefore, suitable quality properties can be used as temperature-time integrators of quality deterioration of oils during microwave treatment [3]. In general, microwave heating have significant effects on quality parameters of vegetable oils. Oxidative stability of vegetable oils is influenced by many factors, mainly fatty acid composition, antioxidants and minor compounds. The effects of microwave pretreatment on the thermo-oxidative degradation and quality of several vegetable oils and fats, i.e. olive oil, sunflower oil, rapeseed oil and lard have been studied [40, 12]. Higher stability of oils extracted from microwave pretreated rapeseeds may arise from their high antioxidant content e.g. tocopherols [12].

II. conclusion

The present study indicates microwave pretreatment can be used as a desirable alternative to conventional oil extraction techniques. The oil yield values extracted by microwave-assisted extraction are higher than those obtained by conventional oil extraction under the same conditions. The major advantage of microwave pretreatment is the reduced time of extraction and energy consumption costs, when is compared to conventional methods. On the obtained results, microwave extracted oil also show similar characteristics to conventionally extracted oil, indicating that quality of oil is not affected by microwave pretreatment. It allows also for better retention and availability of desirable nutraceuticals, such as phytosterols and tocopherols, cananol and phenolic compounds in the extracted oil such as rapeseed oil. This can be a new step to produce nutritional vegetable oils with improved shelf life because of high antioxidant content.

References


