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Effects of Microwave Heating on Chemical Properties of Vegetable Oils: A review

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Abstract:

Microwave heating has a wide application in the field of food manufacturing such as cooking, drying, pasteurization and preservation of food materials. The purpose of this review was to focus on the using of microwaves heating for vegetable oil seeds heating instead of using conventional heating techniques. Quality parameters, including oil composition, thermal properties, oil stability and the effects on tocopherol contents were reported.

Key words: microwave heating, food manufacturing, vegetable oils

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INTRODUCTION

Now, microwave cooking is the most versatile method worldwide. It is energy-efficient and reduces cooking time compared to conventional heating. The appliance user prefers the microwave cooking procedure, which is characterized by speed and short cooking time, compared to classical cooking methods. In fact, microwaves are used in the food industry not only for warming, drying, thawing, and baking but also for other applications, such as for pasteurizing and sterilizing many types of foods (1). Microwave heating can provide several advantages over conventional food processing methods (2). Microwave ovens are present in the majority of homes and today more people use microwave ovens for cooking and reheating than ever before. Nowadays convenience foods that have been subjected to minimal processing are flooding the market (3, 4). The food is exposed to high temperatures for a shorter period of time; this may that fewer heat-sensitive nutrients are lost, thus improving the nutritive value of electronically cooked products, although this point is being debated (5, 6). Although there is sufficient information available on the consequences of microwave heating on the composition and nutritional quality of food, there has been speculation on the ease of free radical formation when fatty foods are exposed to microwave energy (7).

The number of domestic microwave ovens is increasing, mainly because consumers appreciate the advantages, such as, economy, and time savings (8, 9). The differential heating behavior of food components can result in severely uneven heating of certain foods rich in fats and proteins (10). The effects of microwave heating on different animal and vegetable fats have been investigated (11) as have its influences on thermo-oxidative stability of common oils and fats in household use (12,13). Little has been published on the changes in composition and oxidative stability of the oils during microwave oven heating (13). Lassen and Ovesen (14) reviewed the chemical constituents of oils that degrade during microwave heating do so at rates that vary with heating temperature and time, as with other domestic processing methods (e.g., frying, steaming, and roasting). Suitable quality parameters therefore can be used as time–temperature integrators of quality deterioration of oils during microwave heating. Monitoring of many of these parameters makes extensive use of chemicals. Also, the methods for measuring such components can be relatively complex and time-consuming, which can be a major drawback in industrial applications. Instrumental methods involving simpler and faster techniques for determining changes in oil are desired.

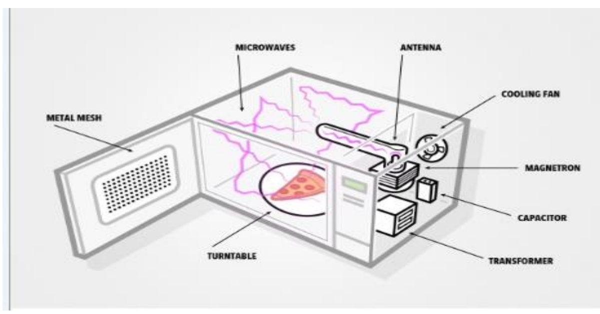

Fig. 1. Schematic view of microwave oven (30)

MICROWAVE MECHANISM

Microwave heating is caused by the ability of the materials to absorb microwave energy and convert it into heat. Microwave heating of food materials mainly occurs due to dipolar and ionic mechanisms. The presence of moisture or water causes dielectric heating due to the dipolar nature of water. When an oscillating electric field is incident on the water molecules, the permanently polarized dipolar molecules try to realign in the direction of the electric field. Due to the high frequency the electric field, this realignment occurs at a million times per second and causes internal friction of molecules resulting in the volumetric heating of the material. Microwave heating might also occur due to the oscillatory migration of ions in the food which generates heat in the presence of a high frequency oscillating electric field (17). There are many factors which affect microwave heating and its heat distribution and the most important of them are the dielectric properties and penetration depth.

CHANGES IN VEGETABLE OILS COMPOSITION DUE TO MICROWAVE HEATING

To evaluate the consequences of microwave heating on lipids, some measurements of lipid oxidation, such as peroxide value, thiobarbituric acid test, carbonyl value, anisidine value and conjugated diene and triene levels, are frequently reported (11,6). Many authors have reported the results of the fatty acid (FA) compositions of total lipids in the oil, sometimes together with those of the different acylglycerol fractions (8); sometimes the effects of microwave treatments on the molecular species percentage composition and FA percentage distribution in triacylglycerols (TAG) were investigated (9,10). Raghuveer and Hammond suggested that acylglycerol structure might affect the relative rates of oxidation of acyl groups in the TAG molecules (11). The influence of the α- and β-positions occupied by unsaturated FA in the glycerol backbone on the oxidation rate was investigated in thermally oxidized oils (12, 15). The levels of free fatty acids also increase in vegetable oils heated in a microwave oven (16).

EFFECTS OF MICROWAVE HEATING ON THERMAL PROPERTIES OF VEGETABLE OIL

Differential scanning calorimetry (DSC) is an instrumental method available to the oils and fats researcher (18). This technique is used for studying various heat-related phenomena in materials by monitoring associated changes in enthalpy. It offers a sensitive and reproducible fingerprint method for identification of vegetable oils and fats. DSC has been used to describe and interpret thermal properties and chemical composition of 17 vegetable oil samples in terms of melting and crystallization behaviors (19), to monitor oxidation processes (20), and to determine total polar compounds in heated oils (21).

CHANGES ON VEGETABLE OIL STABILITY DURING MICROWAVE HEATING

Yoshida et al. (7) reported a minor increase in PV and p-anisidine value in peanut seed oil after 30 min of roasting, and a gradual increase with longer roasting time in sesame seed oil (22,10). In general, PV do not represent the absolute state of oxidation of oil because hydroperoxides are unstable on heating. Lee et al. (12) suggested that the greater the roasting time, the greater would be the increase in PV of the safflower oil. Microwave heating accelerates the formation of some undesirable and harmful compounds (e.g., oxidation products, pigments) during the roasting of peanuts. Thais et al. (22) and Vieira and Regitano (23) investigated the effects of microwave heating on the oxidative stability of refined canola, corn, and soybean oils by measuring absorptivity in the UV spectrum and by chemical analysis (PV and acid values). PV showed a significant difference ($P < 0.05$) in the initial stage of heating (0–6 min) for all oils. After this period PV could not be correlated with absorptivity at 232 nm owing to the instability of hydroperoxides at high temperatures.

EFFECTS OF MICROWAVE HEATING ON TOCOPHEROL CONTENTS

Yoshida et al. (11) has been reported that α-tocopherol showed the highest rate of loss, followed by β-, γ-, and δ- tocopherol, during microwave heating. Yoshida et al. (10, 25, 26). Yoshida and Takagi (27) reported that >80% tocopherol of the original level in soaked soybean oils still remained after 20 min of microwave roasting. Barrera-Arellano et al. (28) found that α-tocopherol losses were very rapid and independent of the unsaturation of the TAG system under their conditions. α Tocopherol degraded faster in less unsaturated lipids. Takagi et al. (29) reported that, with increasing roasting times, as much as 40% of the individual tocopherols present in the seed coat of the soybean was lost at 12 min of roasting. On the other hand, over 80% of the tocopherols were retained in the cotyledons and axis after 20 min of roasting.

APPLICATION OF MICROWAVE IN FOOD INDUSTRIES

The application of microwave oven heating to culinary techniques and food processing is a recent addition to traditional cooking techniques such as roasting, boiling, and frying. Food products designed for microwave heating are popular because of their quick preparation time and convenience. The heating of food in a microwave oven is caused by interaction of an electromagnetic field with the chemical constituents of food. These interactions instantaneously generate heat because of molecular friction and excitation (3.4) and suggest applications in cooking, baking, dehydrating, thawing, tempering, pasteurizing, and sterilizing.

MICROWAVE SAFETY

Microwaves do not contain sufficient energy to chemically change substances by ionization, and so are an example of non-ionizing radiation. The word "radiation" refers to energy radiating from a source and not to radioactivity. It has not been shown conclusively that microwaves (or other non-ionizing electromagnetic radiation) have significant adverse biological effects at low levels. Some, but not all, studies suggest that long-term exposure may have a carcinogenic effect. This is separate from the risks associated with very high-intensity exposure, which can cause heating and burns like any heat source, and not a unique property of microwaves specifically (30).

FUTURE STUDY

Microwave heating has wide range of application and uses in different food processes however it needs more studies aimed at development in specific areas. Particularly, methods to obtain edible oil with high nutritional value and quality.

CONCLUSION

This review concentrated on microwave heating mechanism, effects of heating on edible oils during roasting, changes of oil composition, oil stability and application of microwave heating in food industries. Many studies have shown that microwaves heating can be used as alternative technique and a good result can be achieved.

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