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EFFECT OF MICROWAVE AND OPEN FRYING ON PHYSICO-CHEMICAL PROPERTIES OF FRIED OIL AND POORI - AN INDIAN FRIED FOOD

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ABSTRACT

Frying is one of the traditional methods used to prepare food products in India. In the present study, poori (an Indian fried food) was prepared by microwave oven and open frying methods using wheat germ oil (tocopherols source) as heating medium and the results were dealt on, one, five and fifteen poories fried oils and oil extracted from poories. Physicochemical characteristics of fried oils were increased while the total tocols (tocopherols + total tocotrienols) were reduced in both the methods when compared to fresh oil. Furthermore, microwave oven process performed similarly in the initial frying (1 and 5 poories) but not with 15th poori of open frying. Interestingly, oil uptake, reduced moisture content and hardness of poori of microwave oven was highly significant ($p>0.001$) than the regular method. Free radical scavenging activity of oils extracted from open frying method had better activity than microwave oven method in the 15th poori preparation.

Keywords: Poori, Wheat germ oil, Tocopherols and deep frying.

INTRODUCTION

Worldwide, varieties of new fried foods are available in the market and their preparation at home is becoming popular because of their delicious taste, unique sensory characteristics, appeals and aroma that attracts all age groups. Most of the Indian fried food products such as potato, banana chips, poories etc., are prepared by deep frying process. During the process, food is immersed in an oil bath at a temperature (160-180^{o}C) above the boiling point of water, as a result, water evaporates in the form of bubbles steam at the surface of product (Singh 1995). Repeated use of frying oils produces undesirable constituents that pose health hazards (Holownia *et.al* 2001). During frying, a series of chemical reactions take place, such as thermo-oxidation, hydrolysis, polymerization and fission (Fritsch 1979). The frying oils decompose to form a variety of volatile compounds as well as monomeric and polymeric products. Numerous factors, such as temperature, duration of heating, degree of oil unsaturation and amount of anti-oxidants changes the original characteristics of frying oils. Fried foods are known to increase the nutritive value of food by absorbing vitamin E, carotenoids and unsaturated fatty acids from frying oils. Tocopherols and phenolic compounds present in the oil increases oxidative stability during frying of virgin olive oil to some extent (Stavros Lalas *et.al* 2006). The use of oils with such compounds increases the resistance towards oxidation during frying and minimizes health hazards (Nikolaos *et.al* 2002).

Microwave oven (MO) is mainly used to defrost, reheat and cooking and their use in food preparation have increased from the past decade (Tsuyuki 1982), over 95% of the population in USA is habituated to using microwave oven at home. Microwave heating has significant advantages over conventional methods by reducing the processing time, energy-efficient and improves food qualities like color retention etc. In microwave method of cooking, food particles generate heat, while in the conventional method heat is driven externally. In this regard, there is a need to investigate the effect of microwave heating on the product preparation, physico chemical nutritional properties and sensory characteristics of the product.

Poori is a popular deep-fried product of Indian breakfast and lunch. Wheat germ oil is the richest source of α-tocopherol, which is highly unstable to temperature and light. Several researchers have reported about loss of tocopherols during frying, but the studies on the effect of physicochemical properties and total tocopherols of fried product and the fried oil with different energy sources needs to be evaluated. The present study was focused on physicochemical changes, total tocopherols and tocotrienols (t.tocols) of poori and fried oils. Sensory evaluation of poori prepared from microwave oven and conventional method was compared.

MATERIALS AND METHODS

CHEMICALS AND REAGENTS

Wheat germ oil (refined) was obtained from Falcon Essential Oils, Bengaluru, Maida was obtained from a local store. Standard tocopherols (>96%) were purchased from Sigma Chemical Co. (St. Louis, Missouri, USA). Other chemicals and solvents used were of the analytical grade.

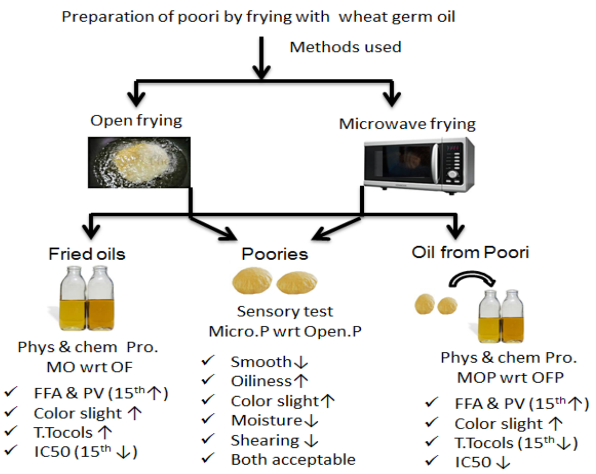
PREPARATION OF POORI DOUGH

Wheat flour (40g) and water at 23% moisture level was mixed well for 3 min to prepare dough. 4.2 g of dough were sheeted to a circular disc using a poori press with a size of ~5.8±0.8 cm diameter and ~1.2 mm thickness. Known amount of oil in separate container was used for making 1, 5, and 15 poories respectively. The rolled dough sheets were fried by both microwave oven and open frying methods. Wheat germ oil was selected to study the t. tocols and quality of oil during poori frying in different methods.

MICROWAVE OVEN AND OPEN FRYING OF POORI

The power level of microwave was set to 900W for 3min for the oil to reach a temperature of 180°C. After attaining the required temperature, the pressed dough was fried in a microwave container for 15s each on both the sides. Again oil was heated until it reaches 180±5°C and the process was repeated for both 5 and 15 poori preparations.

The oil was preheated in a pan to 180±5°C and pressed poori was fried on both sides for 15s each. For further experiments oil temperature was maintained at 180°C and the process of poori making was repeated as above.



OIL EXTRACTION FROM POORIES, FFA, PV, AND FATTY ACID COMPOSITION ANALYSIS

Oil extraction was carried out using soxhlet method by taking 50 g of the sample mixed with 200 mL of hexane at 40-50°C for eight hours and solvent was evaporated in a rotor evaporator. The oil quality was assessed by using the standard methods of AOCS (2002), such as free fatty acid value (FFA) (Ca 5a-40), peroxide value (PV) (Cd 8–53) and fatty acid methyl-esters preparations (Ce1-62).

ANALYSIS OF MOISTURE, COLOR OF POORI, OIL AND BREAKING STRENGTH

Moisture content of the poori samples were determined by the method of AOCS, 2002 (Ca 2c-25). The color of poori and oil used for frying was measured using CIELAB measuring system (model Lab scan, USA). Color was determined using the 10°/D 65 setting and expressed according to Commission Internationale de L'Eclairaige (CIE) system and reported as L*, (lightness), a* (redness) and b* (yellowness) (AOCS, 1995), ΔE represents the total color difference between the samples. Texture of poori was measured using a Universal texture measuring system (LLOYDS Instruments, LR-5K, UK). The texture of poori was expressed as the force (N) required for shearing each poori. The conditions used throughout the experiment included a cross head speed of 10 mm/min and a load cell of 50 N.

ANALYSIS OF TOTAL TOCOPHEROLS, TOCOTRIENOLS AND FREE RADICAL SCAVENGING ACTIVITY

Total tocopherols content was determined after saponification of the oils and extraction of the unsaponifiable matter followed by colorimetric determination using Emmerie Engel procedure as reported in vitamin E panel method (Anon 1959).

The radical scavenging activity (RSA) of the oils was determined by using 2, 2 diphenyl 1-picrylhydrazyl (DPPH) radicals in toluene according to the procedure Ramadan *et al.*, (2006) and was expressed in terms of concentration of oil required to scavenge 50% DPPH free radical.

SENSORY EVALUATION

A trained panel was selected for carrying out sensory evaluation of poori's by following the method of Quantitative Descriptive Analysis (QDA). The definitions of the attributes were discussed and description was prepared by asking the panelists to describe the product with the suitable descriptive terms for development of a score card, which consisted of each attribute on a 15 cm line scale. Quantitative descriptive analysis methods were adopted and the panelists were asked to mark the intensity of each attribute (Stone andSidel 2004). The main desirable sensory attributes of poori such as color, surface oiliness, crunchiness, chewiness, off-taste, flavor and overall quality were assessed by a panel of 15 trained judges. Poori samples with coded numbers were served one at a time for evaluation.

STATISTICAL ANALYSIS

All experiments were carried out in triplicates (n = 3) and the results were expressed as mean ± standard deviation (less than 5%). The significant differences were calculated using demo version of graph pad prism software was used for the analysis of variance (ANOVA two factor) followed by Tukey's comparison of means at $p \leq 0.05$ (Debnath*et al* 2012).

RESULTS AND DISCUSSION

PHYSICO-CHEMICAL PROPERTIES OF FRIED OIL FROM MICROWAVE OVEN AND CONVENTIONAL FRYING METHODS

Free fatty acids and peroxide values increased both in microwave oven (MO) and open fried (OF) oils in the order 1 < 5< 15 (MO -0.41:13.09, 0.44:13.62, 0.59:20.1) and (OF - 0.41:13.1, 0.47:14.29, 0.54:18.32) when compared to fresh oil (0.30; 11.4) the results are presented in Fig. (1a and1b). Microwave fried oil had comparatively less FFA and PV when compared to open fried method in the initial stage (1 and 5 poori preparation) and increased slightly after 15th poori preparation. Formation of FFA either by oxidation or hydrolysis due to moisture content in poori was studied by Ramadan *et al* (2006) and loss of FFA because of its volatile nature under frying conditions was also reported by Suleiman *et al*(2006). Peroxide value is an indicator of lipid oxidation during storage but not for frying oil as it is misleading due to its instability (Che-man and Wan-hussin 1998; Sulieman*et al* 2006). However, some researchers have used PV as indicator in frying studies. Dostalova*et al* (2005) has reported the increase of peroxide values in oil exposed to microwave heating (0 to 40 min). Studies on virgin and refined olive oil had higher peroxide value in microwave than in conventional heating (Abd E-Moneim Mahmoud *et al* 2009). However, Debnath*et al*(2012) have shown that both free fatty acids (FFA) and peroxide value (PV) increased initially for the first two cycles, but in subsequent cycles there were no significant changes. Color of fried oil of both the methods (MO and OF) were compared with fresh oil which was lighter than the fried oils. L*, which indicates lightness, showed that OF oil was comparatively lighter than MO oil after each frying (1, 5 and 15th). In general, MO was darker in color than OF oil. b* indicates the yellowness and the total color difference is denoted by ΔE which also showed similar trends in their values in Fig.(1c). The reason for this change in the color during frying is still not understood, but the darkening of frying oil would be due to dissolving of frying food components in the oil that tend to darken the frying oil (Melton *et al*1994). It could also be due to the fact that product color developed through maillard reaction might leach out into the oil.Nagao *et al* (2006) demonstrated that amino acids of food products are responsible for oil color during frying. The oils extracted from poories fried in microwave oven (MO) and open fried method (OF) and the fried oils of both the processes were analyzed for their fatty acid compositions and no changes were observed (Data not shown). Cossignani*et al* (1998) has also reported similar study on fatty acid composition of microwave heating of olive oil.

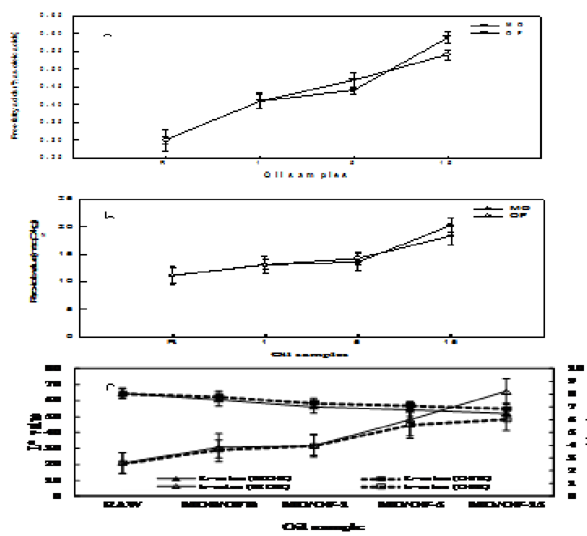


Fig. 1.Physicochemical properties of oil extracted from poories prepared using micro oven and open frying a; Oil uptake, b; Free fatty acids, c; Peroxide value, d; Color value (L*-Light & b*-yellow)

Abbreviations: MOP- Oil from the poories of microwave, OFP- Oil from the open frying process, Raw- Unfried oil. ∗ - indicates significant difference (p <0.05) between MOP and OFP poories at all-time intervals

PHYSICOCHEMICAL PROPERTIES OF OIL EXTRACTED FROM MICROWAVE OVEN (MOP) AND OPEN FRIED POORIES (OFP)

The physico-chemical analysis showed that oil uptake in microwave oven poori (MOP) was 4% higher than that of open fried poori (OFP) presented Fig. (2a). Studies carried out by Vatsala*et al* (2001) using whole wheat flour and traditional method of frying showed 18% oil uptake by poories, similar results were also obtained in the current study which showed 18% OFP, while uptake of MOP was found to be 22% which is 4% higher than OFP. This could be due to the fact that during frying process heat is transferred from oil to food, resulting in the evaporation of water from food and absorption of oil (Krokida*et al* 2000). Studies carried out by Saguy andPinthus(1995) states that water is evaporated from the product during frying, thus rate of oil absorption will increase due to reduced pore internal pressure. FFA value for oil from both microwave oven and open frying (MOP-15/OFP-15) increased significantly when compared to untreated oil by two folds. However FFA and PV of oil from poories of MOP increased when compared to OFP Fig.(2b and 2c). The L* value of poories fried by MOP and OFP showed a reduction from 63 to 58 and 68 to 60 respectively. Thus 1st poori was darker in color than the 15th poori marginally. b* value of the oil from poories showed an increased value in the 5th than in 15th poori, with marginal difference. Similar results was also observed in the total color * (ΔE) values among the two frying types Fig. (2d).

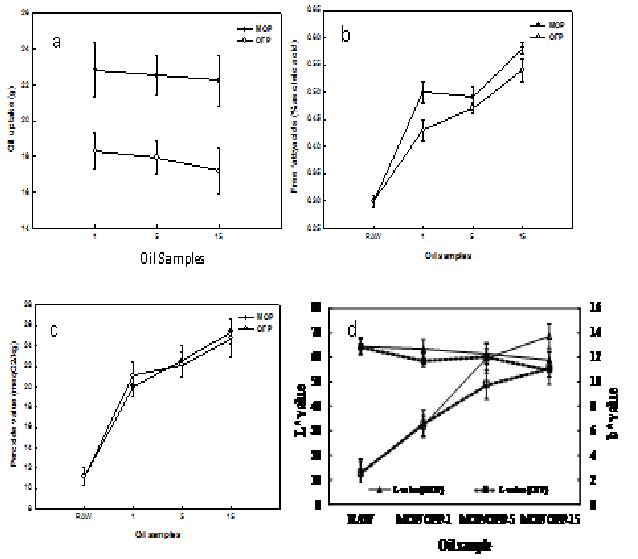


Fig. 2.Physicochemical properties of fried oil from microwave oven and open fried poories a; Free fatty acids, b; Peroxide value, c; Color value (L*-Light & b*-yellow)

Abbreviations: MO- Microwave fried oil, OF-Open frying fried oil, R- Unfried or Raw oil. Asterisk indicates MO is significant (p<0.05) when compared to OF.

TOTAL TOCOPHEROLS AND TOCOTRIENOLS CONTENT IN THE FRIED OIL AND OIL EXTRACTED FROM POORIES

Total tocols (tocopherols + tocotrienols) were estimated in wheat germ oil used for processing in MO and OF as well as oil extracted from poories of both the methods. Total tocols retained in microwave fried oil of one (MO-1; 303 mg /100g) and five (MO-5; 286 mg/100g) poories were more than the opened fried poories of one (OF-1; 282 mg/100g) and five (OF-5; 270 mg/100g) but the fifteenth poories of OF (OF-15; 250 mg/100g) retained more when compared to MO (MO-15; 230 mg/100g). Total tocol estimated in the oil extracted from poories of microwave oven MOP-1; 265 mg/100g and MOP-5; 234 mg /100g which were comparatively higher than the oil from poories of open frying OFP-1; 245 mg/100g and OFP-5; 232 mg/100g whereas, the oil from fifteenth poori of microwave oven decreased (MOP-15; 185mg/100g) when compared to poories of open frying (OFP-15; 200 mg/100g) and the results are presented in Fig.(3). However oils from the poories of both frying methods reduced total tocols significantly when compared to un-fried oil whose t.tocols was 349 mg/100g. It was observed that tocopherols is most rapidly destroyed at frying condition and were also observed by Gordon andKourmsk (1995).The oils obtained from microwave energy roasted hypocotyl soybean had reduced tocopherols with varied time duration (Hiromi Yoshida *et al* 1999) and similar observation was also made in the current study.

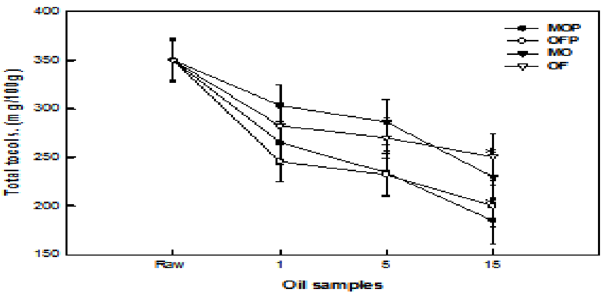


Fig. 3.Total tocopherol and tocotrienol content of raw oil, oil extracted from poories and fried oil obtained after microwave oven and open frying
Abbreviations are as in Fig. 1 and 2

FREE RADICAL SCAVENGING ACTIVITY OF FRIED OIL AND OIL FROM POORIES

Antioxidant activity study was carried out on fried oil and oil from poories of both the methods using DPPH free radical and IC_{50} values were calculated with respect to concentration of sample required to scavenge 50% of the DPPH radicals. Strong IC_{50} value was observed in fresh oil and were decreased in the order of raw >1 poori > 5poori > 15poori. Furthermore, both MOP (45.2) and MO (46.0) were dropped in their IC_{50} value significantly in the 15th poori and oil when compared to OFP (40.0) and OF (38.7) Fig. (4).However, not much significant differences were observed in the initial frying (1 and 5 poories) among the two methods. A similar study of free radical scavenging antioxidant assay was conducted on heating and frying oil and found that the DPPH free radical scavenging activities were reduced with increase in the number of frying cycles (Debnath*et al* 2010). This assay would be taken up to know the extent of antioxidant molecular damage that occurs during frying.

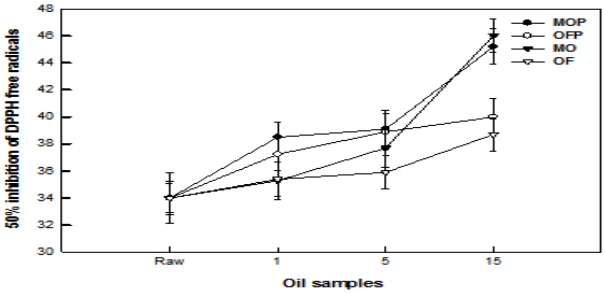


Fig. 4.Oil samples of poories and fried method required to scavenge 50% of DPPH free radicals
Abbreviations are as in Fig. 1 and 2, ∗ - Indicates significant difference (p<0.05) between OFP and OF when compared to MOP and MO respectively.

PHYSICO- CHEMICAL CHARACTERISTIC OF POORIES PREPARED BY MICROWAVE OVEN AND OPEN FRYING METHOD

The results on the physico- chemical properties of the prepared microwave oven poories (MOP) and open frying poories (OFP) method are presented in Fig. (5). Poories of various fryings (1st, 5th and 15th) were pooled and analyzed for moisture content, the results showed significant reduction (four fold) in the moisture content in the poories of microwave oven frying (3.1%) when compared to open fried method (12.8%). This significant difference was quite interesting in our study, since the conditions used were similar for both the methods except heating energy. This could be attributed to absorption of water within food molecules that generates heat due to its increased dipole moment by microwave energy that leads to rapid evaporation (Sutar and Suresh prasad 2008; Hu Lizhi *et.al* 2008). The color difference (ΔE) of MOP had slightly higher value (40) than that of OFP (37). Increase in the color may be due to maillard reaction (between sugar and amino acid) that occurs during frying (Debnath*et al* 2010). However no significant differences were observed between the two methods. Another interesting result observed in our study was that the shearing of MOP was 3.3 fold lesser (1.5 N) than the OFP (5.01 N) indicating that MOP poori was crunchy and broke easily whereas OFP poori was soft with maximum tearing strength. During the deep-fat frying process, oxidation, polymerization and degradation occur (Gloria andAguilera 1998). Hence, texture of poori may change on the surface due to polymerization or complete removal of moisture from the fried products.

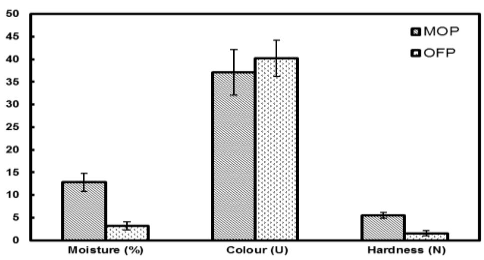


Fig. 5.Effect of microwave oven and open frying on physicochemical properties of poories

Abbreviations are as in Fig. 2,∗ - Indicates MOP is significantly different (p<0.05) when compared to OFP.

SENSORY EVALUATION OF MICROWAVE OVEN AND OPEN FRIED POORIES

Sensory analysis of open frying poori (OFP) and microwave oven (MOP) showed that the color was similar. OFP was softer in texture whereas MOP was very crunchy. Similar results were observed with the texture measurements. Significant difference was observed in chewiness of poori wherein, OFP was chewy compared to MOP. Oiliness of the poories also showed significant difference where MOP showed higher oil content though slight difference were observed in flavor, however, it was marginal. The presence of off taste was negligible which could be due to the odor of heated oil. The overall quality of microwave oven poories was acceptable. However, OFP was highly acceptable compared to MOP Fig. (6). Though the color of poories from both the methods were almost similar, Hunter lab, a color measuring instrument, showed slightly more color in microwave oven poories which is insignificant. In microwave oven fried poories, increased oil absorption, crunchiness, color, and oiliness could be attributed to rapid removal of moisture.

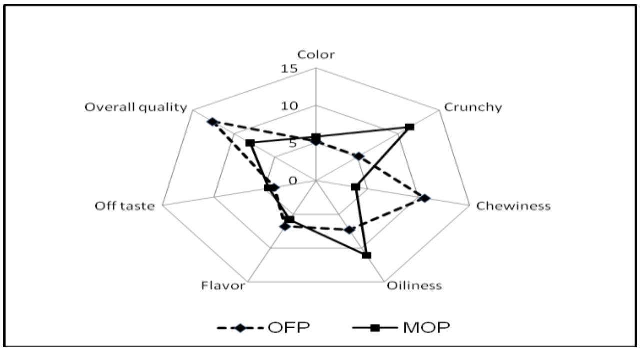


Fig. 6.Sensory evaluation of microwave oven and open fried poories
Abbreviations are as in Fig. 2

CONCLUSION

Our study concludes that oil quality deteriorated with the subsequent frying of poori by microwave oven frying than that of open frying/ traditional method. Hence, microwave frying can be used only for limited number of frying cycles.

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