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Oxidative stability of wheat germ and rice bran oils in frying

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Abstract

Wheat germ oil (WGO) and rice bran oil (RBO) were assessed for their oxidative stability and deteriorative changes after frying operation. Respective oils were blended at 10, 20 and 30% levels with that of corn oil. French fries were prepared and after 10th frying, rancidity tests were carried out. RBO blend T6 (30:70) and WGO treatment T2 (20:80) showed least degenerative changes in peroxide value (POV) i.e. 0.895meq/Kg and 1.46meq/Kg, respectively whilst free fatty acid (FFA) 1.15% and 1.35% were observed. Moreover, oil samples of T2 and T6 blends were drawn at 1st, 5th and 10th frying and assessed for oxidative stability through Rancimat method (at 121.6 C and 20L/h air flow rate). Oil stability index (OSI) had decreased exponentially during frying operation. Considering the induction time (h), there was a decrease of 32.6, 33.7 and 36.7% in T6, T0 and T2, respectively, throughout the frying period. Rancimat assay depicted a significant decrease in OSI in T6, an indicator of relative high resistance of oil towards oxidation during frying. It is envisaged that stability of RBO blend (T6) was not only because of degree of unsaturation but owing to the presence of some essential components like ϒ-oryzanol and α-tocopherols, protective constituents against oxidative degradation.

Key words: Wheat germ oil, rice bran oil, oxidative stability, French fries, Rancimat, ϒ-oryzanol, α-tocopherols

Introduction

Edible plant oils have gained immense attention due to their palatability in the food system. Inherent antioxidant ability of plantain oils acts as a protecting shield against deteriorative changes during the processing and preservation practices. Chemical stability, nutritional properties and shelflife of vegetable oil depend on the complexity of composition, which involve intricate pattern of oxidative reaction. High temperature and moisture trigger a series of degradation process in the presence of atmospheric oxygen as in frying. During the progression of frying, intermediate derivatives are the key factors responsible for the development of off-flavors, hydrolysis and polymerization that may be even toxic if produced in high concentrations (Mezouari et al., 2007; Chiou et al., 2009). From the last few decades, concerted efforts have been made towards exploiting the non-conventional oil sources particularly to explore the agro-based by products for the concern. Cereal industry by-products have attained enormous importance being cost effective alternate source of edible oils. In this context, wheat germ (WG) and rice bran (RB) are the by-products of their allied industry that are probed for oil extraction along with some bioactive molecules. Additionally, they are relatively good sources of several micronutrients. Wheat grain comprises about 2-3g/100g of germ that produces about 11g/100g oil, rich in unsaturated fatty acids especially linoleic acid. Wheat germ oil (WGO) is beneficial as it contains high vitamin E content, provides relief against dermatitis and improves muscle and lymph functioning (Sonntag, 1979; Dunford & Zhang, 2003).

Rice bran comprised of protein (11-15%), carbohydrate (34-62%), crude fiber (7-11%) and lipids (15-20%) (Chen et al., 2008). Oil content of rice bran varies depending upon varietal differences and ranges from 12-25%. Rice bran oil (RBO) is an acceptable substitute of conventional cooking oils because of its healthy constituents and antioxidants especially ϒ-oryzanol, contributes in the oxidative stability of oil (Amarasinghe & Gangodavilage, 2004; Siddiqui et al., 2010).

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Blended oils have gained dietary importance as they improve oil properties in terms of storage stability, thermal resistance and oxidative damage, thus proved as an alternate of vegetable oil. A number of chemical methods are used for the quality assessment of edible oil including free fatty acid (FFA), acid value (AV), saponification value (SV), peroxide value (POV), iodine value (IV), thiobarbituric acid (TBA) value and oil stability index (OSI). Rancimat test is the most commonly used for the measurement of oxidative stability because of its simplicity and reproducibility (Kmiecik et al., 2010).

The instant project was planned to determine the frying behavior of wheat germ and rice bran oils with special reference to oxidative stability through Rancimat. For the purpose, blending of WGO and RBO was carried out with corn oil (CO) to find out the most suitable blend for frying purpose.

between quinones derived from a simple catechin and a gallocatechin. They contributed towards tea brisk, astringent taste and bright golden color to the infusion (Cheng et al., 1997).TRs are a heterogeneous group of phenolic pigments molecular mass in the range 700–40,000 Da. They are water soluble, acidic, and are rust-brown in color that gives the richness in taste of tea (Yuan, 1983).

Levels of theaflavin and thearubigins are the necessary tools to assess the tea quality along with other parameters like caffeine and theabronins. Theaflavin and thearubigins has positive impact on tea quality and important for trade while caffeine and theabronins considered a obsolete in tea so tea quality indicate by the highest level of theaflavin and thearubingins and lower level of caffeine and theabronins (Taguri, et al., 2004).Solvents selected for the extraction of tea active molecules based upon their ability to preserve all the desired compounds. According to the nature of the tea different solvents methanol, acetonitrile and ethanol considered good but the importance of extraction time and temperature cannot be denied (Houghton and Raman 1998). Present research was conducted to explore the chemical profile of different Pakistani teas to set their role in modern life

Material and Methods

2.1. Procurement of raw material

Wheat germ (WG) was collected from Sunny Flour Mills, Lahore (Pakistan), whereas rice bran was (RB) obtained from Reem Rice Mills, Sheikhupura (Pakistan). Corn oil was procured from Rafhan Maize Industry, Faisalabad, (Pakistan).

2.2. Extraction of oil

WG and RB were stabilized by heating at 125–135℃ for 1-3sec to inactivate lipase that accelerates the free fatty acid production. Furthermore, oil extraction was done through Soxtech System (HT2 1045 Extraction Unit, Hoganas, Sweden), using hexane (B.P. 68℃) as solvent by following the AACC method 30-10 (AOCS, 1998). Laboratory scale refining was carried out of respective oils following the steps of degumming, neutralization, bleaching (at 90.7℃ using 1% bleaching earth) and filtration. The bleached oil was deodorized at temperatures between 245 and 257.7℃, and cooled to 45–48.7℃ (Sharif et al. 2009). Moreover, blending of corn oil with RBO and WGO was done by following the scheme given in Table 1.

Table. 1: Treatments used in study

Treat ments	Corn oil (%)	Wheat germ oil (WGO) (%)	Rice bran oil (RBO) (%)
T_0	100	-	-
T_1	90	10	-
T_2	80	20	-
T_3	70	30	-
T_4	90	-	10
T_5	80	-	20
T_6	70	-	30

2.3. Quality assessment tests

2.3.1. Physico-chemical evaluation

Physico-chemical parameters like saponification value (SV), iodine value (IV), acid value (IV), free fatty acids (FFA), peroxide value (POV) and thiobarbituric acid (TBA) value were carried out to assess the deteriorative changes after 10th frying of French fries (AOCS, 1998). Before frying potatoes were peeled, thoroughly washed, wiped, and cut in to uniform pieces (6.6±0.8cm long and 1.0±0.2cm thick, approximately). Samples were fried in 50g lots at a temperature of 190oC in oil blend for 6±2 min, using a Kenwood Deep Fryer (Model No. DF320 series).

2.3.2. Oxidative stability

Oil stability index (OSI) of the respective samples was measured by using Metrohm 743 Rancimat (Metrohm AG, Herisau, Switzerland) capable of operating at 50-220℃. The reaction vessels were thoroughly washed by boiling with sodium hydroxide solution (2%) for 1h, followed by cooling and soaking in concentrated hydrochloric acid. To carry out oil stability index, 3g oil was transferred into a reaction tube. The heater temperature was set at 121.6℃ (at 20L/h air flow) followed by collection of volatiles in cllection vessel. The software of the equipment evaluated the resulting curves automatically (Velasco, 2009). The oil samples were drawn at 1st, 5th and 10th batch of frying for inter-comparison between selected blends from WGO and RBO.

2.3.4. Statistical analysis

The data obtained for each parameter were subjected to statistical analysis by applying completely randomized design to check the level of significance by applying software MstatC (Steel et al., 1997).

Results

3.1. Physico-chemical evaluation

Means regarding saponification value (SV), iodine value (IV), acid value (IV) and rancidity tests which include free fatty acids (FFA), peroxide value (POV) and thiobarbituric acid (TBA) value are given in Table 2.

Quality assessment of WGO and RBO blends was conducted after frying and inter comparison was made to visualize better oil blend for frying purpose. Higher free fatty acid (FFA) content was determined in T0 (2.37%), followed by T1 (2.11%) whereas minimum was observed in T6 (1.150%) (Table 2). As T2 had 20:80 ratio of WGO so were less prone to deterioration in terms of FFA among blends of WGO. Highest acid value (AV) was observed in T0 (4.73%) and minimum was recorded in T6 (2.3%). The acid value was also important quality indicators in oil/fat since it determines the extent to which the gylceroides in oil have been decomposed by the lipase enzyme.

Saponification value was relatively higher in T2 (197.50mg KOH/g) followed by T3 (195.25mg KOH/g) and minimum in T4 (188.32mg KOH/g). The saponification value of WGO was found 207mg KOH/g, which was different from corn germ oil (191.4mg KOH/g) and olive oil (193.9mg KOH/g) as reported by this indicated that the fatty acids present in WGO have a higher number of carbon atoms than corn germ and olive oils. T6 had least peroxide value (POV) of 0.895meq/Kg, whereas T0 (2.109meq/Kg) had highest. T6 proved to be low in iodine value (IV) having 85.05g/100g whereas, among WGO blends T2 (109.46g/100g) had least. Iodine value of WGO was 107g/100g. TBA value was found to be least in T6 (0.05mg MA/Kg) and highest in T0 (0.083 mg MA/Kg). The TBA test was satisfactory for evaluating frying stability of edible oil and checking the changes in early stages of rancidity. Relative fewer declines in TBA value of RBO blend is certainly due to the presence of tocopherol, tocotrienol and oryzanols (Sereewatthanawut et al., 2011).

From the above mentioned results, it is evident that T2 (WGO:CO at 20:80) performed better among rest of the WGO blends whereas T6 (RBO:CO at 30:70) was less prone to deterioration considering the remaining RBO blends during whole frying process. However, these two blends were further probed for their oil stability index via Rancimat.

3.2. Oxidative stability

The oil stability index directly relates to the oxidative resistance of oil. During the present study, oil stability index decreased exponentially during frying process. The current results confirmed that the OSI of the oil blends determined through Rancimat is a useful tool for determining the frying stability of oil (Anwar et al., 2003). The high oil stability of T0 (control) in first frying was remarkable (8.9h), whilst T6 and T2 blends had OSI value of 8.5 and 7.9h, respectively. It is also depicted in Fig.1 that OSI of oils decreased gradually during the frying process.

At the end of 10th frying, there was a decrease in OSI of 32.6%, 33.7% and 36.7% for T6, T0 and T2, respectively, as compared to 1st frying; could be related to peroxide value and iodine value.

Table 2. Effect of frying on quality Parameters of oil blends

Treatments	FFA	AV	SV	POV	IV	TBA
T_0	2.37±0.06	4.73±0.08	156.05±1.46	2.109±0.11	117.84±1.67	0.08±0.01
T_1	2.11±0.025	4.21±0.01	193.27±1.01	1.60±0.1	113.73±1.46	0.07±0.008
T_2	1.35 ±0.11	2.92±0.08	197.50±1.28	1.46±0.11	109.46±0.91	0.07±0.004
T_3	1.63±0.10	3.27±0.18	195.25±0.64	1.55±0.07	113.30±1.56	0.07±0.015
T_4	1.34±0.29	2.69±0.04	188.32±1.58	0.97±0.12	107.79±1.67	0.06±0.01
T_5	1.16±0.18	2.33±0.05	190.30±3.16	0.93±0.04	104.26±1.98	0.05±0.007
T_6	1.15±0.015	2.30±0.2	192.35±2.55	0.89±0.02	85.05±1.40	0.05±0.02

Discussion

4.1. Physico-chemical evaluation

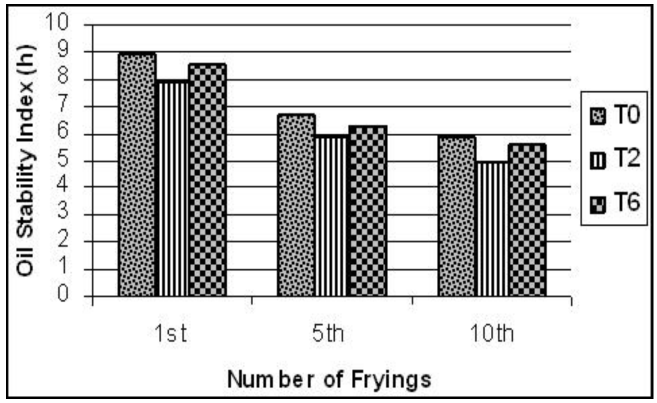
Hydrolysis of triglycerides produced free fatty acids that were the principal cause of deterioration occurring rapidly during the frying. After bran separation, the oil is exposed to lipases, causing its rapid breakdown to free fatty acids. Less lipase activity was observed in T6 because of the presence of tocopherols, tocotrienols and ϒ-oryzanol that were designated as natural antioxidants (Rodrigues & Oliveria, 2010). However, the presence of tocopherols as natural antioxidant in WGO helps to reduce the effect of rancidity in the prepared products by the incorporation of WGO. The nutritional quality and palatability of rice bran deteriorated rapidly as the oil undergo hydrolytic and oxidative rancidity. Hence, stabilizing the bran just after milling could not prevent oil deterioration (Dunford & Zhang, 2003). Peroxide value is a measure of the oxidative rancidity of oils. It is one of the most important chemical characteristics for assessing the degree of deterioration of fats and oils. Peroxide undergoes cleavage to produce aldehydes, ketones and acids responsible for off flavor. These products had a trend in interfering seriously with rancidity, discoloration, vitamin destruction, nutritional losses and polymerization making them unacceptable to the consumer. The POV of the rice bran did not remain low during storage due to presence of enzymes (Sereewatthanawut et al. 2011). The iodine value was often most useful in identifying a source of an oil by measuring the degree of saturation. Generally, the higher iodine values indicated oils and the lower values saturated fat (Savage et al., 1999).

4.2. Oxidative stability

The peroxide value increases with the progressive increment of frying thus oil stability index decreased. A diminishing trend in the degree of unsaturation was observed consequently due to marked decrease in oxidative stability of fried oil until 10th frying, a decrease of 28% was observed in T6 whereas in T2 31%. Nevertheless, the least value for OSI was estimated in T6 indicating relative high resistance of oil towards oxidation during the frying process (Velasco et al. 2009).

Above mentioned results regarding fried oil depicted that its diminishing oxidative stability was due to decrease in the degree of unsaturation and presence of inherent antioxidants. It is observed that not only unsaturation but also ϒ-oryzanol and ϒ-oryzanol were reactive agents that inhibit oil degradation. Rancimat test can be useful and act as an “assessment” test, eliminate the possibility of introducing lower stability oils into the production area. Using this method for oils employed in deep frying, it is possible to compare the degree of deterioration of the oils resulting from the deep frying process.

Figure 1. Oil stability index of oil blends during frying



Conclusion

In the nutshell, RBO is recommended over WGO blend because of its high content of ϒ-oryzanol and α-tocopherols, showed excellent frying performance and oxidative stability. Under the light of results and previously conducted researches, the instant investigation has proposed that rice bran oil blend having ratio 30:70 can produce superior quality fried products that can be an effective and healthy oil in frying industry. The saponification value of rice bran oil increased significantly as a function of frying progression. For rice bran oil, particularly could be related to the formation of a comparatively larger number of secondary oxidation products (e.g. carbonyl compounds) by the conversion of primary oxidation products (Yuldasheva et al. 2010; Vingering et al., 2010).

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