OIL AND MEAL QUALITY

AGRONOMIC PERFORMANCE OF SUNFLOWER (*HELIANTHUS ANNUUS* L.) IN AN ORGANIC CROP ROTATION SYSTEM IN THE HUMID TROPICS

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ABSTRACT

The demand for organic sunflower seeds is very high in the international market. Sunflower is a rustic plant that is cultivated under different production systems across several agro-ecological zones in the world. A locally adapted and late maturing sunflower variety ('Funtua') was sown after soybean, sesame and maize between 2008 and 2012 to assess its agronomic performance under continuous, rotational and conventional cropping systems in the forest – savanna transition zone. The field trials were carried out during the late cropping season (June – Nov.) in a randomized complete block design and replicated four times. Data were collected on plant height at maturity, seed yield and yield attributes of sunflower each year. Varying results were obtained on the effects of cropping systems on the agronomic parameters measured across the years. However, cropping system significantly (*P<0.05; F-test*) affected seed yield of sunflower in 2009, 2011 and 2012. The conventional cropping system only significantly (*P<0.05*) produced seed yield (1642.6 kg.ha^{-1}) higher than the continuous (778.0 kg.ha^{-1}) and rotational cropping (1262.0 kg.ha^{-1})systems in 2009. Thereafter, as the system stabilized, the rotational cropping system recorded higher seed yield than the continuous and conventional cropping systems in 2010, 2011 and 2012. The difference was significant (*P<0.05*) in 2012 with the rotational cropping system producing seed yield higher by 7.3 and 31.3% than the conventional and continuous cropping systems, respectively. Adoption of rotational cropping system is hereby recommended for sustainable organic crop production system in the humid tropics.

Key words: crop rotation, sesame, sunflower, yield, yield characters

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is an oilseed crop that has a very wide range of adaptation ability, low labour requirement for its cultivation and also very suitable for mechanization (Ozer *et al.,* 2004; Kaemeini *et al.,* 2009). Consequently, sunflower can be described as a suitable crop for crop rotation scheme in the tropics where water and not temperature is the major growth limiting factor. It also exhibits erect growth habit, comparable resistance to lodging, short duration, limited ground cover and has easily harvestable heads (Robinson, 1984; Kamal and Bano, 2009). Sunflower is grown principally for its seed that contains oil (36–52%) and protein (28–32%) as reported by Rosa *et al.* (2009). According to NSA (2016), the world's average yield and total land area statistics of sunflower increased appreciably by 11.3% and 9.3% between 2007/2008 and 2012/2013, respectively.

Crop rotation is a planned order (sequence) of specific crops from different genus, species, subspecies or varieties on the same field over a given period of time (Helm, 1993). The advantages of crop rotation include: prevention of soil depletion; improvement of soil fertility, internal resource utilization; reduction of soil erosion, reliance on synthetic chemicals, allelopathic or

phytotoxic effects and environmental impact; control of diseases and pest infestation; enhancement of workload distribution and distribution of economic risks (Helm, 1993). According to Kamal and Bano (2009), over 200 natural allelopathic compounds have been discovered and isolated from different cultivars of sunflower. However, the responses of crops that follow sunflower in a sequence of as companion crops vary (Farooq *et al*., 2011; Nikneshan *et al.*, 2011). It was recently reported that the α-pinene in essential oil of sunflower head is very critical to the inhibitory effect of head extract (Kaya *et al.*, 2013). Consequently, it was suggested that removing the head of sunflower could be beneficial for alleviating the allelopathic effect. Unfortunately, this crop is rarely cultivated in rotation with other crops in the tropics. Therefore, in a bid to develop a production package for some staple and commercial food crops with high export potentials a crop rotation scheme was initiated consisting of four component crops with export potentials (soybean, sunflower, sesame and maize) in 2008. The objective of the study was to evaluate the performance of the component crops in rotation relative to continuous and conventional cropping systems.

MATERIALS AND METHODS

The mean monthly rainfall data during the late copping season of 2008 – 2009 are presented in Table 1. Year 2010 was the wettest year (791.2 mm) during the late cropping season and 2008 was the driest (328 mm). Although, the highest rainfall (288.1 mm) was recorded in 2011 during the most critical month for sunflower (October) which coincided with grain filling. The crop rotation scheme involved four component crops (soybean, sesame, sunflower and maize as shown in Table 2) and the study was carried out at the Organic plot of the Teaching and Research Farm of the University of Agriculture, Abeokuta (7^o 15' N, 3^o 25' E, altitude 140 m.a.s.l). The soil of the experimental field is oxic Paleudulf (Adetunji, 1991). The test variety of sunflower was Funtua (a local adapted and late maturing variety). The experimental design was randomized complete block design (RCBD) with four replicates. Treatments evaluated were continuous, rotational and conventional cropping systems. The plots of the conventional cropping system were located about 15 m away from the organic plots to avoid commingling. The row spacing adopted for sunflower under the three cropping systems was 60 x 30 cm and each plot measured 6.5m by 6.0m ($39m^2$). Sowing of sunflower seeds was done on August 15, 2008, July 2, 2009, August 15, 2010, July 18, 2011 and July 20, 2012 based on the onset of rains in the late cropping season. No herbicides or inorganic fertilizers were applied on the continuous and rotation plots. However, pre-emergence herbicides (Galex and Gramoxone) and fertilizer combination (60 kgN/ha, 56 kg P_2O_5/ha and 100 kgK_2O/ha) were applied on the conventional plots at sowing and 4 weeks after sowing (WAS), respectively. Manual weeding was done on all plots at 3 and 6 WAS. The organic fertilizer (Aleshinloye Fertilizer (Grade B) contained 1.2%N, 76 ppm P, 13.75 cmol K, 10.28 cmol Na) was applied at the rate of 25 tonnes/ha to the continuous and rotational cropping systems plots at 4 WAS. This rate was equivalent to 60 kg N ha/ha of the inorganic fertilizer recommended for sunflower in the transition zone (Olowe *et al.*, 2005). Application of organic fertilizer commenced in 2009 a year after the rotation scheme took off. Harvesting was done at physiological maturity (R8) as described by Schneiter and Milner (1981). Five randomly selected plants per plot were tagged from the net plot for plant height measurement and yield attribute analysis. Data were collected on plant height at physiological maturity, head weight and diameter, number and weight of seeds per head and seed yield on plot basis. All data collected were subjected to analysis of variance and means of significant treatment were separated using the least significant difference method as described by Steel and Torrie (1984).

RESULTS

Effect of cropping systems on plant height, seed yield and yield attributes of sunflower

Cropping system only significantly ($P \leq 0.05$; *F*-test) affected plant height in 2012 with sunflower plants on rotational and conventional plots significantly taller than plants on under continuous cropping system (Table 3). However, the pooled mean indicated that the plant height of sunflower

under the conventional and rotational cropping systems were at par. Average head diameter and weight of sunflower were significantly ($P \leq 0.05$; *F*-test) affected by cropping system in 2009 and when pooled, and the plants under continuous cropping system recorded significantly lower head diameter and weight than those under rotational and conventional cropping systems (Table 4 and 5). Weight of seeds per head was significantly ($P \leq 0.05$; *F*-test) affected by cropping system in 2009, 2012 and when pooled (Table 6). Similarly, the effect of cropping system was only significant ($P \leq 0.05$; *F*-test) for number of seeds per head in 2009 and when pooled (Table 7).However, sunflower seed yield was significantly ($P \leq 0.05$; *F*-test) affected by cropping system in 2009, 2011, 2012 and when pooled. Sunflower under continuous cropping system produced lower (significant at $P \leq 0.05$) seed yield than the plants under rotational and conventional cropping systems during the three years, except when yield values were pooled and the continuous was at par with rotational system (Table 8).

DISCUSSION

Rainfall distribution which is the main growth limiting factor in tropical agriculture varied markedly during the five year period of experimentation. The total rainfall during the late cropping season of 2008 – 2012 ranged between 328.0 and 791.2 mm and these values compared favorably with the rainfall amount (500 – 750 mm) reported to be adequate for optimum performance of sunflower (Weiss, 2000). Year 2008 with the smallest amount of rainfall (328.0 mm) also recorded the lowest seed yield (540.8 kg/ha). This could be attributed to the low rainfall in October (84.5 mm) which coincided with the grain filling period. The rotational and conventional cropping systems recorded grain yields above 1,000 kg/ha between 2009 and 2012, except conventional cropping system in 2010 and 2011. These yield values must have been enhanced by the rainfall in the months of September and October, and the availability of nutrients supplied through fertilizer application and they compared favorably with Nigerian (1000 kg/ha), African (812 kg/ha) averages (Olowe *et al.,* 2013) and world average (1520 kg/ha) according to USDA (2012), and the more recent forecast (1410 kg/ha) for 2012/2013 by NSA (2016). The consistently higher seed yield recorded under rotational cropping system in 2010, 2011 and 2012 could be due to the gradual stabilization of the system following application of organic fertilizers and rotation of soybean and sesame as preceding crops to sunflower.

The main agronomic traits that critically contribute to seed yield of sunflower include number of heads per hectare, weight of seeds per head and number of seeds per head (Robinson, 1978). However, in our study, the pooled mean revealed that cropping system significantly affected grain yield with the conventional and rotational cropping systems recording higher values for weight and number of seeds per head relative to sunflower under continuous copping system. Furthermore, the relatively lower values for plant height, number and weight of seeds per head, head weight and diameter on sunflower under continuous cropping system could also be attributed to depleted nutrients in the soil and accumulation of pest and disease organisms following continuous cropping of sunflower for the fourth year on the same plot. However, no serious disease or pest problem was recorded during our study.

CONCLUSION

Based on the pooled results of this study, the agronomic performance of sunflower that received organic fertilizer under rotational cropping system confirmed the huge potential for sunflower being a crop with high adaptability and low labour requirement as a viable component in organic crop rotation system in the tropics.

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Table 1: Mean monthly rainfall (mm) during the late cropping season (July – November) of 2008 - 2012

Year	**July**	**August**	**September**	**October**	**November**	**Total**

2008	299.2	106.7	136.8	84.5	0.0	328.0
2009	160.0	162.1	151.6	180.1	64.6	718.3
2010	322.9	266.6	257.6	172.3	94.7	791.2
2011	349.5	88.7	204.1	288.1	3.6	584.5
2012	155.4	36.3	181.4	184.7	49.6	607.4

Table 2: Crop rotation scheme involving soybean, sesame, sunflower and maize (2008 -2012)

2008	**2009**	**2010**	**2011**	**2012**
Sunflower	Sesame	Maize	Soybean	Sunflower
Sesame	Soybean	Sunflower	Maize	Sesame
Maize	Sunflower	Soybean	Sesame	Maize
Soybean	Maize	Sesame	Sunflower	Soybean

Table 3: Effect of cropping systems on plant height (cm) of sunflower during the late cropping season (July – Nov.) in 2008 - 2012

Cropping systems	**2008**	**2009**	**2010**	**2011**	**2012**	**Mean**
Continuous	-	184.7	125.8	206.1	218.0	183.7
Rotational	208.0	209.0	224.3	255.8	235.0	226.4
Conventional	192.0	206.4	216.7	243.7	237.8	219.3
LSD 5%	ns	ns	ns	ns	10.19	32.32

Notes: **, * Significant at P $\leq$ 0.001 and 0.05, respectively, ns – non-significant

Table 4: Effect of cropping systems on head diameter (cm) of sunflower during the late cropping season (July – Nov.) in 2008 - 2012

Cropping systems	**2008**	**2009**	**2010**	**2011**	**2012**	**Mean**
Continuous	-	9.6	9.1	14.1	17.1	12.5
Rotational	9.8	12.1	10.5	16.2	18.0	13.3
Conventional	8.6	12.8	11.3	16.4	18.1	13.4
LSD 5%	ns	2.17	ns	ns	ns	0.69

Notes: **, * Significant at P $\leq$ 0.001 and 0.05, respectively, ns – non-significant

Table 5: Effect of cropping systems on head weight (g) of sunflower during the late cropping season (July – Nov.) in 2008 - 2012

Cropping	**2008**	**2009**	**2010**	**2011**	**2012**	**Mean**

systems						
Continuous	-	32.4	39.9	28.5	112.5	53.3
Rotational	60.3	58.0	57.2	41.3	123.5	68.1
Conventional	43.4	68.0	79.1	41.6	122.5	70.9
LSD 5%	ns	26.50	ns	ns	ns	13.36

Notes: **, * Significant at P ≤ 0.001 and 0.05, respectively, ns – non-significant

Table 6: Effect of cropping systems on seed weight (g) of sunflower during the late cropping season (July – Nov.) in 2008 - 2012

Cropping systems	2008	2009	2010	2011	2012	Mean
Continuous	-	20.2	21.9	19.7	41.3	25.8
Rotational	21.5	33.1	31.9	37.9	57.7	36.4
Conventional	28.3	42.2	35.1	36.2	53.4	39.1
LSD 5%	ns	9.53	ns	ns	3.02	9.93

Notes: **, * Significant at P ≤ 0.001 and 0.05, respectively, ns – non-significant

Table 7: Effect of cropping systems on number of seeds per head of sunflower during the late cropping season (July – Nov.) in 2008 - 2012

Cropping systems	2008	2009	2010	2011	2012	Mean
Continuous	-	319.0	580.0	385.0	580.5	466.0
Rotational	540.8	680.0	853.0	547.0	607.0	645.4
Conventional	664.9	715.0	659.7	520.0	591.5	630.2
LSD 5%	ns	257.2	ns	ns	ns	57.44

Notes: **, * Significant at P ≤ 0.001 and 0.05, respectively, ns – non-significant

Table 8: Effect of cropping systems on seed yield (kg/ha) of sunflower during the late cropping season (July – Nov.) in 2008 - 2012

Cropping systems	2008	2009	2010	2011	2012	Mean
Continuous	-	778.0	1000.0	584.7	981.1	835.9
Rotational	540.8	1262.0	1150.0	1348.5	1428.2	906.0
Conventional	664.9	1642.6	750.0	808.9	1324.0	1038.0
LSD 5%	ns	366.75	ns	579.8	75.23	145.0

Notes: **, * Significant at P ≤ 0.001 and 0.05, respectively, ns – non-significant

ESSONS FROM TEN YEARS OF AN INTERPROFESSIONAL SURVEY PLAN ON OILSEEDS FOOD SAFETY

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ABSTRACT

French oilseeds food chain operators are coordinated through a food safety survey plan, in order to get a realistic picture of the contamination in oilseed products (seeds, oilseed meal, and vegetable oil). Concerned crops are those cultivated or processed in France: rapeseed, sunflower and soybean. Grain storage companies, feeding industries and oil industries participate voluntarily, and send their self-data that are pooled in a database. Thirty-three companies are actively involved, providing each year about 60000 to 180000 analytical results coming from about 2000 to 3000 samples of seeds, meals and oils (note: on one sample, several contaminants can be analyzed giving several analytical results). Pesticide residues represent more than 90% of the analytical results of this database as the laboratories can determine a large number of active substances with multi-methods. Other sought contaminants are: trace elements (cadmium, lead, arsenic, mercury, fluorine), mycotoxins (mainly aflatoxin B1 and total aflatoxins), toxic organic compounds (polycyclic aromatic hydrocarbons, dioxins and PCBs), microbiological contaminants (salmonella in meals), botanical impurities (eg seeds of *Datura spp.* in sunflower seeds), mineral oils or compounds likely to be formed during refining such as esters of 3-MCPD and glycidyl esters in oils. The food safety of oilseeds survey plan allows to identify which are main concerns, for instance post-harvest insecticide residues from cross contamination during storage. Results of this monitoring plan were transmitted to the French government and the European Commission in cases of regulatory threshold revisions (eg for cadmium in oilseeds, for the revision of pirimiphos-methyl thresholds).

Key words: Oilseeds, vegetable oil, survey plan, contaminants, pesticide residues

INTRODUCTION

The French oilseed food supply chain got together with food safety issues since the early 2000s that correspond to the establishment of a set of European regulations called “Hygiene Package” (Dauguet et al, 2006). In this context, the food safety survey plan (called PSO) was implemented from the 2005 campaign, helping to control the quality of products (seeds, meal and oil) in a interprofessional framework. Since PSO was launched, more and more operators of the oilseed supply chain have become active partners. This article gives a review of the seven years of the PSO.

Today, each operator of the food chain is facing a legal obligation:

- to implement a HACCP approach, based on sound analysis of health risks inherent in its business,
- to ensure the sanitary compliance of products that it puts on the market,
- to carry out self-monitoring.

The PSO, set up by Terres Inovia, ITERG and Terres Univia since 2005, is an observatory of the sanitary quality of oilseed products in France (Lacoste et al, 2005). This survey plan is based on

a shared private database on oilseed contaminants. This base is fed by self-monitoring data from industries (crushing industry and feed industry) and storage agencies that join this PSO, as well as by series of analyzes on seeds, meal and oil by Terres Inovia, ITERG and Terres Univia (figure 1).

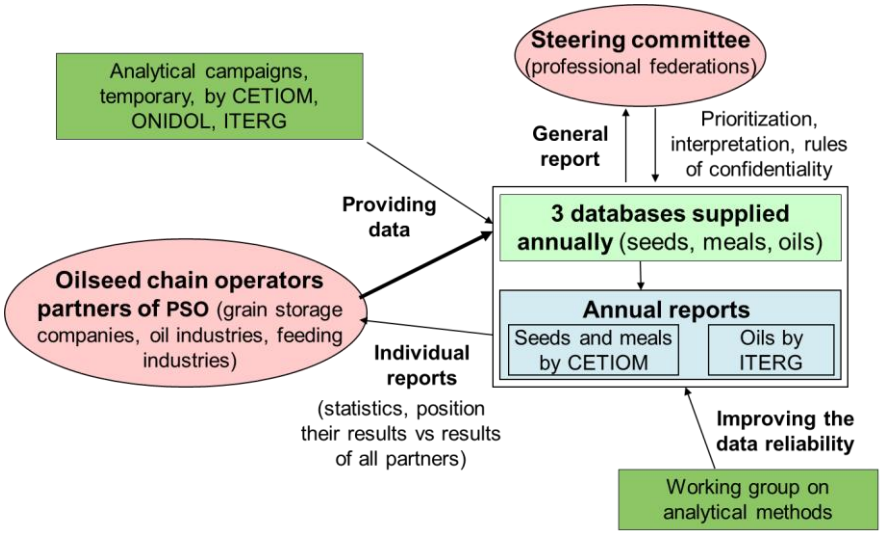

Figure 1. Organization of the Oilseed Survey Plan (PSO)

Intended for storage agencies to industrial oil processors and feed manufacturers, the PSO deals with:

- oilseeds: rapeseed, sunflower, soybean
- products: seeds, meals, crude and refined oils, byproducts of refining
- contaminants: residues of plant protection products, trace metals, mycotoxins, toxic organics, salmonella, botanical impurities ...

The confidentiality of data is guaranteed for partners, and no commercial exploitation of this database is made. The database on seeds and meals is managed by Terres Inovia, and the database on crude and refined oils is managed by ITERG.

So, the PSO is a tool of the oilseed supply chain, allowing a collective coordination on the safety aspects, highlighting progress and contributing to setting realistic regulatory thresholds. It represents also a forum for exchange of information between the operators in the sector, where are identified relevant research avenues.

A GOOD REPRESENTATIVENESS

To date, the PSO has 33 active partners: 28 grain storage agencies distributed throughout France, which represents 30-40% of the of the French oilseed harvest, 4 oil industrials (the main groups in France) and 1 partner in the feed industry, the OQUALIM association, which brings together 57 feeding companies (over 71% of the feed production). The representativeness of the PSO partners is correct. This plan is open to all interested companies and new members join it every year. Thus, each partner provides analysis data from its own self-monitoring data, and annually receives an individual report with its results compared to regulatory limits and to the overall PSO results: a moderate analytical investment gives access to a rich database, allowing refining its risk analysis.

For the last ten years, the PSO collected data annually from about 2,000 to 3,500 samples of seeds, cake, oils, and providing between 40000 and 120000 analytical results per year (several contaminants checked in each sample). Plant protection products residues (pesticides) represent over 90% of the results. The other investigated contaminants are: metal and mineral trace elements (cadmium, lead, arsenic, mercury, fluorine), mycotoxins (aflatoxin B1 and total aflatoxins essentially), toxic organic (PAHs, dioxins and PCBs), microbiological contamination (salmonella

cakes), botanical impurities (seeds of *Datura spp*. in sunflower seeds), mineral oils or compounds likely to form during refining such as the esters of 3-MCPD and glycidol esters in the oil.

THE PSO RESULTS

PSO allows us to check that almost all oilseed products comply with the regulations. Regulatory limits on oilseeds are defined in different texts: maximum limits for pesticide residues (MRLs, EC Regulation No. 396/2005 and Regulations amending it), maximum levels in feed (Directive 2002/32 / EC and texts the modifying) maximum levels in foodstuffs for human consumption (Regulation No. 1881/2006 and other regulations amending it).

However, PSO provides the observation that oil refining is necessary to remove some pesticide residues from crude oils. These are mainly insecticide residues, coming from post-harvest treatments (pirimiphos-methyl, chlorpyrifos-methyl, deltamethrin), applied on the empty storage cells or on cereal grains stored in the same sites, and being incidentally found on oilseeds by cross-contamination (Dauguet, 2007; Dauguet, 2009). These molecules are then removed at various steps of oil refining, and therefore marketed refined oils are pesticide free.

Through the PSO, the real effort provided by crushing plant in order to control the microbiological quality of the meal could be checked: today salmonella nearly disappeared in rapeseed and sunflower meals produced in France.

The PSO suggests that mycotoxins are a danger almost inexistent for oilseeds, considering the regulated toxins. Only aflatoxin can be detected occasionally in sunflower, but at very low levels, far below the regulatory threshold. But monitoring of aflatoxins should as a regulatory threshold for aflatoxins in human food has been fixed for oilseeds intended for direct human consumption (2 mg/kg for aflatoxin B1 and 4 mg/kg for total aflatoxins) without industrial processing (confectionery sunflower), with a much higher maximum levels in feed (20 mg/kg for aflatoxin B1). For other not yet regulated toxins such as toxins of Alternaria, EFSA recommends Member States to acquire data in food. Within PSO, analyzes of these toxins have been carried out and their presence can be seen occasionally on sunflower. However, toxicological studies are not sufficiently substantiated to date to conclude on the risk posed by the toxins of Alternaria.The trace metals are not a family at risk as oilseeds never exceed these regulatory limits. In the case of cadmium, the concentrations found in the sunflower seeds and meal can be sometimes close to the threshold in animal feed (1 mg/kg).

A contaminant was identified recently in the PSO: *Datura spp* seeds, which are botanical impurities that can be found in sunflower seed crops. This weed is toxic, since it contains tropane alkaloids, and the presence of *Datura spp*. seeds is regulated in the raw materials for animal feed (1000 mg/kg of whole seeds of *Datura*). Indeed, the alkaloids contained in these impurities will be transferred in the meal after the oil extraction process.

Organic toxic substances, such as polycyclic aromatic hydrocarbons (PAHs) and dioxins and PCBs, are specifically monitored in crude and refined oils. The levels measured for these substances show that these substances do not pose a problem in the French oilseed sector. Recently, the presence of esters of 3-MCPD and glycidol esters has been reported in refined vegetable oils, and in formulated food products containing vegetable fats (Zelinková, 2006). Palm oil is the oil with the highest infection rates likely related to the high temperatures used during deodorization of physical refining, while the seed oils are generally less prone to the formation of this contaminant (Kuhlmann , 2011). The few results collected via the PSO confirm the low contamination of refined rapeseed and sunflower oils.

Following a sunflower crude oil contamination from Ukraine by mineral oils (Lacoste, 2010), manufacturers have established since 2008 a systematic verification of import sunflower oil. The data collected within the PSO showed that the contamination in 2008 was an isolated case.

PSO, A TOOL FOR THE OILSEED FOOD CHAIN

The results of PSO therefore enable operators in the sector to carry out an analysis of health hazards in oilseed products. Thus, the subject of post-harvest insecticide residues appeared

important. This encouraged the operators to carry out specific actions to identify the sources of cross-contaminations of oilseeds by these pesticide residues in storage facilities. Surveys conducted in collaboration with companies have enabled the identification of these situations leading to cross-contamination (Dauguet, 2007; Dauguet, 2009), and recommendations were relayed by the federations. According to the latest PSO results, the contents of these pesticide residues tend to decline.

The PSO has also been involved to argue for re-examine the maximum residue level of pirimiphos-in oilseeds, taking into account the phenomenon of cross-contamination during storage. This data were studied by EFSA which issued an opinion (EFSA, 2011) in which European food safety authority says that an MRL of 0.5 mg/kg would be suitable for oilseeds (while the current MRL was 0.05 mg/kg).

As part of the review of the regulatory thresholds of cadmium in food, PSO partners have also mobilized to provide the public authorities with data so that future limits are not an obstacle to trade in oilseeds. This issue mainly concerns the sunflower, which accumulates cadmium in its seeds. Today, none sunflower sample exceeded the regulatory threshold for feed, but a lower threshold could be a problem. Finally, this regulation does not apply to oilseeds. PSO data were transmitted to the French authorities in the context of the European discussions on the revision of cadmium thresholds, with the agreement of all PSO's members. This also illustrates the value of reliable data to assist in setting realistic regulatory thresholds.

CONCLUSIONS

The PSO is now considered a sustainable action for the benefit of operators in the French oilseed sector, which has no equivalent in other countries. In 2016, new means of communication and information are available for PSO members, with a dedicated and protected website. This provides more responsiveness and flexibility: more ease for online data entry and data reading.

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THE EFFECTS OF VACUUM AND ATMOSPHERIC DEEP-FAT FRYING PROCESS ON TOTAL FRYING-USE TIME OF SUNFLOWER OIL AND ON FRENCH FRIES QUALITY

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ABSTRACT

Deep-fat frying, which is one of the oldest and popular food preparation methods, is a process of immersing food in hot oil at a high temperature. In this study a vacuum cooking equipment prototype which could work both atmospheric pressure and under vacuum was developed for deep-fat frying process. The effect of vacuum and atmospheric frying temperature and number of frying in the same sunflower oil on the quality of French fries and sunflower oil was evaluated. Potato pieces was fried in ratio 1:6 (potato:oil) at atmospheric pressure and under vacuum at 135 and 180°C, respectively, for 10 min in every frying interval for a total of 7 (atmospheric pressure) and 15 (under vacuum) times of frying in the same oil.

The free fatty acid content of the frying oil at atmospheric condition was determined to be excessively high compared to that of vacuum frying oil. TPM of oil at the atmospheric frying after the 3th frying rapidly reached to TPM content of the 15th vacuum frying oil. It was observed that peroxide value of the oil at atmospheric frying was higher than that of vacuum frying oil. Viscosity of the oil at atmospheric condition increased rapidly with an increase in exposure time compared to that of vacuum frying oil. The color values of vacuum and atmospheric fried French fries were not significantly different from each other. No significant changes in texture of French fries were determined with oil utilization time in the both of frying process.

Key Words : Deep-fat frying, vacuum frying, oil utilization time, sunflower oil, oxidation

EFFECT OF CURCUMIN NANOPARTICLES ON OXIDATIVE STABILITY OF SUNFLOWER OIL-IN-WATER EMULSIONS

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ABSTRACT

Curcumin is a natural polyphenolic compound that is obtained from the root of *Curcuma longa* Linn (turmeric). Oil oxidation is an undesirable series of chemical reactions involving oxygen that degrades the quality of oil. The aim of the present study was to develop a method to nano-particularize curcumin in order to increase its antioxidant efficiency against oxidation of sunflower oil. For this purpose, curcumin was dissolved in dichloromethane, injected in heating water (60 ºC) including tween 80 and then stirred. After characterization of the particle size and distribution of the fabricated curcumin nanoparticles, they were lyophilized. In formation of the oil phase of emulsion with nanocurcumin (ENC), nanocurcumin was added into oil-in-water system in which sunflower oil was used as the oil phase. Oxidation stability of oil-in-water emulsions including curcumin nanoparticles was measured by oxidation test reactor. As a result, 98 % of the particles were in mean diameter of 9-10 nm. The formed nanoparticles were characterized by scanning electron microscope, Fourier Transform Infrared Spectroscopy and thermogravimetric analysis. Unlike curcumin, nanocurcumin was found to be freely dispersible in the presence of the surfactant. The chemical structure of nanocurcumin was the same as that of curcumin, and no remarkable change was observed during nanoparticle preparation. Thermal degradation of the nanocurcumin was similar to that of curcumin. It was found that emulsion with nanocurcumin (ENC) was more effective than those with and without curcumin against oxidation of the sunflower oil, as revealed by the longer induction periods (IP) for ENC (1 hr 20 min) than those for emulsions with and without curcumin (60 min. and 53 min.) The results demonstrated that the water solubility and antioxidant activity of curcumin was markedly improved by particle size within the nano-range.

Key Words : Sunflower oil, nanocurcumin, nanotechnology, oxidative stability, molecular and thermal characterization.

DETERMINATION OF TEXTURAL, RHEOLOGICAL PROPERTIES AND SFC, SMP VALUES OF OLEOGELS PREPARED USING SUNFLOWER OIL

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ABSTRACT

In Recent years, food products which is designed to provide development for human health and researches is to improve such products have been intensively carried out all over the World. Oils Reduced Trans and saturated fatty acids levels have come firstly. To this end, oleogels, which have a spreadable elastic structure, by adding organic or polymer gelling agents (oleogelators) to oils, have been used. In our country, sunflower seed provides about 45% our total oil seed production and sunflower oil comes first in mostly consumed edible oils. Oil obtained from sunflower seed is rich in linoleic acid. Also recently, production of high oleic sunflower oil, by reducing linoleic acid content of sunflower oil, has been started. In this study, creating of oleogels formulations include sunflower and high oleic sunflower oil, have low amount of trans and saturated fatty acids, alternate to margarines and determination of textural, rheological, SFC and SMP values of this samples was purposed. For 6 samples (1 reference and 5 new formulations) Textural properties according to Ogutcu and Yilmaz, 2015; rheological properties according to Lupi et. Al., 2013 (with some modifications); SFC values according to AOCS Official Method Cd 16b-93:2009 and SMP values according to ISO 6321:2002 have been proceeding.

Key Words : oleogels, sunflower oil, rhelogical, SFC

ASSESSMENT OF SUNFLOWER OIL ADULTERATION

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ABSTRACT

The aim of this study is to estimate the sunflower oil adulteration with cheaper oils as raw cottonseed and canola oils. Sunflower oils, raw canola oil and raw cottonseed oil samples were supplied from market to investigate the possibility of adulteration. Main fatty acid composition of samples was detected by using GC-MS. L^*, a^* and b^* color values of the samples were also determined to detect the correlation with fatty acid composition. Increase of linolenic acid and palmitic acid percentages of sunflower oils samples was a good indicator for estimation of canola oil and palm oil addition, respectively. Some of the sunflower oil samples were suspected to be adulterated. L^*, a^* and b^* color values were also discussed on prediction of the possibility of adulteration. b^* values were detected to be higher in suspected oils. Detailed statistical modeling studies may be recommended for estimation of cheaper raw oil addition in sunflower oil.

Key words: Adulteration, Fatty acid, Sunflower oil, Color

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INTRODUCTION

Sunflower is botanically classified as *Helianthus annuus* and is an annual plant. It is thought to have been domesticated around 1000 B.C. by Native Americans. People in many regions began to process vegetable oils, from many oil sources for cooking purposes, before thousands of years ago. In 1860, Russia farmers cultivated sunflower. At that time, they became the world's largest producer of sunflower seeds. (Anonymous, 2010).

Sunflower oil is rich in linoleic acid and it is one of the most economically important vegetable oil source, especially in Turkey. Also, the widely usage of cake/meal of sunflower, obtained after oil extraction, as livestock increases the economic value of sunflower (İncekara, 1972, Dayal et al., 2011).

The tendency of adulteration on olive oil is higher in comparison to other oils, so there are many researches on detection of the adulteration in olive oil (Gegiou and Georgouli, 1983; Mannina et al., 1999; Blanch et al., 1998, 1999, 2000; Salivaras et al., 1992; Dionisi et al., 1995; Flor et al., 1993). Sunflower oil is cheaper than many other oils and sometimes used for adulteration of olive oil (Savaş, 1969) but, in recent years sunflower oil is also subjected to be adulterated with some other cheaper oils.

The fatty acid composition of sunflower oil may vary by the effect of many reasons. Republic of Turkey Ministry of Food, Agriculture and Livestock published a regulation on the 12ht April 2012, called as 'Bitki adı ile anılan yağlar tebliği'. The Ministry announced the ranges of fatty acid

composition of many vegetable oils (Anonymous, 2012). It is attractive that the lower and the higher limits of the ranges are at their maximum and in accordance with the literature.

Raw canola oil and raw cottonseed oil are cheaper than sunflower oil was subjected to this study for our suspect of their use in adulteration of sunflower oil. The ranges of fatty acid composition of sunflower, canola and cottonseed oil's, mentioned in regulation, are shown in Table 1.

Table 1. The ranges of fatty acid composition of sunflower, canola and cottonseed oil in Turkish Food Codex on vegetable oils (%)*

Fatty acids		Sunflower oil	Canola oil	Cottonseed oil
Caproic	(C6:0)	nd[a]	nd	nd
Caprylic	(C8:0)	nd	nd	nd
Capric	(C10:0)	nd	nd	nd
Lauric	(C12:0)	nd - 0.1	nd	nd – 0.2
Myristic	(C14:0)	nd - 1.0	nd - 0.2	0.6 - 1.0
Palmitic	(C16:0)	4.0 - 7.6	2.5 - 7.0	21.4 – 26.4
Palmitoleic	(C16:1)	nd - 0.3	nd - 0.6	nd – 1.2
Margaric	(C17:0)	nd - 0.2	nd - 0.3	nd - 0.1
Heptadecenoic	(C17:1)	nd - 0.1	nd - 0.3	nd - 0.1
Stearic	(C18:0)	2.1 - 6.5	0.8 - 3.0	2.1 – 3.3
Oleic	C18:1	14.0 - 71.8	51.0 - 70.0	14.7 - 21.7
Linoleic	C18:2	18.7 - 74.0	15.0 - 30.0	46.7 - 58.2
Linolenic	C18:3	nd - 0.5	5.0 - 14.0	nd - 0.4
Arachidic	C20:0	0.1 - 0.5	0.2 - 1.2	0.2 - 0.5
Eicosenoic	C20:1	nd - 0.3	0.1- 4.3	nd - 0.1
Behenic	C22:0	0.3 - 1.5	nd - 0.6	nd - 0.6
Docosahexaenoic	C22:1	nd - 0.3	nd - 2.0	nd - 0.3
Lignoceric	C24:0	nd - 0.5	nd - 0.3	nd - 0.1
Nervonic	C24:1	nd	nd – 0.4	nd

[a]: not detected (≤ % 0,05); *Anonymous, 2012.

The aim of this study is to estimate the sunflower oil adulteration with cheaper oils as raw cottonseed and canola oils by the aid of fatty acid composition.

MATERIALS AND METHODS

Thirtysix sunflower oil, one conola oil and one cottonseed oil samples were obtained from market from many regions of Turkey. Names of companies were hidden.

Color measurement:

Color measurements of the oil samples were carried out using a Minalto CR400 colorimeter. The instrument was standardized each time by a white (L=93.01, a=1.11, b=1.30) tile. The color values were expressed as L^* (whiteness or brightness/darkness), a^* (redness/greenness) and b^* (yellowness/blueness) (Hunter, 1948). 20 ml oil samples were poured in a petric plate on a white tile for measuring the color values (Morello et al., 2004; Sikorska et al., 2007).

Determination of fatty acid composition:

Fatty acid composition was carried out by Agilent 6890 series GC system (Agilent Technologies, USA) fitted with a capillary column packed with 100% cyanopropyl methyl polysiloxane (Supelco SP-2380 model, 60 m × 250 μm × 0.2 μm i.d.; Bellefonte, PA, USA) and equipped with a flame ionization detector. Before injection, oil samples were converted to fatty acid methyl esters (FAMEs). 0.1 g of oil sample was weighed in a sample tube and dissolved in 10 mL hexane. Then 1 mL of 2 N potassium hydroxide in methanol was added and shaken for one minute before the centrifugation procedure. After centrifugation, the clear supernatant was transferred to a GC auto-sampler vials for injection. One μL FAMEs were injected into the GC-FID system using an auto-sampler with a split ratio of 100:1. The oven's initial temperature was set to 50°C for 2 mins and then increased at a rate of 4°C/min up to 240°C, where it was held for 10 min. Both the injector and the detector temperatures were set to 250°C. The flow rate of carrier gas (hydrogen) and make-up gas (nitrogen) were set to 1 mL/min^{-1} (AOCS, 1984). The data were recorded by using the Agilent ChemStation data processor. FAMEs peaks were identified by comparison with retention times of known standards (Sigma Chemical Co.) and quantification was determined as the percent area of each peak relative to the sum of all peak areas. All analyses were conducted in duplicate and results are provided as average values.

Statistical analysis:

Data were subjected to analysis of variance with mean separation by Duncan's multiple range tests. Differences were considered statistically significant at the $P < 0,05$ level. Statistical analysis was performed using SPSS 10.0 for Windows. The statistical results were evaluated according to Düzgüneş et al., 1987.

RESULTS

The detected *L**, *a** and *b** value ranges for 36 sunflower oil samples were 69,177-70,670, (-1.903) - (-4.233) and 7.597-16.060, respectively. *L** value of the samples were changed in a narrow range but the range for *a** and *b** were wide that reflects the sensitivity on them. *a** value of 30th sample were higher in comparison with other sunflower oil samples. And, the value of *a** was similar to values obtained for cottonseed and canola oils. *b** value was the lowest for 12th sunflower sample and was the highest for the 30th sunflower oil sample (Table 2).

10th and 26th sunflower oil samples were found to be higher in myristic acid content than the other sunflower oil samples as 1,529 % and 4,055 %, respectively. Myristic acid content of the samples doesn't give any confirmative idea on suspicion of adulteration of sunflower oils by the use of canola and cottonseed oil. Other fatty acid profile of these samples was belonging to fatty acid profile of sunflower oil. Especially the detection of high myristic acid content may cause a formation of doubt of adulteration with palm, coconut and babassu oil, but lauric acid was not detected in these samples which may be a parameter for removal of doubt (Table 2).

Table 2. Main fatty acid composition (%) and *L**, *a**, *b** values of oil samples

Samples	Myrstic acid	Palmitic acid	Oleic acid	Linoleic acid	Linolenic acid	Arachidic acid	Behenic acid	L^*	a^*	b^*
1	0.045 e*	4.924 ö	31.523 ghıijk	62.173 ab	0 c	0.321 k	0.741 efghı	70.090 efgh	-2.720 l	10.613 l
2	0.059 e	6.782 klm	29.675 jklmno	61.371 abc	0 c	0.814 efghıij	1.037 cd	70.460 abcde	-2.757 l	10.790 jk
3	0 g	5.701 mnoö	32.482 fghıi	59.487 bcde	0 c	0.640 hıijk	0.954 cde	70.563 abc	-2.350 f	8.417 u
4	0 g	9.200 ı	28.039 oöp	59.398 bcdef	0 c	1.459 abc	1.535 ab	69.187 m	-2.417 g	8.947 sş
5	0 g	8.375 ıij	34.538 ef	56.430 fghı	0 c	0.334 k	0.380 jk	70.260 defg	-2.870 n	10.873 j

6	0 g	8.304 ıijk	30.959 ıijklm	57.496 efgh	0 c	1.255 bcde	1.628 a	69.693 jkl	-2.507 h	9.840 n
7	0.223 d	8.683 ıi	34.470 ef	55.405 hıi	0 c	0.417 jk	0.646 ghı	70.003 ghıi	-2.677 k	9.530 ö
8	0.044 e	6.368 lmno	29.976 ijklmno	62.506 ab	0 c	0.514 ijk	0.744 efghı	69.910 hıij	-2.940 o	11.193 i
9	0.022 efg	5.656 mnoö	34.957 ef	58.452 cdefg	0 c	0.405 jk	0.748 efghı	70.650 ab	-2.587 ij	9.137 pr
10	1.529 b	7.657 ijkl	40.863 d	48.427 mnoö	0 c	0.348 k	0.660 ghı	70.050 fghı	-2.720 l	9.763 no
11	0.056 e	5.351 oö	44.656 c	49.105 mno	0 c	0.568 ıijk	0.640 ghı	70.670 a	-2.150 c	7.653 v
12	0 g	8.487 ıij	33.855 fg	56.419 ghı	0 c	0.561 ıijk	0.644 ghı	70.527 abcd	-1.857 a	6.783 y
13	0 g	8.635 ıij	34.467 ef	55.406 hıi	0 c	0.524 ıijk	0.649 ghı	70.533 abcd	-2.530 hı	9.447 ö
14	0.038 ef	7.125 jkl	30.536 ijklmn	61.267 abcd	0 c	0.528 ıijk	0.704 fghı	70.403 cdef	-2.297 de	8.830 t
15	0 g	5.330 oö	29.133 klmno	64.480 a	0 c	0.648 ghıijk	0.657 ghı	69.827 ıijkl	-3.230 s	11.997 h
16	0 g	16.219 de	24.608 rs	57.652 efgh	0 c	0.941 defghı	0.730 fghı	70.430 abcdef	-1.903 a	7.597 v
17	0.040 e	13.417 fg	26.297 öpr	59.149 bcdefg	0 c	0.638 hıijk	0.610 hı	70.660 ab	-2.610 j	9.703 o
18	0.053 e	7.416 jklm	37.286 e	54.279 ıij	0 c	0.464 jk	0.632 ghı	69.887 hıijk	-2.407 fg	9.213 p
19	0 g	8.232 ıijk	31.736 ghıij	58.568 cdefg	0 c	0.548 ıijk	0.698 fghı	69.597 l	-3.010 ö	11.090 i
20	0 g	12.344 gh	30.751 ıijklmn	55.303 hıi	0 c	1.084 bcdefg	0.727 fghı	70.420 bcdef	-2.563 ıi	9.780 no
21	0 g	14.707 ef	28.657 mnoö	54.583 ıij	0 c	1.112 bcdef	0.732 fghı	70.163 efg	-2.720 l	10.037 m
22	0 g	16.465 d	33.662 fgh	47.653 noöp	0 c	1.265 bcd	0.740 efghı	69.773 ijkl	-3.643 ü	14.553 d
23	0 g	17.237 d	30.753 ıijklmn	50.470 klm	0 c	1.027 cdefgh	0.752 efghı	70.440 abcdef	-2.730 l	10.093 m
24	0 g	14.232 ef	31.222 hıijkl	52.481 jk	0 c	1.426 abc	0.682 fghı	70.513 abcd	-3.133 r	12.210 g
25	0 g	21.377 bc	23.522 s	52.640 ijk	0 c	1.345 bcd	0.810 defgh	69.660 kl	-2.013 b	8.257 ü
26	4.055 a	11.530 h	33.265 fghı	49.721 lmn	0 c	0.733 fghıijk	0.669 fghı	70.297 cdef	-2.843 m	10.573 l
27	0 g	22.614 b	28.394 noö	46.557 oöp	0 c	1.210 bcde	0.874 def	70.100 efgh	-2.940 o	10.737 k
28	0.054 e	5.678 mnoö	46.585 c	46.406 öp	0 c	0.549 ıijk	0.664 ghı	70.567 abc	-2.753 l	9.740 no
29	0 g	14.781 ef	33.259 fghı	50.478 klm	0 c	0.899 defghıi	0.709 fghı	70.550 abc	-2.347 ef	9.053 rs
30	0 g	6.622 klmn	58.456 b	26.634 r	5.251 b	2.058 a	1.169 bc	69.917 hıij	-4.233 y	16.060 c
31	0 g	14.427 ef	25.669 prs	58.113 defgh	0 c	1.110 bcdef	0.659 ghı	70.523 abcd	-2.413 g	9.767 no
32	0 g	22.327 b	28.820 lmno	46.459 oöp	0 c	1.123 bcdef	0.744 efghı	69.177 m	-3.403 t	12.967 e
33	0 g	21.618 bc	30.509 ijklmno	45.538 p	0 c	1.104 bcdef	0.816 defg	70.630 abc	-2.263 d	8.850 şt
34	0 g	20.440 c	23.464 s	49.369 mn	5.295 b	1.115 bcdef	0.339 l	70.573 abc	-3.333 ş	11.773 ı
35	0 g	11.518 h	28.450 mnoö	53.400 ij	5.400 b	0.734 efghıijk	0.357 k	70.233 defg	-3.470 u	12.530 f
36	0 g	9.199 ı	37.226 e	52.344jkl	0 c	0.578 ıijk	0.564 ıi	70.217 defg	-3.077 p	11.827 ı
Cottonseed	0.502 c	28.268 a	16.533s	53.392ij	0 c	0.818	0 m	66.903 n	-4.120	32.057

oil						efghıij			v	b
Canola oil	0 g	5.475 noö	68.251a	17.414s	7.557 a	1.547 ab	0 m	64.933 o	-5.893 z	53.973 a

*Means with different superscript letters differ significantly.

The samples, 1, 2, 3, 8, 9, 10, 11, 14, 15, 18, 28 and 30 were found to be in the range in palmitic acid as mentioned in the regulation (4,0 - 7,6 %) announced by the Ministry. The palmitic acid content was ranged between 8,232 % - 9,200 % for the samples 4, 5, 6, 7, 12, 13, 19 and 36. The samples, 17, 20, 21, 24, 26, 29, 31 and 35's palmitic acid content were detected to be from 11.530 % to 14.781 %. It was surprising to detect the palmitic acid content of the samples 16, 22, 23, 25, 27, 32, 33 and 34 in between 16,219 % and 22,327 %. This classification aroused the suspicion of adulteration of sunflower oil with cottonseed oil for the last group, due to higher amount of palmitic acid.

Oleic acid content of sample 30 was 58,456 % which was found to be higher than other sunflower oil samples. Oleic acid content of samples 10, 11 and 28 were from 40,863 % to 46,585 %. The lower range of oleic acid content was from 23.464 % to 26.297 % for the samples 16, 17, 25, 32 and 34. The range for oleic acid content in sunflower oil, canola oil and cottonseed oil was announced as 14,0 - 71,8 %, 51.0-70.0 % and 14,7 - 21,7 %, respectively. Estimation of adulteration by the aid of data on oleic acid content of sunflower oils looks too hard to evaluate the suspicion of addition of canola and cottonseed oil.

The lowest linoleic acid content of sample 30 was 26,634 %. The linoleic acid content of sunflower oil, canola oil and cottonseed oil in the regulation announced by the Ministry was ranged as 18,7 - 74,0 %, 15,0 - 30,0 % and 46,7 - 58,2 %, respectively. Linoleic acid content of sample 22, 27, 28, 32, 33 and 34 was from 45,538 to 49,369 %. The other sunflower oil samples were detected to have a linoleic acid range in between 48,427 and 64,480 %. In general, the linoleic acid content of sunflower oil and cottonseed oil is similar and it is not possible use the linoleic acid data as estimation parameter on adulteration of sunflower oil by cottonseed oil. But the addition of canola oil in sunflower oil may cause a little decrease in linoleic acid content of sunflower oil.

Linolenic acid may be a good estimation parameter for addition of canola oil in sunflower oil due to apparent increase in percentage. In the announce of the Ministry's regulation, the range for linolenic acid was from 0 to 0,5. The detection of linolenic acid in sample 30, 34 and 35 was from 5,251 to 5,400 % that increases the suspect of canola oil addition in sunflower oil. If linolenic acid content is taken in to account, the possibility of estimation of cotton seed oil addition in sunflower oil is very poor due to low ranges of linolenic acid content in cottonseed oil (0 - 0,4 %). Detection of linolenic acid in sunflower oil arouses the suspicion of adulteration of sunflower oil with canola oil due to a visible increasement. Linolenic acid was not detected in the sunflower oil samples except for the samples 30, 34 and 35.

Arachidic acid content of sample 30 was found as 2, 058 % and was higher than the other sunflower oil samples. It was the sample that was highly suspected to be adulterated with canola oil by the data on linolenic acid. The arachidic acid data was the second hint to strength this suspicion for the sample 30. The arachidic acid content of samples 4, 6, 20, 21, 22, 23, 24, 25, 27, 31, 32, 33 and 34 was from 1,084 to 1,459 %. These data on arachidic acid are higher than the announcement of the Ministry (0,1 - 0,5 %) for sunflower oil. According to these results, it may be offered to the Ministry to increase the limits of arachidic acid content up to 1,5 % in sunflower oil.

Behenic acid content of all tested samples was in the range that Ministry announced. Behenic acid is not a good parameter for estimation of adulteration of sunflower oil with the addition of canola and cottonseed oil.

DISCUSSION

Raw canola and cottonseed oils are cheaper than sunflower oil. By this study the suspense of adding these cheaper oils in sunflower oil was inspected by the evaluation of the possibility of the usage of fatty acid composition as a verification parameter.

Detection of linolenic acid in sunflower oil may strength the suspense of adding canola oil in suflower oil. Palmitic acid content increases by the addition of cottonseed into sunflower oil.

Sample 30 is a special example that may be announced to be the most suspected sunflower oil to be adulterated by the addition of canola oil, individually. Linolenic acid was detected in sample 30 and also the amount of oleic acid was relatively higher enough to strength the possibility of suspicion.

The palmitic acid and linolenic acid content of sample 34 and 35 were higher in comparison to other sunflower oil samples those shift the tendency of suspense on addition of both canola and cottonseed oils.

Especially *b** value was found to be the highest for the sample 30. b* was also high in samples 34 and 35. Those oils were thought to be most suspected ones among the other samples which could be adulterated.

Detailed statistical modeling studies may be recommended for estimation of cheaper raw oil addition in sunflower oil.

Detection of linolenic acid in sunflower oil may be a good indicator for addition of any other oil, especially the addition of canola oil. Palmitic acid may be a parameter for estimation of cottonseed addition but it is not a strong indicator individually.

b* value was found to be high in the sample which was the most suspicious to be adulterated with the addition of raw canola oil. *b** value of other suspected samples were also high in comparison to the other sunflower oil samples.

Additionally, revision of the arachidic acid range of sunflower oil in the related regulation may be referred to Ministry to increase the upper limit up to 1,5 %.

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EFFECT OF DIFFERENT STORAGE CONDITIONS ON QUALITY PROPERTIES OF RAW AND ROASTED SUNFLOWER KERNELS

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ABSTRACT

Quality of raw sunflower kernels changes due to the biochemical changes throughout the storage period. Thus, quality of sunflower kernels (SK) roasted after different storage periods may have different shelf lives. Relative humidity and temperature are the main factors affecting the quality of raw SK, whereas packaging material (O2 and water vapour barrier) properties and the gas composition in the package are the main factors affecting the quality of roasted sunflower kernels. The purpose of the present study was to explore the influences of storage conditions (room conditions-LOCAL and 10°C, Relative Humidity<%65 - MAM) on the quality of raw SK and to extend our knowledge concerning the changes in oxidative stability of roasted sunflower kernel processed at various storage periods (just after harvest, 8 and 12 months after harvest). Roasted products were packed in packaging material with high oxygen barrier (<0.008 ml/m²/day at 23°C) properties and kept at 10, 20 ve 30°C storage conditions under normal atmospheric conditions and nitrogen gas (>95%). Peroxide value, free fatty acids, contents of hexanal and vitamin E were determined at 2 months intervals during the storage for 12 months. Oxidative quality of the raw SK was similar when stored at cool (10°C, RH<65%) and local conditions (avg. 51 %RH, 19°C). SK roasted at 8th and 12th month storage periods lost quality more rapidly than the kernels roasted just after the harvest. Packaging under nitrogen gas rather than cold storage had the strongest influence in the prevention of oxidative changes of the roasted products.

Key Words : Sunflower kernel, oxidation, rancidity, peroxide value, free fatty acid, hexanal, vitamin E

QUALITY CHARACTERISTICS OF ROASTED SUNFLOWER SEEDS DURING STORAGE

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ABSTRACT

Sunflower seed being a part in both oil and dried nut industry is a highly nutritious oil seed. The oil and unsaturated fatty acids content plays an important role in determining the shelf life of seeds depending on lipid oxidation while increasing the nutritional value of the seeds. The oil seeds, like sunflower seed, which have high unsaturated fatty acid content, are exposed to oxidation during the long time storage that cause off-flavour, taste and rancidity. This may result in reduced overall sensory score when consumed. The packaging material properties (oxygen and water vapour permeability) have important effects on the shelf life of roasted dried nut products. The main objective of this study is to investigate the quality changes of sunflower seed in different packaging conditions and to optimize storage conditions for longer shelf life. In this study, the sunflower seeds obtained from different planting areas (Ankara, Kayseri, Bursa-İnegöl) were first roasted and then packaged under atmospheric and nitrogen gas conditions, and stored at 20°C for estimation of the shelf life. Peroxide value, free fatty acids, hexanal content, Vitamin E content and sensory quality properties were monitored during the shelf life study. As a result of this study; bio-chemical and sensory qualities of the stored products decreased within 2 months of storage period. It was observed that the product which is obtained from Bursa-İnegöl planting area packaged under nitrogen has the best chemical and sensory quality properties.

Key Words : Sunflower seed, oxidation, peroxide value, hexanal, Vitamin E, sensory

ACCEPTABILITY OF CHAPATI MADE WITH SUPPLEMENTATION OF SUNFLOWER (HELIANTHUS ANNUS L.) SEED MEAL

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ABSTRACT

The nutritional value of lab processed sunflower seed meal prepared from different sunflower seed cultivares i.e HSFM-848 and Morden as well as commercially processed cake (CPC) of sunflower seeds.*Chapati* was standardized in the lab by addition of sunflower seed meal and protein isolates (obtained from CPC) at 10,20 and 30% level. Nutritional evaluation revealed that lab processed seed meal of HSFM-848, Morden and CPC contained crude protein 42.51,51.44 and32.66%, fat 1.48, 0.86 and 0.55% crude fibre 4.16,2.48 and 14.56%, calcium 170.00,224.00 and 192.33mg/100g and iron 4.28, 25.12 and 22.13 mg/100g, respectively. Lab processed meals had significantly lower amount of polyphenols and higher amount of saponins as compared to the value of CPC. *in vitro* protein digestibility of lab processed seed meal as well as CPC was found to be improved after processing. *Chapatis* were found to be organoleptically acceptable. All the developed *chapatis* were rated in the range of like moderately to like very much category on Nine-Point Hedonic scale. Incorporation of sunflower seed meal and protein isolates at 10% level with wheat flour was the desirable level without altering the organoleptic traits and can be used for preparation of other traditional products like halwa suhali,cake & biscuits. These sunflower seed meal supplemented products if added in children diet can help in over coming protein energy malnutrition among infants & children in india.

Key Words : supplements, nutritional value, sunflower seed meal, acceptability, chapatti

SOME ANTINUTRIENTS AND IN VITRO PROTEIN DIGESTIBILITY OF HOME PROCESSED SUNFLOWER SEED MEAL

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ABSTRACT

Lab processed seed meals obtained from HSFM-848 was prepared by decorticating the seeds manually followed by grinding and extracting the oil with Hexane. Commercially Processed Meal contained average polyphenol content of 1675.00, 2001.66 and 1945.00 mg per 100g, saponin content of 1935.35, 1420.75 and 1112.25 mg per 100g respectively. Polyphenol content of CPC was significantly higher than those of Lab processed seed meals, whereas saponin content of CPC was significantly lower than those of lab processed seed meals Lab processed seed meals prepared from HS-1 and Morden cultivars and commercially processed cake contained on the average crude protein content (41.75, 50.68 and 31.75%), fat (1.45, 0.95 and 0.45%), crude fibre (3.75, 2.12 and 14.85%), respectively. But the polyphenol content of commercially processed cake (1936.00 mg/100g) was found to be significantly higher than those of both the lab processed seed meals. Saponin content of lab processed seed meal prepared from HSFM-848 variety (1922.68 mg/100 g) was significantly higher than that of Morden variety whereas the saponin content of commercially processed cake (1112.65 mg/100g) was found to be significantly lower than that of both the lab processed seed meals.It may be concluded from the study that the seed meal obtained from sunflower seeds after laboratory processing is nutritionally superior, in the preparation of various traditional food products. These food products if added in the diet will improve the nutritional quality of home diet .Processing has a significant effect on lowering antinutrients present in sunflower seeds which results in increase of *in vitro* digestibility of proteins and availability of minerals from sunflower seed meal.

Key Words : In vitro protein digestibility, home processed, sunflower seed, saponins, polyphenol

CONTENT AND OIL PRODUCTIVITY IN SUNFLOWER GENOTYPES PRODUCED IN CAMPO NOVO DO PARECIS – MT, BRAZIL

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ABSTRACT

This study aimed to evaluate genotypes of sunflower seeded second harvest in the year 2014 in Campus Campo Novo do Parecis, in the experimental field of the Instituto Federal de Educação Ciência e Tecnologia de Mato Grosso. The experimental design was a randomized block design with treatments 16 (16 genotypes) and four replications. The experimental plots consisted of four rows 6.5 m long with row spacing of 0.45 m, containing area of 11.7 m², totaling an area of 748 m². The population of 45000 plants per hectare is used. Data were subjected to analysis of variance and the Scott - Knott test at 5 % probability. The genotypes that stood out in relation to achenes productivity were the MG 360, AGUARÁ 06, MG 305, AGUARÁ 04, CF 101, SYN 045, GNZ NEON, HELIO 251 and SYN 3950HO. For the achenes oil content and productivity, the MG 360 genotype was the highest value and stands in relation to other genotypes.

Keywords: spectroscopy, *Helianthus annuus* L., lipids, oilseeds, achenes productivity.

INTRODUCTION

Among oilseeds grown in the world, the sunflower stands out among the main, both in production and in planted area. Sunflower (*Helianthus annuus* L.) is an annual cycle plant and its rapid growth characteristics, resistance to drought, cold and heat, more than most species of economic cultivation in Brazil and can be used for various purposes (Leite et al., 2005) as high quality oil extraction for human consumption or as raw material for biodiesel production, among others.

In general, sunflower seed it has about 45 to 65% oil in its composition (Grunvald et al., 2014A). Sunflower oil essentially consists of triglycerides (98 to 99%). It has a high content of unsaturated fatty acids (about 83%) and Vitamin E (alpha-tocopherol), but a reduced content of linolenic acid (≤ 0.2%). Sunflower oil is essentially rich in essential fatty acid (EFA) linoleic acid, about 60% that helps in reducing serum cholesterol and LDL. Thus contributing to the prevention of arteriosclerosis and cardiovascular problems (Turatti et al., 2002).

Changes in oleic are the result not only of the genotype, but also of climatic differences during their cultivation. Thus, among the various technologies developed for sunflower production, the appropriate choice of the genotype that has high yield and / or oil is important to ensure the success of the culture as a component of the production system (Porto et al., 2007).

In the region of Campo Novo do Parecis, sunflower is grown second summer harvest from February/March, due to the occurrence of rainfall conditions and temperatures suitable for its cultivation (Castro and Farias, 2005). However, despite being the main growing region in the country, little information is available on the agronomic characteristics of genotypes as content and productivity of oil, to facilitate the cultivation practices, reducing risk and increasing profitability.

MATERIAL AND METHODS

The work was carried out at the experimental fields and facilities of the Instituto Federal de Educação Ciência e Tecnologia de Mato Grosso - Campo Novo do Parecis in second-crop system in succession to soybeans in the agricultural year 2013/2014. The soil, according to the American System of Soil Classification (USDA, 1960) is the Typic Tropudox. The initial characterization of fertility, for the first layer of 0-0.20 m, presented the following values: pH ($CaCl_2$) = 5,7; MO = 26 g dm^{-3}; P (resina) = 5,9 mg dm^{-3}; K, Ca, Mg e H+Al = 1,5; 32; 11 e 40 $mmol_c$ dm^{-3}, respectively; with V = 54,8%.

Average temperatures occurred during the experimental period were: 30.3; 23.2 and 18.9 °C for maximum temperature, medium and minimum, respectively, and 570 mm rainfall, meeting the water demands required by sunflower between 500 and 700 mm distributed along its growing cycle (Castro and Farias, 2005).

The experimental design was a randomized complete block design with 16 treatments (genotypes) and four replications, as follows: ADV 5504, AGUARÁ 04, AGUARÁ 06, BRS 323, BRS G42, CF 101, GNZ NEON, HELIO 250, HELIO 251, HLA 2012, M734, MG 305, MG 360, PARAISO 20, SYN 045 and SYN 3950HO. The experimental plots consisted of 4 rows with 6.5 m long, with row spacing of 0.45 m, containing area of 11.7 m² (1.8 x 6.5 m). Only the two 5 meters central rows of each genotype were considered for data collection. The plotted area comprises 4.5 m².

The plot of the rows, was done on March 7, 2014, and the previous application of fertilizers was carried out with the aid of a sowing machine and was distributed at a depth of 0.10 m, 45 kg ha^{-1} Potassium Chloride + 267 kg ha^{-1} NPK 10-30-20, totalizing: 26.7 kg ha^{-1} N; 80 kg ha^{-1} P2O5; 80 kg ha^{-1} K_2O, according to the results of soil analysis and recommendation (EMBRAPA, 2004). Further, beside the row fertilization at 0.04 m deep, three seeds were placed in each hole, each 0.495 m, by manual planter.

The desiccation and the application of boron was performed on March 07, using trawl trailed sprayer with an application volume of 150 L ha^{-1} using glyphosate (648 g a.i. L^{-1}) at a dosage of 2 L ha^{-1} + Prometryn dosage 2 L ha^{-1} + mineral oil (0.5 L ha^{-1}) + boric acid dosage of 3 kg ha^{-1} (600 g ha^{-1} Boron).

Thinning was done 10 days after emergence (DAE) with a scissor, leaving only one plant per hole, reaching a population of 45,000 plants ha^{-1}.

The following coverage fertilizations were made: 1) 32 DAE with a dosage of 50 kg ha^{-1} N (urea); 2) foliar application of boron, with knapsack sprayer at 35 DAE using a dosage of 3 kg ha^{-1} (600 g ha^{-1} Boron), and 43 DAE with a dosage of 11 kg ha^{-1} (1.1 kg ha^{-1} of Boron). The source of Boron used was boric acid 150 L ha^{-1} according to the requirement of sunflower of 2 kg ha-1 B, Control of weed, pests and diseases have been carried out according to the recommendations of EMBRAPA (2004).

To avoid birds attacks, the plotted sections of the central rows were protected (stage R6) by using polypropylene based bags (30 x 30 cm) and fixed with clips.

The following agronomic characteristics were evaluated: productivity achenes (**PR**; kg ha-1), determined based on two central lines 5 meters, which is corrected for moisture condition of 11% (wet basis) obtained by reading the humidity value of the achenes; oil content (**OC**; %), predicted by near infrared spectroscopy (NIR) according to the methodology described by Grunvald et al. (2014b); and oil yield (**OY**, kg ha-1), calculated by multiplying the achenes oil content (%) and productivity achenes (kg ha-1) / 100.

The harvest of the capitulums was performed manually in the two of 5 meter central rows in R_9 with pruning shears aid. Later the capitulum inflorescence were the natural dryied, cleaned and weighed.

The results were submitted to analysis of variance followed by the average test Scott-Knott, both 5% probability, with the statistical program SISVAR (Ferreira, 2011).

RESULTS AND DISCUSSION

All variables showed significant differences ($p < 0.05$) in the analysis of variance (Table 1). The data from the achenes productivity variables, oil content and oil yield are shown in Table 2. For the achenes productivity, genotypes were stood SYN 3950HO (2205.5 kg ha^{-1}) and HELIO 251 (2204.1 kg ha^{-1}), but not statistically different genotypes GNZ NEON, SYN 045, CF 101, AGUARÁ 04, MG 305, AGUARÁ 06 and MG 360, which had average productivity ranging from 1836.8 e 2132.5 kg ha^{-1}. However, it appears that even the lowest yields were found in genotype HLA 2012 e BRS G42, with average 40% lower than those observed in the most productive genotypes.

Table 1. ABSTRACT of the analysis of variance for the sunflower productivitiy parameters (Campo Novo do Parecis, MT, 2014).

Parameters[1]	F[2]	CV (%)[3]	GA[4]
PR (kg ha^{-1})	6.4*	12.4	1846.9
OC (%)	27744.6*	0.1	43.2
OY (kg ha^{-1})	6.8*	12.4	796.5

[1] PR = achenes productivity, OC = oil content, OY = oil yield; 2 * significant at 5%; 3 CV = Coefficient of variation; 4 GA = General average.

Values higher than this study were found by Backes et al. (2008) for HELIO 250 genotypes (1849.0 kg ha^{-1}), M734 (2052.0 kg ha^{-1}), AGUARÁ 04 (2252.0 kg ha^{-1}) and below to HELIO 251 (1882.0 kg ha^{-1}) in second-crop cultivation in northern Santa Catarina. Additionally, Vogt et al. (2010), in sunflower crop sown in November in northern Santa Catarina, reported higher yields for genotypes AGUARÁ 04 (1916.0 kg ha^{-1}) e M734 (1962.0 kg ha^{-1}) and means inferior to HELIO 250 (1450.0 kg ha^{-1}). Already Capone et al. (2012) evaluated the performance of cultivars in southern Tocantins state reported productivities 2834.1 e 2997.6 kg ha^{-1} para os genótipos HELIO 250 e HELIO 251, respectively. Poletine et al. (2013) reported an assay developed in the northwestern region of the state of Paraná, for genotypes BRS G42, SYN 3950HO, M734 and MG 305, with productivities 715.5 kg ha^{-1}, 1215.0 kg ha^{-1}, 1225.0 kg ha^{-1} e 1592.0 kg ha^{-1}, respectively. These variations in productivity reveal the importance of evaluation of genotypes in different producing regions to verify the feasibility of its use.

Analyzing the oil content of genotypes, the MG 360 genotype had the highest oil content, 47.8% (Table 2), differing from the other investigated genotypes.

Table 2. Mean values for productivity achenes (PR), oil content (OC) and oil yield (OY) from different sunflower genotypes.

Genotypes	PR (kg ha^{-1})	OC (%)	OY (kg ha^{-1})
ADV 5504	1446.9 c	47.1 b	681.5 b
AGUARÁ 04	2084.1 a	45.9 d	956.6 a
AGUARÁ 06	1859.5 a	41.6 n	773.7 b
BRS 323	1782.0 b	42.1 l	750.2 b
BRS G42	1425.9 c	42.0 m	598.9 b
CF 101	2104.4 a	45.1 f	949.1 a
GNZ NEON	2132.5 a	37.8 p	806.1 a

HELIO 250	1694.7 b	43.5 h	737.2 b
HELIO 251	2204.1 a	39.1 o	861.8 a
HLA 2012	1313.0 c	46.7 c	613.2 b
M734	1673.7 b	37.6 q	629.3 b
MG 305	1993.8 a	43.3 i	863.3 a
MG 360	1836.8 a	47.8 a	878.0 a
PARAISO 20	1685.3 b	43.2 j	728.5 b
SYN 045	2108.5 a	43.6 g	919.3 a
SYN 3950HO	2205.5 a	45.2 e	996.9 a

Different letters differ by Scott-Knott test at 5% probability.

However, the ADV 5504 genotypes (47.1%) and HLA 2012 (46.7%) also showed considerable oil content. In contrast, the M734 genotype was presented the lower oil content, with the representative average 37.6%. Some industries have been remunerating the sunflower producers from the oil content contained in achenes and no longer by simple mass achenes, since not always the genotype with the highest productivity of achenes per area results in greater productivity of oil in the same area , and the oil product of greater interest at the end of the manufacturing process and currently the main commercial sunflower crop product.

Watching the oil yield data, the averages of the genotypes SYN 3950HO, AGUARA 04 CF 101, SYN 045, MG 360, MG 305, HELIO 251 and GNZ NEON were the ones that showed the highest values (Table 2), getting between 806.1 (GNZ NEON) and 996.9 kg ha^{-1} (SYN 3950HO), but all belonging to the same statistical group. Thomas et al. (2012), testing different planting dates mentioned lower oil yield for AGUARA 04 genotypes, with 928.0 kg ha^{-1}, and HELIO 250, with 717.0 kg ha^{-1}. For the M734 genotype, the value was 864.0 kg ha^{-1}.

CONCLUSIONS

For achene productivity variable stood out the AGUARA 04 and 06 genotypes, CF 101, GNZ NEON, HELIO 251, MG 305 and 360 and 045 and SYN 3950HO, whose values were ranging between 1836.8 and 2205.5 kg ha^{-1}. However, for the oil content of the MG 360 was the one with the highest percentage, especially also in the group of genotypes with the highest oil productivity values, confirming its high potential for use in production systems Brazilian savannah.

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DETERMINATION OF FATTY ACID COMPOSITION FOR FRYING SUNFLOWER OIL USING GAS CHROMATOGRAPHY

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ABSTRACT

Frying of sunflower oil has been carried out for 7 running days at 175°C±2 in this study. The aim of this study is to determine fatty acid composition of sunflower oil under real domestic frying conditions. In the frying processes, potato has chosen for food and the processes have continued during seven days. The composition, trans fatty acid (TFA) amount and average molecular weight of sunflower oil have been determined by gas chromatography (GC) technique. This work focuses on finding changes in free fatty acid after repeated batch potato frying. Unsaturated fatty acid (UFA) contents of sunflower oil have been decreased and saturated fatty acids (SFA) have also been increased during frying process. When the frying times run on, the analysis of oil samples have showed that trans fatty acids such as elaidic and linoelaidic acids occur quite slowly. At the end of the repeated frying series, the elaidic acid (C18:1 trans) has been determined in oils for sunflower 1.5%. And also linoelaidic acid (C18:2 trans) has been detected 0.3%. At the end of the seventh day of frying, the relative contribution of oleic acid has been decreased.

Key words: Sunflower, frying, fatty acid composition

INTRODUCTION

Today, frying is one of the most popular methods for the preparation of food stuff, because the method is fast and relatively cheap and results in yellow brown products with a typical taste and smell, preferred by the consumer. The oil plays a critical role as a heat transfer and impregnation medium, and it is the crucial component of the frying process. For the quality of products being fried the quality of the frying medium is very important, because during frying the food takes up the oil becoming a significant part of the product. (Taha et al., 2014). Many factors affect the deterioration of a frying oil, such as the presence of unsaturated fatty acids, the oil temperature, oxygen absorption, the presence of metals, and the type of food (Arroyo et al. 1992). During frying, oil or fat is subjected to high temperatures in the presence of air and water from the food, thus producing a wide range of compounds resulting from thermal, oxidative, and hydrolytic reactions (Chatzilazarou et al. 2006, Dobarganes et al. 2013). As a result of the deterioration, the oil sustains some physical changes: the colour darkens, the viscosity increases, and smoke appears (Paul and Mittal, 1997).

The fatty acid composition of the frying oil is an important factor affecting fried food flavor and its stability; therefore, it should be low level of polyunsaturated fatty acid such as linoleic or linolenic acids and high level of oleic acid with moderate amounts of saturated fatty acid (Kiatsrichart et al., 2003, Mehta and Swinburn, 2001). Partial hydrogenation decreases polyunsaturated fatty acid but increases saturated fatty acid and trans-fatty acid to produce more stable frying oil. However, trans-fatty acids (TFA) adversely effects on cardiaovascular health (Rehab and Anany 2012). One approach to increasing the stability of unsaturated oil is partial hydrogenation (Li et al., 2008; Bysted et al., 2009), but hydrogenation also results in the formation

of SFA and trans fatty acids. Trans isomers of fatty acids have been reported to increase the ratio of low-density-lipoprotein (LDL) to high-density-lipoprotein cholesterol (HDL) in the plasma and increase the risk of coronary heart disease (CHD), and play a part in atherosclerosis development (Willett et al., 1993; Dalainas and Loannou, 2008). Low levels of trans fatty acids and saturated fatty acids that are basis of nutritional and diet physiological aspects also play important roles in selecting a frying oil. Since the fatty acid composition alone is not enough to explain the stability of oils, a variety of minor components, such as tocopherols, polyphenols, phospholipids, caretonoids and certain sterols are also beneficial to oil stability during frying (İnanç and Maskan 2012).

Oil and fats are one of the important components of human diet and ingredients of food industry. Oils and fats are preferred as carriers of fat soluble vitamins (A, D, E and K) and source of essential fatty acids and energy (Öğütcü et al., 2015). Vegetable oils are recognized as important compounds of our life. Sunflower is between the five biggest oilseeds in world production (Anwar et al., 2008). Sunflower oil contains a wide range of unsaturated fatty acids and is rich in essential fatty acids. Sunflower oil is considered nutritious due to high content of polyunsaturated fatty acids (PUFA), mainly linoleic acid (18:2). However, due to high PUFA, it is more susceptible to oxidative degradation leading to rancidity, off-flavors, and discoloration (Gordon 1991). And also sunflower oil is characterized by high content of tocopherols (up to 935 ppm) higher than those of other oils such as soybean and peanut. It is considered an oil of high stability due to its high content in natural antioxidants (Bramley et al., 2000; Shahidi, 2005). The nutritional aspects of edible oils associated with the presence of minor and major components play an important role in preventing diseases and improving health. It is important to formulate vegetable oil blends with special composition in order to enhance their stability and nutritional value (Frankel et al., 1994; Shiela et al., 2004).

The objective of the present study was to obtain the fatty acids combination of refined sunflower oil under normal frying conditions. Frying processes were done with potato repeating seven days.

MATERIALS AND METHODS

Frying Process

At the beginning of frying, the fryers have been stuffed with 2 L of fresh oil samples, and then oils have been heated to 175 ± 2 °C. The frying temperature has been controlled using a probe joined to the thermometer. An electrical domestic deep-fat fryer has been used for frying experiments. Prior to frying, potato slices have been dried on both sides on filter paper to remove any excess water. The frying process started 30 minutes after the temperature reached at 175 ± 2 °C. The frying time has been 6 minutes for potato slices. One frying has been done per day for seven consecutive days. All physical and chemical analyses of oils have been performed immediately after the frying. During frying process, fresh oil has not been added to frying pans.

Determination of Fatty Acids Composition

Gas chromatography has been used for the qualitative and quantitative determinations of the fatty acids reported in relative area percentages. Fatty acids have been methylated prior to analysis by gas chromatography. Analysis have been performed on Agilent 9C 6890N gas chromatograph (CA, USA) equipped with a DB-23 capillary column (60 m, 0.32 mm, 0.25μm film thickness) and a flame ionization detector. The oven temperature has been arranged from 160°C to 185°C at a rate of 7 minutes, later programmed from 195°C to 220°C for 3 minutes, finally kept 20 minutes at the last temperature. The injector and detector temperatures have been 230°C and 255°C, respectively. Nitrogen has been used as carrier gas at a flow rate of 1.0 ml/min. FAME has been identified by comparing their retention time with known commercial standard mixtures.

RESULTS AND DISCUSSION

The fatty acid compositions of sunflower oils are shown in Table 1. Composition of fatty acid in sunflower oil contained palmitic acid (7.1 %), stearic acid (4.3 %), oleic acid (19.0 %), linoleic acid (67.5 %) and linolenic acid (0.8 %). These results belong to before starting fryings. Linoleic acid (C18:2) is determinated the most abundant unsaturated fatty acid in the sunflower oil. Linolenic acid (18:3) is highly sensitive to oxidation because it contains three double bonds, while oleic acid (18:1) is less reactive as it contains only one double bond. At the end of the frying processes, composition of fatty acid in sunflower oil contained palmitic acid (11.4 %), stearic acid (4.9 %), oleic acid (9.1 %), linoleic acid (47.9 %) and linolenic acid (0.0 %). It is observed that there is a decrease in polyunsaturated fatty acids and resulting increase in the saturated acids content. When the frying times run on, the analysis of oil samples have showed that trans fatty acids such as elaidic and linoelaidic acids occur quite slowly. The elaidic acid ($C18:1_{trans}$) has been determined in oils for sunflower %1.5. And also linoelaidic acid ($C18:2_{trans}$) has been detected 0.3%. At the end of the seventh day of frying, the relative contribution of oleic acid has been decreased for sunflower oils.

Table 1 Changes in fatty acid composition (%) during frying processes.

Fatty Acids	Fresh oil	1st day	2nd day	3rd day	4th day	5th day	6th day	7th day
$C_{14:0}$	0.1982	0.2472	0.4000	0.5772	0.7579	0.9120	1.0700	1.2035
$C_{15:0}$	-	-	-	0.1859	0.3580	0.4727	0.5674	0.6498
$C_{15:1\ cis}$	0.2683	0.2037	0.1229	0.0680	0.0391	0.0253	0.0157	0.0102
$C_{16:0}$	7.0560	7.4007	8.0065	8.4157	9.2316	10.0710	10.8954	11.3895
$C_{16:1\ cis}$	0.1731	0.1710	0.1698	0.1687	0.1654	0.1619	0.1559	0.1463
$C_{16:1\ trans}$	-	-	-	-	-	-	-	-
$C_{17:0}$	-	-	-	-	-	-	-	-
$C_{17:1\ cis}$	-	-	-	-	-	-	-	-
$C_{18:0}$	4.3061	4.4458	4.5834	4.7435	4.8403	4.9146	4.9414	4.9502
$C_{18:1\ cis}$	18.9617	18.1325	17.2031	16.3104	15.1967	13.5689	11.2314	9.1256
$C_{18:1.\ trans}$	-	-	0.139	0.4793	0.7193	0.9486	1.2546	1.4876
$C_{18:2\ cis}$	67.5091	63.1032	59.9364	56.0213	53.4558	51.0132	49.0135	47.9356
$C_{18:2\ trans}$	-	0.0601	0.1147	0.1625	0.2053	0.2421	0.2748	0.3059
$C_{18:3\ cis}$	0.7778	0.5364	0.4915	0.3221	0.2287	0.2032	0.0913	-
$C_{18:3\ trans}$	-	-	-	-	-	-	-	-
$C_{20:0}$	0.2939	0.3192	0.3605	0.3989	0.4408	0.4854	0.5073	0.5231
$C_{20:1\ cis}$	0.1552	0.1187	0.0983	0.0812	0.0706	0.0567	0.0364	0.0286
$C_{20:1\ trans}$	-	-	-	-	-	-	-	-
$C_{20:2}$	-	0.0102	0.0243	0.0411	0.0618	0.0825	0.1026	0.1168
$C_{20:3}$	-	-	0.0306	0.0052	-	-	-	-
$C_{20:5}$	0.062	0.0245	0.0056	-	-	-	-	-
$C_{22:0}$	0.6325	0.6726	0.7094	0.7532	0.7831	0.8029	0.8203	0.8316
$C_{22:1}$	0.0153	0.0102	0.0044	-	-	-	-	-
$C_{23:0}$	0.0447	0.0635	0.0976	0.1368	0.1732	0.2123	0.2419	0.2604
$C_{24:0}$	-	0.1201	0.2032	0.2713	0.3404	0.3941	0.4402	0.4657
$C_{24:1}$	-	0.0223	0.0445	0.0614	0.0727	0.0802	0.0889	0.0901

Poor frying stability in sunflower oil comes primarily from the high level of linoleic acid. Therefore, sunflower oil must also be hydrogenated to reduce its linoleic acid content to 35% or lower for industrial frying. On the other hand, fatty acid compositions do not fully explain frying stability of oils. For understanding of the frying stability of oil, there are so many parameters. Stability of oil indicates that the oil must be low in free fatty acids, peroxide value, conjugated

dienes, anisidine value, monoacylglycerols, diacylglycerols, and trace impurities, such as iron, phosphorus, calcium, and magnesium. All of these quality parameters have specific significance in influencing the performance of the frying oil.

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BIOPELLET PRODUCTION FROM WASTE MATERIALS OF THE SUNFLOWER IS A MAJOR INDUSTRIAL PLANT

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ABSTRACT

Sunflower is the most important industrial plant with oil content and consumption percent in Turkey. The highest production of sunflower with 44% is made in Thrace and a large content of waste materials (core-shell, sunflower bat etc.) are obtained after harvest and processing. These materials have alternative assessment opportunities. Untreated agricultural waste is generally used for heating directly. However, this method is not economical, efficient and suitable for environmental point. Harmful gases such as CO2 release during the combustion process occur. These waste materials leave to the field and return to the land again because of the difficulties and the lack of economic benefits with usage of heating material. However, it is possible that the waste materials can be converted into heating material, biopellet, is not harmful and has higher energy value. Biopellet is important heating material for farmer and sunflower oil industry. Farmers have a large amount of waste after sunflower harvest. Besides, high content of core-shell and solid material also get to stay in oil factories and cooperatives. Sunflower oil industry only annually produces 800 000 tons of solid waste in Turkey as a byproduct. Failure in evaluation of sunflower waste materials is too big to ignore is a serious economical loss. There are various studies about converting the sunflower waste materials after harvest and/or oil extraction. All of them say that biopellet production is valuable method for both environmental and economical. At the same time, the waste materials used as a heating material directly but inefficient combustion and excess content of volatiles were determined. All for these reason, biopellet is environmental friendly waste is a great need to improve fuel production. Although the ban, a significant amount of agricultural waste are burned in the field or using as fuel in homes in our country for each year. However, biopellet is a modern technic for heating offers integrated solutions for sustainable development in developed and industrial countries. Besides, it also serves the purpose of preventing climate change, erosion and efficiency, ecosystem health and loss of biodiversity. So, biopellet production is an ecological solution.

Key Words : Biopellet, core-shell, sunflower bat, sunflower waste.

FACTORS AFFECTING THE NUTRIENT COMPOSITION OF SUNFLOWER MEAL

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ABSTRACT

Sunflower (*Helianthus annus L.*) is a high oil-yielding seed crop cultivated worldwide that adapts very well to a wide range of climates. Sunflower seed meal is a by-product of the oil extraction of sunflowers and it is produced in large quantities. Sunflower meal (SFM) is mainly used as feed source that offer cheap, eco-friendly substrates for the animal nutrition. The meal is initially used as a protein complement in ruminant diets, and also monogastric animal rations in appropriate amounts. The chemical compositions of SFM have been extensively evaluated and it has been found that the chemical composition of SFM is varied greatly. The mean moisture and dry matter contents of SFM were reported as 9.0 % and 91.0 %, respectively. SFM is composed basically on lignocellulosic fiber and proteins. The content of crude protein in SFM ranges from 23.0 to 42.0 % and the crude fiber level varies between 13.0 % and 35.0 % depending on the extent of dehulling. The concentration of ether exracts in SFM varies from 0.50 to 13.0 % depending on the extraction process. The large variation of ether exract level was mainly related to the different extraction process. The differences in production methods, such as heating temperature, pressure and time during the process might lead to the changes in ether exract values. The different production techniques also caused the variation of the other chemical components of SFM. The content of phenolic compounds such as chlorogenic acid and caffeic acid in SFM ranges from 3 to 4 %. The average ash composition of sunflower meal was reported to be 6. 0 %. In conclusion, the processing techniques is one of the major factor affects the nutritional composition of SBM. Processing techniques are initially effective in the levels of ether exracts, the crude fiber levels and other nutrients therefrom. The variations of nutrient composition in SFM might result from dehulling process too. SFM composition can vary somewhat according to extrinsic factors such as genetic, seed varieties, climate and soil conditions. In addition, the chemical concentration of SFM is also affected in each plant and collecting typical samples in person and the analysis method used.

Key Words : Crude protein, crude fiber, nutrient composition, processing techniques, sunflower meal

EFFECT OF HIGH OLEIC SUNFLOWER OIL INCLUDING OLEOGEL ON THE TEXTURAL AND SENSORY PROPERTIES OF CAKE

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ABSTRACT

The existence of the relation between health and diet has motived people to consume food products with lower adverse health effects. As known consumption of excessive saturated fatty acid increases the risk of cardiovascular disease. Therefore, decreasing saturated fatty acid content of the food materials without damaging the quality of the food products is important issue in the food industry. When considering the importance of fats in the quality of the products, liquid oils are structured to transform them to solid fats. Oleogelation is one of the way which has been recently used for this aim. In the present study, probable usage of oleogels prepared from high oleic sunflower oil (HOSO) in the formulation of cake was investigated. For this aim three different oleogel formulations were studied: (i). 50 % cottonseed oil (CSO) + 25 % shortening + 25 % HOSO, (ii). 50 % HOSO + 50 % CSO and (iii) it is the same with second formulation however, this oil blend was oleogelled with dehydrated wax. Textural and sensorial properties of oleogel including cakes and control sample were investigated. Hardness, chewiness and gumminess values of the cakes prepared by oleogels were found to be higher than those of control sample. According to sensory analyses, the sample prepared from third formulation had the highest overall acceptability value. Wax type used in the formulation as well as oil types significantly affected textural and sensory properties of cakes. The findings of the present study highlighted that oleogels rich in unsaturated fatty acid content could be used in the cake formulation instead of shortening rich in saturated fatty acids.

Key Words : Oleogel, cake, high oleic sunflower oil, texture, sensory