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Effects of roasting on physico-chemical properties and fatty acid concentration of different edible oil-seeds

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Abstract

The purpose of the present study was to explore the influence of heating on the composition of different oil seeds and concerning the changes of fatty acid profile (FA), as well as Physico-chemical (PC). Four types of oil-seeds were roasted and milled for analysis. These are ground nut (GN), linseed (LN), brown mustard (BM) and yellow mustard (YM). As a result, roasting of these seeds, bring out some changes in total fat content (%), as well as change in fatty acid profile of the extracted oils. The de-oiled cake analysis also revealed nutritional values change in crude fiber (%), total ash (%), crude protein (%), total carbohydrates (%), and Energy (kcal) that were attributable to the non-roasted. Furthermore, chemical analysis of the extracted oils has demonstrated no significant increase in acid value (AV), iodine value (IV), refractive index (RI), and saponification value (SV), after roasting for 10 minutes. The iodine values of the oils were also increased (P<01.5), whereas, fatty acid profiles of all oilseeds got affected differentially.

Keywords: Roasting, FA, oilseeds, de-oiled cakes, AV, RI.

Introduction

India is amongst the biggest producer of oilseeds around the globe and Indian vegetable oil sector occupies an important position in the agricultural economy of the country. Oilseeds are in the middle of the major crops that are full-grown in the country apart from cereals. These crops are second only to food grains, in terms of acreage, production and economic value. Moreover, India is the fifth largest edible oil economy in the world, next to USA, China, Brazil and Argentina. India accounts for 12-15% of oilseeds area, 7-8% of oilseeds production, 6-7% of vegetable oils production, 9-12% of vegetable oils import and 9-10% of the edible oils consumption.

India has rich agro-ecological diversity, which is apt for growing all the macro and micro annual oilseed crops. Amongst all the nine oilseed crops grown, seven are of edible i.e., soybean, groundnut, rapeseed-mustard, sunflower, sesame, safflower and niger. India ranks first in the production of groundnut, second in rapeseed-mustard, and fifth in soybean in the macro oil seeds production and consumption. However, for micro oil seeds, India is on first position in the production of most of oilseeds such as castor, niger, safflower and sesame[1].

Edible oils are the one of the rudimentary components in food which has imperative effects on human health and its nutritional physiology. Vegetable oil requirement for food purposes has expanded considerably in terms of oilseed crops production[2].

Groundnut seeds (*Arachis hypogaea*): Peanuts are similar in taste and nutritional profile to tree nuts such as walnuts and almonds, and are often served in similar ways in Western cuisines eastern cousins. It is widely used, as Indian Cuisines, snacks, peanut butter and flour, but it also used for extraction of edible oil. Ground oil is used in cooking, because it has a mild flavor and a relatively high smoke point. Due to its high monounsaturated content, it is considered healthier than saturated oils, and is resistant to rancidity. The several types of groundnut oil include: aromatic roasted groundnut oil, refined groundnut oil, extra virgin or cold-pressed groundnut oil, and groundnut extract.

Linseeds (*Linum usitatissimum*): Flaxseeds or linseeds occur in two basic varieties: brown and yellow or golden linseeds[3]. Most types have similar nutritional characteristics and equal numbers of short-chain omega-3 fatty acids. Flaxseeds produce a vegetable oil known as flaxseed oil / linseed oil, which is one of the oldest commercial oils. It's edible oil extracted by expeller pressing, remaining oil obtained by solvent extraction. Solvent-processed flaxseed oil has been used as a drying oil in painting and varnishing[4]. Linseed sprouts are edible, with a slightly spicy flavor. Excessive consumption of flaxseeds with inadequate amounts of water may cause bowel obstruction. In northern India, flaxseed, called *tisi* or *alsi*, traditionally is roasted, powdered, and eaten with boiled rice, a little water, and a little salt.

Mustard Seeds (*Brassica juncea*): The small round seeds of various mustard varieties used as spices and for extraction of oil. The seeds are usually about 1 to 2 millimeters (0.039 to 0.079 in) in diameter and may be colored from yellow, brown and black[5]. They are very much important spice in many

regional foods. Small amount of the seeds used as condiment mix prepared by grinding and mixing with spices, vinegar, water or other liquids, creates the yellow condiment known as prepared mustard. And majorly it is used for oil extraction[5].

For the study we have taken four major oilseeds (groundnuts, linseeds, brown mustard and yellow mustard), on an account, all these seed were roasted for 5-10 minutes and studied with their proximate composition and fatty acid profile in comparison to the non-roasted seeds as well. The base objective was to study changes, brought up in oilseeds by roasting method. Heat treatment by roasting is used to stimulate the improvement in color, taste and flavor; as well as change the chemical composition, modifies nutritional value and shelf life[6]. During roasting of seeds, pleasant aromas and flavors (nut-like or peanut butter-like) transfer to the oil.

Roasting is one of the conventional step for making condiment oil or oleo resins, because the processing condition affects color, flavor, composition and quality of the oil[7]. Oxidation of lipids decreases shelf life and affects sensory characteristics of oil seeds and depends upon factors like the concentration of saturated and unsaturated fatty acids[8].

Materials and methods

Sample collection: Various types of readily available oilseeds were taken from market in 1kg packaging. This includes yellow and brown mustard, groundnut seeds and linseeds. And for comparative analysis among roasted and non-roasted these seed were segregated and stored in 500g airtight zip packing till completion of analysis. Duplicate samples of seeds were collected.

Reagents and Chemicals: All chemicals (analytical and GLC) used in this study were from either E. Merck (Darmstadt, Germany), Avantor's Rankem (India), Central Drug House (Delhi, India), Fischer Scientific (Mumbai, India) unless otherwise noted. Pure standards of FAME C8 to C24 were purchased from Sigma-Aldrich Chemical Co. (St. Louis, MO).

Sample preparation: Roasting of edible oilseeds: 100g seeds were separately poured in curry pan of 1kg capacity and then roasted at 160-180°C for 10min. After roasting, all seeds were allowed to cool to ambient temperature and thoroughly mixed prior to crushing in consumer-model mixer grinder. Lastly, Oil extracted through solvent extraction method.

Proximate analysis: Analysis of seeds: Moisture%, total fat%, total ash%, total carbohydrates%, crude fiber%, crude protein%, and total energy contents of both types of seeds roasted and non-roasted were determined by using the standard methods of the AOAC[9]. The organic nitrogen content was determined by using the Kjeldahl method, and crude protein content was estimated by multiplying the organic nitrogen content with 6.25 factor[10].

Analysis of extracted oils: i. Physical and chemical parameters of oils: This includes Refractive index at 40˚C, acid value, iodine value, and saponification value[11]. ii. Determination of fatty acid concentration: Methyl esters of various oils, prepared according to a method reported[12]. Methyl ester sample (0.6 µL) was injected into pre-programmed FID injector at 150℃-230℃ gas chromatography (Nucon, 5765 series, New Delhi) equipped with a flame ionization detector.

Gas Chromatograph oven initial temperature was maintained at 150˚C for 2 min, and then increased at 5℃ per min till 230℃ where it was again held for another 5 min. The carrier gas was nitrogen. The fatty acid peaks were identified by comparing the retention times with those of a mixture of standard FAMEs (Sigma-Aldrich's Chemicals, Deisenhofer, Germany).

Results and discussion

Physico-chemical composition: Results of the Physico-chemical analysis of the unroasted (control sample) and roasted oilseeds are shown in Table-1.

Fatty acid profile: Fatty acid profiles of various oilseeds are given in Table-2.

Physico-Chemical Parameters: Moisture %: Moisture is the amount of molecular water present in any substance is called as moisture. Only control seeds exhibits moisture content in which highest value shown by linseed i.e. 4.64% and lowest value was shown by yellow mustard of 3.46%, whereas seeds which were roasted at 160-180℃ have shown nil moisture.

Ash content %: It represents inorganic residue left after destruction of organic matter on high temperatures. Ash content ranged between 2.28% to 6.72%. Highest ash content shown by yellow and brown mustard varieties i.e., 6.72 and 6.56% respectively, whereas lowest amount of ash was accounted in ground nuts whether it is roasted or control. With comparison it can be stated that on roasting ash content percentage rises.

Crude Protein %: Protein is the next major nutrient components of different oil seeds. Protein content is genetically controlled. It is also influenced by nitrogen fertilizer application and agronomy practices. The protein content was determined on moisture free basis. Protein content of all seeds is given in Table-1. With the exposure roasting, protein content of seeds has grown in the range of 2% and more in every sample in comparison to non-roasted seeds[13].

Crude Fiber %: Crude fiber is the insoluble residue of an acid hydrolysis followed by an alkaline one. This residue contains true cellulose and insoluble lignin. Brown mustard and linseeds have highest amount of crudefibre, 12.45% and 11.98% respectively, whereas, ground nut has shown lowest presence of crude fibre with only 4.41%.

Table-1: Physico-Chemical Properties of seeds and their oils.

Parameters	Yellow mustard seed		Brown mustard seed		Linseed seed		Groundnut seed	
	Unroasted	Roasted	Unroasted	Roasted	Unroasted	Roasted	Unroasted	Roasted
Moisture (% by weight)	3.46	NIL	3.84	NIL	4.64	NIL	3.81	NIL
Crude Protein (% by weight)	27.02	31.40	27.28	28.65	20.66	22.06	35.32	36.39
Total Fat (% by weight)	45.74	48.78	41.25	45.54	38.21	42.30	46.93	48.78
Crude Fiber (% by weight)	8.7853	9.61	12.29	12.45	11.41	11.98	4.33	4.41
Total ash (% by weight)	3.705	6.72	6.32	6.56	5.75	6.20	2.28	4.69
Total Carbohydrate (% by weight)	11.29	3.49	9.02	6.80	19.33	17.46	7.33	5.73
Extracted oil properties								
Energy (kcal)	564.9	578.58	516.45	551.66	503.85	538.78	572.77	603.34
Refractive Index at 40°C	1.4647	1.4652	1.4650	1.4658	1.4743	1.4742	1.4635	1.4636
Saponification value	172.21	172.68	167.73	170.05	190.04	191.89	191.23	189.60
Acid value	0.5428	0.5472	0.6609	0.6663	3.30	2.91	0.7740	0.7643
Iodine Value (Wij's)	94.55	95.20	102.29	103.27	177.89	178.49	91.56	97.09

Note* for graphical illustrations and figures, YM=yellow mustard, BM=brown mustard, LD = linseeds, GN=ground nuts, UN= unroasted, R = roasted.

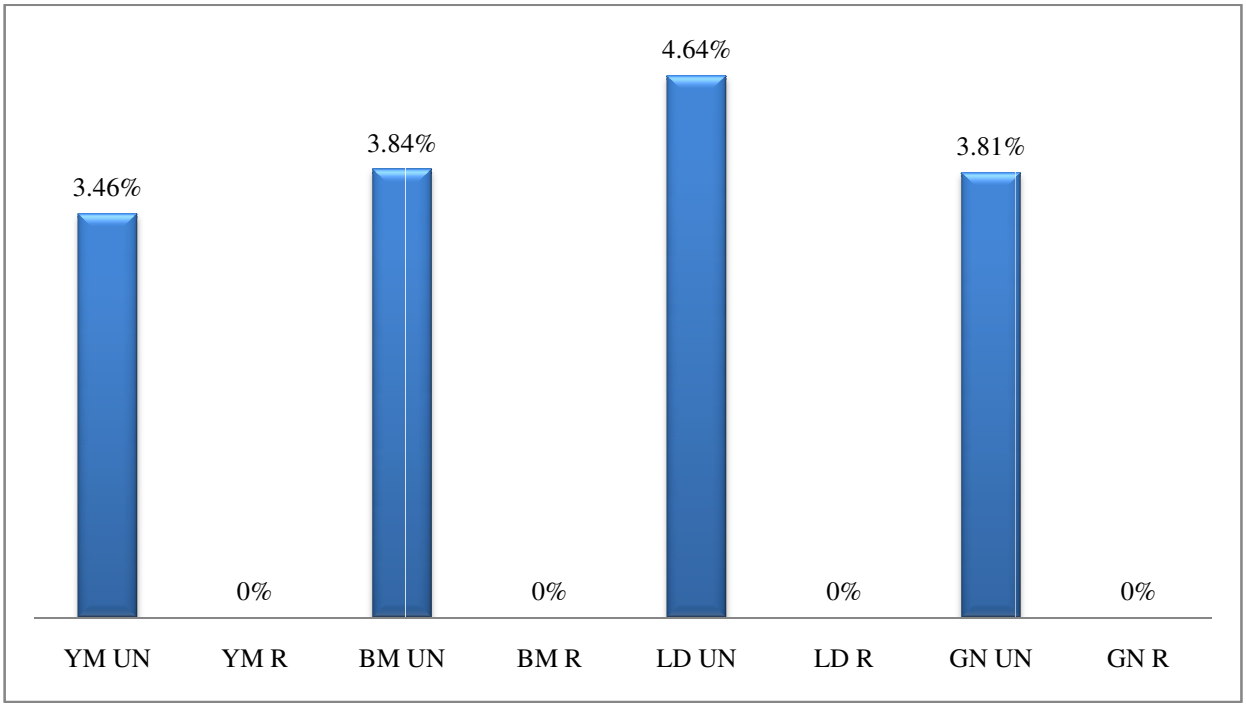

Figure-1: Moisture percentage of extracted oils from roasted and unroasted oilseeds.

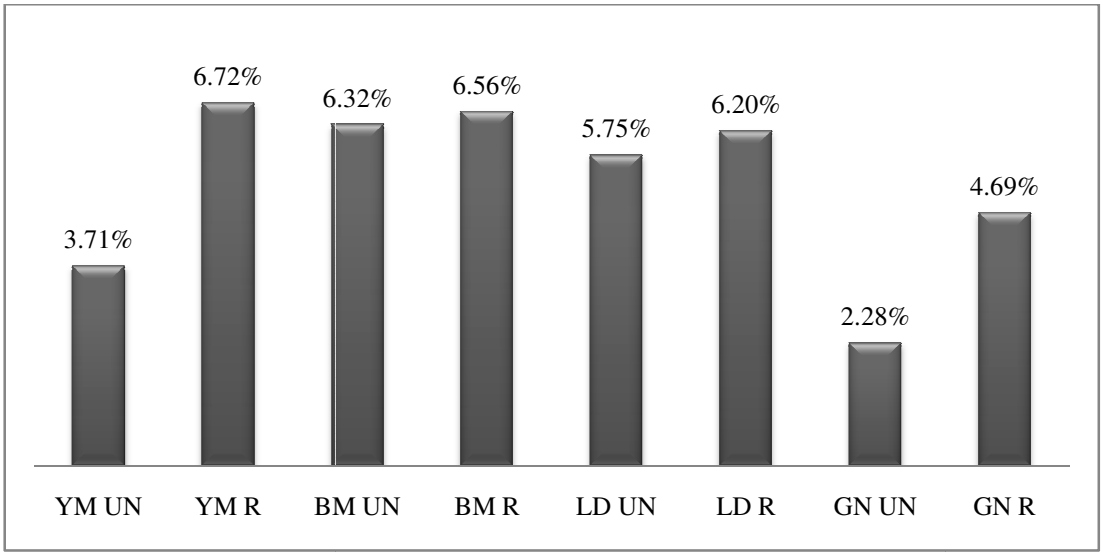

Figure-2: Total Ash percentage of extracted oils from roasted and unroasted oilseeds.

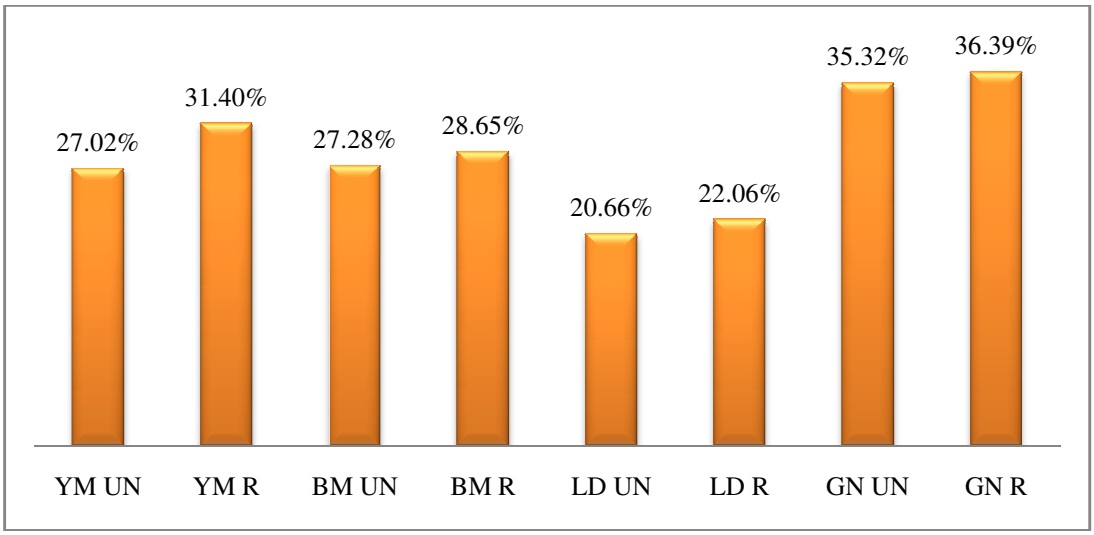

Figure-3: Crude Protein percentage of extracted oils from roasted and unroasted oilseeds.

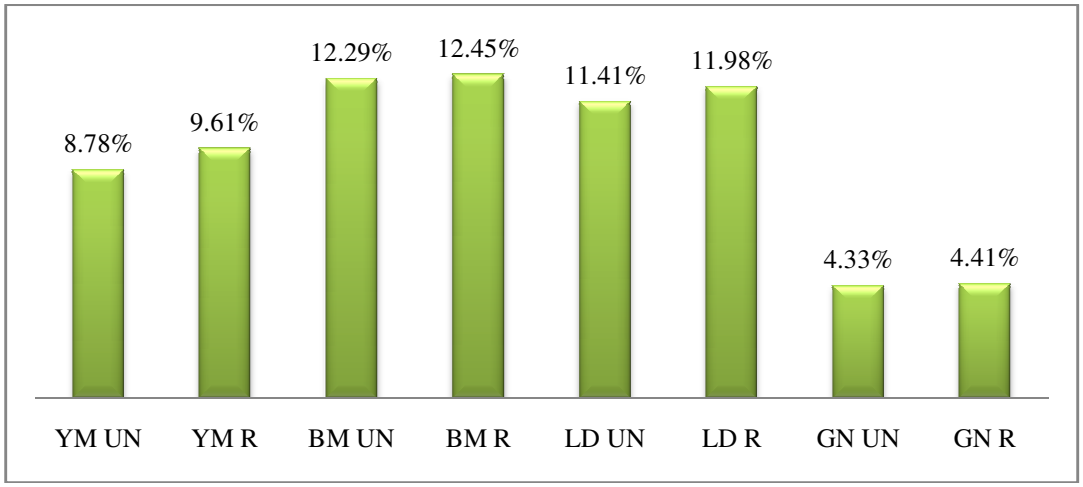

Figure-4: Crude Fibre (% by weight) of all extracted oils of roasted and unroasted oilseeds.

Total Fat %: The oil content of seeds depends upon many factors like genetic factors, geographical sites and geological factor as well as crop management. A significant variation in the crude oil content was observed in 4 different oilseeds. Here highest volume fats were of ground nuts which about 46.93% in control and 48.78% in roasted ground nuts, whereas lowest volume of oil was seen in linseeds whether roasted or control[14].

Carbohydrates %: In oilseeds starch, hemicelluloses, pectin and lignin are major source of carbohydrates. Linseeds are richest source of carbohydrates as compared to other 3 oilseeds. It has 19.33% in control and 17.46% in roasted. Overall roasting decreases the carbohydrates content by 2-6% in all seeds.

Energy (kcal): Foods are composed chiefly of carbohydrates, fats, proteins, water, vitamins, and minerals. Carbohydrates, fats, proteins, and water represent virtually all the weight of food, with vitamins and minerals making up only a small percentage of the weight. It has been observed that on roasting, energy has been increased as compared to control samples. This is due to increase in total fat content rise in oilseeds on roasting (Wikipedia.org). Highest amount of energy was released by roasted groundnuts i.e. 603.34 kcal and lowest amount of energy was released by linseeds i.e. 538.78 kcal. The comparative detailed data of all seeds is in Table-1.

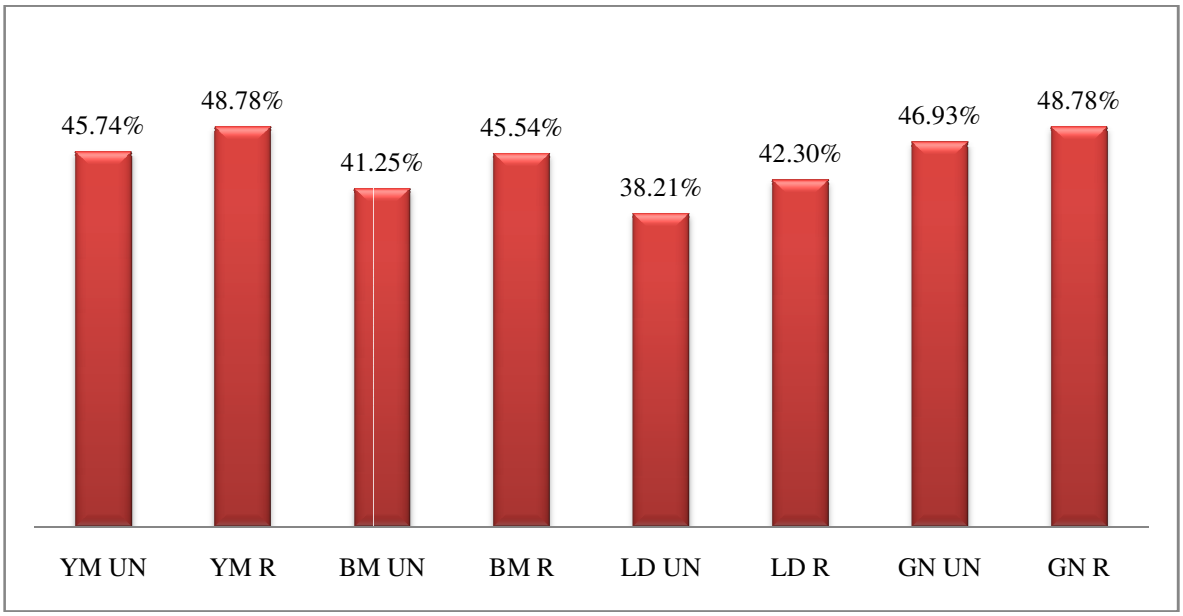

Figure-5: Total Fat percentage of all extracted oils from roasted and unroasted oilseeds.

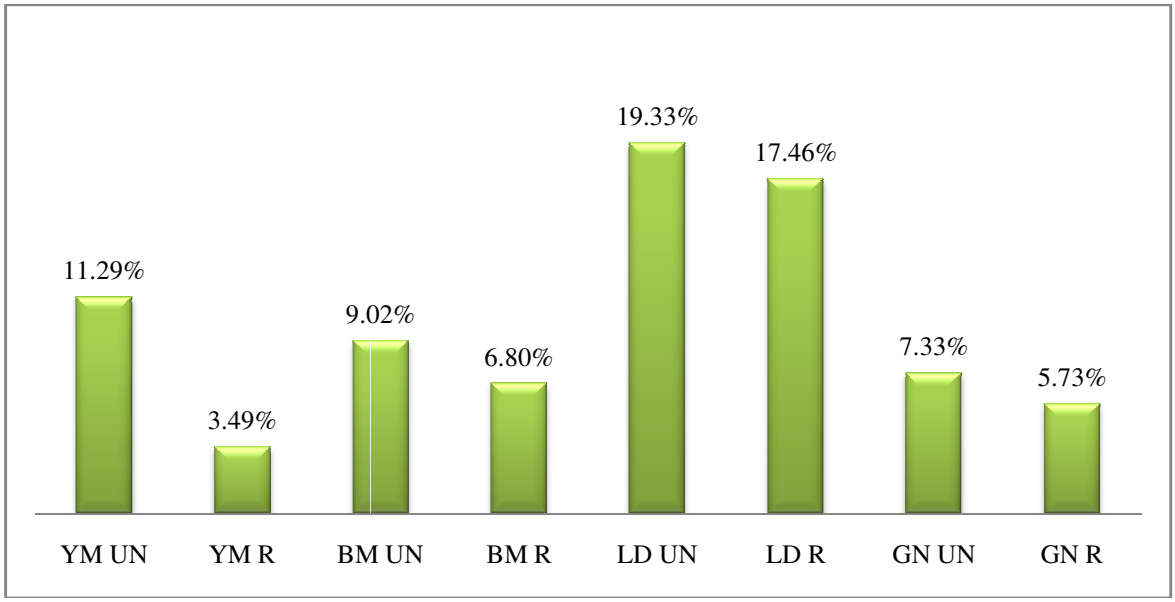

Figure-6: Carbohydrates percentage of roasted and unroasted oilseeds.

Extracted oil analysis: Refractive Index at 40℃: The refractive index of a medium is the ratio of the velocity of light of a definite wavelength in vacuum to velocity of light of the same wavelength in the medium. Refractive Index varies with temperature and wave length. In comparison to all, highest refractive index is of linseed oil due to higher viscosity and it shows no major drop over roasting. However, ground nuts refractive indices were lowest of them all. In broad-spectrum, the higher the refractive index the greater the degree of unsaturation or conjugation and vice versa.

Chemical analysis of extracted oil: Saponification Value: The saponification value is the number of mg of potassium hydroxide required to saponify 1g of oil/fat. It is an index of mean molecular weight of the fatty acids of glycerides comprising a fat. Lower the saponification value, larger the molecular weight or more long chains of fatty acids in the glycerides structure and vice-versa. Before and after roasting, highest value of saponification was recorded in linseeds and lowest was of brown mustard.

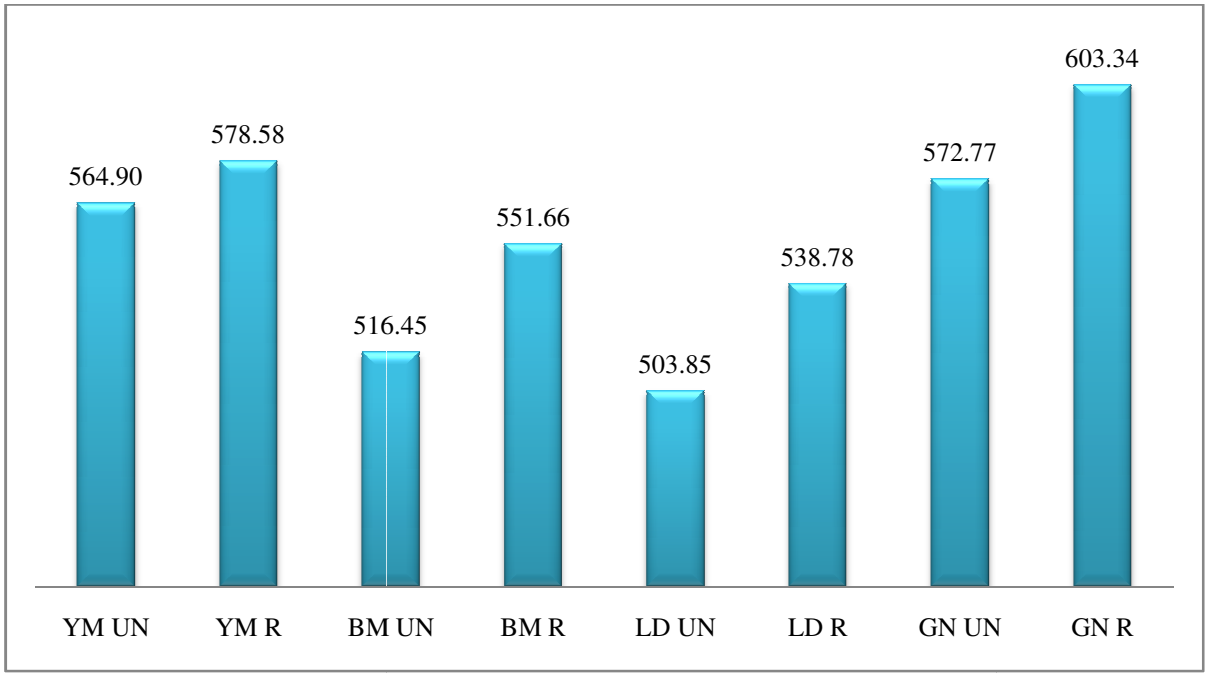

Figure-7: Energy (kcal) comparison of oil extracted from roasted and unroasted oilseeds.

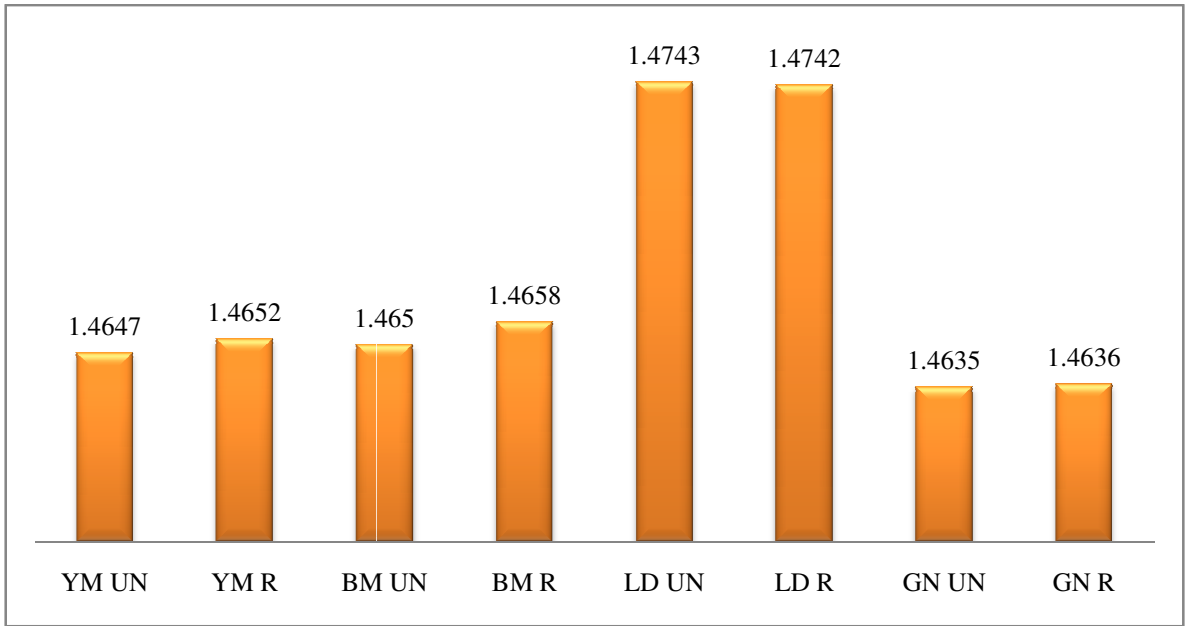

Figure-8: Refractive Indices of oils extracted from oilseeds.

Acid value: Acid Value is defined as number of milligrams of potassium hydroxide required to neutralize the free fatty acids calculated in one gram of fat. Its analytical importance is that, it is used to determine the amount of fatty acids which have been liberated by hydrolysis from their glycerides due to action of moisture, temperature, and lipases. Acid value of linseed oil got affected largely with fall of 0.4% after roasting; however, acid value from other edible oil has not shown any major changes.

Iodine value (WIJ'S): The iodine value of a fat is the number of grams of iodine absorbed by 100g of the oil, when determined by wij's solution. It tells about the unsaturation (number of double bonds) in a fat. Similarly, iodine values of linseed oil were found to be greatest of them all, i.e. 177.89 in control and 178.49 in roasted. However, no significant affect of roasting was observed in mustard seed oils and linseed oil, but in groundnut oil, iodine value increased by 5.5%.

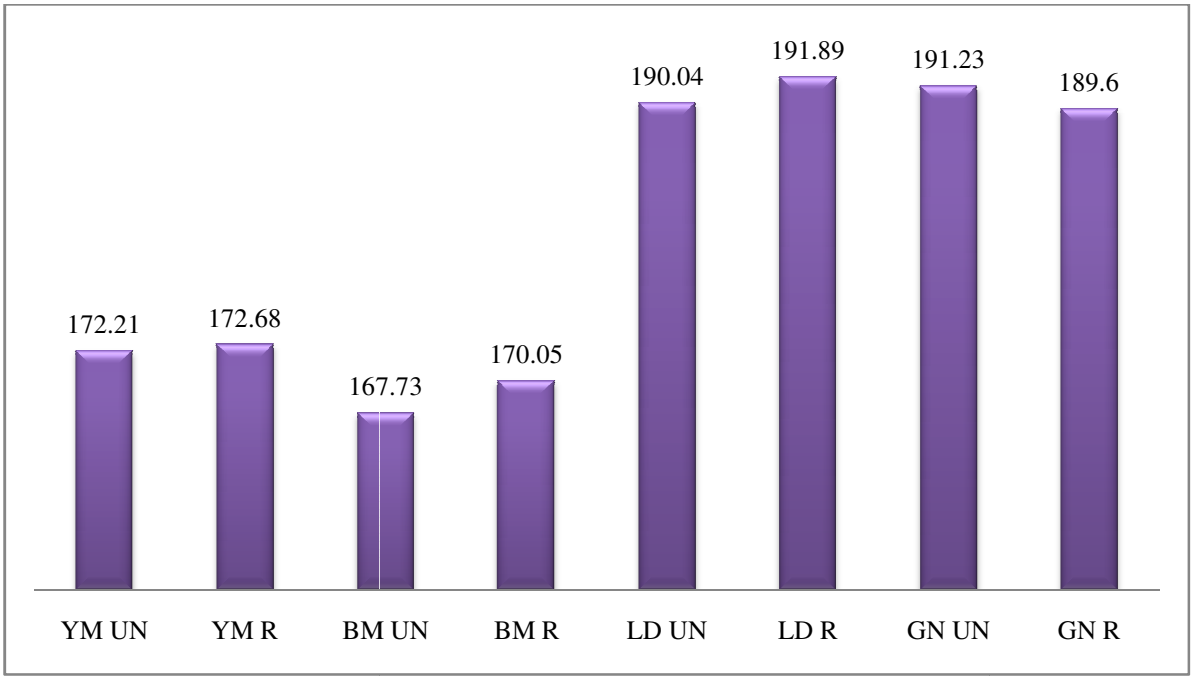

Figure-9: Saponification Value from oils of four oilseeds.

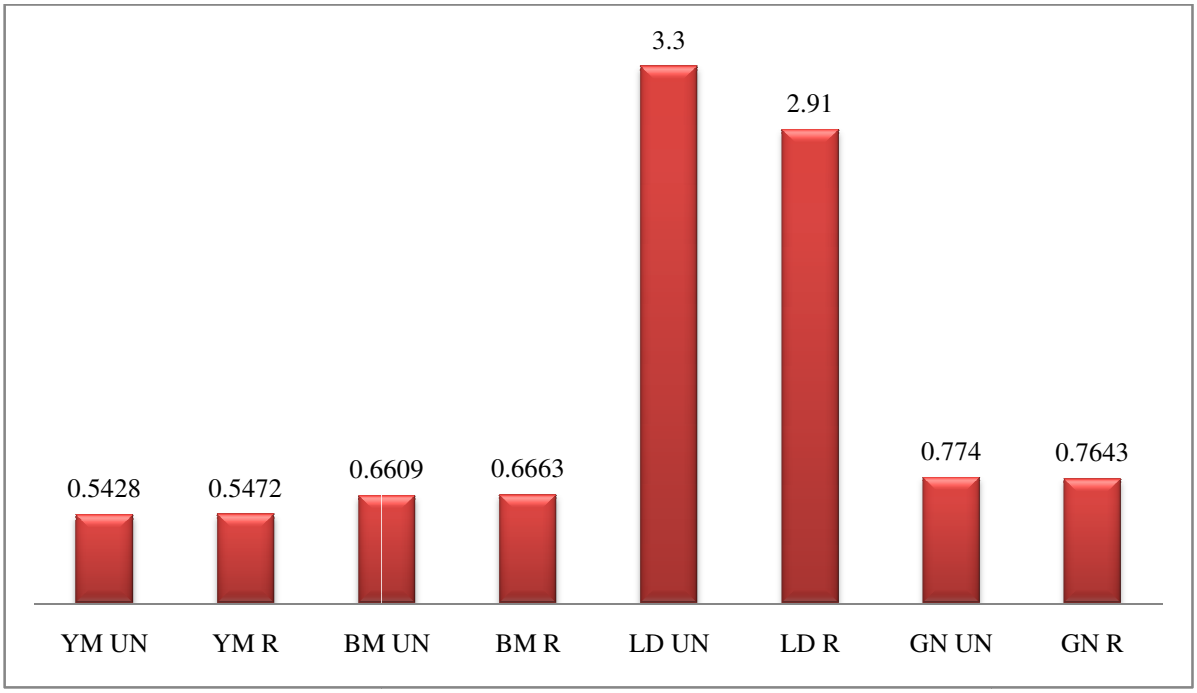

Figure-10: Acid Value of oils from roasted and unroasted oilseeds.

Fatty Acid composition: F.A. compositions of control and roasted oilseeds are given in Table-2. The principal F.A. components of oils from the control and roasted linseeds, ground nuts, yellow mustard and brown mustard, brown mustard, are Palmitic, Stearic, Oleic, Linoleic, Linolenic, Eicosenoic and Erucic acid whereas minor are Archidic, Behenic, Lignoceric, and Nervonic acids. These principal fatty acids make 80-90% of total oil content. However minor fatty acids make only 1-10% of total oil content.

When these varieties were roasted for 10 min, a significant change was marked in the FA composition as compared to the control of those oilseeds. It has been resulted that Palmitic acid content of mustards got increase by 0.2% and shown drop of 0.04 – 0.27% in linseed and groundnuts respectively. Oleic acid has shown rise in yellow, brown mustards and ground nuts by 0.25–0.6%. Whereas, oleic acid content in linseeds falls with difference of 0.4% on roasting. Similarly, stearic acid of all seeds falls due to effects of roasting, by 0.01–0.1%. Furthermore, linoleic acid stayed in almost same range with slight difference of ± 0.3% in all oilseeds. Linolenic was not present in groundnuts. Ground nuts also had two more lipids composition i.e. of Lignoceric and Behenic acid in 3.5% and 1.2 % respectively. Similarly Eicosenoic, Nervonic, Erucic acid were absent in linseed oil but present in rest three oil seeds.

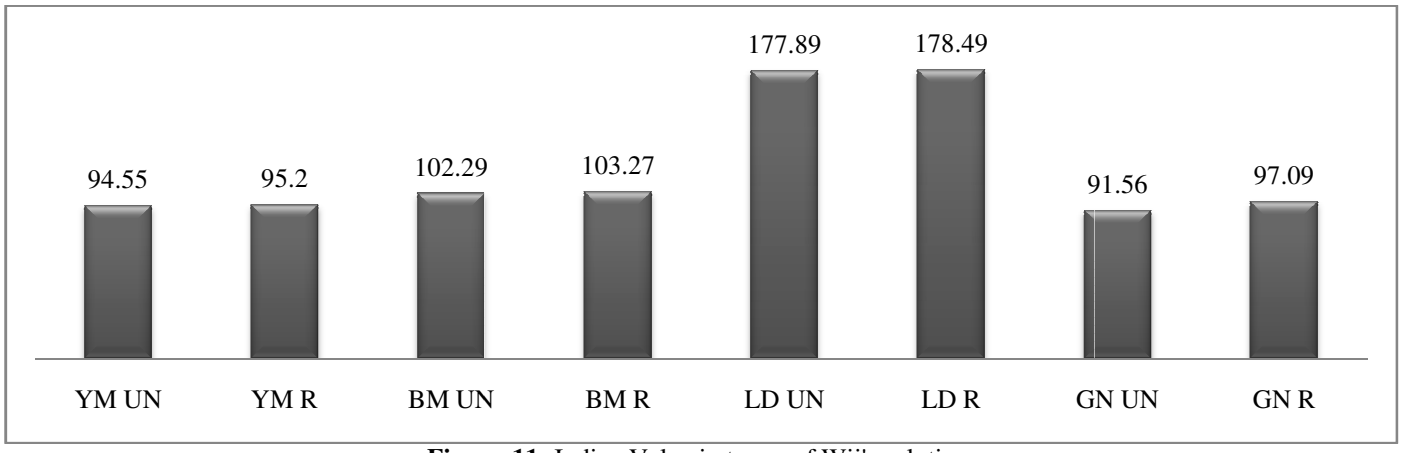

Figure-11: Iodine Value in terms of Wij's solution.

Table-2: Fatty Acid Profiles of Oil extracted from different roasted and unroasted seeds.

Fatty Profile	Yellow Mustard		Brown Mustard		Linseed		Ground-Nut	
	Unroasted	Roasted	Unroasted	Roasted	Unroasted	Roasted	Unroasted	Roasted
Palmitic acid	1.65	1.82	2.17	2.37	6.19	6.15	11.71	11.54
Stearic acid	1.05	0.93	1.16	1.09	4.72	4.65	3.41	3.40
Oleic acid	15.18	15.70	10.71	10.98	16.92	16.56	39.18	39.49
Linoleic acid	10.77	11.00	14.65	14.86	15.48	15.41	37.03	36.67
Linolenic acid	7.95	7.78	10.61	10.58	55.74	55.88	_	_
Arachidic acid	_	_	_	_	_	_	1.93	2.63
Eicosenoic acid	8.48	8.61	7.27	7.21	_	_	1.23	1.28
Behenic acid	_	_	_	_	_	_	3.54	3.54
Lignoceric acid	_	_	_	_	_	_	1.52	1.56
Erucic acid	51.04	51.81	45.53	46.53	_	_	_	_
Nervonic acid	1.18	1.01	2.20	2.04	_	_	_	_

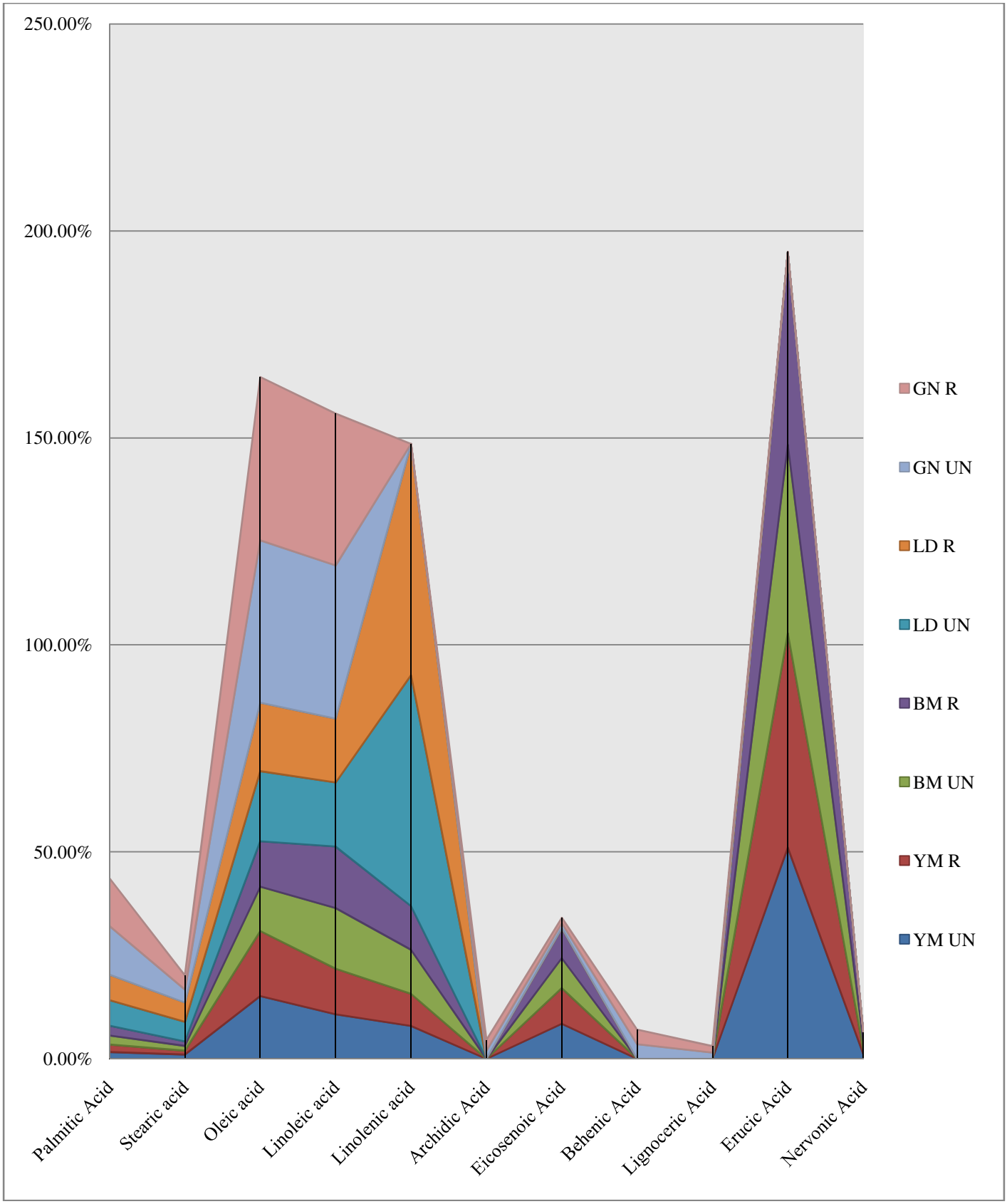

Figure-12: %fatty acid comparison of oils from both roasted and unroasted oilseeds.

Conclusion

In this study, different types of raw oilseeds were taken from market and then roasted conventionally at 160˚-180℃ for 10 minutes. After roasting, various molecular changes have occurred in the oilseeds by which their Physico-Chemical and fatty acid composition got affected and it has shown noticeable differential changes in overall parameters. It was found that, all the functional parameters have shown rise in their compositions except Total carbohydrates % whose quantity has decreased with difference of 2-7%. However, Total Energy (kcal) count of all seeds has risen with 10-30%. Furthermore, fatty acid profiles of seeds got changed variably, with fluctuation in every fatty acid.

All in all, we can conclude that heat treatment to oilseeds, helps in getting higher nutritional values because on roasting, fat content of seeds raises which affect the energy proportionally.

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