Research Article

Chemical Composition and Sensory Analysis of Peanut Butter from Indigenous Peanut Cultivars of Pakistan

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Abstract | Three indigenous peanut cultivars from Pakistan specifically Local-334, Bard-92 and Bard-479 were investigated in the study for compositional quality and peanut butter development. Chemical composition of peanut cultivars indicated 5.53±0.20 to 5.93±0.02 % moisture, 2.00±0.11 to 2.17±0.05% ash, 49.80±3.54 to 50.90±0.93% fats, 23.83±1.71 to 26.43±1.15 % proteins, 13.23±2.20 to 19.42±3.83 % carbohydrates and 4.95±0.06 to 8.53± % fiber. Mineral analysis of peanut cultivars showed 12.60±0.38 to 16.61±1.51 mg/100g Fe , 2.34±0.075 to 3.37±0.040 mg/100g Zn, 38.64±3.50 to 48.24±32.58 mg/100g Ca, 67.81±7.86 to 82.72±9.09 mg/100g Mg, 199.19±33.18 to 342.00±19.03 mg/100g Na and 1220.6±9.045 to 1411.3±1.71 mg/100g P and 841.01±50.41 to 992.98±36.10 mg/100g K. Fatty acid characterization of groundnut cultivars through gas liquid chromatography revealed six fatty acids namely palmitic acid, oleic acid, linoleic acid, arachidic acid, eicosenoic acid and behenic acid. The peanut cultivars Bard-479 and Local-334 were more suitable for oil extraction and peanut butter development because of their high oleic acid to linoleic acid ratio (2.3-2.4). Bard-92 was less preferable cultivar for product development owing to its high linoleic acid (42.56%) and low O/L ratio (0.93) that attributed to its oxidative instability. Sensory evaluation of peanut butter samples showed overall good acceptability of product among the people. Storage study of peanut butter samples demonstrated shelf stability of product up to three months at room temperature.

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Introduction

Groundnut (*Arachis hypogea*) is an important plant of Leguminose family. It is ranked as third major source of edible oil in the world besides rich source of energy and proteins (Isanga and Zhang, 2007). Groundnut has diverse uses owing to its valuable nutritional composition. It consists of 47-50% oil content which has greater percentage of unsaturated fatty acids that makes it an edible oil of choice for human nutrition and good health (Pattee, 2005). Groundnut comprise of 25-30% protein content which enables its seeds and oilseed cake to be utilized as good source of dietary protein with digestibility comparable to animal proteins (Singh and Singh, 1991). Peanuts are rich in vitamins, minerals and bioactive compounds that contribute towards its protective effects against cardiovascular ailments,

cancer, diabetes, osteoporosis and other degenerative diseases (Isanga and Zhang, 2007).

Peanuts can be utilized in production of cheap and wholesome foods like peanut butter, peanut bars, nimko, peanut milk etc. which can alleviate the situation of protein calorie malnutrition and iron deficiency in the country especially among women and children (Khalil and Chughtai, 1983; Ali and Nigam, 1993). Peanut butter is the most important product made from peanuts in the world as it is utilized as extremely nutritious spread as well as delicacy in porridge, cookies, cakes and ice cream. It became popular in developed countries due to its wholesomeness, longer shelf life, microbial stability and ease of consumption (Woodroof et al., 1983).

Peanut butter is considered healthier alternative to butter and margarine because it mostly consists of plant based unsaturated fats with negligible amount of trans-fats (Sanders, 2001). Its consumption has also been suggested to be preventive in diseases like hypercholesterolemia, diabetes, obesity, gallstones and constipation due to high percentage of unsaturated fats, fiber and phytonutrient contents. Peanut butter has been utilized successfully for treatment of malnourishment in impoverished countries by World Health Organization (Atasie et al., 2009; Kane et al., 2010).

Emphasis on groundnut crop in Pakistan can solve complex problems of edible oil deficiency and malnutrition in the country. But lack of government focus, little awareness among farmers, low input usage, non-availability of short duration cultivars and certified seeds restricts the production of groundnut crop in the country (Naeem-ud-din et al., 2012). Groundnut because of its high oil extraction rate, less input intensive nature and suitability to existing cropping system is the best choice for attaining self-sufficiency of edible oil in Pakistan (Ali and Nigam, 1993; Cecil et al., 2013).

Large number of groundnut cultivars has been developed in Pakistan to meet the needs of country's agricultural system, however little work has been done on their phytochemical and fatty acid composition for differentiation on the basis of their end use (Shad et al., 2012). Three local groundnut cultivars namely Bard-92, Bard-479 and Local 334 were selected in present study owing to their adaptability to local climate conditions, high yielding ability, large pod size and sweet taste. These cultivars were evaluated for nutritional analysis, fatty acid characterization and product development so that low cost but extremely nutritious foods are made available in the country to deal with protein-calorie deficiency issues.

Materials and Methods

Research work was carried out in different institutes of National Agriculture Research Centre, Islamabad (NARC). Seeds of three indigenous groundnut cultivars namely Bard-92, Bard-479 and Local 334 were obtained from Crop Sciences Institute, NARC. Other ingredients used in peanut butter preparation including salt, sugar, stabilizer (Glycerol mono-stearate), palm oil shortening were purchased from local market. Proximate analysis, mineral assay and storage studies were carried out in Food Science and Product Development Institute, NARC. While fatty acid profile of groundnut cultivars was determined through Gas Chromatography technique in Oil Quality Lab, NARC.

Peanut butter preparation

Peanut butter was prepared by the method described by Woodroof et al. (1983). Peanuts belonging to different cultivars were shelled and spread on aluminum trays. Peanuts were roasted at 160° C for 40-60 mins in hot air oven (Memmert Model No. 600) until desirable flavor and golden color was obtained. Peanut seeds were manually processed to remove red skin, hearts and scorched seeds. Peanuts and all other ingredients were weighed according to set formulation and then subjected to two stage grinding process in dry mill. First 81 g peanuts (90% w/w) was ground in mill for 30 seconds, then sugar (7% w/w), stabilizer, salt, fat were added (1% w/w of each ingredient) and the mixture was ground for one minute until smooth paste was obtained. Peanut butter was stored in pre-sterilized, air tight glass bottles at room temperature to determine shelf life (Figure 1).

Proximate analysis

Moisture analysis of peanut and peanut butter samples was performed by method no. 44-19 (AACC, 2000). Ash content of raw peanuts and peanut butter was determined by method No. 950.49 of AOAC (2000). Weighed amount of samples were ignited in Muffle furnace (Carbolite-1100, USA) at 550°C for overnight. Crude fat content of raw peanuts and peanut butter samples were measured by adopting

AACC (2000) method no. 30-20 with the help of soxtech instrument (Buchi B-811, Switzerland) using n-hexane as solvent. Crude protein contents in raw peanuts and peanut butter samples were determined following AOAC method no. 950.48 using Buchi Auto Kjeldahl (Model K-370). Protein percentage of sample was obtained by multiplication of its nitrogen contents with 5.46 protein factor (USDA, 1941). Carbohydrate percentages in both peanuts and peanut butter samples were calculated by the subtraction of other dry matter components from 100 (Riveros et al., 2009; Shokunbi et al., 2012).

Mineral determination

Iron, Zinc, Calcium, Magnesium, Sodium, Potassium and Phosphorous contents were determined in raw peanuts and peanut butter samples after extraction with Mehlich 1 reagent (0.05 M HCl + 0.025 M H_2SO_4) as described by Ryan et al. (2001). Fe, Zn, Ca, Mg, Na and K were measured through Atomic Absorption Spectrophotometer (Varian Spectraa 220-FS) while P was determined colorimetrically on spectrophotometer (Spectronic 21) at 430 nm wavelength.

Fatty acid profiling of peanut cultivars

Fatty acid composition of peanut cultivars was determined by gas liquid chromatography according to the method described by Raney (1987).

Preparation of fatty acid methyl esters (FAME): First 0.5 ml petroleum ether was taken in a vial. Then methylating solution (sodium methoxide and methanol) and a loop of peanut oil sample was added and the vial was vortexed for five seconds. The mixture was then allowed to stand for 30 min to derivatize FAME. Thereafter 1 ml NaCl was added for proper separation of FAME layer. At the end 1 µL of FAME was taken with much care from the upper layer of the vial, and it was injected to Gas Chromatograph for analysis (Aslam et al., 2015).

Conditions for fatty acid analysis: Fatty acid analysis was carried out on Gas Chromatograph (Agilent Technologies, Model 7890A) equipped with flame ionization detector and packed glass column (3% SP-2310, 2% SP-2300 on 100/120 Chromosorb material W AW; 8.5′×1/8″×2 mm; Supelco, USA). The injector and column temperature were set at 260°C and 230°C respectively. Machine was set on isothermal programme during elution process while helium was used as carrier gas with flow rate of 20 ml/min. Fatty acids were identified on the basis of retention time and their peak area which was calculated using Agilent Gas Chromatograph Chemstation Version B.04.02. Identity of fatty acids was determined on the basis of their retention time in comparison to elution time of fatty acid standards from Sigma Aldrich company (99.99% purity).

Storage study

Storage study of peanut butter samples was performed during May to August months of summer season when average room temperature and relative humidity was 35 °C and 52 % respectively. Deterioration of peanut butter samples upon storage was determined by calculation of free fatty acid percentage and peroxide values until samples got rancid. These quality attributes were analyzed three times during storage period with one month interval. Oil extracted from peanut cultivars was also checked for free fatty acids and peroxide value before product preparation. Free fatty acid content and peroxide value of raw peanuts and peanut butter samples were determined according to method no. Ca 5a-40 and method no. Cd 8b-90 as described in Standard Methods Manual of AOCS (2005).

Sensory evaluation

Sensory evaluation of peanut butter samples was carried out by eighteen judges who were presented three test peanut butter samples along with control sample. Nine point hedonic scale was used to rate peanut butter samples on the basis of color, aroma, taste, flavor, oiliness, spreadability and overall acceptability. Judges were served plain water and bread to clean their palate alternatingly before testing each sample (Dhamsaniya et al., 2011).

Statistical analysis

Research data was analyzed for statistical significance by using Statistix software (version 8.10). Statistical methods as described by Steel et al., 1997 were used to differentiate among peanut cultivars for nutritional characteristics, physico-chemical properties and suitability of peanut butter preparation. All analyses were performed in triplicate.

Results and Discussion

Proximate analysis of peanuts and peanut butter samples

Proximate composition of indigenous groundnut cultivars is shown in Table 1. Moisture, ash, fiber and

carbohydrate contents were significantly different in peanut cultivars, while crude fat and protein contents did not exhibited significant difference at 5% level of significance. Results of proximate analysis of local peanut cultivars were found in agreement with earlier findings of Shahzad et al. (2011) and Shokunbi et al. (2012). However, the higher fiber percentage of Bard-479 cultivar (8.53%) than other two cultivars (4.95%; 5.17%) is attributed to its Virginian origin which is supported by work of Jonnala et al. (2005) who evaluated nutritional composition of genetically modified Virginian peanut varieties.

Chemical composition of peanut butter samples made from local cultivars is presented in Table 2. Statistical analysis showed non-significant difference among peanut butter samples made from different cultivars for ash and protein contents while significant difference was found among peanut butter samples for moisture, fat, fiber, and carbohydrate contents. Moisture content of peanut butter samples in present research varied between 0.038 to 0.37% which is in accordance with results of Woodroof et al. (1983) and Dhamsaniya et al. (2011) who reported moisture contents of peanut butter to be less than one percent and suggested it to be the cause of longer shelf life and microbial stability of peanut butter. Ash percentage of peanut butter samples in present study fluctuated between 3.16 to 3.26% that corresponded with the range mentioned by Galvao et al. (1976). Furthermore, ash percentage of peanut butter samples was greater than raw peanuts; Woodroof et al. (1983) attributed this increase to gain in solid mass percentage upon roasting of peanuts during peanut butter preparation.

Fat, protein and fiber contents of groundnut samples decreased on peanut butter preparation which has been ascribed to addition of extraneous ingredients like flavors and stabilizers in peanut butter formulation by earlier scientists (Woodroof et al., 1983; Oczan and Seven, 2003). Crude fat of peanut butter samples in the present study were found to be 20.5 to 23 %, protein content ranged between 40.43 to 47.59 % and fiber contents varied between 2.11 to 4.46% which are in conformance to findings of former researchers (Riveros et al., 2009; Dhamsaniya et al., 2011). Carbohydrate percentage of peanut butter samples in present study varied between 24 to 32% which was little higher than range reported by earlier researchers (Shokunbi et al., 2012). This increase in carbohydrate percentage from peanuts to peanut butter conversion process was also recognized by Woodroof et al. (1983) who attributed it to varying level of sugar added during manufacturing process for flavor development.

Mineral composition of peanuts and peanut butter samples

Mineral composition of groundnut cultivars per hundred grams is presented in Table 1. Analysis of mineral contents in indigenous groundnut cultivars revealed 38.6±3.50 to 48.24±3.26 mg/100g calcium, 12.60±0.38 to 16.61±1.51 mg/100g iron, 2.34±0.07 to 3.37±0.04 mg/100g zinc, 67.81±7.86B to 82.72±9.09 mg/100g magnesium, 1220.6±9.04 to 1411.3±1.71 mg/100g phosphorous, 199.19±33.18 to 342.00±19.03 mg/100g sodium and 841.01±50.41 to 992.98±36.10 mg/100g potassium in peanut kernels. All three groundnut cultivars were found comparable for Ca, Fe, Zn and Mg contents and their findings resembled with the literature (Khalil and Chughtai, 1983); Woodroof et al., 1983; Shokunbi et al., 2012). Significant difference was found among peanut cultivars for phosphorous, sodium and potassium contents. The potassium content of peanut cultivars in present research is similar to the results of Woodroof et al. (1983) and Asibuo et al. (2008). Phosphorous and sodium contents of peanut cultivars in present research was little higher than range described by earlier scientists, however Ozcan and Seven (2003) had reported even more elevated percentages of these minerals and credited that increase to difference in soil fertility conditions.

Mineral composition of peanut butter samples in Table 2. exhibited 58.06±6.98 to 64.45±3.26 mg/100g calcium, 1.65±0.26 to 1.96±0.03 mg/100g iron, 1.51±0.03 to 1.97±0.53A mg/100g zinc, 146.73±36.25 to 203.3±5.3 mg/100g magnesium, 245.11±72.48 to 264.46±28.94 mg/100g phosphorous, 603.16±161.59 to 790.87±53.78 mg/100g sodium and 661.14±25.36 to 820.86±29.20 mg/100g potassium contents in present research. Statistical examination of mineral contents revealed non-significant difference among peanut butter samples for calcium iron, zinc, phosphorous, sodium and potassium, however the amount of magnesium was found significantly different in samples. Minerals concentration of peanut butter samples in present research was found in accordance to reference dietary limits established by USDA (2008). Moreover, Ca, P, Mg, Na and K contents of peanut butter samples in the present study increased on manufacturing of peanut butter, while Fe and Zn content decreased from peanuts to peanut

Table 1: *Nutritional composition of raw peanuts.*

Cultivars	Moisture(%)	Ash(%)	Protein(%)	Fat(%)	Fiber(%)	Carbohydrate(%)	Ca (mg/100g)	Fe (mg/100g)	Zn (mg/100g)	Mg (mg/100g)	P (mg/100g)	Na (mg/100g)	K (mg/100g)
BARD-92	5.9± 0.04*A***	2.17± 0.046A**	26.43± 1.15A^{NS}	50.90± 0.93A^{NS}	5.17± 0.46B***	15.33± 1.15B**	38.64± 3.5045A^{NS}	12.60± 0.38A^{NS}	2.34± 0.075A^{NS}	82.72± 9.09A^{NS}	1368.7± 56.46A***	199.19± 33.18B**	841.01± 50.41B***
BARD-479	5.93± 0.002A	2.17± 0.21A	25.33± 1.04 AB	50.73± 3.12A	8.53± 0.30 A	13.23± 2.20B	41.18± 3.79A	16.61± 1.51A	3.37± 0.040A	69.30± 0.875AB	1411.3± 1.71A	309.93± 69.45A	907.49± 17.82B
Local 334	5.53± 0.20B	2.00± 0.11B	23.83± 1.71B	49.80± 3.54A	4.95± 0.058B	19.42± 3.83A	48.24± 32.58A	14.83± 3.54A	2.85± 0.93A	67.81± 7.86B	1220.6± 9.045B	342.00± 19.03A	992.98± 36.10A

RDA: *Recommended Daily Allowance;* **% DV:** *percentage daily value of nutrient provided by one serving of peanut butter (2 Tbsp.); * Values represent average of three replicates ± standard deviations; ** Significant at 5% level of significance; *** Highly significant even at 1% level;* **NS:** *Non-significant; Means followed by same letters are not statistically significant at 5% level of significance.*

Table 2: *Nutritional composition of peanut butter along with daily value percentages.*

Cultivars	Moisture(%)	Ash(%)	Protein(%)	Fat(%)	Fiber (%)	Carbohydrate(%)	Ca (mg/100g)	Fe (mg /100g)	Zn (mg/100g)	Mg (mg/100g)	P (mg/100g)	Na (mg/100g)	K (mg/100g)
BARD-92	0.038± 0.042A**	3.20± 0.046A^{NS}	20.50± 1.15A^{NS}	41.27± 0.93B**	2.12± 0.46B***	32.92± 1.15A**	64.45± 3.26A***	1.78± 0.33A^{NS}	1.51± 0.03A^{NS}	203.3± 5.3A***	264.46± 28.94A^{NS}	671.11± 41.80A^{NS}	661.14± 25.36A^{NS}
BARD-479	0.005± 0.002B	3.16± 0.21A	23.00± 1.04A	47.59± 3.12A	2.47± 0.305B	23.78± 2.20B	59.51± 10.54A	1.65± 0.26A	1.97± 0.53A	146.73± 36.25B	245.11± 72.48A	603.16± 161.59A	673.45± 149.24A
Local 334	0.37± 0.20A	3.27± 0.115A	22.63± 1.71A	40.43± 3.54B	4.47± 0.058A	29.20± 3.83A	58.06± 6.98A	1.96± 0.035A	1.79± 0.05A	163.27± 5.50B	256.44± 6.97A	790.87± 53.78A	820.86± 29.20A
R.D.A	N/A	N/A	20g	30g	26g	55g	800mg	6mg	9.4mg	350mg	580mg	3000mg	2500mg
Average % DV	N/A	N/A	31.5%	40.9%	3.3%	14.85%	21.6%	85.6%	53.5%	140%	126%	6.55%	8.2%

RDA: *Recommended Daily Allowance;* **% DV:** *percentage daily value of nutrient provided by one serving of peanut butter (2 Tbsp.); * Values represent average of three replicates ± standard deviations; ** Significant at 5% level of significance; *** Highly significant even at 1% level;* **NS:** *Non-significant; Means followed by same letters are not statistically significant at 5% level of significance.*

butter conversion which was similar to the trend observed by Galvao et al. (1976) and Woodroof et al. (1983) who attributed these changes in composition to the ingredients added in peanut butter formulation.

Percentage daily values of nutrients per serving of peanut butter samples in present study are also shown in Table 2 which have been calculated according to procedure of Galvao et al. (1976) and compared with daily recommended allowance of these nutrients suggested by USDA. Average peanut butter sample yielded 31.5% protein, 40.9% fat, 3.3% fiber, 14.85% carbohydrate, 6.55% sodium, 8.2% potassium, 85.6% iron, 53.5% zinc, 21.6% calcium, 140% magnesium, and 126% phosphorous nutrients. This rich nutritional profile suggests peanut butter can be effectively utilized in diet for mitigating the situation of protein, energy and iron deficiency especially among women and children of Pakistan (Khalil and Chughtai, 1983).

Fatty acid composition of peanut cultivars

Characterization of local groundnut cultivars on the basis of their fatty acid composition is necessary to separate them for different utilization purposes (Wang et al., 2011). Gas chromatography of groundnuts in present study showed significant difference among indigenous cultivars for fatty acid composition (α=0.05). Six fatty acids were isolated out of which oleic (C-18:1) and linoleic (C-18:2) acids were constituting the major portion while palmitic (C-16:0), arachidic (C-20:0), eicosenoic (C-20:1) and behenic acids (C-22:0) were making up small percentage (Table 3). The oleic acid contents of groundnut cultivars showed Bard-479 and Local-334 had comparable amount of oleic acid (59.7% and 59.23% respectively) while Bard-92 cultivar had lowest oleic acid percentage (39.64%). Linoleic acid percentages showed Bard-479 and Local-334 cultivars possessed similar amounts (24.86% and 25.5% respectively) while Bard-92 cultivar had highest linoleic acid percentage i.e. 42.56% (Table 3). Bard-479 and Local Cultivar No.334 showed oleic acid to be the major fatty acid, however fatty acid profile of Bard-92 cultivar showed linoleic acid to be the most abundant fatty acid. Moreover, results of fatty acid analysis of peanut cultivars in present research were found to be compatible with the work of earlier scientists (Akhtar and Hamid, 2008; Shahzad et al., 2011).

Oleic to linoleic acid ratio of edible oil is called its stability index. Oleic acid is a mono-unsaturated fatty acid which is more resistant to oxidative rancidity than linoleic acid which has greater degree of unsaturation (Frederich et al., 1991). Peanut varieties with O/L ratio approaching two are considered suitable for peanut butter production by possessing relative oxidative stability (Dhamsaniya et al., 2011). In the research two groundnut cultivars namely Bard-479 and Local-334 exhibited appropriateness for peanut butter preparation by possessing O/L ratio ranging between 2.3-2.4, while Bard-92 cultivar displayed its susceptibility to rancidity by possessing lower O/L ratio (0.93) and greater linoleic acid percentage. Peanut oil of all three groundnut cultivars showed characteristic ratio of 80: 20 for percentage of unsaturated and saturated fatty acids (Table 3). High percentage of unsaturated fatty acid in peanut oil is considered advantageous for preventing heart diseases and controlling bad cholesterol level in human body (Wang et al., 2011; Shad et al., 2012).

Table 3: *Fatty acid composition of groundnut cultivars.*

Fatty acids	Bard 92	Bard 479	Local 334
Palmitic acid	12.03C**	9.32C**	9.45C**
Oleic acid	39.60B	59.70A	59.22A
Linoleic acid	42.54A	24.90B	25.50B
Arachidic acid	1.41F	1.57E	1.52E
Behenic acid	2.80D	2.89D	2.69D
Eicosenoic	1.57E	1.66E	1.59E
O/L ratio	0.93	2.40	2.32
SFA	17.81	15.44	15.26
UFA	82.2	84.56	84.73

O/L ratio (Stability index) = Oleic acid/ Linoleic acid; **SFA:** *Saturated fatty acids;* **UFA:** *Un-saturated fatty acids; ** Significant at 5% level of significance; Means followed by same letters are not statistically significant at 5% level of significance.*

Storage studies

Free Fatty Acid Content: Free fatty acid content of oil measures extent of deterioration that has occurred by action of heat and lipase enzyme (Anaysor et al., 2009). FFA content of peanut oil should range between 0.02-0.6 percent in order to be fit for human consumption (Pattee, 2005). Free fatty acid contents of peanuts before processing and peanut butter samples up to two month storage intervals are shown in Table 4. FFA contents of raw peanuts and peanut butter samples remained under safe limits until one month of storage period but afterwards the samples showed significant heat induced rancidity by having greater free fatty acids dissociation.

Table 4: *Free fatty acid contents of raw peanuts and peanut butter.*

Cultivars	Raw Peanuts	Peanut Butter		
	Fresh	Fresh	30 days	60 days
BARD-92	0.09± 0.003*AB^{NS}	0.12± 0.01A^{NS}	0.22± 0.00B***	1.01± 0.115A^{NS}
BARD-479	0.11± 0.02A	0.16± 0.02A	0.45± 0.00A	0.80± 0.10A
Local-334	0.087± 0.003B	0.135± 0.025A	0.57± 0.115A	0.80± 0.10A

** Values represent average of three replicates ± standard deviations; ** Significant at 5% level of significance; *** Highly significant even at 1% level;* **NS:** *Non-significant; Means followed by same letters are not statistically significant at 5% level of significance.*

Peroxide Value: Peroxide value of oil is measure of its oxidative rancidity. When peroxide value of edible oil approaches 10 meq/kg, it develops a rancid taste (Anaysor et al., 2009). Peroxide value of peanuts before processing and peanut butter samples up to two month storage intervals is shown in Table 5. Peroxide values of fresh peanuts and peanut butter samples was under safe limits at within one month of storage but then the samples worsened and exhibited significant rancidity with peroxide contents greater than 10 meq/kg both after one and two month storage intervals.

Table 5: *Peroxide value (meq/kg) of raw peanuts and peanut butter samples.*

Cultivars	Raw Peanuts	Peanut Butter		
	Fresh	Fresh	30 days	60 days
BARD-92	1.20± 0.100A***	3.60± 0.4A^{NS}	16.00± 4.00A**	32.00± 4.00A^{NS}
BARD-479	0.58± 0.02B	2.80± 0.4B	12.00± 0.00AB	24.00± 4.00B
Local-334	0.68± 0.02B	2.80± 0.40B	8.00± 0.00B	32.00± 4.00A

** Values represent average of three replicates ± standard deviations; ** Significant at 5% level of significance; *** Highly significant even at 1% level;* **NS:** *Non-significant; Means followed by same letters are not statistically significant at 5% level of significance.*

High free fatty acid contents and peroxide values of peanut butter samples after one month of storage in summer season agreed with the findings of Woodroof et al. (1983) and El Tom and Yagoub (2007) who noticed deterioration of peanut butter samples from processing damage and high storage temperatures.

Peroxide values of high oleic acid peanut cultivars (Bard-479 and Local 334) are markedly lower than low oleic and high linoleic acid peanut cultivar specifically Bard-92. Oxidative stability of high oleic and low linoleic acid content peanut varieties utilized for confectionary and peanut butter preparation was also noticed by Dhamsaniya et al. (2011) and Wang et al. (2011) which corresponded with the findings of present study. Refrigerated storage of peanut products is recommended in summer season for prevention of rancidity and prolonged shelf life (Woodroof et al., 1983).

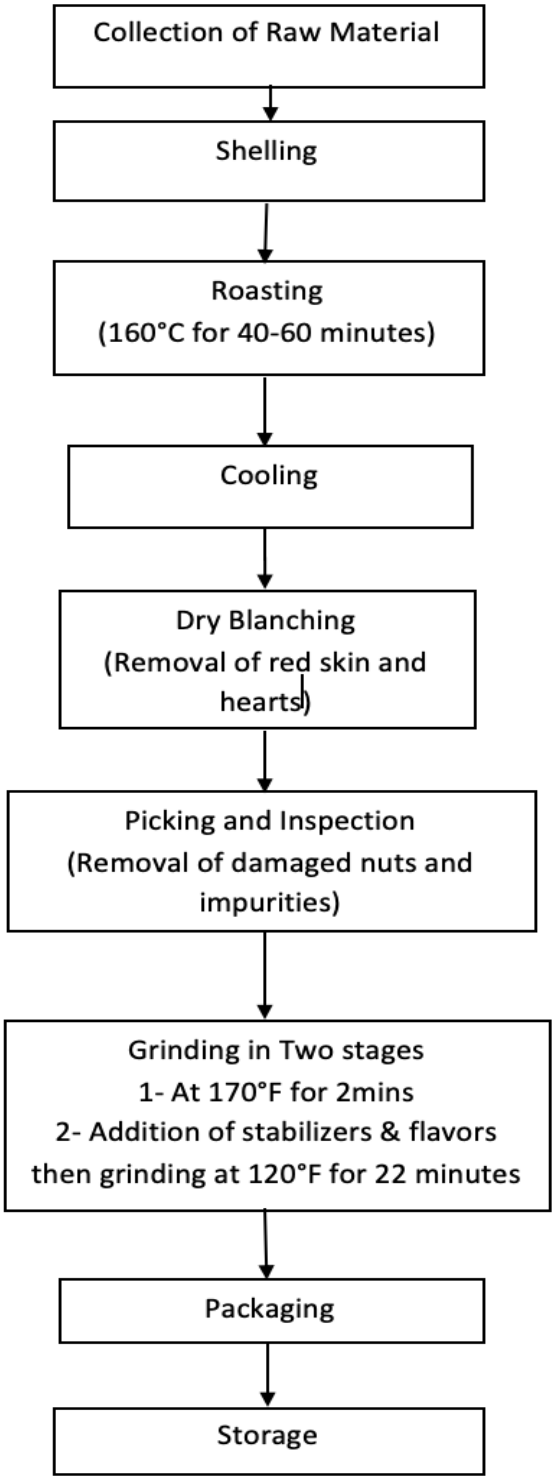

Figure 1: *Flow Chart for Peanut butter Preparation.*

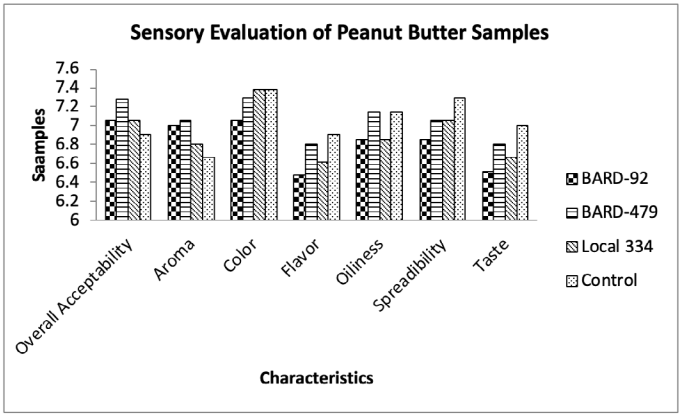

Figure 2: *Sensory Evaluation of Peanut Butter Samples.*

Sensory evaluation

Statistical evaluation of sensory analysis of peanut butter samples showed non-significant difference among peanut butter made from different cultivars and control sample (Commercial brand Peanut butter). All peanut butter samples obtained similar scores for color, aroma, taste, flavor, oiliness, spreadability and overall acceptability which indicate judges were unable to differentiate among samples (Figure 2). Although statistically no significant difference was found among peanut butter samples for sensory characteristics yet some samples were liked more by judges for particular characteristic than other samples as indicated by their mean scores. Average score for color characteristic of peanut butter showed peanut butter samples made from Local. 334 and control had most favorable color. Average score of aroma characteristic showed peanut butter sample made from Bard-479 cultivar had best aroma among all samples. Average scores of taste, flavor and spreadability characteristics of peanut butter samples showed peanut butter control sample scored maximum for these characteristics. Average score of oiliness characteristic showed peanut butter sample made from Bard-479 and control sample had most desirable oiliness. Average score of overall acceptability of samples indicated peanut butter sample made from Bard-479 cultivar was most liked by the panelists.

Results of organoleptic evaluation recommend Bard-479 to be most favorable choice for peanut butter preparation. Bard-479 is a Spanish large seeded cultivar that has been specially developed for confectionary purposes; furthermore, O/L ratio of 2.40 indicates oxidative stability of Bard-479 for product development (Ali and Nigam, 1993). Seven different varieties were checked in India for suitability of peanut butter preparation and it was also noticed that judges could not discriminate among peanut butter samples made from different varieties. However, it was established that color, aroma, taste and spreadability had overall positive effect on acceptance of peanut butter (Dhamsaniya et al., 2011).

Multiple regression model for overall acceptability of peanut butter: The effect of different sensory characteristics on overall acceptability of peanut butter is presented in the form of multiple regression equation, where overall acceptability (Y) is dependent or response variable while all sensory characteristics of peanut butter (X_1-X_6) are independent or predictor variables (Table 6).

Table 6: *Un-weighted least squares for linear regression of overall acceptability.*

PredictorVariables	Coefficient	Standard Error	T	P	VIF
Constant	0.37972	0.55836	0.68	0.4985	
Aroma	0.22365	0.08087	2.77	0.0071	2.2
Color	0.08040	0.08961	0.90	0.3724	1.7
Flavor	0.34509	0.10509	3.28	0.0015	4.2
Oiliness	0.14503	0.08388	1.73	0.0878	2.2
Spreadability	0.00858	0.08230	0.10	0.9172	2.3
Taste	0.17470	0.08714	2.00	0.0485	3.4

R^2 = 0.7472 Adjusted R^2 = 0.7275

$$Y = a + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6$$

Overall Acceptability = Constant + B_1 (Aroma) + B_2 (Color) + B_3 (Flavor) + B_4 (Oiliness) + B_5 (Spreadability) + B_6 (Taste)

Overall Acceptability (Y) = 0.38 + 0.17 (Taste) + 0.22 (Aroma) + 0.08 (Color) + 0.345 (Flavor) + 0.145 (Oiliness) + 0.01 (Spreadibility)

Multiple regression equation indicates positive relationship of all independent variables on overall acceptability of peanut butter samples. Coefficients for taste, aroma, color, flavor, oiliness and spreadability variables are 0.17, 0.22, 0.08, 0.345, 0.145 and 0.01 respectively which signify that rise of 0.17, 0.22, 0.08, 0.345, 0.145 and 0.01 figures in the sensory characteristics will cause overall acceptability of peanut butter to increase by exactly one unit. "R^2" is coefficient of determination of equation which signifies 74.7% variation in overall acceptability of peanut butter is described by independent variables of multiple regression equation, while 25% variation

in dependent variable is due to unexplained factors (Table 6).

Table 7: *ANOVA of multiple regression equation.*

SOV	Df	SS	MS	F	P
Regression	6	89.341	14.8902	37.93	0.0000***
Residual	77	30.230	0.3926		
Total	83	119.571			

*** Significant at 5% level of significance; *** Highly significant at 1% level of significance.*

ANOVA of multiple regression model showed significant effect of independent variables on overall acceptability of peanut butter even at 1% level of significance (Table 7). "VIF" is variance inflation factor which measures multicollinearity among independent variables. All VIF's are less than ten which signifies effectiveness of multiple regression equation is not affected by correlation among independent variables (Table 6).

Conclusions and Recommendations

It can be inferred from the study that local groundnut cultivars of Pakistan are comparable to internationally grown peanut varieties in terms of nutritional value. Groundnut production should be focused in the agricultural policy of Pakistan for achieving self-reliance in edible oil. Excess or by-products of groundnut crop after oil extraction can be processed for production of highly nutritious foods like peanut butter and protein rich snacks which can be particularly helpful in addressing protein calorie malnutrition and iron deficiency problems in the country. Out of three groundnut cultivars analyzed in present research Bard-479 and Local 334 had desirable fatty acid profile while Bard-92 was found unsuitable for edible oil production by having greater linoleic acid percentage. Bard-479 cultivar is found out to be the most suitable cultivar for peanut butter production in the present research with respect to its greater seed weight, better sensory characteristics and storage stability. More work is required on fatty acid characterization and biochemical evaluation of other indigenous peanut cultivars with the target of development of new varieties for specialized end uses. Shelf life of peanut butter prepared from indigenous sources can be extended by storing at low temperature. Product development studies needs to be done on groundnut so that country can earn more revenue from export of both raw and processed food products.

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Author's Contributions

Sahar Shibli: Executed research plan.
Nouman Siddique, Amer Mumtaz, Naeem Safdar: Participated in research analysis.
Erum Raza: Analyzed the data statistically.
Farzana Siddique and Saeeda Raza: Reviewed the manuscript and gave technical input.

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