Pod Characteristics and Crude Oil Quality Attributes of Selected Peanut (*Arachis Hypogaea* L.) Varieties

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ABSTRACT

Peanuts are a popular crop that is grown in many parts of the world and have a long history of cultivation and consumption. It is a valuable source of oil, protein isolates, vitamins, and minerals and has the potential to alleviate malnutrition, especially among vulnerable populations, by providing high-quality nutrition. The present study was conducted to examine pod characteristics and crude oil quality of four selected peanut verities i.e., Bari 2011, Golden, China gold, and Choondko local. The study found pods from Bari 2011 having higher values for fat (47.86%), edible portion (63.65%), peanut kernel length (2.00cm), and peanut kernel width (1.00cm). Pods from the Golden variety showed higher values for 100 kernel weight (63.32g), non-edible portion (47.53%), and seed coat (1.02%) while pods from the Choondko local variety had higher values for moisture (4.03%). All differences were statistically significant with a p-value less than 0.05. The results of oil quality revealed that Bari 2011 had the highest values for oil yield (41.49%), pH (6.52), specific gravity (0.92g/ml), total fatty acid content (78.29%), and smoke point (226.2ºC). Oil from the China gold variety showed the highest values for moisture content (1.80%), free fatty acid (1.64%), and peroxide value (4.79 meq O2/kg). The study found that Bari 2011 had the best pod characteristics, followed by Golden and Choondku local. Meanwhile, Bari 2011 also had promising oil quality attributes, followed by China gold and Choondko local variety.

Keywords: Peanut varieties, Pod characteristics, Crude oil quality, Oil yield

INTRODUCTION

Peanut (*Arachis hypogaea* L.) is a popular legume and oilseed crop grown worldwide, particularly in tropical and subtropical regions. The United States Department of Agriculture forecasts global production of peanuts for 2021-22 as 50.43 million metric tons of which China alone produced 18.31 million metric tons (USDA, 2023). Peanuts, also known as groundnuts or earthnuts, are rich in oil (47–50 wt.%) and protein (around 30 wt.%) with high levels of oleic and linoleic acid (Dun *et al.,* 2018; Juan-Polo *et al.*, 2022). Peanuts are a valuable crop, providing edible oil, protein isolates, essential fatty acids, vitamins, and minerals. They have the potential to help alleviate malnutrition worldwide, particularly for vulnerable populations, serving as a crucial protein source for low-income individuals (Mondal *et al.,* 2020). Peanuts also contain minor compounds such as tocopherols and volatile compounds. They are a low-cost crop with essential nutrients (Zhang *et al.*, 2020).

In Pakistan, peanut is mainly cultivated in rainfed areas of Punjab, Sindh, and North-West Frontier Province (Mubeen *et al.,* 2019). It is the second-largest oilseed crop after mustard and rapeseed, occupying the largest area of cultivation (Aslam *et al.*, 2017). According to the United States Department of Agriculture (2023), Pakistan cultivated 154 thousand hectares of groundnut, producing 145 thousand metric tons during 2021-2022.

Peanuts are a significant cash crop worldwide and their yield and quality characteristics are influenced by their genetic diversity. Pod characteristics provide information about yield estimation, kernel size, and visual attributes, while the oil quality assessment reveals its physicochemical properties and suitability for edible purposes. Different peanut varieties have distinct yield percentages and quality characteristics (Bakal & Arioglu, 2021; Yang *et al.*, 2021). The peanut pod is crucial in determining peanut varieties. Besides nutrition, other factors like profitability, adaptability, and moderately drought-tolerant nature are considered for cultivation. Peanuts absorb nutrients directly from the soil as the pods develop underground, which is unique compared to other legume crops (Kadirimangalam *et al.,* 2022). In food industries, peanut is a highly demanded crop for extracting edible oil, peanut powder, and butter, as well as in confectionery and snack production. Additionally, peanut by-products such as seed coats and peanut shells have applications in non-food industries (Wang *et al.,* 2018).

In Pakistan, several peanut cultivars have been developed to meet the needs, but little scientific research has been done to assess their attributes. The present study aimed to compare the pod and oil quality attributes of four peanut varieties (i.e., Bari 2011, Golden, China Gold, and

Choondko Local) grown in Pakistan. Despite the development of several peanut cultivars, scientific research on their attributes is limited.

MATERIALS AND METHODS

Raw materials

Freshly harvested peanut varieties (namely Bari 2011, Golden, China Gold, and Choondko Local) were purchased from the fields of Sukkur and Baluchistan, Pakistan, packed into cleaned bags, labeled, and brought to the laboratories of IFST, Sindh Agriculture University, Tandojam.

Sample Processing

The peanut pods were manually cleaned to remove any unwanted materials and distributed into two lots. Lot 1 was used for the determination of peanut pod characteristics while lot 2 was used for extracting crude peanut oil.

Extraction of peanut oil

The crude peanut oil extraction was performed as per the method described by Suri *et al.* (2019) with slight modifications. Peanut kernels were obtained from pods and roasted at 170°C for 30 minutes in a hot air oven. After roasting, kernels were hand-rubbed to remove the skin (seed coats) and were pressed to facilitate the oil extraction using a laboratory-scale oil press machine. Crude peanut oil was recovered, placed in desiccators for 24 hours, and kept in airtight amber glass bottles, labeled, and stored at ambient temperature and was used for quality characterization within 2 days of extraction.

Sample Analysis

Determination of pod characteristics

The peanut pods were assessed for moisture (%) and fat (%) as per the method of AOAC (2012). The peanut kernels were randomly selected and determined for measuring their length (cm) and thickness (cm) using a vernier caliper. A hundred kernel weight (g) was determined by weighing 100 peanut kernels using an analytical balance. For determining edible and non-edible portions, 100g of peanut pods were weighed, and pods were manually separated to obtain kernels. The kernels and shells were weighed separately using an analytical balance. The reading was noted and multiplied by 100 using the given formula:

$$\textbf{Edible portion (\%)} = \frac{\textbf{Peanut kernel weight}}{\textbf{Total weight of peanut pods}} \times 100$$

$$\textbf{Non-edible portion (\%)} = 100 - \textbf{edible portion of peanut}$$

For determining seed coat (%), the seed coat of 100g peanut kernels were carefully removed and weighed. The formula given below was used for calculating seed coat (%).

$$\textbf{Peanut seed coat (\%)} = \frac{\textbf{Seed coat weight}}{\textbf{Total weight of seeds}} \times 100$$

Determination of oil characteristics

The pH value of the peanut oil was determined by using a pH meter, specific gravity was determined as per the method described by AOAC (2000) using pycnometer, and moisture (%) was determined as per the method described by AOAC (2012). The total fatty acids were determined by multiplying the conversion factor of 0.8 with the fat (%) of a given sample (Akinyeye *et al.*, 2010). For determining the smoke point, 20ml peanut oil was taken in a crucible and heated till the smoke was liberated. The digital food thermometer was inserted into the oil and the reading was noted as smoke point. The rancidity test was performed as per the Kries test. The oil yield % was determined by extracting oil from 100 grams (W1) of peanut kernel. The extracted oil was weighed (W2) and the oil yield % was calculated by the given formula:

$$\textbf{Oil yield (\%)} = W2/ W1 \times 100$$

Free fatty acids were determined by taking 5g of peanut oil in a beaker with 50 ml of neutral 95% alcohol. The content was heated to boil on a hot plate, cooled at room temperature, and titrated against 0.1 N sodium hydroxide using a phenolphthalein indicator. The alkali was added till the endpoint. Free fatty acids were determined using the formula given below:

$$\textbf{Free fatty acids (\%)} = (\text{NaOH used}) \times (N) \times 28.2/ \text{Weight of sample used}$$

For determining peroxide value, 5g of oil was taken in a 250 ml flask in duplicate (one sample other was served as blank). About 30 ml of acetic acid and chloroform solution was added into both flasks and mixed properly. One ml of saturated KI was added, and the content was allowed to stand for I minute in the dark. Fifty ml of distilled water was added, and the content was titrated against 0.1 N sodium thiosulphate solution until the yellow color disappeared. The starch indicator was added and titrated to release iodine from the $CHCl_3$ layer until the color disappeared. The blank sample was determined, and the reading was subtracted from the sample titration. The peroxide value was calculated using the given formula:

$$\textbf{Peroxide value (meq } O_2\textbf{/kg)} = (S - B) \times N \times 1000/ W$$

Whereas

W = Wt. of sample in grams

N = Normality of sodium thiosulphate

B = Blank titration

S = Sample titration

Statistical analysis

The data obtained from the present study were analyzed according to the method described by Gomez and Gomez (1984). The recovered data was tabulated on Excel sheets and statistically analyzed using Statistical Package for the Social Sciences (SPSS IBM 20) for mean values at p-value$\geq$ 0.05.

RESULTS AND DISCUSSION

Pod characteristics of different peanut varieties

The results regarding pod characteristics from different peanut varieties are presented in Table 1. The one-way ANOVA showed that all treatments were statistically different ($p \leq 0.05$) from one another.

Moisture (%): The moisture content of peanut kernels varied from 4.3 to 5.2%, with Choondko local having the highest mean moisture content (4.03%) followed by Golden (3.3%) and China gold (3.16%). While Bari 2011 had the lowest mean moisture content (2.46%). Payman *et al.* (2011) reported that groundnuts undergo moisture content ranges of 35% when underground, 15-25% at harvest, and 18-24% at threshing, which need to be reduced to 7% before storage. Shahzad *et al.* (2011) also found the moisture content of different Pakistani peanut cultivars to be in the range of 4.6% to 5.26%.

Fat (%): The fat content of different peanut varieties ranged from 44.98% to 48.24%. Bari 2011 showed the highest fat content at 47.86%, followed by Choondko local (46.00%) and golden (45.69%). In contrast, China gold had the lowest fat content at 45.12%. Groundnut seeds generally contain 45-50% oil, which is good for nutrition and cooking as it has high levels of beneficial fatty acids like oleic acid and linoleic acid (Chaiyadee *et al.*, 2013). Different varieties of ground nuts have varying fat contents due to genetic differences and environmental factors. Similar results were also observed by Shahzad *et al.* (2011) who noted fat content ranging from 41.38 to 51.82% in different Pakistani peanut cultivars.

100 peanut kernel weight (g): The study analyzed peanut kernel weight in different varieties and found significant differences between all treatments, with weights ranging from 36.88 to

64.23g. Golden variety had the highest mean kernel weight (63.32g), followed by China gold (56.52g) and Choondko local (53.36g), while Bari 2011 had the lowest mean kernel weight (37.21g). The differences in 100-kernel weight between different varieties of peanuts are primarily due to variations in their genetic makeup or genotype. Each variety has a unique set of genes that governs various traits, including seed size and weight. These results are consistent with a previous study by Gojiya *et al.* (2020), which found differences in average weight between two peanut varieties namely GG-20 and TG-37A which were 56.40g and 37.04g respectively.

Edible portion (%): The edible portion of peanut kernel samples ranged from 51.88 to 63.89%. Bari 2011 had the highest mean edible portion (63.65%), followed by China gold (54.80%) and Choondko local (53.78%). In contrast, Golden had a significantly lower mean edible portion (52.46%). Peanut pods consist of a non-edible shell and an edible kernel. The shell is an agro-based waste residue that has not been fully utilized. According to FAO, about 20% of worldwide peanut production, which is approximately 46 million tons, is comprised of peanut shells (Macedo *et al.*, 2017). The peanut shell contains dietary fiber, crude protein, and fat, and can be used for various purposes such as metal adsorption and fuel. However, the edible kernel of the peanut is more nutritionally valuable than the non-edible shell. While both portions are economically important, the exceptional nutritional value lies in the peanut kernel.

Non-edible portion (%): The non-edible portion of peanut varieties ranged from 36.11 to 48.12%. Golden had the highest mean non-edible portion (47.53%), followed by Choondko local (46.22%) and China gold (45.19%). Bari 2011 had the lowest mean non-edible portion (36.35%). The mean non-edible portion (%) in peanut pods refers to the percentage of the pod's weight that is not edible, including the outer shell and seed coat. This percentage varies by peanut variety and can be influenced by harvest maturity and processing methods. This information is important for evaluating peanut production efficacy, profitability, nutritional content, and quality.

Peanut seed coat (%): The average percentage of peanut seed coats in different peanut varieties ranged from 0.6 to 1.1%. Golden had the highest percentage of the seed coat (1.02%), followed by Choondko local (0.94%) and China gold (0.90%), while Bari 2011 had the lowest percentage (0.73%). The seed coat of peanuts is a nutritious part of the kernel that contains nutraceuticals (Kuang *et al.*, 2017), and its color can vary depending on the cultivar (pink, peach, red, or yellow). Although the seed coats are typically removed in food processing, recent research indicates that they contain phytochemicals and antioxidants (Hoang *et al.*, 2009).

Peanut kernel length (cm): The mean lengths of peanut kernels in different varieties ranged from 1.89 to 2.1 cm. Bari 2011 had the longest mean kernel length (2.0 cm), followed by China gold (1.93 cm) and Choondko local (1.81 cm). Golden had the shortest mean kernel length (1.67 cm). Kernel size, including length, is an important characteristic for assessing the quality of nuts. While kernel size is generally consistent within a species, variations in size can indicate the superiority or inferiority of a given variety. Gojiya *et al.* (2020) studied the length distribution of peanut variety GG-20, finding that lengths ranged from approximately 1.33 to 1.53 cm, which is in line with the present research.

Peanut kernel width (cm): The average width of peanut kernels in different varieties ranged from 0.4 to 0.9 cm. Bari 2011 had the widest kernels with an average width of 1.00 cm, followed by Choondko local (0.8 cm) and China gold (0.7 cm). Golden had the narrowest kernels with an average width of 0.6 cm. The determination of kernel width reveals information about the second-longest axis of the kernel or seed. In a similar study, Gojiya *et al.* (2020) determined peanut kernel width in different peanut varieties and noticed that TG-37A peanut kernels had a 6.5 mm width that is closely parallel to the present findings.

Oil yield (%): The average oil yield percentage in different peanut varieties ranged from 33.5 to 42.01%, with Bari 2011 having the highest mean oil yield (41.49%), followed by Golden (40.38%) and Choondko local (35.35%). China gold had the lowest mean oil yield (33.80%). Peanut oil yield is much more dependent on the method of oil extraction, the proportion of fat or oil in the peanut kernel, and on peanut varieties as well. The oil yield percentage can be better attributed if the extracted peanut oil had gone through the necessary refining process so that the impurities often interfere with the yield percentage.

Table 1. Mean pod characteristics from different peanut varieties

Pods from different peanut varieties	Moisture %	Fat (%)	100 peanut kernel weight (g)	Edible portion (%)	Non-edible portion (%)	Peanut seed coat (%)	Peanut kernel length (cm)	Peanut kernel width (cm)	Oil yield (%)
Bari 2011	2.46±0.120c	47.86±0.229a	37.21±0.412c	63.65±0.124a	36.35±0.124d	0.73±0.066c	2.00±0.02a	1.00±0.057a	41.49±0.269a
Golden	3.3±0.152b	45.69±0.159bc	63.32±0.113a	52.46±0.294d	47.53±0.294a	1.02±0.115a	1.67±0.034c	0.6±0.033c	40.38±0.314b
China Gold	3.16±0.145b	45.12±0.122c	56.52±0.301b	54.80±0.039b	45.19±0.039c	0.90±0.057bc	1.93±0.012b	0.7±0.033bc	33.80±0.173d
Choondko Local	4.03±0.088a	46.00±0.170b	53.36±0.460bc	53.78±0.057c	46.22±0.057b	0.94±0.033ab	1.81±0.014bc	0.8±0.033b	35.35±0.155c
LSD =	0.342	0.554	1.347	0.5422	0.5422	0.2601	0.0804	0.1526	0.884

Table 2. Mean oil quality characteristics of different peanut varieties

Oil from different peanut varieties	pH value	Moisture (%)	Specific gravity (g/ml)	Free fatty acid content (%)	Total fatty acid content (%)	Smoke point (°C)	Peroxide value (meq O_2/kg)
Bari 2011	6.52±0.040a	1.02±0.0296d	0.92±0.0005a	1.41±0.006d	78.29±0.18a	226.2±0.202a	3.20±0.012d
Golden	6.13±0.0371c	1.60±0.0375b	0.911±0.0008d	1.58±0.01b	76.55±0.12c	225.4±0.185b	4.39±0.036b
China Gold	5.85±0.061d	1.80±0.0233a	0.915±0.0003c	1.64±0.018a	76.10±0.098d	224.9±0.120d	4.79±0.012a
Choondko Local	6.33±0.0260b	1.19±0.0152c	0.917±0.0005b	1.51±0.01c	76.80±0.13b	224.4±0.120c	3.71±0.026c
LSD =	0.1632	0.1087	0.0002	0.0491	0.443	0.1683	0.0764

Oil quality characteristics of different peanut varieties

The results regarding oil quality characteristics from different peanut varieties are presented in Table 2. The one-way ANOVA showed that all treatments were statistically different ($p \leq 0.05$) from one another.

pH value: The pH values of oil from different peanut varieties ranged from 5.74 to 6.53, with Bari 2011 having the highest mean pH value (6.52), followed by Choondko local (6.33) and Golden (6.13), while China gold had the lowest mean pH value (5.85). The pH value is a crucial quality attribute for edible oils. According to a study by Awogbemi *et al.* (2019), the pH of vegetable oils can range from 7.38 to 8.63. This range indicates the acidity or alkalinity of the oil and is an important factor in determining its overall quality.

Moisture (%): The study found that the moisture content of peanut oil samples ranged from 0.98 to 1.84%. China gold showed the highest moisture content at 1.80%, followed by Golden at 1.60% and Choondko local at 1.19%. On the other hand, Bari 2011 showed the lowest moisture content at 1.02%. The higher moisture content may be attributed to the lack of refining of the peanut oil after extraction, which resulted in the presence of endogenous water in the crude oil. Excessive moisture in edible oils can lead to rancidity, loss of nutrients, flavor, and aroma. Improper oil extraction, handling, storage, contamination, and adulteration are some factors that contribute to oxidation (Okparanta *et al.,* 2018). Moisture content is a crucial parameter in determining oil deterioration, and the ideal moisture content for edible oils should not exceed 0.2%.

Specific gravity (g/ml): The specific gravity of oil ranged from 0.91 to 0.921g/ml. Bari 2011 had the highest mean specific gravity (0.92g/ml), followed by Choondko local (0.917g/ml) and China gold (0.915g/ml). However, Golden had the lowest mean specific gravity (0.911g/ml). These findings are relatively similar to those reported in a previous study by Negash *et al.* (2019) on the specific gravity of edible oils, which ranged between 0.823 and 0.807g/ml.

Free fatty acid content (%): The oil samples analyzed had a free fatty acid content between 1.41 to 1.67%. China gold had the highest mean free fatty acid content (1.64%), followed by Golden (1.58%) and Choondko local (1.51%). Bari 2011 had the lowest mean free fatty acid content (1.41%). Free fatty acids are produced when triglycerides in oils are hydrolyzed, which typically occurs during storage and handling. High levels of free fatty acids in edible oils can pose health risks, rendering them unsuitable for consumption.

Total fatty acid content (%): The total fatty acid content in peanut oil across different varieties ranged from 75.98 to 77.96%, with Bari 2011 having the highest mean content (78.29%), followed by Choondko local (76.80%), Golden (76.55%), and China gold having the lowest mean content (76.10%). The total fatty acid content of peanuts includes free fatty acids, saturated and unsaturated fatty acids, monounsaturated fatty acids, polyunsaturated fatty acids, cis and trans fatty acids, etc. Peanuts contain significant amounts of essential fatty acids such as linoleic acid. However, it is important to note that the roasting process can affect the quality of fatty acids in peanuts.

Smoke point (°C): The smoke point of the oils ranged between 224.1 to 226.5°C, with Bari 2011 showing the highest mean smoke point (226.2°C), followed by Golden (225.4°C) and Choondko local (224.4°C). However, China gold had a significantly lower mean smoke point (224.9°C). The smoke point is the temperature when the edible oil starts emitting smoke. An edible oil with a greater smoke point means it may be used for many cooking methods since an edible oil with more smoke points is more suitable.

Peroxide value (meq O_2/kg): The peroxide values ranged from 3.18 to 4.82 meq O_2/kg, with Bari 2011 having the highest mean peroxide value (4.79 meq O_2/kg), followed by Golden (4.39 meq O_2/kg) and Choondko local (3.71 meq O_2/kg). On the other hand, China gold had the lowest mean peroxide value (3.20 meq O_2/kg). The peroxide values of all the fresh vegetable oils must be less than the 10 meq O_2/kg oil. The higher temperature, visible light, and O_2 may promote primary oxidation, which increases the peroxide values of edible oils.

The results regarding the mean rancidity value of oil from different varieties of peanut showed that all treatments remained non-significant ($P \leq 0.05$) from one another.

CONCLUSION

Based on the findings of the present study, Bari 2011 emerged as the superior variety for both pod and oil quality parameters, followed by Golden, Choondko local, and China gold. These results suggest that Bari 2011 has the potential to be a valuable resource for addressing malnutrition and providing high-quality nutrition, particularly among vulnerable populations. This variety could be utilized to improve the nutritional value and profitability of peanut crops.

RECOMMENDATIONS

It is recommended that Bari 2011 remained superior in comparison to other varieties for pod and oil quality parameters. So, it is suitable for availing good nutrition. Therefore, this variety may be used to improve the nutritional status of consumers.

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Conflict of Interest

The authors declare no conflict of interest.

Authors' Contribution

The research was conducted by Abdul Raheem. Aijaz Hussain Soomro and Asadullah Marri supervised the research. Nida Shaikh and Asif Irshad contributed to experiments, data analysis, and manuscript writing. Chaker Khan and Aamir Azeem assisted with the whole research process.

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