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Exploring quality assessment of peanut oil for encapsulation

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Abstract
Peanut oil, a vegetable oil extracted from *Arachis hypogaea* L., is a valuable carrier for encapsulation processes. This study assesses the quality of peanut oil from three cultivars (GG-20, GJG-22, GJG-32) in Gujarat, India, with a focus on its suitability for encapsulation. Physical properties, viscosity and specific gravity were similar. Peroxide values (4.90-5.70 meq/kg oil) revealed acceptable oxidative stability which is crucial for preserving encapsulated compounds. Varying iodine values (74.45-82.49 mg/100g) and saponification values (176.90-184.10 mg KOH/g) offer formulation flexibility. Fatty acid analysis showed high unsaturated fatty acid content (80.09-84.05%), enhancing stability and resistance to oxidation, favouring encapsulation. GJG-32, with a significantly higher polyunsaturated fatty acid (PUFA) content (38.17%), faces potential oxidative degradation. Its lower MUFA/PUFA (1.10) and UFA/SFA (4.02) ratios indicated higher susceptibility to oxidative degradation. Thus, from the selected cultivars, GJG-32 peanut oil exhibits promise as an encapsulation carrier.

Keywords: Encapsulation, fatty acid profile, peanut oil, peroxide value

1. Introduction
Peanut (*Arachis hypogaea* L.), known as 'The king of oilseeds', holds a prominent position as the most important oilseed crop cultivated in Gujarat during the kharif season (Misra *et al*., 2006; Gojiya *et al*., 2020, Dhamsaniya *et al*., 2012) [13, 11, 9]. With its wide range of health benefits (Berry *et al*., 1992; Kris-Etherton *et al*., 1999; Moreno and Mitjavila, 2003; Psaltopoulou *et al*., 2004) [4, 12, 14, 16] and culinary applications, peanut oil, extracted from peanut kernels, has gained significant attention across various industries. As a versatile and widely used vegetable oil, peanut oil is pale-yellow in colour and imparts a delightful nutty flavour to products (Sanders, 2002) [17].
Encapsulation, a process that involves entrapping active ingredients within a protective matrix, offers an efficient means to deliver bioactive compounds while enhancing their stability during storage and transportation (Bhuva and Dhamsaniya, 2023) [5]. The success of encapsulation primarily depends on the quality of the carrier oil employed. Thus, evaluating the quality of peanut oil becomes crucial in ensuring the effectiveness and safety of encapsulated products. The quality assessment of peanut oil for encapsulation involves evaluating its physical and biochemical properties. Notably, peanut oil shows a great potential as a carrier for a diverse array of active ingredients, including vitamins, minerals, antioxidants, and essential oils (Bishi *et al*., 2015) [6].
In this regard, the present study focuses on the quality assessment of peanut oil extracted from three popular cultivars: GG-20, GJG-22, and GJG-32, cultivated in Gujarat. The objective is to determine the suitability of cultivar for encapsulation purposes. The study examines key physical and biochemical properties along with fatty acid profiles to assess the advantages and limitations of cultivar for encapsulation. By comprehensively evaluating the quality of peanut oil for encapsulation, this research look for the contribution of valuable insights to the fields of food technology, pharmaceuticals, nutraceuticals, and beyond. Understanding the distinctive characteristics of these cultivars will aid in developing high-quality encapsulated products with enhanced bioavailability, extended shelf life, and improved effectiveness.

2. Materials and Methods
2.1 Extraction of peanut oil: The study involved obtaining peanut pods of specific cultivars (GG-20, GJG-22 and GJG-32) from the local market, ensuring they were certified seeds of the desired variety. The pods were manually decorticated to avoid kernel damage. Immature, rotten, or scorched kernels were removed, leaving only healthy ones.

The oil extraction process was carried out at room temperature using a Universal Testing Machine (UTM) equipped with a cylinder-piston assembly developed by Sindhal *et al*. (2019) [19] at the Department of Processing and Food Engineering of Junagadh Agricultural Univeristy, Junagadh (Gujarat). To remove solid impurities, the crude oil was then filtered through muslin cloth and subsequently subjected to centrifugation at 5000 rpm for 5 minutes. The resulting filtered peanut oil from the selected cultivars was then used for various investigations and analyses.

2.2 Physical properties of peanut oil: The viscosity and specific gravity of the extracted oil samples were determined. The viscosity was measured using Ostwald viscometer (Valantina *et al*., 2017) [20]. The specific gravity was determined by Pycnometer as suggested by Aluyor *et al*. (2009) [1].

2.3 Biochemical characteristics of peanut oil

The peroxide, iodine, acid and saponification value as well as fatty acid profile of peanut oil samples were carried out. Peroxide value was determined by titration method (Cirlini *et al*., 2012) [7]. For this, 0.1 N sodium thoisulphate solution was used for the titration of sample prepared in glacial acetic acid-chloroform (2:1) and potassium iodide solutions. A blank was also set for comparison and calculation. Iodine value was determined by saturating oil samples with bromine-glacial acetic acid solution and titrated by 0.1 N sodium thoisulphate (Anyasor *et al*., 2009) [2].

Acid value was determined with the help of ethanol-ether as a solvent. The samples were titrated by 0.1 N potassium hydroxide (KOH) after adding phenolphthalein as an indicator (Pearson, 1981) [15]. For determination of saponification value, 1 g of oil sample was dissolved in 12.5 ml of methanolic KOH and the mixture was refluxed. Phenolphthalein indicator was added in samples as well as blank and titrated against 0.5 N HCl (Aluyor *et al*., 2009) [1].

2.3.1 Fatty acid profile: Gas chromatography (GCMS Ultra 2010, Shimadzu, Kyoto, Japan) with flame ionization detector (FID) was used to profile the fatty acid composition of peanut oils. Samples were prepared by slight modification in Boron-trifluoride method suggested by Zhu *et al*. (2015) [21]. For this, 0.5 ml oil sample was taken in round bottom flask and dissolved by adding 2-3 ml of hexane. Alcoholic NaOH (3 ml) was added to the mixture and mixed well. This mixture was condensed in reflux-condenser for 5-10 min followed by adding 2 ml boron-trifluoride with 2 min continuous boiling. After adding 15 ml of Milli-Q water sample was transferred to test tube and allowed the upper layer to separate. The upper hexane layer was transferred to the tubes containing sodium sulphate for moisture removal. The prepared sample was transferred to vial by filtering with 0.45 µm polytetrafluoroethylene (PTFE) filter.

Samples containing fatty acid methyl esters were injected in GC-FID by AOC-20i Auto injector (Shimadzu, Kyoto, Japan) with an injection volume of 2 µl at injector temperature of 225°C (Carrier gas: helium) through ELITE-2560 column of 100 m length (Internal dia.: 0.25 mm). Make-up gas was maintained at 45 ml/min (Danish and Nizami, 2019) [8]. Samples were run for 50 min fatty acids. Fatty acids were quantified by normalizing the graph area by comparing fatty acid methyl ester reference standard (Sigma- Aldrich, St. Louis, MO).

2.4 Statistical analysis

All the samples were analysed in triplicate and the average data is provided. The fatty acid compositions were analysed by One-way Analysis of Variance (ANOVA) in MS Excel 2015.

3. Results and Discussion

The quality of peanut oil plays a critical role in the encapsulation process. It directly impacts the stability and effectiveness of the encapsulated compounds. High-quality peanut oil with low levels of oxidation and rancidity ensures that the encapsulated active ingredients remain intact and effective over time. Therefore, an assessment of peanut oil quality ensures product safety and reliability, making it an essential step in the encapsulation process.

3.1 Physical properties of peanut oil

The physical properties of three different peanut oil cultivars, namely GG-20, GJG-22, and GJG-32, were evaluated for their potential suitability in encapsulation applications (Table 1). The viscosity and specific gravity of the three peanut oil cultivars, GG-20, GJG-22, and GJG-32, were found to be similar. GG-20 exhibited a viscosity of 35.36±1.2 Pa.s, GJG-22 showed 35.99±2.0 Pa.s, and GJG-32 had a viscosity of 35.59±1.3 Pa.s. While specific gravity was found to be 0.926±0.009, 0.921±0.007 and 0.927±0.002 for GG-20, GJG-22 and GJG-32 peanut oil, respectively. This similarity indicates that all three oils possess comparable flow properties, making them well-suited for encapsulation processes that require controlled and consistent material flow.

3.2 Biochemical characteristics of peanut oil

The biochemical properties of peanut oil covering peroxide value, iodine value, acid value, saponification value, and fatty acid profiles play a pivotal role in evaluating its oxidative stability and suitability for preserving and protecting encapsulated active ingredients over time. The peroxide value and acid value provide insights into the oxidative stability and degradation of oils. GJG-32 exhibited a peroxide value (5.32±1.5 meq/kg oil) and acid value (74.45±7.1 mg/100g) that were comparable to GG-20 and GJG-22. Although the peroxide values were slightly higher for GJG-32 as compared to GG-20 (4.90±1.7 meq/kg oil), the difference was lower. This suggested that GJG-32 possessed acceptable oxidative stability, indicating its potential suitability for encapsulation applications where oxidation resistance is crucial to maintain the integrity of the encapsulated compounds.

The iodine value and saponification value reflect the level of unsaturation and the average molecular weight of the fatty acids in the oils, respectively. GJG-32 demonstrated a lower iodine value than GG-20. Additionally, GJG-32 had a slightly higher saponification value than GG-20 and GJG-22. These differences in iodine and saponification values may offer advantages in specific encapsulation formulations, where controlled release rates and molecular interactions are critical.

Considering the above properties of peanut oil, initially GJG-32 cultivar appears to be a suitable for encapsulation applications. The properties could potentially be advantageous in achieving specific encapsulation objectives, such as adapting release rates or enhancing stability. Additionally, GJG-32 exhibited acceptable oxidative stability, which is essential for prolonging the shelf life of encapsulated compounds. However, detailed investigations into the fatty acid composition is necessary to validate its suitability.

Table 1: Properties of peanut oil extracted from different cultivars

Properties	GG-20	GJG-22	GJG-32
Viscosity (Pa.s)	35.36±1.2	35.99±2.0	35.59±1.3
Specific gravity	0.926±0.009	0.921±0.007	0.927±0.002
Peroxide value (meq/kg oil)	4.90±1.7	5.70±1.9	5.32±1.5
Iodine value (mg/100g)	82.49±11.0	79.52±2.8	74.45±7.1
Acid value (mg KOH/g)	2.99±0.62	3.27±0.50	2.99±0.62
Saponification value (mg KOH/g)	178.21±8.4	176.90±8.0	184.10±6.1

3.3 Fatty acid profile of selected peanut oils

The fatty acid composition of peanut oil plays a critical role in determining its suitability for encapsulation applications. In this study, three different peanut oil cultivars, GG-20, GJG-22, and GJG-32, were analysed with a focus on unsaturated fatty acids (UFA), monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), and saturated fatty acids (SFA), as well as the MUFA/PUFA and UFA/SFA ratios. Table 2 presents the fatty acid profile of oils obtained from GG-20, GJG-22 and GJG-32 peanut.

All three peanut oil cultivars showed relatively high UFA content, ranging from 80.09% (GJG-32) to 84.05% (GJG-22). High UFA content is generally advantageous for encapsulation, as it provides improved stability and resistance to oxidation, ensuring better preservation of the encapsulated active ingredients. Shad *et al*. (2012) [18] observed that the unsaturated fatty acid content in different cultivars of peanut was in range of 82.06 to 85.93% of total fat. Sindhal *et al*. (2019) [19] also reported the range of unsaturated fatty acids in peanut was 75.10-81.23%.

GJG-32 had the lowest MUFA content (41.92%), while GG-20 and GJG-22 had higher levels (66.04% and 65.31%, respectively). GJG-32 exhibited the highest PUFA content (38.17%), while GG-20 and GJG-22 had lower PUFA levels (17.46% and 18.74%, respectively). PUFAs can enhance the release of encapsulated compounds and improve their dispensability, making GJG-32 a potentially favourable option for certain encapsulation applications. MUFAs and PUFAs were found significantly different among the oil samples.

Previous studies have confirmed the results of MUFA and PUFA content in peanut oils of the current study. The MUFAs were found 44.0% in crude oil of peanut obtained by pressing (Zhu *et al*., 2015) [20]. The PUFA content was reported 15.01-32.31% in the peanut oils by Sindhal *et al*. (2019) [19]. Aung *et al*. (2018) [3] reported 13.5 and 17.8% PUFAs were present in non-branded and branded peanut oil, respectively. Dun *et al*. (2019) [10] observed 32.50-39.48% of PUFAs in 23 peanut oil samples, of which 20 hot-pressed and 3 were cold-pressed.

GJG-32 had the highest SFA content (19.91%), while GG-20 and GJG-22 had slightly lower SFA levels (16.50% and 15.95%, respectively). GJG-32 had the significantly lowest MUFA/PUFA ratio (1.10), suggesting a higher proportion of PUFA relative to MUFA. GJG-22 exhibited the highest UFA/SFA ratio (5.27), followed closely by GG-20 (5.06). GJG-32 had a relatively lower UFA/SFA ratio (4.02).

Table 2: Fatty acids profile of oil extracted from different peanut cultivars

Particulars	UFA	MUFA	PUFA	SFA	MUFA/PUFA	UFA/SFA
GG-20	83.50^{b}	66.04^{a}	17.46^{c}	16.50^{b}	3.78^{a}	5.06^{b}
GJG-22	84.05^{a}	65.31^{b}	18.74^{b}	15.95^{c}	3.49^{b}	5.27^{a}
GJG-32	80.09^{c}	41.92^{c}	38.17^{a}	19.91^{a}	1.10^{c}	4.02^{c}
SEM	0.007	0.006	0.006	0.008	0.001	0.002
CD @1%	0.039	0.03	0.033	0.04	0.006	0.013
CV	0.016	0.017	0.045	0.076	0.069	0.088

*UFA: Unsaturated fatty acids; MUFA: Mono-unsaturated fatty acids; PUFA: Poly-unsaturated fatty acids; SFA: Saturated fatty acids

The quality assessment of peanut oil for encapsulation revealed that the GJG-32 cultivar oil is rich in polyunsaturated fatty acids (PUFA), making it highly susceptible to oxidative degradation. Higher PUFA content increases the chances of lipid oxidation, potentially leading to rancidity and degradation of the encapsulated active compounds. The relevant ratios, such as MUFA/PUFA and UFA/SFA ratios, were significantly lower for GJG-32 compared to other cultivars, indicating a higher susceptibility to degradation, particularly oxidative degradation, during processing, storage, and transportation. Despite its higher susceptibility to degradation, the unique characteristics of GJG-32 peanut oil make it a suitable choice for encapsulation in certain applications. Further studies are recommended to validate its performance and effectiveness in preserving and protecting encapsulated active compounds.

4. Conclusion

The study was conducted on a comprehensive assessment of peanut oil quality, with a focus on its suitability for encapsulation purposes, using three cultivars: GG-20, GJG-22, and GJG-32 from Gujarat, India. The oils exhibited similar viscosity (around 35.6 Pa.s) and specific gravity (around 0.924), making them all suitable for controlled material flow in encapsulation. The oils demonstrated acceptable peroxide and acid values, indicating reasonable oxidative stability. GJG-32, with slightly higher peroxide values (5.32 meq/kg oil) than GG-20 (4.90 meq/kg oil), still maintained acceptable stability. Fatty acid profiling revealed high unsaturated fatty acid content in all cultivars (80.09% to 84.05%). GJG-32 raised out with the highest PUFA content (38.17%), indicating potential advantages for specific encapsulation applications. However, it also displayed the lowest MUFA/PUFA (1.10) and UFA/SFA (4.02) ratios, suggesting a higher susceptibility to oxidative degradation. Thus, GJG-32 peanut oil, while more prone to oxidation due to its PUFA content, possesses unique attributes suitable for select encapsulation applications. Further research is recommended.

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