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NUTRITIONAL VARIATIONS IN SESAME (*SESAMUM INDIUM* L.) SEEDS VARIETIES FROM PAKISTAN: A COMPARATIVE STUDY

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Abstract
In the present study, ten registered sesame (Sesamum indicum L.) varieties cultivated in Balochistan, Pakistan, were evaluated for proximate composition and mineral profile to identify nutrient-dense genotypes suitable for food, industry, and breeding programs. Moisture content ranged from 3.01 ± 0.12% (Niab-Sesame) to 25.90% (TS-5), while oil content varied significantly (P < 0.05) from 37.66 ± 1.02% (TH-6) to 51.01 ± 0.88% (Til-18). An inverse relationship was observed between moisture and oil content, with improperly dried varieties (TH-6, TS-5, TS-3, Anmol-Till) showing markedly lower oil yields. Seventeen elements were quantified using ICP-OES after microwave digestion. All varieties were rich sources of essential macro-elements (Ca, Mg, K, P, S > 2000 µg/g) and micro-elements (Fe, Zn, Mn, Cu). Til-18 exhibited the highest concentrations of Ca (9699 ± 212 µg/g), Fe (186 ± 8 µg/g), and Zn (67.5 ± 2.7 µg/g), whereas Local-White was superior in K (4756 ± 98 µg/g), Mg (3043 ± 67 µg/g), Mn (20.2 ± 0.9 µg/g), and Sr (128 ± 5 µg/g). Potentially toxic elements (Al, Ni, Ti) were detected at low, safe levels. Til-18 and Local-White emerged as nutritionally superior genotypes, combining high oil yield with exceptional mineral density. These varieties are recommended for commercial oil extraction, for mineral-fortified functional foods, and as parental lines in breeding programs aimed at enhancing nutritional security in sesame.

Keywords: *Genotype selection, ICP-OES, Local-White, Mineral composition, Oil content, Pakistan, Sesamum indicum, Sesame varieties, Til-18*

INTRODUCTION

Sesame (*Sesamum indicum* L.), known as the "queen of oilseeds", is one of the oldest oil crops cultivated by mankind (1). Its seeds are valued globally for their exceptionally high oil content (45–55%), good oxidative stability, and rich profile of protein, lignans (sesamin, sesamolin), tocopherols, and minerals (2, 3). Sesame contributes significantly to dietary intake of calcium, iron, zinc, and magnesium in many Asian and African countries where animal-source foods are limited (4).

In Pakistan, sesame is cultivated on approximately 80,000 hectares with Punjab and Balochistan as major regions (5). Despite its nutritional and economic importance, very few studies have systematically compared registered Pakistani varieties for oil and mineral content (6). Most published data refer to exotic germplasm or commercial samples of unknown genetic background (7, 8). This knowledge gap hinders the identification of superior genotypes for farmers, food industry, and breeding programs. Consequently, variety-specific recommendations remain unavailable, leading to suboptimal selection for both rainfed and irrigated systems. Without such baseline data, fortification strategies and value-chain improvements cannot be effectively tailored to local genetic resources. The present study was therefore conducted with the objectives, to determine variation in moisture, oil, and 17 mineral elements among ten registered sesame varieties grown under uniform conditions in Balochistan, and to identify genotypes combining high oil yield with superior mineral density for nutritional enhancement and industrial applications.

METHODOLOGY

PLANT MATERIAL AND SAMPLING

Ten registered sesame varieties (Niab-Sesame, Niab-Pearl, Local-White, Til-18, S-17, Black-Till, TH-6, TS-3, Anmol-Till, TS-5) were obtained from the Agriculture Research Institute (ARI), Quetta, harvest 2023. Each variety was picked randomly from mass storage in three replicates (completely randomized sampling). Mature, healthy seeds (500 g per replication) were cleaned, placed in paper bags, and stored at 4 °C until analysis.

PROXIMATE ANALYSIS

Moisture was determined using a halogen moisture analyzer (Mettler Toledo HE53) at 105 °C until constant weight (triplicate, 5 g sample). Oil content was measured non-destructively using a bench-top NMR analyzer (Oxford MQC+, UK) calibrated with pure sesame oil (30g standard).

MINERAL ANALYSIS

Seeds were oven-dried (60 °C, 48 h), ground to <0.5 mm, and 0.500 g was microwave-digested (Milestone Ethos Up) with 8 mL HNO_3 (65%) + 2 mL H_2O_2 (30%). Digests were diluted to 25 mL with Milli-Q water. Seventeen elements were quantified by ICP-OES (Spectro Arcos, Germany) using multi-element standards, Y as internal standard, and certified reference material (NIST 1573a – tomato leaves) for quality control (recovery 94–104%). All analyses were performed in triplicate.

RESULTS AND DISCUSSION

PROXIMATE COMPOSITION

Ten sesame (*Sesamum indicum* L.) varieties were analyzed for moisture content and oil content. The Moisture content ranged from 3.01% to 25.90%. Lowest in Niab-Sesame (3.01%) whereas highest in TS-5 (25.90%). Varieties with low moisture (<8%): Niab-Sesame (3.01%), Niab-Pearl (5.20%), Black-Till (7.83%). And varieties TH-6 (24.98%), TS-5 (25.90%), TS-3 (21.73%), Anmol-Till (20.96%) were with high moisture (>20%) as depicted in Table I.

Oil content ranged from 37.66% to 51.01% with lowest oil yield in TH-6 (37.66%). Whereas highest in Till-18 (51.01%). Most varieties fell between 46–49%, with seven out of ten varieties having oil content ≥47.69%. Only two varieties were below 46%: Black-Till (44.99%) and TH-6 (37.66%). TH-6 shows the poorest profile (highest moisture 24.98%, lowest oil 37.66%) as expressed in Fig. 1.

Table I. The concentration of moisture and oil content (%) in sesame seed varieties

S. No	Seasme variety	Moisture %	Oil content %
1	Niab-Sesame	3.01%	47.69%
2	Niab-Pearl	5.20%	48.35%
3	Local-White	15.42%	47.95%
4	Till-18	12.83%	51.01%
5	S-17	16.10%	48.14%
6	Black-Till	7.83%	44.99%
7	TH-6	24.98%	37.66%
8	TS-3	21.73%	49.47%
9	Anmol-Till	20.96%	46.32%
10	TS-5	25.90%	48.48%

ELEMENTAL COMPOSITION

Highly significant varietal differences were observed for all elements (Table 2). Among macro-elements following ranges were recorded for Calcium 7889–9699 μg/g: Potassium 3820–4756μg/g, Magnesium 2343–3043μg/g, Phosphorus 2653–3474μg/g and Sulfur 2226–2832μg/g. Whereas for micro-elements Fe 57–186, Zn 38–67.5, Mn 13.3–20.2, Cu 12.4–15.6μg/g recorded. Besides their rich nutritional status, few potentially toxic elements, *i.e*, Al, Ni, and Ti were also detected but in low concentrations and within safe limits.

Til-18 was outstanding for Ca, Fe, and Zn, while Local-White excelled in K, Mg, Mn, and Sr. These values are comparable or superior to sesame from Ethiopia (12), Turkey (13), and India (14), confirming Pakistani germplasm as a rich mineral source.

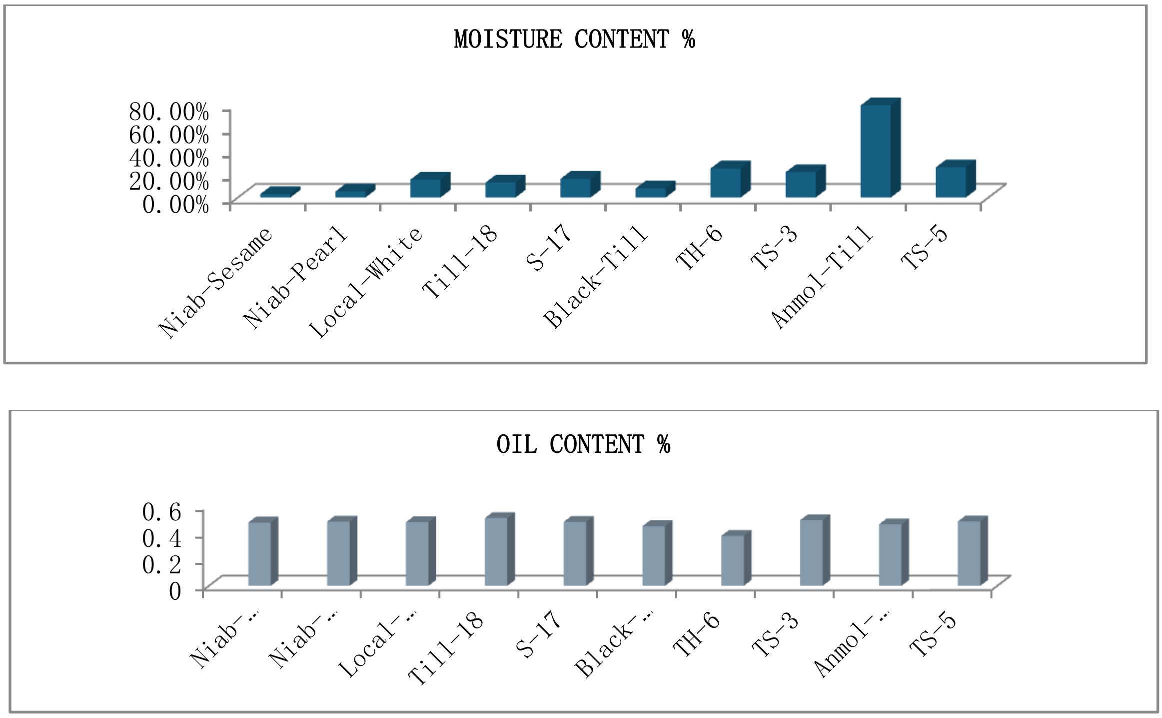
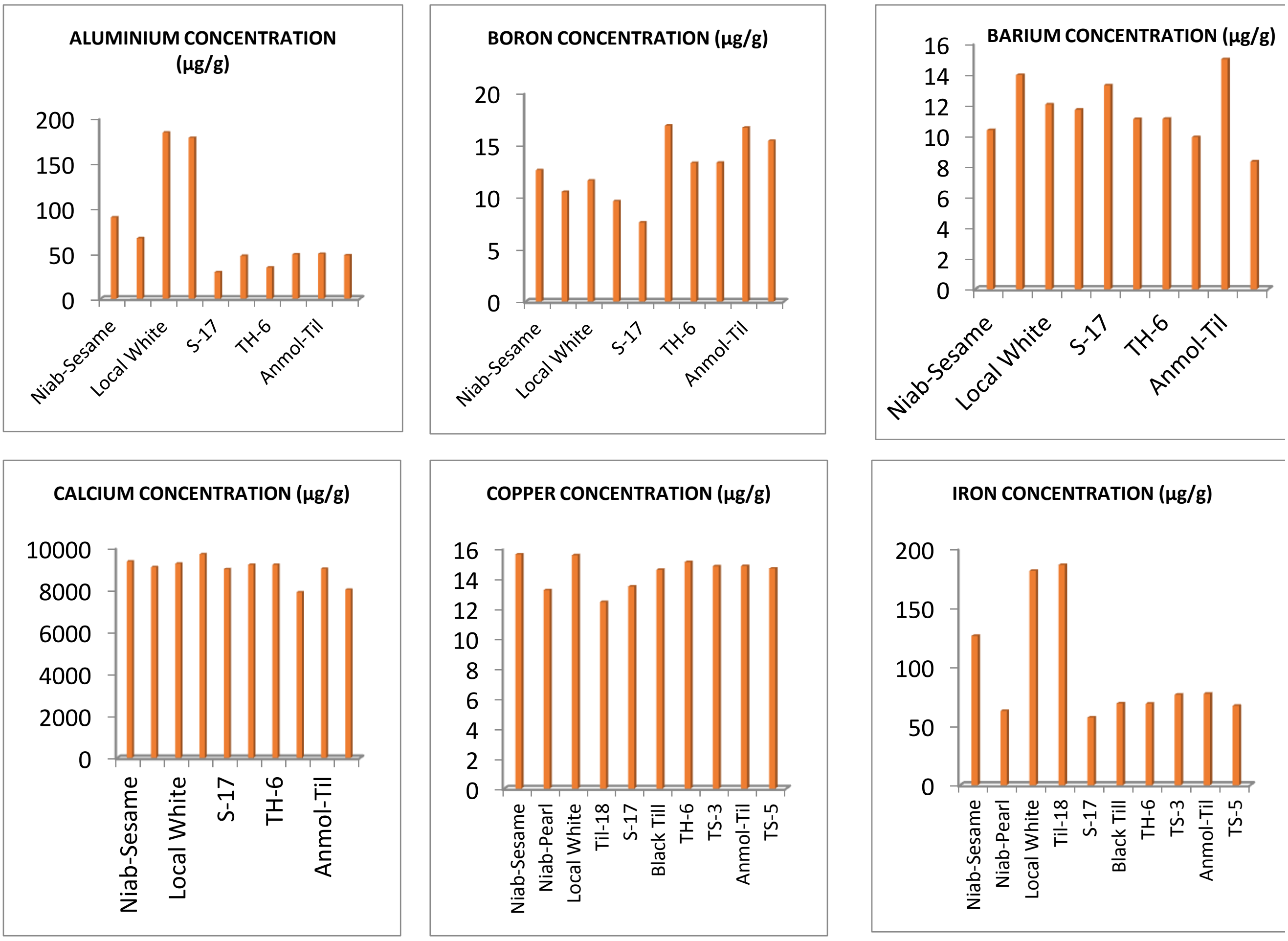


Fig. 1. Graphical representation of moisture and oil content (%) in ten sesame seed varieties

Genetic factors predominantly control oil and mineral accumulation in sesame (15, 16), although soil type and climate of Balochistan (calcareous soils, arid climate) may also contribute to the high Ca and Mg levels observed.



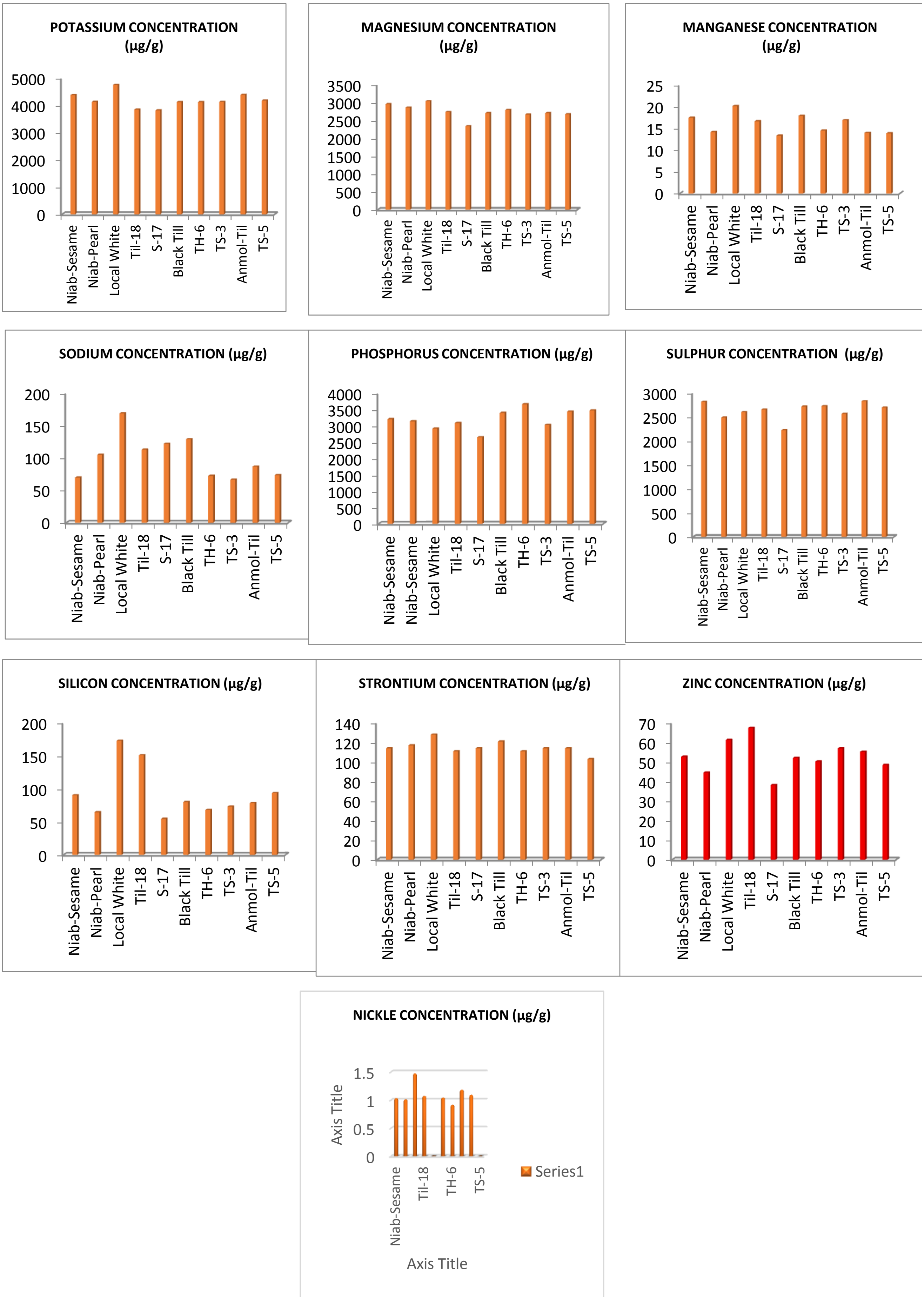


Fig. 2. Graphical representation of elemental analysis in ten sesame seed varieties

Table II. Elemental composition (µg/g dry weight) of ten Sesame seed varieties

S.No.	Elements	Niab-Sesame	Niab-Pearl	Local-White	Till-18	S-17	Black Till	TH-6	TS-3	Anmol-Till	TS-5
1	Al	90.02	66.93	184	178	29.34	47.39	34.50	49.01	49.59	48.08
2	B	12.58	10.50	11.59	9.61	7.57	16.85	13.28	13.29	16.65	15.40
3	Ba	10.34	13.93	12.02	11.67	13.26	11.07	11.08	9.89	14.96	8.30
4	Ca	9357	9080	9257	9699	8988	9196	9194	7889	9006	8008
5	Cu	15.59	13.21	15.53	12.42	13.45	14.57	15.08	14.80	14.82	14.65
6	Fe	126	62.57	181	186	57.10	68.94	68.71	76.27	77.14	67.00
7	Hg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8	K	4383	4135	4756	3850	3820	4126	4127	4132	4394	4184
9	Mg	2961	2864	3043	2739	2343	2712	2796	2668	2710	2677
10	Mn	17.47	14.17	20.15	16.64	13.33	17.89	14.50	16.89	13.97	13.89
11	Na	69.83	105	169	113	122	129	16.89	66.60	86.67	73.53
12	Ni	1.03	1.01	1.47	1.07	ND	1.04	66.60	1.18	1.09	ND
13	P	3207	3142	2918	3089	2653	3399	1.18	3030	3439	3474
14	S	2818	2490	2604	2656	2226	2721	3030	2568	2832	2699
15	Si	90.29	64.54	173	151	54.54	80.00	2568	73.15	78.47	93.57
16	Sr	114	117	128	111	114	121	111	114	114	103
17	Ti	0.54	0.87	1.02	0.79	ND	ND	ND	ND	ND	ND
18	Zn	52.69	44.57	61.32	67.48	38.15	52.14	50.29	56.97	55.24	48.52

PRACTICAL IMPLICATIONS

Farmers may prefer cultivating Til-18 over TH-6 to increase oil yield by >30%. In commercial context, especially in food industry, Til-18 and Local-White are ideal natural sources for mineral-fortified products (e.g., tahini, snacks, infant foods). Breeding of these two varieties is suggestive and should be used as parents to combine high oil with high mineral density.

CONCLUSION

Significant genetic variation exists among Pakistani sesame varieties for oil and mineral content. Til-18 exhibited the highest oil (51.01%), Ca, Fe, and Zn, whereas Local-White was superior in K, Mg, and Mn. Both genotypes represent valuable genetic resources for improving nutritional security, developing functional foods, and breeding mineral-den se varieties. Future research should focus on protein content, fatty acid profile, lignan concentration, and multi-location trials to confirm stability of these traits. There is a general inverse relationship between moisture and oil content: varieties with very high moisture (especially TH-6 and TS-5) tend to have lower oil percentages, likely due to incomplete drying oil content varies considerably (37.66–51.01%) among the tested varieties, with Till-18, TS-3, TS-5, and Niab-Pearl exhibiting the highest values (>48%). Proper post-harvest drying is critical, as high residual moisture (seen in TH-6, TS-5, TS-3, etc.) significantly reduces recoverable oil percentage and increases spoilage risk.

Conflict of interest:

The authors declare no conflict of interest.

Author's contributions:

FY & MAS Conducted elemental analysis; AM Supervised the study;; AMq & MM Contributed in discussing the results and refining manuscript; TI Statistical analysis.

Declaration of generative AI-Assisted Tools:

No AI-assisted tools were used.

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