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Original Research Article

Morphological variation in sensory, disparities in lipids and protein contents of corn grain germplasms grown in the *Western Region* of Cameroon

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ABSTRACT

Maize is known as one of the most cultivated cereals worldwide, especially in Africa, where it is used to feed people and animals. In Cameroon, maize is highly produced in the Western Region, where a survey was carried out among maize producers and main markets, with forty maize grain accessions collected. These seeds were morphologically characterised using three seed descriptors. Dry matter, lipid and protein contents were determined using standard methods. Results showed that white-seeded (42.5%) and yellow-seeded (35.0%) accessions were the most dominant. Flint (40%) and Flint-Dent (37.5%) textures were the most prevalent. Floury-corn seeds (92.5%) dominated popcorn seeds (7.5%). Significant differences were observed among accessions for dry matter, lipids and protein content. Dry matter varies from 84.75% (A34) to 88.33% (A8). Lipid and protein contents vary respectively from 4.25 (A34) to 12.62% (A15) and from 0.32 (A28) to 13.92% (A21). Three accessions (A16, A17, and A21) had simultaneously high lipid and protein content. White-purple maize seeds had a high amount of lipids and proteins. Dry matter was more important in yellow seeds. Horney seed texture was found to have much higher lipid and lower protein concentration. Popcorn seed had high lipid content and low protein level compared to the Floury-corn seed with low lipid content and high protein level. The important variability found in these maize germplasms suggests a methodical preservation of local materials for the crop improvement agenda.

Keywords: Cameroon; Crude protein; Kernel composition; Landraces; Lipid content; Seed colour; Seed texture

INTRODUCTION

Food insecurity is a major concern for development as the global food demand increased by 35% in 2010 and is expected to be 56% in 2050, with the population at risk of hunger changing from -91% to +8% over the same period (van Dijk et al., 2021). Maize (Zea mays L.) is one of the most cultivated cereals worldwide and a staple food in Africa and developing countries (Asfaw et al., 2024). Maize is native to Mexico (Ruiz et al., 2024). It was initially introduced to Africa by the Portuguese from the Gold Coast in the seventeenth century and was quickly spread and adopted by farmers across the continent (Cherniwchana and Moreno-Cruz, 2019). The crop is grown globally on around 40 million hectares and primarily by smallholder farmers and yields around 81 million t (Mbah et al., 2023). In Cameroon, maize production is over 2.1 million tons, with a harvesting area of around 1.32 million ha, according to FAOSTAT (2022) and it is a strategic crop, important for food security and sovereignty, concluded Mbah et al. (2023). Given the socio-economic context, FAO (2012) estimates that around 20.04 % of Cameroonians are unable to feed themselves properly and appeals to the genetic improvement of quantity and quality traits in the main crops used. This likely appears to be the most appropriate response for food security, with maize known as a model plant species for genetic improvement (Gao et al., 2024). Modern Cameroonian maize represents a complex genetic gradient ranging from ancestral landraces to modern hybrids and their open-pollinated descendants. While the ‘local’ landraces historically grown in Cameroon are presumed to have descended from these early colonial introductions, the genetic landscape has likely changed with time, with the development of high-yielding hybrid maize varieties by research agencies and multinational companies. These varieties are widely introduced to Cameroonian farmers to boost their productivity.

Cameroon has a diverse range of maize varieties cultivated in all agro-ecological sites of the country. These varieties play a significant role in feeding 15 million people (Mbah et al., 2023). Maize also plays a substantial role in animal nutrition and serves as a raw material for food processing and many industries, such as breweries, soap and oil production (Mbah et al., 2023). The Western highlands zone is the country’s second-largest maize producer after the Sahelian site in Northern Cameroon (Tsafack et al., 2024). Enhancing productivity is the main objective of maize producers in Cameroon, and improving its nutritional quality seems to be an important step towards food security for the population.

Maize, like other cereals, is rich in carbohydrates and poor in protein and fat content (McKevith, 2004). The crop’s main protein, called zein, is deficient in the main essential amino acids that are lysine, methionine, and tryptophan (Khan et al., 2019). Zein is also a source of sulphur amino acids such as cysteine (Wu et al., 2012). Although at low levels compared to carbohydrates, maize’s fat is one of the richest in polyunsaturated fatty acids. It contains 65% to 85% of unsaturated fat: oleic acid (19.5–30.5%) and linoleic acid (53–65%), and 10% to 19% of saturated acid: palmitic acid (9.2–12.1%) and stearic acid (2–3%; Goffman and Böhme, 2001).

Increasing the levels of lipids and proteins in maize, in addition to boosting crop yield, would make a significant contribution to improving food security in Cameroon, as was the case in Italy (Berardo et al., 2009) and in Turkey (Kahriman et al., 2020a; Kahriman et al., 2020b). In fact, maize germplasm has already been subjected to genetic improvement through screening and identification of suitable genotypes with high protein and/or lipid content (Berardo et al., 2009; Kahriman et al., 2020a; Kahriman et al., 2020b). Without considering the nutritional status of maize germplasm, many researchers in Cameroon have been focusing on improving crop yield, resistance to biotic and abiotic stresses, or selecting early maturing varieties (Guibert et al., 2016). In addition to achieving high agricultural yields, improving nutritional quality is also a key factor in food security.

As a novelty, there is a lack of information on the nutritional status of the existing maize accessions in Cameroon. Our study offers originality in terms of unique germplasm, analysing 40 locally adapted maize landraces in total that have not been nutritionally evaluated. These landraces likely hold valuable genetically important traits associated with local adaptation and farmer preferences, and the nutritional evaluation will point out important parents that are to be used in prospect for maize genetic improvement. These landraces are at a high risk of extinction because of the continuous spread of modern cultivars. The main goal of this study is to determine the level of variation in sensory as well as the nutritive characteristics of maize accessions used by local community in the *Western Region* of Cameroon with the following null hypothesis: **(1)** there is no variation among accessions for each nutritional attribute, **(2)** nutritional attribute does not differ according to seed colour, **(3)** nutritional attribute does not differ according to seed texture, and **(4)** Floury-corn seed does not differ from popcorn seed.

MATERIALS AND METHODS

Plant material and collection sites

A representative set of 40 maize germplasm was collected from all eight divisions representing the *Western Region* of Cameroon (Table 1)

Table 1: Distribution of the maize grain accessions collected in the *Western Region* of Cameroon.

Division	Collection district	Collection site	Number of accessions	Accessions
Bamboutos	*Mbouda*	Central Market	4	A21, A22, A23, A40
Haut-Nkam	*Bafang*	Central Market	4	A24, A25, A26, A32
Hauts-Plateaux	*Baham*	*Baham* central market	8	A10, A11, A12, A13, A14, A15, A38, A39
Koung-Khi	*Bandjoun*	Municipal Market	5	A16, A17, A18, A19, A20
Menoua	*Dschang*	*Marché* A, *Marché* B and IRAD	7	A1, A2, A3, A4, A35, A36, A37
Mifi	*Bafoussam*	*Marché* A and *Marché* B	3	A27, A28, A30
Ndé	*Bangangté*	*Marché* A and *Marché* B	3	A7, A8, A9
Noun	*Foumbot*	Municipal Market and IRAD	6	A5, A6, A29, A31, A33, A34
Total			**40**	

Note: A – Accession

Source: Authors' analysis from the field survey

These germplasms were from the main markets and from the Institute of Agricultural Research for Development (IRAD) stations. Seed morphologies of these germplasms are shown in Fig 1. The collection period was chosen according to the entrance of the maize sowing period, between February and March, before rainfall.

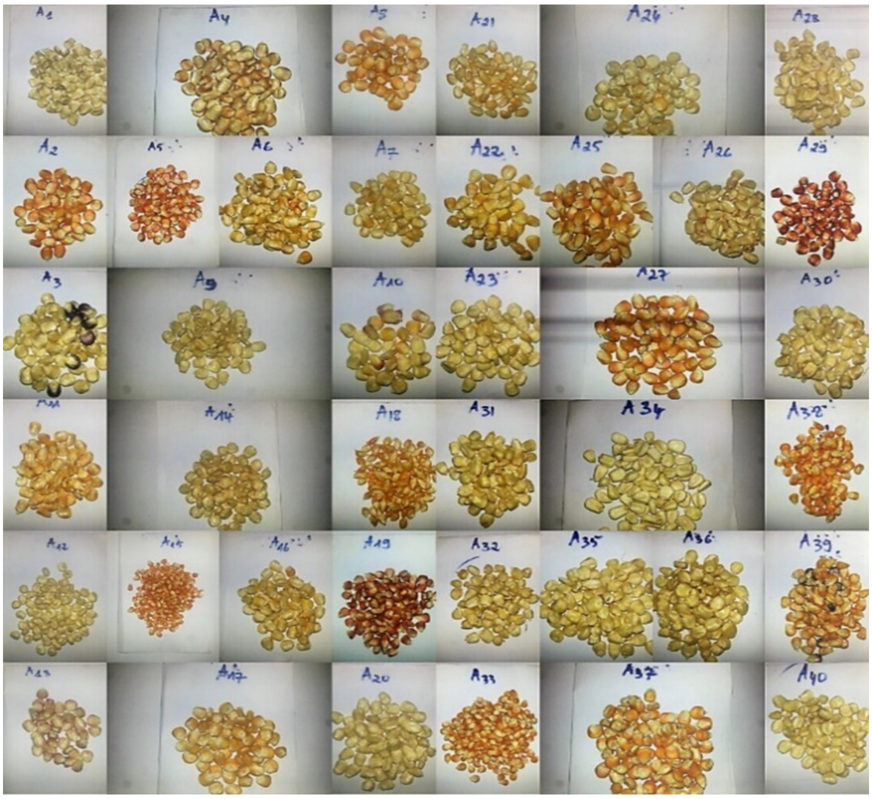

Figure1: Seed morphology of the 40 accessions of maize germplasm collected in the *Western Region* of Cameroon

Note: A – Accession

Study limitations and genetic assumptions

While the primary objective of the sampling strategy was to capture the maximum phenotypic diversity of maize actively cultivated by local farmers in the Western Region of Cameroon, the authors acknowledge certain genetic limitations. Because samples were collected directly from local municipal markets and IRAD stations, we cannot definitively certify whether specific accessions represent pure landraces, commercial hybrids, or their subsequent generations. Due to the high proximity of smallholder farms in Western Cameroon, cross-pollination between open-pollinated local landraces and nearby commercial hybrids is highly probable. Therefore, some of the genetic material characterised in this study likely contains hybrid lineage or genetic introgressions from modern commercial cultivars.

Morphological characterisation and nutrient content determination

Descriptive analysis of the sensory was carried out for each accession during the collection. The characteristics were seed colour and texture, two distinctive sensory criteria for maize seed descriptors (IBPGR / CIMMYT, 1991). Seed type was also assessed. These morphological characterisations aim at highlighting differences in seed morphotypes present in the region. The chemical composition of maize was determined using conventional nutrient quantification techniques. These were mainly total dry matter, protein and lipid contents. Dry maize seeds were first crushed using a grinding machine (Micro Soil Grinder: FT102). The maize powder obtained was sieved using a 200 µm mesh sieve and stored in anhydrous flasks until the bromatological analysis was carried out. The dry matter contents were determined according to Desta et al. (2023). Crude protein contents were estimated by the Kjeldahl method, multiplying measured nitrogen content by a universal nitrogen-to-protein conversion factor of 6.25 (Pferdmenges et al., 2025), and lipid contents were determined by the Soxhlet method described by Caprioli et al. (2016).

Statistical analysis

For each accession, sensory and nutrient attributes were recorded in an Excel sheet before analysis. For each qualitative trait, the overall phenotypic diversity was assessed by calculating the observed (Na) and the effective (Ne) number of phenotypic variants as carried out Ngompe-Deffo et al. (2017) Nei's genetic diversity was calculated according to the following Nei (1987) with the formula and the Shannon-Weaver diversity index was estimated according to Jain et al. (1975) as follows: , with representing the frequency of the phenotypic class of the character. Values of the different nutrient contents determined were expressed as means and standard deviations for each accession, seed texture, seed colour and type, and were subjected to analysis of variance using XLSTAT software, version 2016. This was done to identify significant differences between the means of the determined variables. Once significance was detected, the Tukey HSD test at a 5% probability level was performed for the mean separation of each variable. Chi-square test was performed to assess the dependence between qualitative variables and Pearson correlation was used to estimate the relationship between quantitative variables.

RESULTS

Morphological traits of the collected maize accessions

Direct observation of the morphological descriptors (colour, texture and type) of the different maize accessions allowed their differentiation. As shown in Table 2, five colour variants were observed on seeds (White, yellow, white-yellow, white-purple, and brown) and four different textures were detected (Flint, Flint-Dent, Dent and tunicate). Two distinct types of seed were found (Floury-corn and Pop-corn types). Table 2, presenting the descriptive analysis of these seed accessions, revealed the morphological diversity observed. As for colour, white (17) representing 42.50% and yellow (14) representing 35.00% were the most representative, while Flint (16) and Flint-Dent (15) textures representing respectively 40.00% and 37.50% of the entire collection were the most prevailing. However, white/purple colour (1 accession, 2.50%) and the tunicate texture (1 accession, 2.50%) were the least representative, as shown in Table 2. Among the 40 accessions, 37 (97.50%) were Floury-corn seeds compared to pop-corn seeds, which were only 3 accessions (7.50%, Table 2). This table shows that white seeds were mostly Flint-Dent (27.50%), and yellow seeds were mostly Flint (20.00%)

Table 2: Descriptive analysis of the 40 maize accessions collected in the *Western Region* of Cameroon

Accessions	Colour	Texture	Type	Descriptions	Sensory / morphology attributes	Effective (No)	Frequency (%)
A1	White	Flint-Dent	Floury-corn				
A2	Yellow	Flint	Floury-corn		White	17	42.50
A3	White	Dent	Floury-corn		Yellow	14	35.00
A4	White	Flint-Dent	Floury-corn	Colour	White-Yellow	5	12.50
A5	Yellow	Flint-Dent	Floury-corn		Brown	3	7.50
A6	Yellow	Dent	Floury-corn		White-Purple	1	2.50
A7	White/Yellow	Flint-Dent	Floury-corn				
A8	Yellow	Flint-Dent	Floury-corn		Flint	16	40.00
A9	White	Dent	Floury-corn	Texture	Flint-Dent	15	37.50
A10	White	Flint-Dent	Floury-corn		Dent	8	20.00
A11	Yellow	Dent	Floury-corn		Tunicate	1	2.50
A12	White	Flint	Floury-corn				
A13	White/purple	Dent	Floury-corn	Type	Floury-corn	37	92.50
A14	White	Flint-Dent	Floury-corn		Pop-corn	3	7.50
A15	Yellow	Flint	Pop-corn				
A16	White/Yellow	Flint	Floury-corn		Flint	3	7.50
A17	Yellow	Flint	Floury-corn	White	Flint-Dent	11	27.50
A18	Yellow	Tunicate	Pop-corn		Dent	3	7.50
A19	Brown	Flint	Floury-corn		Flint	8	20.00
A20	White	Flint-Dent	Floury-corn	Yellow	Flint-Dent	3	7.50
A21	White/Yellow	Flint	Floury-corn		Dent	2	5.00
A22	White/Yellow	Dent	Floury-corn		Tunicate	1	3.50
A23	White	Dent	Floury-corn		Flint	3	7.50
A24	White/Yellow	Flint	Floury-corn	White/yellow	Flint-Dent	1	2.50
A25	Yellow	Flint	Floury-corn		Dent	1	2.50
A26	White	Flint-Dent	Floury-corn	White/purple	Dent	1	2.50
A27	White	Flint	Floury-corn	Brown	Tunicate	2	5.00
A28	Yellow	Flint	Floury-corn		Dent	1	2.50
A29	Brown	Dent	Floury-corn				
A30	Yellow	Flint	Floury-corn	Flint	Floury-corn Pop-corn	14 2	35.00 5.00
A31	White	Flint-Dent	Floury-corn	Flint-Dent	Floury-corn Pop-corn	15 0	37.50 0.00
A32	White	Flint-Dent	Floury-corn	Dent	Floury-corn Pop-corn	8 0	20.00 0.00
A33	Yellow	Flint	Pop-corn	Tunicate	Floury-corn Pop-corn	0 1	0.00 2.50
A34	White	Flint	Floury-corn				
A35	White	Flint-Dent	Floury-corn	White	Floury-corn Popcorn	17 0	42.50 0.00
A36	White	Flint-Dent	Floury-corn	Yellow	Floury-corn Popcorn	11 3	27.50 7.50
A37	Yellow	Flint-Dent	Floury-corn	White/yellow	Floury-corn Popcorn	5 0	12.50 0.00
A38	Yellow	Flint	Floury-corn	White/purple	Floury-corn Popcorn	1 0	2.50 0.00
A39	Brown	Flint	Floury-corn	Brown	Floury-corn Popcorn	3 0	7.50 0.00
A40	White	Flint-Dent	Floury-corn				

Note: A – Accession

Source: Authors' analysis from the survey.

Genetic variation and dependence of the analysed qualitative traits

Table 3 shows the diversity indices estimated for the morphological traits considered in this study. Among the three characteristics of the maize accessions, seed colour and texture had higher diversity indices with Nei and Shannon-Weaver indices above 0.50 and the number of observed phenotypic variants of 5 (colour) and 4 (texture). Seed type had the lowest diversity with Na = 2, He = 0.10 and H'= 0.09. Considering all the traits, the average number of observed (Na) and effective (Ne) phenotypic classes were Na = 3.67 and Ne = 2.37. The average Nei index was He= 0.48, and the Shannon-Weaver diversity index was H' = 0.38. The analysis of dependence between these traits was assessed and the analysis revealed the dependence between seed texture and seed type, and between seed texture and seed colour. Independence was observed between the type and the colour of seeds (Table 4).

Table 3: Diversity variables for three qualitative traits of 40 maize accessions grown in *Western Region* of Cameroon

Trait	Diversity variables			
	Na	Ne	He	H'
Colour	5	3.07	0.68	0.55
Texture	4	2.93	0.66	0.50
Type	2	1.10	0.10	0.09
Mean	**3.67**	**2.37**	**0.48**	**0.38**

Note: Na – number of observed phenotypic classes, Ne – number of effective phenotypic classes, He – Nei diversity index; H'– Shannon-Weaver diversity index

Source: Authors' analysis from the survey

Table 4: Dependence between the analysed qualitative traits in maize accessions from the *Western Region* of Cameroon (Chi-square values below the diagonal and significance level above the diagonal).

	Colour	Texture	Type
Colour	/	**	NS
Texture	χ^2 = 17.41	/	**
Type	X^2 = 6.02	X^2 = 14.77	/

Note: ** Significant at 0.010 probability level, NS – Not significant

Source: Authors' analysis from the survey

Nutrient estimates of the collected maize accessions

The analysis of variance (ANOVA) allowed the detection of differences in the contents of the different nutrient components between accessions, as shown in Table 5. From this table, regardless of the colour, texture and type of maize seed, dry matter percentage ranges from 84.75% (A34) to 88.33% (A8), with an average of 86.77%. Lipid contents of maize accessions fluctuated between 4.25 g/100g DM (A34) and 12.62 g/100 g DM (A15) with an average of 9.20 g/100 g DM (Table 5).

Concerning the protein concentration of the maize accessions studied, we recorded a variation from 0.32 g/100 g DM (A28) to 13.92 g/100 g DM (A21) with a mean of 4.96 g/100g DM. Three accessions had simultaneously high lipid and protein content (Table 5). They are A16 (11.5 g/100 g DM of lipids and 13.4 g/100 g DM of proteins), A17 (11.4 g/100 g DM of lipids and 13.7 g/100g DM of proteins) and A21 (11.8 g/100g DM of lipids and 13.9 g/100 g DM of proteins).

Regarding the colour of seeds, Table 6 shows that there is higher lipid content (10.55 g/100 g DM), elevated protein concentration (9.19 g/100 g DM) and lower Dry matter (86.44%) in white-purple seeds. Yellow seeds were characterised by higher dry matter (87.08%) and lower concentration of protein (3.83 g/100 g DM).

Depending on the texture of the maize seeds, the analysis of variance revealed significant differences on dry matter, lipid and protein content (Table 7). The highest dry matter content (87.25%) was obtained with tunicate seeds compared to dent seeds. Seeds having this texture also had high lipid content (11.13 g/100 g DM) and very little protein (1.25 g/100 g DM). Seeds with Dent texture gave the highest protein content (6.05 g/100 g DM), lowest lipid and dry matter content, 8.20 g/100 g DM and 86.33%, respectively (Table 7).

Fig 2 shows that dry matter did not differ between Floury-corn and popcorn seeds. However, popcorn seed has significantly higher lipid (11.93 g/100 g DM) and lower protein (0.95 g/100 g DM) compared to Floury-corn seeds: lipid = 8.97 g/100 g DM and protein = 5.28 g/100 g DM.

Table 8 shows the variations in nutrient content in relation to the colour and texture combination. The table shows that seeds with the white-yellow / Flint combination had higher dry matter (86.86%), higher lipid (10.52 g/100 g DM) and the highest protein content (9.35 g/100 g DM). The lowest dry matter and lipid content was observed with the white/Flint combination: dry matter = 85.86% and lipid = 5.36 g/100 g DM. The combination brown/Dent produced the lowest protein content (1.12 g/100 g DM). Dry matter content of maize accessions collected in the *Western Region* of Cameroon was significantly correlated with lipid content ($r = 0.273$; $p < 0.010$) and with protein content ($r = 0.167$; $p < 0.05$). There was no significant association between protein and lipid contents ($r = 0.110$; $p > 0.050$).

Table 5: Nutrient content of different maize accessions collected in the *Western Region* of Cameroon

	Nutrient composition		
Accessions	**Dry matter (%)**	**Lipids (g/100 g DM)**	**Proteins (g/100 g DM)**
A1	86.94 ± 0.63^{abcde}	5.61 ± 0.16^{pq}	2.85 ± 0.13^{j}
A2	88.04 ± 0.65^{ab}	10.36 ± 0.33^{bcdefghi}	3.28 ± 0.19^{j}
A3	85.36 ± 2.47^{ef}	10.33 ± 0.25^{bcdefghi}	3.24 ± 0.28^{j}
A4	87.15 ± 0.34^{abcde}	11.02 ± 1.04^{abcde}	3.61 ± 0.17^{ij}
A5	87.03 ± 0.68^{abcde}	11.67 ± 1.74^{ab}	3.01 ± 0.29^{j}
A6	86.48 ± 0.22^{abcdef}	6.28 ± 1.31^{mnopq}	2.79 ± 0.15^{jk}
A7	87.88 ± 1.25^{abc}	10.31 ± 0.22^{bcdefghi}	3.01 ± 0.13^{j}
A8	88.33 ± 0.06^{a}	8.67 ± 1.12^{ghijkl}	1.23 ± 0.56^{kl}
A9	85.63 ± 0.48^{def}	6.14 ± 1.53^{nopq}	0.72 ± 0.26^{l}
A10	88.00 ± 0.74^{abc}	10.68 ± 0.55^{abcdefg}	11.54 ± 0.99^{cd}
A11	86.75 ± 0.34^{abcde}	7.62 ± 1.13^{klmno}	12.86 ± 0.62^{abc}
A12	87.34 ± 0.49^{bcdef}	4.79 ± 0.96^{pq}	8.68 ± 0.19^{e}
A13	86.44 ± 0.11^{abcde}	10.55 ± 0.77^{abcdefgh}	9.12 ± 1.17^{e}
A14	86.80 ± 0.40^{abcde}	10.45 ± 0.34^{abcdefgh}	7.67 ± 0.52^{ef}
A15	87.10 ± 0.25^{abcde}	12.62 ± 0.19^{a}	0.91 ± 0.11^{l}
A16	86.83 ± 0.28^{abcde}	11.58 ± 1.19^{ab}	13.43 ± 1.06^{ab}
A17	87.15 ± 0.71^{abcd}	11.45 ± 0.52^{abc}	13.74 ± 1.26^{ab}
A18	87.25 ± 0.70^{abcd}	11.23 ± 0.43^{abcd}	1.25 ± 0.08^{kl}
A19	87.35 ± 0.57^{bcdef}	8.20 ± 0.56^{jklmn}	11.25 ± 0.51^{d}
A20	86.40 ± 0.65^{abcd}	10.85 ± 0.34^{abcdef}	12.18 ± 1.39^{bcd}
A21	87.30 ± 0.34^{bcdef}	11.85 ± 0.57^{abcd}	13.92 ± 0.73^{a}
A22	86.45 ±0.19^{bcde}	6.41 ± 0.59^{bcdef}	7.79±0.60^{ef}
A23	86.95 ± 0.47^{abcde}	7.90 ± 0.38^{jklmn}	10.77 ± 1.21^{l}
A24	86.45 ± 0.77^{bcdef}	8.15 ± 0.34^{jklmn}	0.72 ± 0.21^{d}
A25	86.95 ± 0.25^{abcde}	10.60 ± 0.16^{abcdefgh}	0.79 ± 0.18^{l}
A26	86.80 ± 0.76^{abcde}	9.45 ± 0.34^{cdefghijk}	0.72 ± 0.22^{l}
A27	85.50 ± 0.66^{def}	7.04 ± 0.42^{lmno}	7.06 ± 0.92^{f}
A28	87.33 ± 0.09^{abcd}	10.00 ± 0.56^{bcdefghij}	0.32 ± 0.05^{l}
A29	86.60 ± 0.23^{abcdef}	10.40 ± 0.58^{bcdefghi}	1.12 ± 0.08^{l}
A30	86.45 ± 0.99^{bcdef}	8.35 ± 0.34^{ijklm}	3.37 ± 0.40^{j}
A31	86.15 ± 0.44^{cde}	8.96 ± 0.69^{efghijkl}	0.46 ± 0.05^{l}
A32	86.70 ± 0.38^{abcde}	7.55 ± 0.66^{klmno}	0.70 ± 0.08^{l}
A33	86.40 ± 0.43^{bcdef}	11.95 ± 0.41^{ab}	0.68 ± 0.09^{l}
A34	84.75 ± 0.44^{f}	4.25 ±0.77^{q}	0.82 ± 0.47^{l}
A35	86.70 ± 0.82^{abcde}	8.70 ± 1.06^{ghijkl}	0.76 ± 0.07^{l}
A36	86.65 ± 0.34^{abcde}	9.13 ± 0.51^{defghijk}	4.14 ± 0.17^{hij}
A37	86.55 ± 0.25^{abcdef}	8.80 ± 0.73^{ghijkl}	5.22 ± 0.04^{g}
A38	86.67± 0.27^{abcde}	8.56 ± 0.61^{hijkll}	4.21 ± 0.02^{hij}
A39	86.50 ± 0.20^{abcdef}	8.65 ± 0.57^{ghijkl}	4.96 ± 0.02^{gh}
A40	86.80 ± 0.20^{abcde}	10.73 ± 0.41^{abcdefg}	3.61 ± 0.06^{ij}
Mean ± SEM	86.77 ± 0.49	9.20 ± 0.85	4.96 ± 0.71
Min	84.75% (A34)	4.25 g/100 g DM (A34)	0.32 g/100 g DM (A28)
Max	88.33% (A8)	12.62 g/100 g DM (A15)	13.92 g/100 g DM (A21)

Note: Values with different superscript letters in the same column differ significantly at p = 0.050 probability level.

Source: Authors' analysis from the survey

Table 6: Nutrient composition of different maize accessions according to seed colour

	Nutrient Composition		
Seed colour	Dry matter (%)	Lipids (g/100 g DM)	Proteins (g/100 g DM)
White	86.51 ± 0.13[b]	8.45 ± 0.27[c]	4.67 ± 0.49[c]
Yellow	87.03 ± 0.09[a]	9.87 ± 0.26[ab]	3.83 ± 0.56[c]
White-yellow	86.98 ± 0.19[ab]	9.66 ± 0.49[ab]	7.77 ± 1.23[ab]
White-purple	86.44 ± 0.06[b]	10.55 ± 0.39[a]	9.16 ± 0.58[a]
Brown	86.82 ± 0.15[ab]	9.08 ± 0.32[b]	5.77 ± 1.26[b]

Note: Values with the same letter in the same column are not significantly different at the 5% threshold.

Source: Authors' analysis from the survey

Table 7: Nutrient composition of different maize accessions according to seed texture.

	Nutrient composition		
Seed texture	Dry matter (%)	Lipids (g/100 g DM)	Proteins (g/100 g DM)
Flint	86.76 ± 0.11[ab]	9.27 ± 0.31[b]	5.51 ± 0.63[b]
Flint-Dent	86.99 ± 0.10[ab]	9.51 ± 0.22[b]	4.05 ± 0.47[b]
Dent	86.33 ± 0.17[b]	8.20 ± 0.36[c]	6.05 ± 0.79[a]
Tunicate	87.25 ± 0.35[a]	11.13 ± 0.22[a]	1.25 ± 0.04[c]

Note: Values with the same letter in the same column are not significantly different at the 5% threshold.

Source: Authors' analysis from the survey

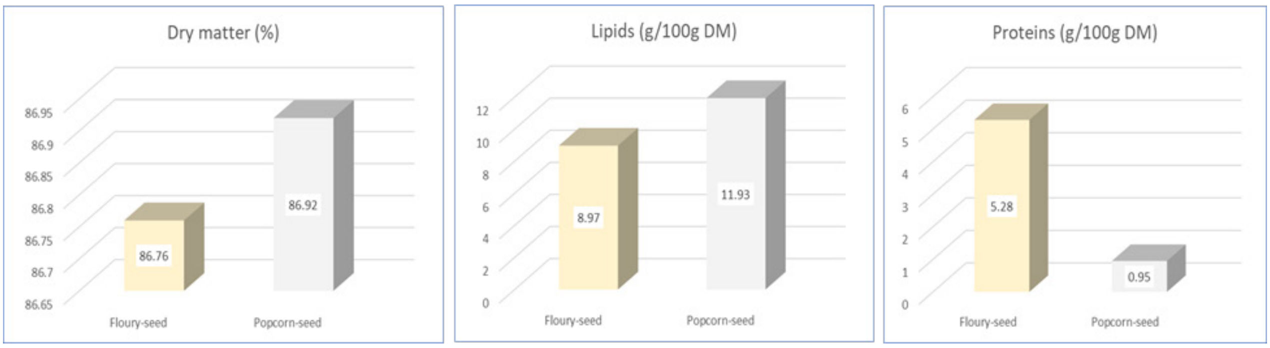

Figure2: Nutrient composition of different types of maize seed

Source: Authors' analysis from the survey

Table 8: Nutrient composition of different maize accessions according to seed colour/texture combination.

	Nutrient composition		
Colour-texture	**Dry matter (%)**	**Lipid content (g/100 g DM)**	**Protein content (g/100 g DM)**
White / Flint	85.86 ± 1.24[c]	5.36 ± 1.43[c]	5.52 ± 3.58[bc]
White / Flint-Dent	86.91 ± 0.77[ab]	9.45 ± 1.65[ab]	4.27 ± 3.98[bcd]
White / Dent	85.98 ± 1.52[c]	8.12 ± 1.98[b]	4.91 ± 4.51[bc]
White-yellow / Flint	86.86 ± 0.59[ab]	10.52 ± 1.89[a]	9.35 ± 6.42[a]
White-yellow / Dent	86.45 ± 0.19[bc]	6.41 ± 0.59[c]	7.78 ± 0.59[abc]
White-purple / Dent	86.44 ± 0.11[bc]	10.55 ± 0.77[a]	9.11 ± 1.16[a]
Yellow / Tunicate	87.25 ± 0.70[a]	11.23 ± 0.44[a]	1.25 ± 0.07[d]
Yellow / Flint	87.01 ± 0.69[ab]	10.49 ± 1.49[a]	3.41 ± 0.78[bcd]
Yellow / Flint-Dent	87.30 ± 0.88[a]	9.76 ± 1.85[ab]	3.15 ± 1.73[cd]
Yellow / Dent	86.61 ± 0.31[b]	6.95 ± 1.35[ab]	7.83 ± 1.95[abc]
Brown / Flint	86.93 ± 0.60[ab]	8.43 ± 0.58[b]	8.10 ± 3.38[ab]
Brown / Dent	86.60 ± 0.32[b]	10.40 ± 0.59[a]	1.12 ± 0.08[d]

Note: Values with the same letter in the same column are not significantly different at the 5% threshold.

Source: Authors' analysis from the survey

DISCUSSION

For any crop species, knowledge of the existing genetic variability is essential for successful plant breeding. Information on this genetic variation can be assessed through morphological, biochemical and DNA markers. Using morphological traits to screen an available plant collection has usually been the initial step in describing the genetic resources of a plant species (Kumar et al., 2025; Khadivi et al., 2025). According to Smith et al. (1991) and Kumar et al. (2025), any genetic improvement program cannot be without morphological variability. It provides geneticists with vital information on traits in their efforts to carry out fruitful plant breeding. Based on some morphological and biochemical descriptors, maize seed accessions from the *Western Region* of Cameroon were analysed and a remarkable degree of polymorphism was observed. This reflects the existence of high genetic variability. Differences in nutritional content in plants are highly explained by the genetic constitution of individuals (Amponsah et al., 2026).

Some other factors, such as differences in farming techniques, type and doses of fertilisers, and environmental stress during cultivation, also explain variation found in nutrient composition in crops (Djoufack et al., 2023). The most abundant nutrient in maize grain is starch (carbohydrates), although several other nutrients, including proteins, lipids and minerals, are significant in human nutrition. The mean values of protein and lipid found in this set of 40 maize accessions were 9.20 and 4.96%, respectively. These values are within the ranges: [8.69–10.41%] for protein and [3.90–5.76%] for lipid reported by Joshi et al. (2022). The mean values of protein and lipid content found in this set of accessions (9,20g/100g DM and 4.96g/100g DM, respectively) were higher than those of previous reports for maize landraces (Salvador-Reyes et al., 2020; Sanchez-Ramirez et al., 2022).

As an example, Salvador-Reyes et al. (2020) reported 6.65% mean protein and 3.89% mean lipid. The ranges for both nutrient estimates observed in the current study were larger than those of the previous studies on nutrient composition in maize landraces. This is expected given the larger germplasm collection in the present study. Our results are close to those of Ogalde et al. (2020) in maize germplasm, who reported 12% protein and 4.2% lipid in maize germplasm from Chile. Berardo et al. (2009) also reported similar results for maize germplasm mainly from Italy with 12.52–15.16% mean protein and 5.26–7.16 % mean lipid. We found in this study significant variation for all sensory and nutrient attributes for the forty maize genotypes analysed. This follows reports from previous studies on maize grain with nutritional composition differing between genotypes (Ogalde et al., 2020; Sanchez-Ramirez et al., 2022).

Nutrient composition was found to be dependent on seed colour, texture, type and the colour/texture combination, as also reported by Salvador-Reyes et al. (2020). While tunicate seed texture had the highest lipid content (11.13%) and the lowest protein level (1.25%), seeds with Dent texture displayed the lowest lipid content (8.20%) and the highest protein level (6.05%). Flint seed type had intermediate values with 9.27% lipids and 5.51% proteins. Lim and Yi (2019) also reported a significant difference in nutrient content in maize genotypes when comparing seed texture. Differences among genotypes for nutrient content were also observed when comparing seed colours. White seed had the lowest dry matter (86.51%) and the lowest lipids (8.45%), while yellow grains had the highest dry matter (87.08%) and the lowest protein content (3.83%). Purple maize seeds were characterised by the lowest dry matter (86.44%), the highest lipid level (10.55%) and maximum protein content (9.16%).

When comparing the nutrient content of maize seeds differing by colour, Salvador-Reyes et al. (2020) also reported the highest protein content in purple maize, although the value (7.98%) is significantly lower than the one obtained in this study. They also obtained lower lipid content (4.5%) and comparable dry matter (87.98%) in their purple seeds. The protein content obtained for white maize in this study (4.67%) is low compared to 6.84% obtained by Sanchez-Ramirez et al. (2022) and 12% reported by Ogalde et al. (2020) with white maize from Chile. The lipid content (8.45%) is rather high compared to 4.84% of Sanchez-Ramirez et al. (2022) and 4.20% of Ogalde et al. (2020).

Dry matter is obtained when water is removed from a product. It is made up of sugars, lipids, proteins, minerals, and secondary compounds such as carotenoids (Wang et al., 2017). This study showed significant correlations between dry matter and lipid content, dry matter and protein concentration. These positive correlations found can be explained by the fact that the biosynthesis mechanism of dry matter and nutrients is associated with photosynthetic activity (Davey and Smith, 2013).

The remarkable morphological and biochemical polymorphism observed in this study reflects a rich genetic variability. This variability is likely a combined result of long-term local adaptation of historical landraces and genetic introgressions from modern commercial hybrids. The presence of commercial genetics in local farmer-saved seed systems is common in Sub-Saharan Africa and this genetic mixing highlights the dynamic nature of 'local' germplasm, where farmers continually select for desirable traits such as high protein and lipid contents within a genetically open system.

CONCLUSIONS

The present study shows that: **(1)** there is significant variation between accessions for each nutritional and sensorial attribute; **(2)** nutritional attributes are significantly differentiated according to kernel colour; **(3)** nutritional variables highly depend on the kernel structure; and (4) regular and popcorn kernels show differences in nutritional and sensorial attributes. These results would enable the breeder to select the best accession for future maize improvement and the development of new cultivars. Because of their nutritional value and health benefits, maize seeds are being increasingly used worldwide. At the individual level, accessions A16, A17, and A21 were found to have high nutritional components. A16: lipids = 11.58 g/100 g DM and proteins = 13.43 g/100 g DM; A17: lipids = 11.45 g/100 g DM and proteins = 13.74 g/100 g DM and A21: lipids = 11.8 g/100 g DM and proteins = 13.92 g/100 g DM. White-purple-coloured seeds had the highest lipids (10.55 g /100 g DM) and proteins (9.16 g/100 g DM). Tunicate seed structure displayed important lipid content (10.52 g/100 g DM) and the lowest protein content (1.25 g/100 g DM). Considering colour/structure combinations, the white-yellow-horned-seeded accessions (lipids = 10.52 g/100 g DM and proteins = 9.35 g/100 g DM) and white-purple-Dent genotypes (lipids = 10.55 g/100 g DM and proteins = 9.11 g/100 g DM) displayed the highest lipid and protein contents. However, further similar studies are needed to confront the observed results in comparison to other localities as the plant production, minerals, and nutrient compositions fluctuate with locality and particularly with the type of soil.

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CONFLICT OF INTEREST

The authors declared no conflicts of interest concerning the research, authorship, and publication of this article.

DECLARATION OF GENERATIVE AI USE

The authors confirm that no generative AI or AI-assisted technologies were utilised in the writing, data analysis, or visual creation phases of this manuscript.

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