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Morphological traits and nutritional value of six local cultivars of maize (*Zea mays*) from Gorontalo, Indonesia

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Abstract. *Kandowangko NY, Solang M, Febriyanti, Ahmad A. 2025. Morphological traits and nutritional value of six local cultivars of maize (Zea mays) from Gorontalo, Indonesia. Biodiversitas 26: 2289-2298.* Maize local varieties are grown in Gorontalo, Indonesia, namely *doti, siropu, momala, kiki, pulo* and *damahu*. The existence of this corn is utilized by the community to make various types of traditional processed foods such as *binthe biluoto, balobinthe*. However, this local corn is starting to be rarely found. The morphological traits and nutritional benefits of these six indigenous corns have not been extensively researched. This research aimed to characterize the morphology of local corn plants and analyze their nutritional value. Descriptive and quantitative analysis. The findings of the analysis indicated that local maize plants have different traits. The height of the plant ranges from 115-195 cm, the number of leaves is between 11-15, and the seeds are orange (*Zea mays* var. *doti*), orange red tip (*Z. m.* var. *siropu*), marron red (*Z. m.* var. *momala*), white (*Z. m.* var. *pulo*), clear white (*Z. m.* var. *damahu*). The composition of the nutritional value of local corn is as follows: Water content 6.69-15.69%; Ash content 0.92-2.48%; Fat content 2.85-5.09%; Protein content 8.82-12.53%, Carbohydrate ranges from 71.22-77.22; Amylosa 7.46-22.00%. Reduction sugar 0.54-1.92%, In addition, local corn contains high levels of Zn, K, and Mg minerals. The existence of local corn that is rich in nutrients needs to be preserved so that it can support the development of food products to meet human nutritional needs.

Keywords: Food products, maize, morphology, nutrition, proximate

INTRODUCTION

Maize (*Zea mays*) is a significant cereal crop and is known as the "*queen of cereals*" because corn is widely used in various food products compared to other cereal crops (Borase et al. 2018). This is supported by the nutritional content contained in corn kernels, namely carbohydrates ranging from 68-76%, protein ranging from 9.56-12.53%, and fat ranging from 4.26-5.59% (Suleman et al. 2019; Ahmad et al. 2021). Maize kernels are also a source of provitamin A carotenoids, precursors of vitamin A (Hwang et al. 2016; Serna-Saldívar and Pérez-Carrillo 2018) Maize can be consumed in various forms, including fresh, dry, and processed, which provides an array of nutritional benefits to individuals from diverse socioeconomic backgrounds, especially those in Latin America, Africa, and Asia (Serna-Saldívar 2016). Maize production is crucial to address the increasing global food demand driven by population growth. However, challenges such as damage by insects and plant pathogens, nutrient depletion in soils due to overuse of chemical fertilizers, and the diversion of maize for animal feed and biofuel production impact the sustainable production of this important crop (Dowd and Johnson 2020). Examining the proximate and macronutrient composition of local maize varieties is essential to ensure the sustainable production of this staple crop.

In Gorontalo, Indonesia, maize or also called *binthe* is the second staple food after rice. Local maize found in Gorontalo consists of several varieties, including maize var. *momala*, *pulo* (glutinous corn) and *kiki*. Gorontalo *momala* corn has the following characteristics: plant height ±220 cm, anthocyanin color on the supporting roots is very strong, anthocyanin on the hair has a strong intensity, and popcorn-type seeds with the main color on the surface red. *Pulo* (glutinous corn) has a height of 135-180 cm, biologically matures at 80 Days After Planting (DAP), and the type of seed is small white grains with a weight of 1000 grains of 250 g. Meanwhile, maize var. *kiki* is a plant that is resistant to lodging, the stem is sturdy, the color of the stem is green, the roots are good, the hair appears when the plant is 35-40 DAP, the position of the cob is ±57 cm in the middle of the stem, the shape of the cob is small cylindrical, the color of the hair is reddish brown, the number of rows per cob is 10-14 rows, the shape of the corn kernels is, the color of the corn kernels is orange yellow, the husk is well closed, the harvest age is 70-80 DAP, the physiological maturity is 70-75 DAP (Plant Variety Protection Official News 2014, 2018a, b).

The community processes local corn by boiling, drying, and grinding it as a mixture of rice, making corn porridge (in Gorontalo language it is called *sada* porridge), roasting it and seasoning it (in Gorontalo language it is called *binte biluti*), and corn pudding (in Gorontalo language it is called *kokole*) (Kandowangko et al. 2020). These various corn preparations show that local corn has been optimally utilized by the community. The utilization of local corn needs to be supported by a study of its nutritional content, such as mineral content. Minerals are needed by plants, animals, and humans to regulate various functions in the body, namely forming structural components such as frameworks, acting as enzyme cofactors, and as building blocks of organic compounds. Calcium (Ca), Magnesium (Mg), Potassium (K) are macro-minerals found in large quantities in plants, while Zinc (Zn) and Cuprum (Cu) are found in relatively small amounts, so they are called microminerals. These minerals can be obtained from foods that come from plants. Integration of various sources of nutrients, from organic fertilizers, has been shown to increase the productivity and nutritional content of food crops, and can maintain and preserve soil productivity (Gezahegn et al. 2021). The factors influencing the production and nutritional quality of local corn include oxygen availability, pH measured with KCl, organic carbon content, total nitrogen, potassium availability, soil composition, nutrient retention, nutrient accessibility, erosion, land management practices, and rock presence (Nurdin et al. 2021).

Minerals are also nutrients that are associated with several health problems such as malnutrition and the presence of malnutrition will cause several metabolic diseases (Ndukwe et al. 2015; Solang and Andriani 2021). There is not much data on the nutritional value of local corn from Gorontalo. Data on nutritional composition is crucial for dietary planning and to aid in the support of epidemiological research findings. The objective of this study is to characterize the morphology of corn plants and evaluate the proximate, macronutrients and micronutrients of six local corn varieties in Gorontalo. Information on the mineral content of local corn is an important study because it can support the use of corn to meet the body's mineral needs normally or to improve nutrition in malnutrition conditions.

MATERIALS AND METHODS

Samples collection

Plant material: 6 types of local corn from Gorontalo, Indonesia, namely *binthe doti, binte kiki, binthe siropu, binthe momala, binthe pulo* and *binthe damahu* were taken from July to September 2024. The location of corn sampling, status and coordinate points are listed in (Table 1, Figure 1).

Research methods

The state of the plant in the cultivation area was observed in order to collect the morphological characteristic data for this study. To examine the morphological traits of the plant, the seeds were subsequently gathered and replanted in the trial garden of the Agricultural Instrument Standard Implementation Centre in Gorontalo. The study referred to the description guidelines, which include quantitative characteristics (stalk height, cob height, stalk thickness, quantity of leaves, average leaf length, leaf width, axillary bud presence, shape of the tip, weight of the cob including husk, weight of the cob without husk, cob length, cob width, number of kernels per row, and weight of one thousand kernels) and qualitative characteristics (color, shape, and direction of the leaf blade) (Budiarti et al. 2004). The color scheme was standardized using the Royal Horticultural Society Color Chart. Additionally, the proximate of the nutritional values was analyzed using a quantitative method. The proximate content (water, ash, fat, protein, crude fiber, and carbohydrate) was examined using a particular technique based on the Indonesian National Standard (henceforth, SNI); the Association of Official Analytical Chemists (AOAC) recommended this technique in 2005 (Murningsih et al. 2019). In the laboratory of the sizable post-harvest agricultural instrument standard testing center in Bogor, the nutritional qualities of the maize kernels were measured.

Habitus

Plant height (cm): measured after the plant enters the milky maturity phase (R3), from the ground surface to the base of the panicle. Location of the upper ear (cm): Ratio of the height of the upper ear to the height of the plant: Measured after the plant enters the milky maturity phase, measured from the ground surface to the node where the upper ear is located. Stem color, observed on the stem located between the top two cobs if the corn has more than one cob. Observations are made when the plant is fully flowering. To match the color, the Royal Horticultural Society Color Chart is used (Budiarti et al. 2004; Ahmad et al. 2021)

Table 1. Sampling locations and conditions of their existence and physicochemical characteristics of the soil

Variety	Sample site	Status	Coordinate	Average soil pH	Average humidity (%)	Average temperature (°C)
Binthe Doti	Pinogu Village, Pinogu Sub-district, Bone Bolango District	rarely	Lat 0.509968” Long 123.422742º	6.8	79	24.7
Binthe Momala	Tanah Putih Village, Dulupi Sub-district, Boalemo District	rarely	Lat 0.564027” Long 122.41854º	7.2	80	26.3
Binthe Pulo	Bolihutuo Village, Botumoito Sub-district, Boalemo District	rarely	Lat 0.480875” Long 122.192211º	6.7	67	26.3
Binthe Siropu	Longalo Village, Bulango Sub-district, Bone Bolango District	rarely	Lat 0.403575” Long 123.436518º	6.8	75	26.7
Binthe Kiki	Biluhu Barat Village, Biluhu Sub-district, Gorontalo District	rarely	Lat 0.306802” Long 122.444752º	5.8	65	26.7
Binthe Damahu	Bolihutuo Village, Botumoito Sub-district, Boalemo District	rerely	Lat 0.480875” Long 122.192211º	6.5	70	26.8

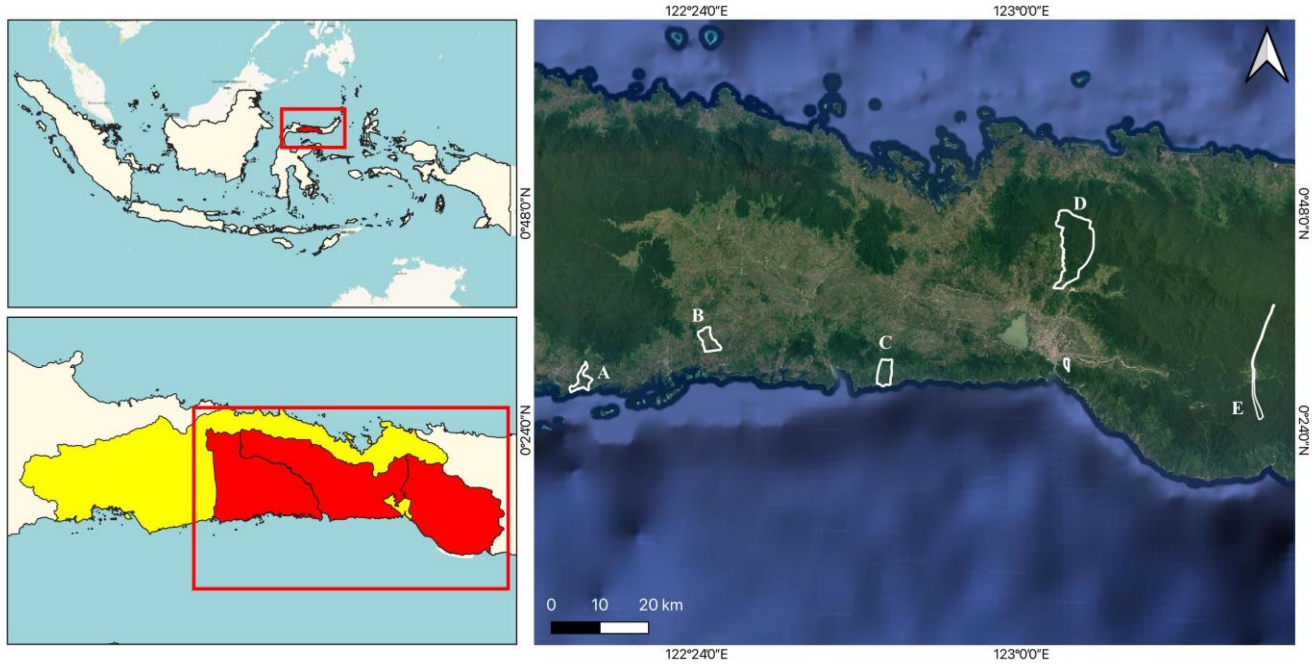

Figure 1. Sampling location of local corn varieties in Gorontalo, Indonesia. A. Bolihutuo Village; B. Tanah Putih Village; C. Biluhu Barat Village; D. Longalo Village; E. Pinogu Village

Features of leaves

The number of leaves: a single maize plant's entire leaf count was determined. The measurement was taken following the blooming of the plant's blossoms. On top of the top cob: the number of leaves was counted, including those at the cob. At least 20 plants on average were used for the measurement. Length of leaves: measured from the leaf node to the leaf tip. If the plant had more than one cob, the leaves that were measured were on top of the top cob. The width of the leaves was measured at the same location as the length of the leaves. The leaf's length was measured from its center to determine its width. Shape of leaf tips: the following criteria were used to observe the shape of the leaf tips: i) rounded; ii) acute (45^o-90^o); iii) acuminate (less than 45^o); iv) truncate. If the plant has more than one cob, the angle between the leaf blade and stem is measured using the following parameters, starting with the axillary bud location at the leaves on top of the top cob: Very small ≤5^o; small ±25^o; moderate 50^o; large 75^o; and very large >90^o. The number of leaf bones divided by the number of leaves is the index of leaf bones (Budiarti et al. 2004; Ahmad et al. 2021).

Features of seeds and blooms

Panicle length is determined by measuring from the spike tip to the center point where the bottom panicle branch protrudes. Following anthesis, the plant was in the close-to-ripeness phase when the measurement was taken. The distance between the lowest panicle branch and the top node beneath the flag leaf indicates the flower stalk's length (in centimeters). The measurement was taken after anthesis, or when the plants were almost ripe. The distance (in centimeters) between the initial panicle branch and the tip of the male flower stalk was measured. When at least half of the plants are fully blooming, the male blossoming age is determined. When at least 50% of the plants have shed silk on their cobs, the female's blossoming age is determined. If there are more than one cob in the maize, the color of the stems is seen on the stems that are situated between the top two cobs. The plants were in full bloom when the observation was made. When panicle branches are present, the type of panicle is identified using the following criteria: Primary, primary-secondary, and primary-secondary-tertiary are the three categories. The length of the cobs to the ends is used to compute the cob length (in centimeters). Measurements were taken on huskless maize. The cobs' diameter (in centimeters) is determined at their center. After the corn has been dried, the weight of the cobs with husks is used to compute the weight of the cobs with weight (kg/cobs). The following criteria were used to express up to three different sorts of seeds based on frequency: i) flour; ii) semi-flour with an outer layer of hard endosperm; iii) horse tooth shape; iv) semi-horse tooth shape, which is slightly different from a pearl but more akin to one; v) semi-pearl, which has a soft tip; vi) pearls; vii) popcorn; viii) sweet corn; ix) Opaque 2 (QPM); x) sticky rice; xi) corn pod. Using the following criteria, seed color is represented for up to three different types of seeds based on their frequency: White, yellow, purple, varied colors, chocolate, orange, striped, white tip, and red are some examples. Number of seeds per row was calculated using the amount of seeds per row. Weight per 1000 kernels (grammes): 1000 kernels' weight was calculated by converting their dry weight to a 10% water content (Budiarti et al. 2004; Ahmad et al. 2021).

Analysis of the nutritional value of corn flour was carried out in the testing laboratory of the center for the application of post-harvest agricultural instrument standards using the following method.

Water content

Using the assumption that weight loss during heating at 105°C was considered to be the water content contained in the sample, the water content was calculated gravimetrically in accordance with SNI 01-2891-1992 (National Standardization Agency 1992). One to two grammes of the sample were weighed and then oven-dried for three hours at 105°C. A desiccator was then used to cool the sample, and it was weighed until it reached a consistent weight.

$$\text{Water content} = \frac{(w + w1) - w2}{w1}\ x\ 100\%$$

Where,
w : Empty container weight (g)
w_1 : Sample weight before heating (g)
w_2 : Container and sample constant weight after heating (g)

Total ash content

Based on the idea that organic materials were broken down into water and CO_2 during the ashing process while inorganic materials were not, the total ash content was calculated gravimetrically in accordance with SNI 01-2891-1992 (National Standardization Agency 1992). 2-3 gr of the material were weighed and placed in a porcelain cup. A furnace set to 550°C was used for the ashing process, which lasted for four hours until the smoke and ashing were totally gone. Following that, a desiccator was used to cool the sample, and it was weighed until a consistent weight was achieved.

$$\text{Ash content} = \frac{w1 - w2}{w}\ x\ 100\%$$

Where:
w : Sample weight before ashing process (g)
w_1 : Porcelain cup and sample weight after ashing process (g)
w_2 : Empty porcelain cup weight (g)

Protein content

Protein content was measured using titrimetric analysis (SIG 2021b). This method was based on the idea that nitrogen compounds were broken down into ammonium sulphate by concentrated sulphuric acid, which was then broken down by sodium hydroxide. The ammonia that was released was then bound with boric acid and titrated with a standard acid solution. A 300 mL Kjeldahl tube was filled with 1 g of a selenium combination and 12 mL of concentrated sulphuric acid after a total of 1±0.1 g of sample had been weighed. The Kjeldahl tube holding the sample was kept inside the Kjeldahl digester device after it had been heated to 420°C. After turning on the scrubber unit, digestion was done for an hour at 420°C. The tube rack was then taken out, the Kjeldahl digester tool was switched off, and it was allowed to cool to room temperature. 50 mL of distilled water and 50 mL of 40% sodium hydroxide were roughly added to the Kjeldahl tube holding the digestion sample after it had been placed in the distillation machine. The distillation unit was equipped with a 250 mL Erlenmeyer flask that held 25 mL of 4% boric acid as a reservoir. The distillation process was continued until the volume of the distillate reached three times the initial volume of the container, or until the distillation time was set at four minutes. The container's hue turned from red to green during the distillation process. A solution of 0.2 N hydrochloric acid was used to titrate the distillate until the color transitioned from green to red. The process was repeated for the blank at each digestion cycle.

$$\text{Protein content} = \frac{(V1 - V2)\ x\ N\ x\ 1.4007\ x\ fk}{w}\ x\ 100\%$$

Where,
w : Sample weight (g)
V1 : 0.2 N HCl volume for sample titration (mL)
V2 : 0.2 N HCl volume for blank titration (mL)
N : 0.2 N HCl normality
fk : Conversion factor for food protein (6.25)

Fat content

After the sample hydrolyzed in an acidic environment, the fat content was measured gravimetrically (SIG 2021c) using the Weibull hydrolysis method, which is based on the idea of free fat extraction using nonpolar solvents. A solid sample weighing 1±0.1 g was put into a beaker after being weighed. Following that, distilled water, a 25% hydrochloric acid solution, and multiple boiling stones were added. After boiling the beaker on a hot plate for fifteen minutes with a cover glass, the residue was filtered through ash filter paper and cleaned with hot distilled water. After being oven-dried for one hour at 105°C, the residue was placed into cotton-plugged filter paper sleeves (hulls). The hulls were dried and weighed after being placed within a Sokhlet apparatus that was attached to a 300 mL boiling flask filled with boiling stones. Hexane was then poured until all the Sokhlet's hulls were buried and the boiling flask's capacity was half. After combining the Sokhlet apparatus with a water bath and condenser, extraction was done for three hours. The fat residue was then oven-dried at 105°C after the hexane was distilled. After using a desiccator to bring the boiling flask containing the fat residue down to room temperature, it was weighed until a consistent weight was achieved.

$$\text{Fat content} = \frac{w - w1}{w}\ x\ 100\%$$

Where,
w : Boiling flask and sample constant weight after heating (g)
w_1 : Empty boiling flask weight (g)
w_2 : Sample weight (g)

Carbohydrate content

Carbohydrate content was determined by difference calculation (SIG 2021d) as follows:

Total carbohydrate = 100% - (% protein + % fat + % water + % ash + % alcohol)

Mineral

Mineral Calcium (Ca), Iron (Fe), Magnesium (Mg), Sodium (Na), Zinc (Zn), Phosphorus (P), and Potassium (K) were analyzed using ICP-OES (SIG 2020). A total of 0.5 to 1 g of sample was placed into the vessel and added with 10 mL of pure nitric acid. The vessel was closed and put into microwave digestion. The digestion product was put into a 50 mL volumetric flask, supplemented with 0.5 mL of internal standard yttrium 100 mg/L, diluted using distilled water until tera mark, and then homogenized. Filter paper was used to filter the solution, and the ICP-OES apparatus was used to measure the sample.

Data analysis

A descriptive analysis was conducted to assess the nutritional value of six indigenous maize varieties, while the data regarding morphological traits were outlined based on the visual characteristics of each plant organ observed in the field; afterward, the plant was evaluated using the descriptor guidelines.

RESULTS AND DISCUSSION

Morphological traits of the indigenous maize variety

According to the study's findings, the local variety of maize plants exhibits the following morphological traits, which are displayed in Table 2. Cobs maize and seeds are shown in Figure 2. Maize from Gorontalo has a plant height of 115-195 cm. The stem diameter ranges from 5.3-6.5 cm, the number of leaves is 11-15 strands. The distance between the appearance of male and female flowers is 2-3 days. The longest maize cobs are found in *siropu*, and the shortest maize cobs are found in *kiki*. The type of seeds mostly has the Pearl type, while the color of the seeds varies, some are orange, orange red tip, maroon red, white and clear white. The color of the maize cobs is mostly white. But there is also corn with brownish red cobs, such as *siropu* corn. Differences in the morphological characteristics of maize are thought to be due to differences in varieties, soil and environmental factors, maturity stage, morphology, and genetic factors (Ndukwe et al. 2015; Vaswani et al. 2016). Local corn has several superior properties, namely being able to adapt well to planting land. Local corn is early maturing, tolerant to drought, tolerant to pest attacks, and has a distinctive taste according to the tastes of the local community (Kandowangko 2019; Wawo et al. 2019; Latif et al. 2023).

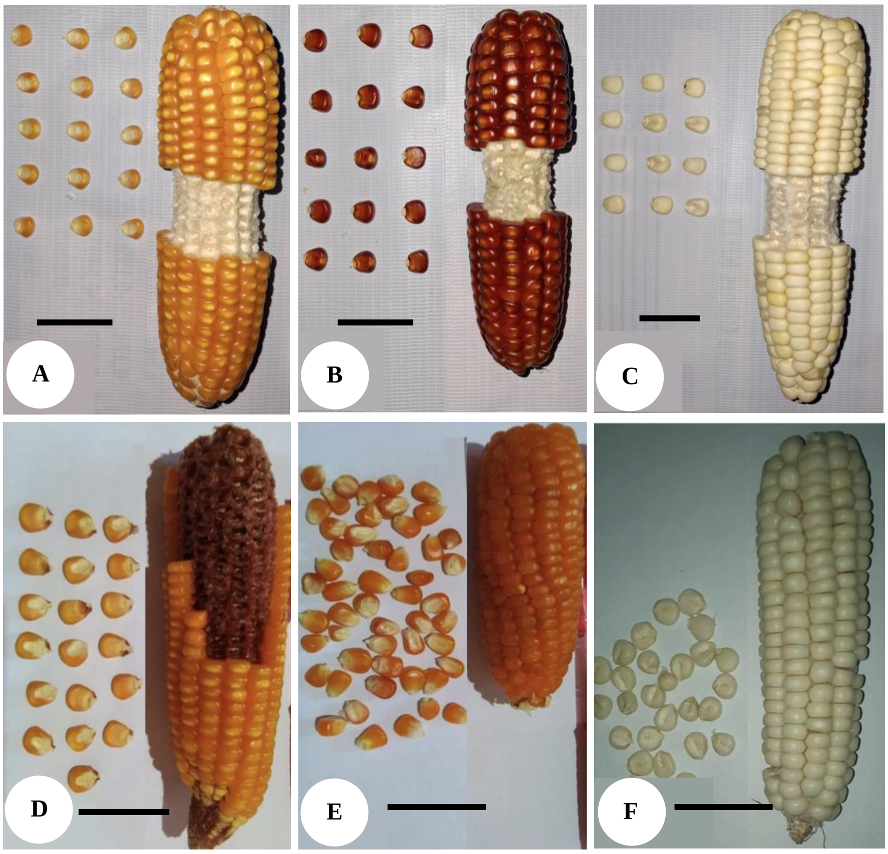

Figure 2. A. Maize variety *binthe doti*; B. Maize variety *binthe momala*; C. Maize variety *binthe pulo*; D. Maize variety *binthe siropu*; E. Maize variety *binthe kiki*; F. Maize variety *binthe damahu*. Bar = 3 cm

Table 2. Morphological characteristics of local maize variety

Parameters	Average					
	Doti	Kiki	Siropu	Momala	Pulo	Damahu
Habitus						
Plant height (cm)	144±5.44	161±4.60	115±3.13	140±1.414	195±3.44	140±2.40
The location of the top cob (cm)	52.2± 3.05	119±4.56	75±3.70	80±2.828	66±4.40	65±2.15
The ratio of the height of the top cob to the plant height	144±5.44 / 52.2±3.05	161±4.60 / 119±4.56	115±3.13 / 75±3.70	140±1.414 / 80±2.828	195±3.44 / 66±4.40	140±2.40 / 65±2.15
Stem						
Stem circumference (cm)	5.7±0.89	6.35±0.54	6.5±0.44	6.3±0.471	5.3±0.640	5.9±0.569
Stem color	Brown and slightly green near the stem internodes	green and slightly brownish near the stem segment	Green and purplish near stem internodes	Green and slightly purplish	Green and purplish near stem internodes	Green
Leaves						
Number of leaves (plant)	11±0.44	12±1.41	14±1.41	15±1.41	12±1.47	11±1.414
Blade length (cm)	74.05±1.37	71.12±2.76	81±4.5	83.39±2.41	83.7±1.50	75±2.828
Leaf width (cm)	6.1±0.23	5.21±0.41	7.4±0.51	7.8±0.23	6.6±0.58	6.5±0.141
Leaf bone index	14±0.30	16±1.53	16±1.67	16±1.21	14±0.71	15±1.414
Leaf tip shape	Round	Pointed	Pointed to round	Pointed to round	Round	Pointed
The direction of the leaf blade	Slightly curved	Slightly curved	Curved	Slightly curved	Slightly	Slightly curved
The angle between the leaf blade and the stem	Currently (±50°)	Relatively small (±25°)	Relatively small (±18.3 °)	Relatively small (±18.3 °)	Currently (±50°)	Relatively small (±18.3°)
Flowers						
Long panicles (cm)	31.8±1.47	26.3±1.08	28±2.75	30±4.050	25.65±1.274	27±1.67
The length of the male flower stalk (cm)	8.4±0.271	33.5±2.36	25±1.26	27±1.855	5.1±0.754	15±2.76
Distance between panicle branches (cm)	9.4±0.66	8.5±0.39	10±1.63	12±1.414	14.20±0.885	10±2.24
Male flowers bloom (DAP)	39±1.41	51±4.24	50±3.89	53±2.449	46±3.347	73±1.897
Female flowers bloom (DAP)	44±2.28	53±3.28	53±3.34	56±1.897	48±2.757	76±5.56
Length of cobs (cm)	15±1.58	8.4±0.54	19±1.41	15.05±1.414	17±1.401	13.5±1.001
Diameter of cobs (cm)	4.2±0.23	2.74±0.32	4.5±0.34	4.0±0.626	3.0±0.400	3.3±0.486
The type of panicles	Primary	Primary-secondary	Primary-secondary	Primary-secondary	Primary	Primary-secondary
Weight of cob (kg/cob)	0.125±0.010	0.060±0.012	0.208±0.02	0.145±0.011	0.107±0.005	0.100±0.015
Weight of husk-less cob (kg/cob)	0.118±0.021	0.054±0.018	0.198±0.014	0.136±0.008	0.099±0.032	0.094±0.013
Corn cob hair color	Red	has a very strong anthocyanin coloring	yellow	Reddish brown	white	white
Seed						
Type of seed	Pearl-type	Pearl-type	dent	Semi-dent	Pearl type	Semi dent
Color of seed	Orange	Orange	Orange red tip	Marron red	white	Clear white
Number of seeds per row (seed)	30±2.68	24±1.624	42±2.60	28±1.414	36±1.356	30±2.608
Number of seed rows per cob (row)	14±2.09	16±2.059	13±0.89	11±1.42	12±1.744	10±1.702
1000 grain weight (g/plant)	310±5.84	145±2.607	290±3.286	320±4.472	210±4.665	240±3.847

The main advantages of local Gorontalo corn varieties are that they are easily adaptable, resistant to drought, resistant to downy mildew, have an early maturity, have a unique and distinctive taste, and contain high levels of amylopectin (Genesiska et al. 2020). Quantitative characters of plant age, plant height, tasseling age, silking age of local corn plants vary (Table 2). This aligns with the findings of Sa'adah et al. (2022), quantitative characters of plant height have heterogeneous diversity while tasseling age, silking age and sweetness level have homogeneous diversity. According to the information presented in Table 2, the period for the appearance of male and female flowers varies between 2 to 3 days. This brief period for the emergence of male and female flowers enhances the likelihood of comprehensive and effective pollination, thereby potentially leading to ears filled with seeds and maximizing harvest outcomes (Subaedah et al. 2018).

Plant height data, cob position and the ratio between cob position and plant height in Table 2, also affect the lodging and corn seed yield of corn plants. These findings align with the research conducted by Fiddin et al. (2018), that plant height greatly affects plant lodging and has an impact on seed yield, the higher the plant, the more prone to lodging. In addition to plant height, cob height, cob ratio, stem diameter and number of segments above the cob are each related to stem resistance to plant lodging (Huang et al. 2017; Xue et al. 2017; Wang et al. 2020).

In addition, the data in Table 2 shows the leaf area and leaf vein index and the lowest dry weight of 1000 g/plant found in *kiki* corn. Its weight is only 145 g/plant. Based on the data listed in Table 1, the growing environment of *kiki* corn has a low pH, low air humidity, and relatively high temperature. Environmental conditions also affect plant growth. This is in line with the results of research from Yasin et al. (2024), Drought stress in plants can significantly reduce plant height (13%), leaf area (5%), and corn stalk diameter (13%), compared to control. Kiki corn plants are local corn varieties that are resistant to drought (Ahmad et al. 2021).

Information on morphological and molecular characterization is important as an initial stage in assembling superior varieties that are early maturing, highly productive, and resistant to drought stress (Badu-Apraku and Fakorede 2017; Amzeri et al. 2022). Investigating the genetics of complex traits typically necessitates a genetic population exhibiting a range of phenotypes. This involves obtaining various genetic samples from multiple geographic areas (Li et al. 2020).

Nutritional values of local maize variety

The nutritional value of local maize Gorontalo is listed in Table 3. The research results show that the nutritional content of maize varies as well. Water content of local maize seeds ranges from 6.69-15.69%. Ash content ranges from 0.92-2.48%; Fat content (%) ranges from 2.85% in *damahu* and the highest in *momala* 5.09%. Protein content (%) ranges from 8.82-12.53%, the lowest in *damahu* corn and the highest in *kiki* corn (12.53%); Carbohydrate ranges from 71.22-77.22; Amylosa (%) ranges from 7.46-22.00%, the highest in *binthe kiki* corn and the lowest in *pulo* corn. Reduction sugar (%) ranges from 0.54-1.92%, the highest in *damahu* and the lowest in *momala.*

The results of this research are in line with those reported by Sinay and Harijati (2021), who analyzed 7 (seven) local corn varieties originating from Kisar Island, Maluku with the following proximate content: water content ranging from 10.39-14.02%; ash content ranging from 1.13-2.04%, Fat ranging from 3.47-5.10%; Protein ranging from 9.14-13.02%; Total sugar ranging from 58.66-68.7% and total carbohydrates ranging from 69.7-75.74%.

The nutritional value of corn listed in Table 3 is almost similar to the data from corn research in the area around Gorontalo. The nutritional value of corn flour from Uedele Village, Tojo Una-Una Regency, Central Sulawesi, is 17.02% water content, 4.21% ash content, 10.57% crude protein, 2.41% crude fiber and 4.60% crude fat (Lapui et al. 2021). The protein and fat values of this corn flour are higher than *siropu* corn (8.54% protein and 3.45% fat) and *damahu* (8.82% protein and 2.85% fat), but the nutritional value is almost the same as *pulo* corn (10.24% protein and 4.72% fat).

Furthermore, when compared with the nutritional composition of corn originating from North Sulawesi, Manado, Indonesia, yellow corn variety has a water content of 11.04%, ash content of 1.84%, crude protein content of 10.24%, crude fat content of 6.44%, carbohydrates of 69.27% (Laluyan et al. 2017). The water content value of 11.04% is smaller than the water content of *doti* corn, *pulo* corn and *siropu* corn, but higher than the water content of *kiki* corn, *momala* corn and *damahu* corn. On the other hand, the ash content of 1.84% is greater when compared to the five local corn varieties found in Gorontalo, except for the ash content of *kiki* corn. The protein content of 10.24% is the same as the protein value of *pulo* corn, this value is smaller than *kiki* corn, but greater than the protein value of *doti, siropu* and *damahu* corn. On the other hand, the Fat content is 6.44%, this value is higher than the six local corn varieties in Gorontalo, which only have a fat content ranging from 2.85-5.09%. Furthermore, the carbohydrate content of yellow Manado corn is 69.27%, this value is lower than the carbohydrate content found in the six local corn varieties of Gorontalo, which range from 71.07%-75.19%.

Next is the comparison of nutritional value with local corn from Moa Island, Southwest Maluku District, Indonesia, which has red corn, yellow corn, and white corn. The corn flour has the following nutritional value: water content ranges from 5.38-6.01%, ash content ranges from 0.26-0.44%, fat content ranges from 0.39-0.43%, protein content ranges from 8.01-8.39%, carbohydrate content ranges from 84.92-86.36%, and fiber content ranges from 8.56-9.36% (Augustyn et al. 2019). Interestingly, the carbohydrates are about 15 points higher when compared to the carbohydrate value of local Gorontalo corn. However, the protein and fat content are lower. On the other hand, the protein content of local Gorontalo corn, which ranges from 8.82 to 12.53% (Table 3), is higher when compared to the BH-546 variety of corn grown in Ethiopia. The crude protein content of the BH-546 variety of corn is 5.02%, in monoculture cultivation and in intercropping cultivation it has a crude protein content of 6.28% (Kussie et al. 2024).

Maize consists of about 73% starch, 10% protein, and 5% oil, with the rest made up of fiber, vitamins, and various macronutrients and micronutrients. The differences in composition are influenced by the genetic characteristics of the maize endosperm, the parent plant, and environmental factors. There is considerable genetic variety in maize, featuring types like white, yellow, sweet, popcorn, blue, waxy, and quality protein corn. This genetic diversity is crucial for cultivating high-quality corn varieties that can thrive in different environmental conditions and fulfill specific nutritional requirements, thereby supporting sustainable food production (Serna-Saldívar and Pérez-Carrillo 2018).

Maize-based products can address a variety of health issues due to their nutritional content. These products act as analgesics, astringents, antiallergics, and emollients, and are useful in treating skin rashes and sore throats. They also have antianginal and antihypertensive properties and can aid in managing gallbladder disease, prevent the formation of kidney stones, provide antidiarrheal effects, and assist with urinary tract conditions such as dysuria, cystitis, urethritis, and nocturnal enuresis, among others. Additionally, maize is a rich source of vitamins A, B, and E, as well as numerous minerals. Studies have indicated its potential to lower blood pressure and reduce the risk of neural tube defects during childbirth (Huma et al. 2019). The findings of the current research strongly support the traditional use of Corn Steep Liquor (CSL) extract from *Curculigo pilosa* as an antidiabetic treatment. Both the extract and its butanol fraction have demonstrated hypoglycemic effects, corrected abnormal lipid profiles, and some markers of organ damage in the serum. Furthermore, they also mitigated the oxidative stress in liver tissue caused by hyperglycemia (Karigidi and Olaiya 2020). These results are similar to the results of corn research in Italy, where the nutrition of *nostrano* variety corn has a protein content of 11.42% and a fat content of 5%, *marano* variety corn has 13.67% protein; 4.75% fat, *dorotea* variety corn has a protein content of 12.56%; 4.47% fat, *spin* variety corn has 10.63% protein; 3.48% fat (Pedrotti et al. 2024).

Humans require minerals, which are inorganic nutrients, in modest amounts (between 1 and 2500 mg daily). One macro-mineral that is abundant in maize is calcium (Vaswani et al. 2016). Macro minerals are needed by the body in amounts of more than 100 mg/dL. Calcium plays an important role in the formation of Calcium is crucial for the development of bones, teeth, regulation of the nervous and muscle systems, activating enzyme activity and playing a role in the blood coagulation process. Calcium contained in food will be absorbed by the duodenum and the amount of calcium absorbed depends on the food source, intestinal pH, calcium phosphorus ratio, and vitamin D and fat.

The maize of *pulo* variety has a Ca content with a value of 1.03 times higher than the *momala* variety and 1.06 times higher than the *kiki* variety. The Ca content of the *momala* variety of maize in the results of this study was higher than the *momala* taken from Biluhu village. The Ca content of the *momala* taken from Biluhu village, Gorontalo was 0.046±0.0071 ppm (Kandowangko et al. 2020).

In addition, the Ca content in the 3 maize varieties from the study was also higher than the maize varieties grown in Nigeria (Ndukwe et al. 2015) and the *Pena Tunu'ana'* maize variety (Murningsih et al. 2019). The calcium content of maize varieties grown in Nigeria ranged from 163.77±0.03-180.68±0.24 mg/g (Ndukwe et al. 2015). It is believed that variations in varieties, soil and environmental conditions, maturity stages, morphology, and genetic variables are the causes of the variation in calcium content observed in local Gorontalo maize. This is consistent with the findings of Vaswani et al.'s (2016) study.

According to the study's findings, of the two native kinds of maize grown in Gorontalo and East Nusa Tenggara, the *momala* type had the highest Mg concentration. Furthermore, compared to maize cultivated in Cuba and Norway, *momala* has a higher Mg concentration (Ndukwe et al. 2015; Cruz et al. 2017). It is believed that both genetic and soil nutritional factors contribute to the variation in Mg levels among local Gorontalo maize types.

Local maize variety *kiki* has a Zn content of 1.26 times higher than *momala* and 1.48 times higher than corn variety *pulo*. The Zn content in local maize variety *momala* Gorontalo from this study is higher than *momala* tested by Kandowangko et al. (2020), which is 0.005 ppm. Qamar (2017) explained that white maize has a Zn content of 6.1-6.4 ppm and yellow maize contains 33.69 ppm Zn. Vaswani et al. (2016), stated that the Zn content in maize varieties with normal protein quality and high protein, has a varying Zn content, ranging from 27.12-58.20 ppm.

The Zn content of corn from several varieties and different regions is presented in Table 3. The different Zn content in maize is thought to be due to environmental factors such as soil mineral content, genetics, and topographic variations (Vaswani et al. 2016; Qamar et al. 2017). The results of this study also show that local maize varieties *momala*, *pulo*, and *kiki* grown in Gorontalo have high Zn content. The high Zn content in local maize grown in Gorontalo can be utilized to meet the micro mineral needs of the community. The community can benefit from knowing the nutritional content of local maize, which can also serve as a dietetics guide.

Table 3. Analysis result of nutritional value of seed maize powder

Parameter	Method	Maize flour					
		Doti	Kiki	Siropu	Momala	Pulo	Damahu
Water content (%)	Gravimetic	12.08± 0.071	7.60±0.14	15.69±0.26	7.91±0.11	12.45±0.21	9.80±0.18
Ash content (%)	Gravimetic	1.13±0.035	2.48±0.16	1.07±0.07	0.92±0.07	1.52±0.23	1.18±0.11
Fat content (%)	Soxhlet	4.22±0.042	4.24±0.08	3.45±0.14	5.09±0.09	4.72±0.25	2.85±0.21
Protein content (%)	Kjeldahl	9.29±0.092	12.53±0.11	8.54±0.12	10.89±0.15	10.24±0.14	8.82±0.17
Carbohydrate (%)	By Different	73.28± 0.106	73.15±0.07	71.25±0.07	75.19±0.11	71.07±0.13	77.32±0.14
Reduction sugar (%)	Titrasi	1.09±0.092	1.85±0.08	1.82±0.04	0.54±0.07	1.64±0.11	1.92±0.06
Amylose (%)	SNI 6128: 201	16.88±0.170	22.00±0.14	19.40±0.08	21.47±0.11	8.63±0.18	20.06±0.08
Total sugar (%)	Titrasi	2.77±0.148	3.37±0.16	4.85±0.07	0.87±0.12	3.46±0.14	4.39±0.29
Mineral							
Zn (ppm)	AAS	17.03±0.106	46.89±0.15	17.62±0.10	36.69±0.18	31.36±0.14	20.79±0.20
Cu (ppm)	AAS	1.04±0.064	2.36±0.11	2.11±0.06	3.07±0.07	3.85±0.21	1.07±0.07
Ca (ppm)	AAS	32.94±0.120	2.666.44±0.19	36.65±0.25	2.764.03±0.16	38.50±0.23	59.23±0.22
Mg (ppm)	AAS	494.16±0.106	1.087.73±0.24	475.36±0.16	1.034.66±0.17	505.64±0.20	690.84±0.08
K (ppm)	AAS	1.892.10±0.099	15.684.09±0.13	2.531.80±0.11	13.628.78±0.14	2.289.07±0.28	4.052.46±0.20

Minerals are needed by plants, animals, and humans to regulate various functions in the body, namely forming structural components such as skeletons, acting as enzyme cofactors, and as components of organic compounds. Calcium (Ca), Magnesium (Mg), Potassium (K) are macro-minerals found in large quantities in plants. Zinc (Zn) and Copper (Cu) are found in relatively small amounts, so they are called microminerals. These minerals are obtained from food including from plants. Minerals are also nutrients that are associated with several health problems such as malnutrition and the presence of malnutrition will cause several metabolic diseases (Ndukwe et al. 2015; Solang and Andriani 2021).

In conclusion, the study has shown that local corn originating from Gorontalo shows significant diversity in plant growth characteristics and nutritional content of corn kernels. The existence of local corn that is rich in nutrients needs to be preserved, so that it can support the development of food products to meet human nutritional needs.

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