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MINERAL CONTENTS OF FIVE MANGO (*MANGIFERA INDICA* L.) VARIETIES GROWN IN SENEGAL: EFFECTS OF VARIETY AND FRUIT POSITION IN THE TREE CANOPY

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ABSTRACT

Minerals contribute to the nutritional value of mango, but their contents vary from one variety to another. This study compares the calcium, magnesium, sodium and potassium contents of five mango varieties grown in Senegal (Sierra Leone, Boukodiékhal, Diourrou, Kent and Keitt), harvested at three positions in the tree canopy (bottom, intermediate and top). As normality was rejected for all four minerals (Shapiro-Wilk test, $p < 0.05$), the data were analysed with non-parametric tests (Kruskal-Wallis test and pairwise Wilcoxon tests with Holm adjustment). Variety had a significant effect on all four minerals (calcium: $p = 0.028$; magnesium: $p = 0.0026$; sodium: $p = 0.0058$; potassium: $p = 0.0066$), whereas harvest position had no significant overall effect ($p = 0.53–0.80$). The combined variety × position effect (15 groups) was significant for magnesium ($p = 0.049$) and potassium ($p = 0.032$). Keitt had the lowest contents of all four minerals and differed significantly from Boukodiékhal and Diourrou (adjusted $p = 0.022$). The highest medians were found in Boukodiékhal (magnesium, potassium) and Diourrou (calcium, sodium). These results show that varietal choice is a major determinant of the mineral supply provided by Senegalese mangoes.

KEYWORDS: *Mangifera indica*, minerals, varieties, harvest position, Senegal.

INTRODUCTION

Mango (*Mangifera indica* L.) is one of the main tropical fruits grown in West Africa. Beyond its sugars, vitamins and phenolic compounds, the pulp supplies minerals whose contents depend on variety, production area, climatic conditions and ripening stage.[1,2]

Potassium and sodium are involved in fluid–electrolyte balance and blood pressure regulation,[3] while calcium[4] and magnesium contribute to bone mineralisation and to numerous enzymatic functions. The mineral content of a fruit results from sap fluxes towards the fruit during its growth: calcium, which has low phloem mobility, is mainly delivered through the xylem, whereas potassium and magnesium are more mobile.[5-7] In mango, the fruit load relative to foliage influences fruit mineral contents,[8] suggesting that fruits from the same tree located at different positions in the canopy may differ in composition.

Data comparing several varieties grown in Senegal while accounting for fruit position in the tree remain scarce. The aim of this study was to compare the Ca^{2+}, Mg^{2+}, Na^{+} and K^{+} contents of five Senegalese mango varieties and to assess the effect of harvest position on these contents.

MATERIALS AND METHODS

Plant material

Five mango varieties grown in Senegal were studied. They are identified in the dataset by the codes SL (Sierra Leone), BK (Boukodiékhal), Dr (Diourrou), Knt (Kent) and Kt (Keitt) (Fig. 1). For each variety, fruits were harvested at three positions in the tree: bottom, intermediate and top, giving 15 variety × position combinations. Fresh fruits of Kt, Knt, Dr and SL were harvested at Kaguitte (Ziguinchor region) and those of BK at Keur Mbir Ndao (Thiès region, Niayes zone).



Fig. 1: Photograph of the five mango varieties studied: Kt, Knt, BK, SL and Dr.

Mineral determination

The mineral composition of each variety was determined as follows. Two grams of pulp were weighed and ashed at 550 °C for 4 h. The crucibles were then removed and cooled in a desiccator, 10 mL of 6 M HCl were added, and the mixture was evaporated before being made up to 100 mL in a volumetric flask. Iron, copper and zinc were determined with a HACH DR 2500 spectrophotometer, sodium by flame photometry and potassium with a Palintest photometer. Magnesium and calcium were quantified by volumetric titration.

For sodium, the calibration curve was (Equation 1):

$OD = 42.6x + 273.4;\ R^2 = 0.9941$ (1)

Ca^{2+}, Mg^{2+}, Na^{+} and K^{+} contents are expressed in mg/100 g.

Statistical analysis

Analyses were performed with R software.[9] For each mineral, descriptive statistics (mean, standard deviation, minimum and maximum) were computed for each variety × position combination. Normality was tested with the Shapiro-Wilk test.[10] As the distributions of all four minerals departed from normality, the effects of variety, position and their combination (a 15-level factor) were tested with the Kruskal-Wallis test.[11] A significant effect of the combined factor indicates that at least one of the 15 groups differs from the others, which reflects a possible interaction between the two factors. The three positions were also compared within each variety (Kruskal-Wallis test). Pairwise comparisons of varieties (10 pairs) were performed with the Wilcoxon rank-sum test,[12] with p-values adjusted by the Holm method.[13] The significance level was set at 5%.

RESULTS

Data distribution and overall tests

The distributions of all four minerals departed significantly from normality (Shapiro-Wilk, $p < 0.05$; Table 1), which justifies the use of non-parametric tests. Variety had a significant effect on the contents of all four minerals ($p = 0.0026–0.028$), whereas harvest position had no significant overall effect ($p = 0.53–0.80$). The combined variety × position factor was significant for Mg^{2+} ($p = 0.049$) and K^{+} ($p = 0.032$), and close to the threshold for Na^{+} ($p = 0.062$) and Ca^{2+} ($p = 0.074$).

Table 1: Normality of distributions (Shapiro-Wilk) and Kruskal-Wallis tests for the effects of variety, position and the combined variety × position factor. Values: statistic (p).

Sr. No.	Mineral	Shapiro-Wilk, W (p)	Variety, χ^2 (df = 4)	Position, χ^2 (df = 2)	Variety × position, χ^2 (df = 14)
1.	Ca^{2+}	0.882 (0.0032)	10.89 (0.028)	1.28 (0.527)	22.25 (0.074)
2.	Mg^{2+}	0.929 (0.0475)	16.36 (0.0026)	0.78 (0.678)	23.73 (0.049)
3.	Na^{+}	0.901 (0.0087)	14.53 (0.0058)	0.44 (0.804)	22.89 (0.062)
4.	K^{+}	0.918 (0.024)	14.23 (0.0066)	0.58 (0.747)	25.30 (0.032)

Source: R outputs of the analysis. p-values < 0.05: normality rejected (W column); significant effect (other columns).

Mean contents by variety and position, read from Fig. 2, 4, 6 and 8, are presented in Table 2. They varied widely among varieties and, for some of them, according to position (e.g. Ca^{2+} for SL, or K^{+} for Knt).

Table 2: Approximate mean mineral contents (mg/100 g) by variety and harvest position.

Sr. No.	Variety	Position	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}
1.	BK	Bottom	27	5.3	15.2	19.4
2.	BK	Intermediate	14	3.25	5.9	20.6
3.	BK	Top	23	3.9	10	24.5
4.	Dr	Bottom	30	4.65	11	18.8
5.	Dr	Intermediate	25	2.9	18.1	16.5
6.	Dr	Top	42	4.65	15.1	19.8
7.	Knt	Bottom	7	1.95	12	26.5
8.	Knt	Intermediate	39	2.8	8.7	19.5
9.	Knt	Top	15.5	0.7	0.95	6.1
10.	Kt	Bottom	1	0.4	0.45	0.6
11.	Kt	Intermediate	10	1.35	2.95	8.8
12.	Kt	Top	2	0.17	0.45	1.25
13.	SL	Bottom	38	2.9	7.5	7.8
14.	SL	Intermediate	1	0.3	0.45	1.1
15.	SL	Top	40	2.6	10	21.1

Values read from Fig. 2, 4, 6 and 8 (limited precision, about ±1 for Ca^{2+}, Na^{+} and K^{+}, and ±0.2 for Mg^{2+}).

Calcium

Variety had a significant effect on Ca^{2+} content (χ^2 = 10.89; p = 0.028), whereas the effect of position was not significant (p = 0.527). The highest medians were observed for varieties Dr (≈ 27.5 mg/100 g) and SL (≈ 26.5 mg/100 g), and the lowest for Kt (≈ 2 mg/100 g; Fig. 3). Dispersion was high for SL, Knt and Dr (Fig. 2). Pairwise comparisons showed that Kt differed from BK and Dr (adjusted p = 0.022; Table 4).

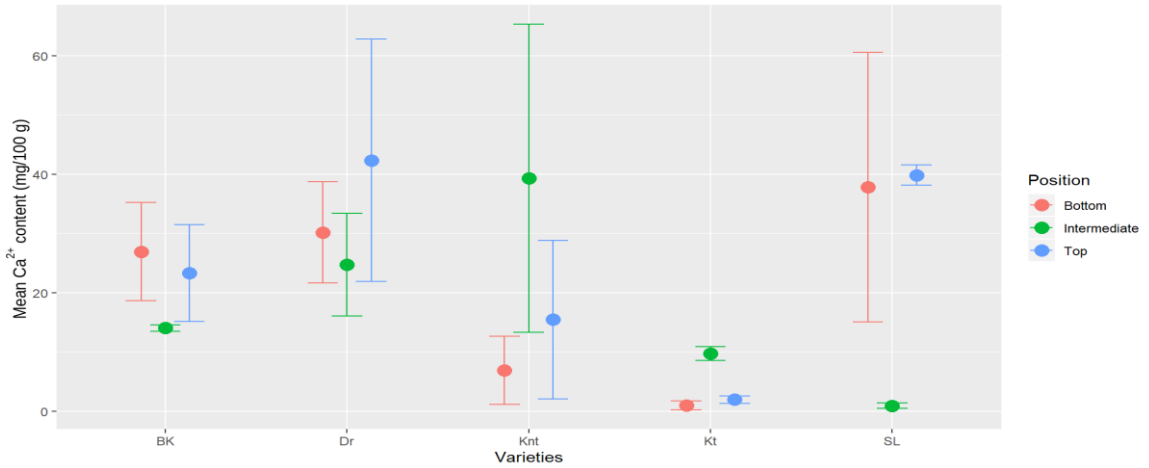


Fig. 2: Mean Ca^{2+} contents (mg/100 g) by variety and harvest position (points: means; bars: minimum and maximum values).

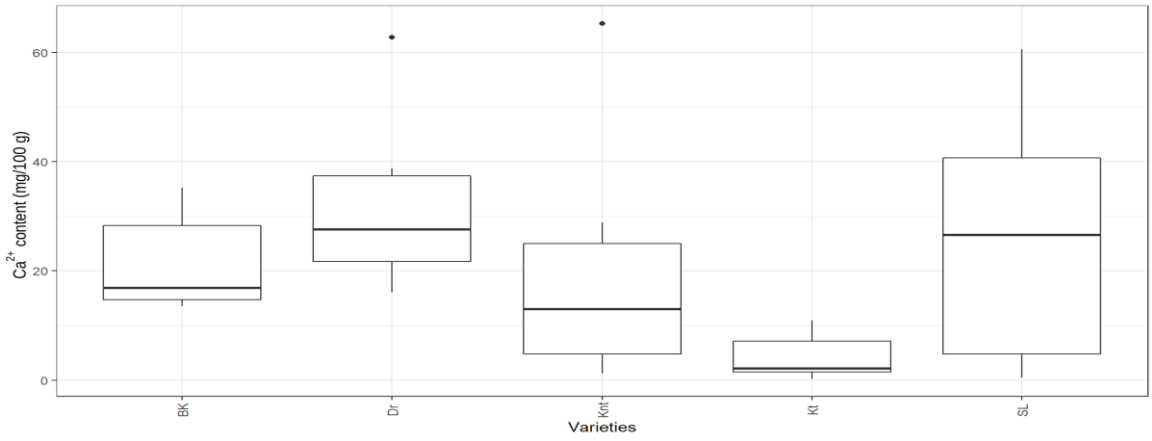


Fig. 3: Distribution of Ca^{2+} contents (mg/100 g) by variety, all positions pooled (box plots; thick line: median).

Magnesium

Variety strongly influenced Mg^{2+} content ($\chi^2 = 16.36$; $p = 0.0026$), whereas position had no overall effect ($p = 0.678$). The combined variety × position factor was significant ($p = 0.049$). BK and Dr had the highest medians (≈ 4 mg/100 g) and Kt the lowest (≈ 0.45 mg/100 g; Fig. 5). Kt differed from BK and Dr (adjusted $p = 0.022$); the difference between BK and Knt (unadjusted $p = 0.0087$) was no longer significant after adjustment (adjusted $p = 0.069$).

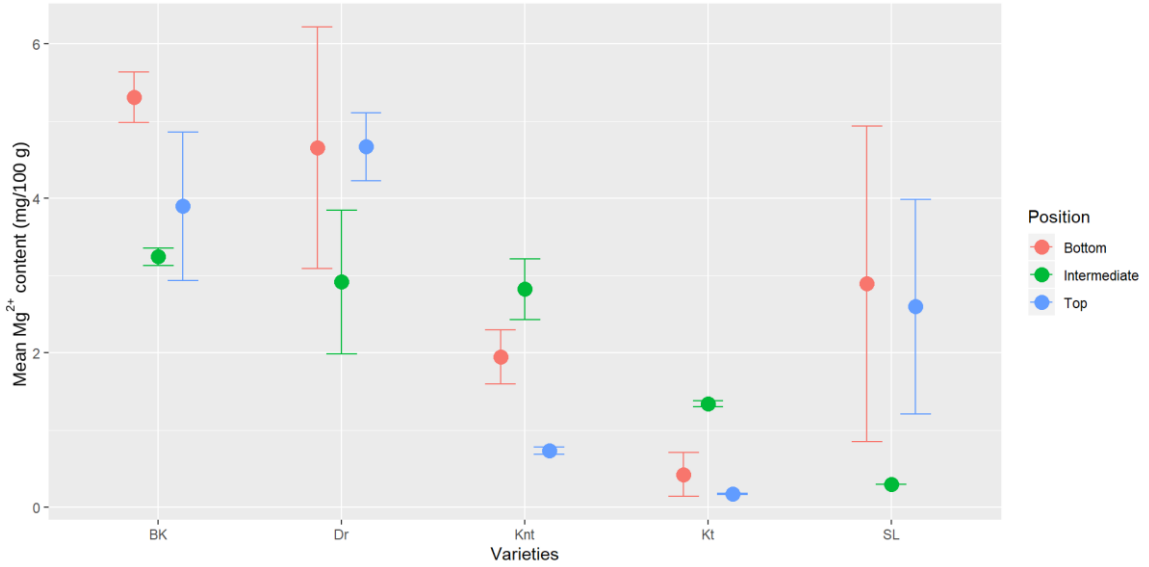


Fig. 4: Mean Mg^{2+} contents (mg/100 g) by variety and harvest position (points: means; bars: minimum and maximum values).

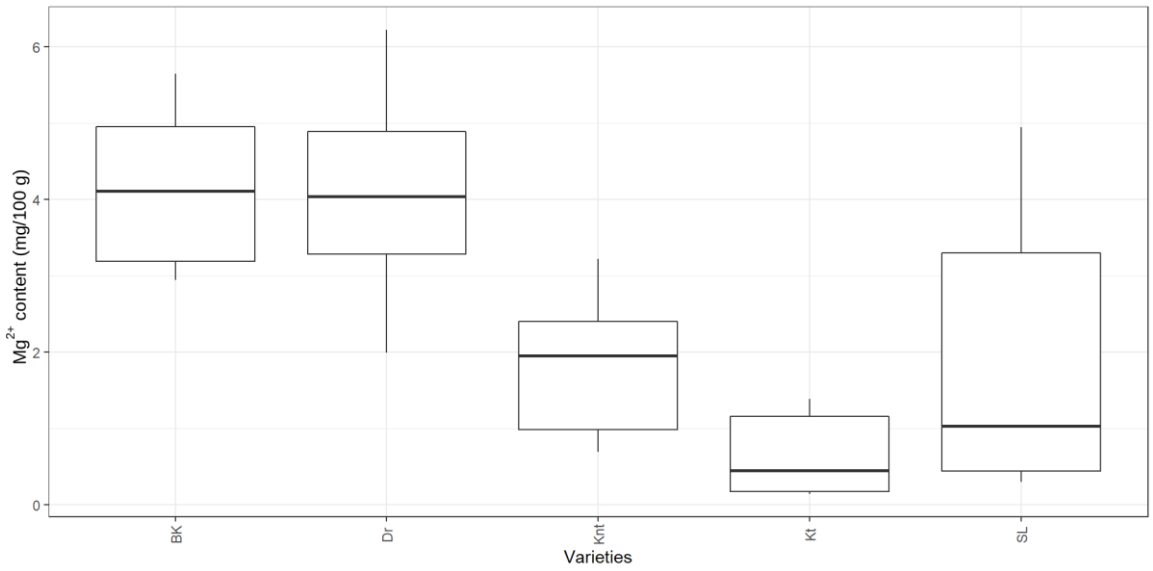


Fig. 5: Distribution of Mg^{2+} contents (mg/100 g) by variety, all positions pooled (box plots; thick line: median).

Sodium

Na^+ content depended on variety ($\chi^2 = 14.53$; $p = 0.0058$) but not on position ($p = 0.804$). Dr had the highest median (≈ 15 mg/100 g), followed by BK (≈ 9 mg/100 g), while Kt had the lowest (≈ 0.7 mg/100 g; Fig. 7). As for calcium, only the differences between Kt and BK and between Kt and Dr remained significant after adjustment ($p = 0.022$).

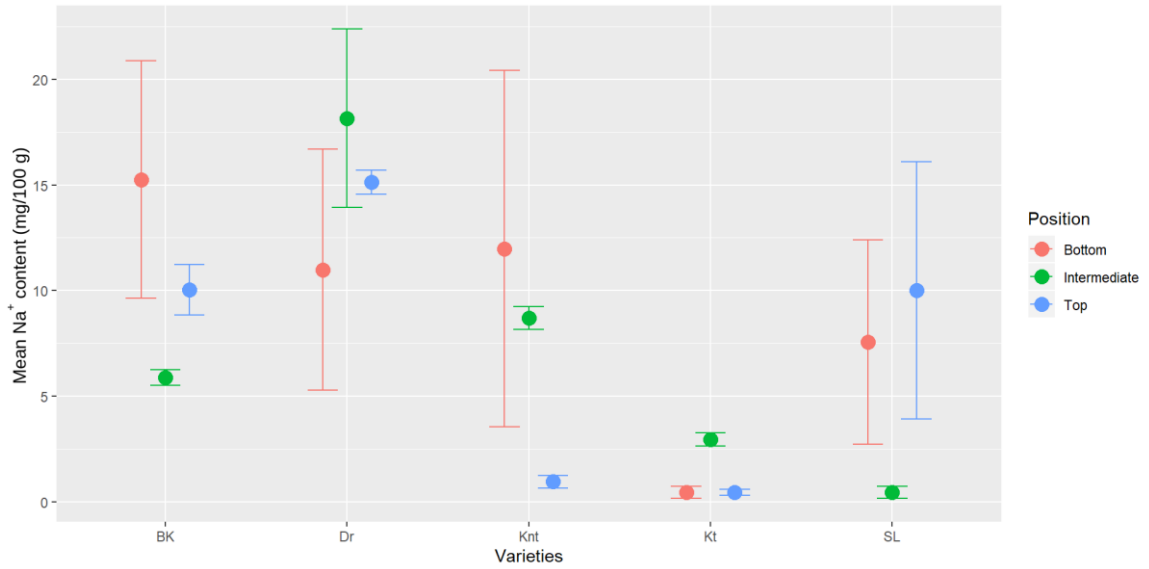


Fig. 6: Mean Na^+ contents (mg/100 g) by variety and harvest position (points: means; bars: minimum and maximum values).

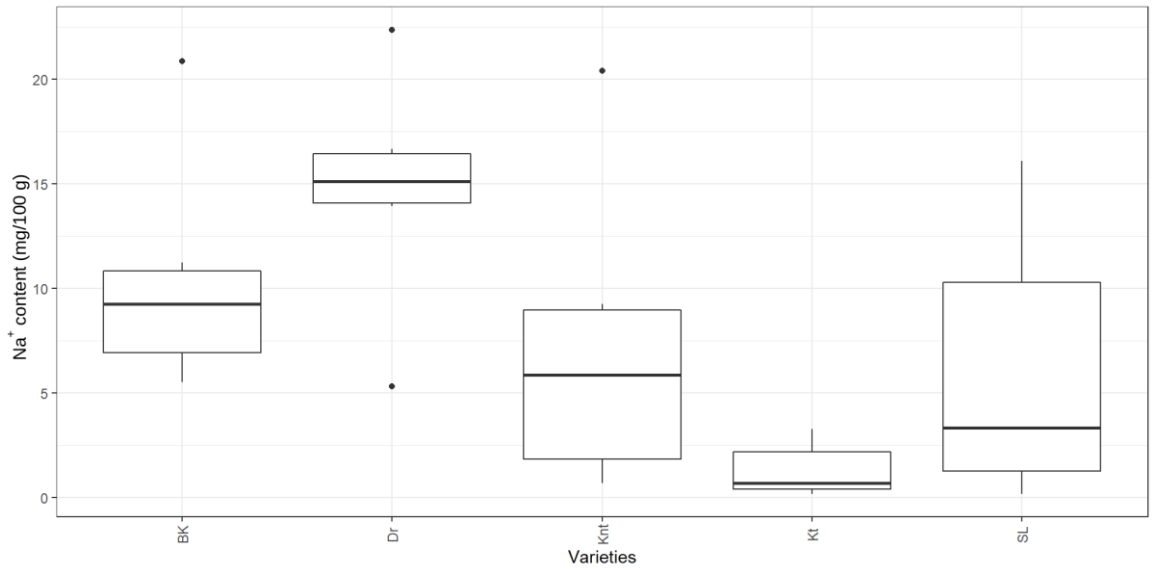


Fig. 7: Distribution of Na^+ contents (mg/100 g) by variety, all positions pooled (box plots; thick line: median).

Potassium

K^+ content depended on variety ($\chi^2 = 14.23$; $p = 0.0066$) and not on position alone ($p = 0.747$), but the combined variety × position factor was significant ($p = 0.032$). The medians of BK, Knt and Dr were similar (≈ 19–23 mg/100 g), that of SL was lower (≈ 8 mg/100 g) and that of Kt was the lowest (≈ 1.3 mg/100 g; Fig. 9). Position strongly affected the content of some varieties: for Knt, bottom fruits were markedly richer than top fruits, whereas for SL, top fruits were richer than those from the other positions (Fig. 8; Table 2). Kt differed from BK and Dr (adjusted $p = 0.022$).

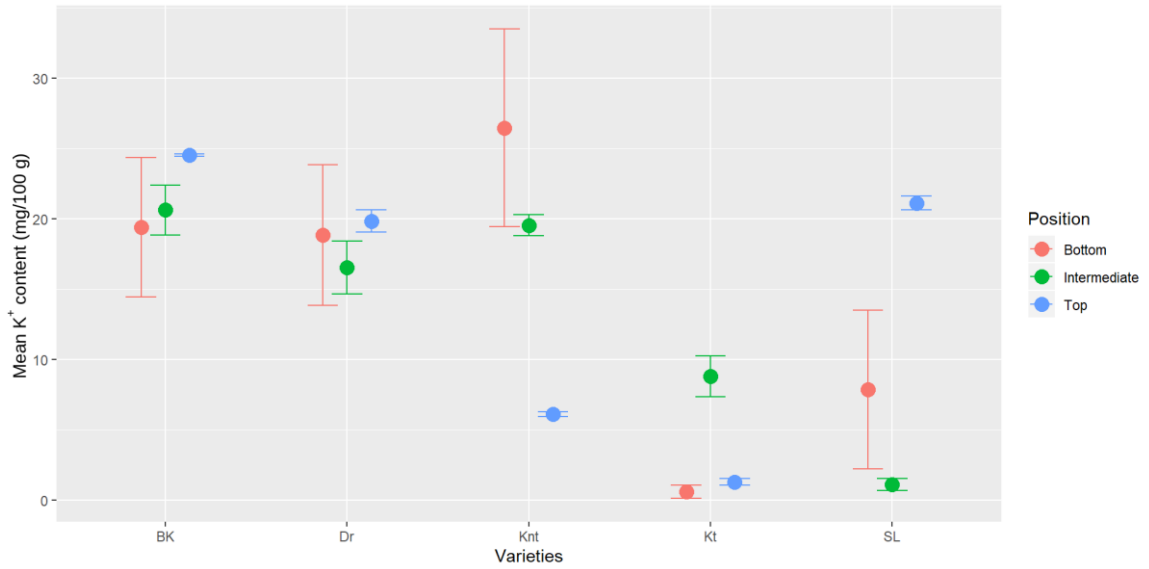


Fig. 8: Mean K^+ contents (mg/100 g) by variety and harvest position (points: means; bars: minimum and maximum values).

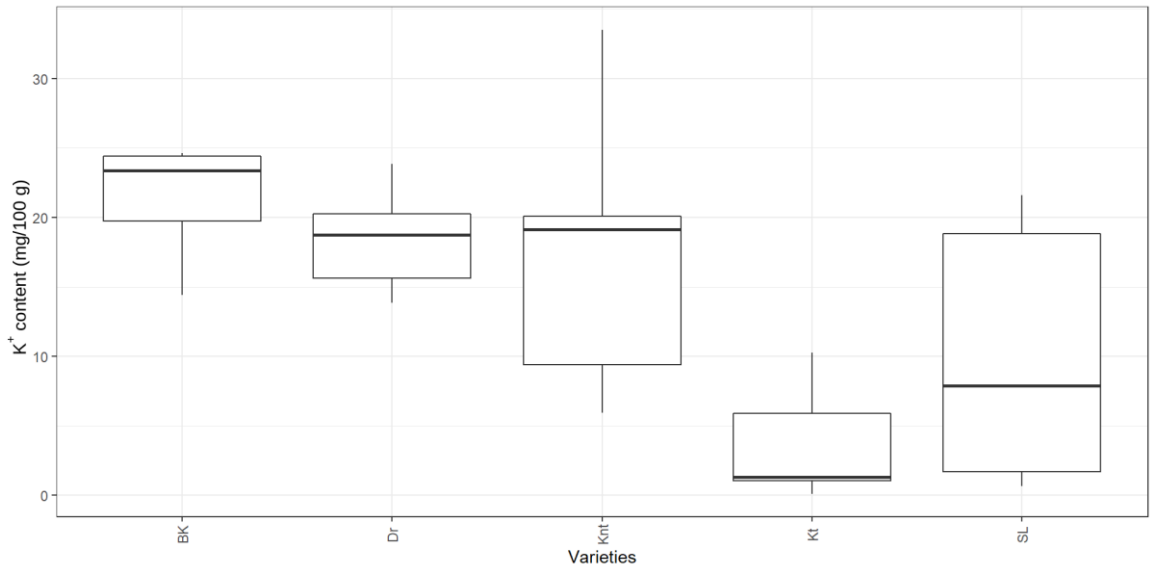


Fig. 9: Distribution of K^+ contents (mg/100 g) by variety, all positions pooled (box plots; thick line: median).

Effect of position within each variety

Contents were also compared among the three positions within each variety. None of these comparisons was significant: p-values ranged from 0.10 to 0.87 (BK, Dr, Knt, Kt and SL, respectively: Ca^{2+} 0.16; 0.56; 0.28; 0.16; 0.18 – Mg^{2+} 0.18; 0.37; 0.10; 0.18; 0.17 – Na^+ 0.16; 0.87; 0.18; 0.18; 0.16 – K^+ 0.18; 0.56; 0.16; 0.16; 0.10). As each variety × position combination comprised only 2 to 3 points visible in the figures, these tests have very low power: the lack of significance therefore does not allow us to conclude that position has no effect.

The observed profiles nevertheless differed between varieties. For SL, fruits from the intermediate position had very low Ca^{2+}, Mg^{2+}, Na^+ and K^+ contents, whereas those from the bottom and top positions were markedly richer. For Knt, Mg^{2+}, Na^+ and K^+ contents were lowest at the top of the tree, and Ca^{2+} contents highest at the intermediate position. For Kt, the intermediate position was the richest for all four minerals, within a generally low range of contents. In varieties BK and Dr, profiles were more homogeneous, particularly for K^+ (≈ 17–25 mg/100 g). These between-variety differences in profile explain why the combined variety × position effect was significant for Mg^{2+} and K^+ whereas position alone was not.

Overall comparison of the five varieties

Table 3 summarises the medians by variety and the grouping derived from the pairwise comparisons (Table 4). The pattern was identical for all four minerals: Kt had the lowest contents and differed significantly from BK and Dr, whereas Knt and SL, which were more dispersed, did not differ significantly from any other variety.

Table 3: Approximate median contents (mg/100 g) by variety and groups derived from pairwise comparisons.

Sr. No.	Variety	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}
1.	BK	17 b	4.1 b	9.3 b	23.4 b
2.	Dr	27.5 b	4.05 b	15.1 b	18.7 b
3.	Knt	13 ab	1.95 ab	5.85 ab	19.1 ab
4.	Kt	2 a	0.45 a	0.7 a	1.3 a
5.	SL	26.5 ab	1.0 ab	3.35 ab	7.85 ab

Medians read from Fig. 3, 5, 7 and 9. Within a column, varieties sharing the same letter are not significantly different (adjusted $p \geq 0.05$).

Table 4: Holm-adjusted p-values of pairwise comparisons between varieties (Wilcoxon test).

Sr. No.	Pair	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}
1.	BK – Dr	1	1	0.96	1
2.	BK – Knt	1	0.069	0.96	1
3.	BK – Kt	**0.022***	**0.022***	**0.022***	**0.022***
4.	BK – SL	1	0.46	0.96	0.21
5.	Dr – Knt	1	0.18	0.56	1
6.	Dr – Kt	**0.022***	**0.022***	**0.022***	**0.022***
7.	Dr – SL	1	0.46	0.33	1
8.	Knt – Kt	1	0.25	0.33	0.21
9.	Knt – SL	1	1	0.96	1
10.	Kt – SL	1	0.69	0.86	1

** Adjusted $p < 0.05$.*

DISCUSSION

The significant effect of variety on all four minerals is consistent with the literature, which reports a pulp composition that depends on genotype, production area and maturity.[1,2] In the present study, variety Kt consistently stood out with the lowest Ca^{2+}, Mg^{2+}, Na^{+} and K^{+} contents, whereas BK and Dr had the highest median contents. This pattern, common to all four minerals, could reflect a concentration or dilution effect related to the fruit physiology of this variety, but the available data do not allow this to be determined.

For calcium, the varietal effect was the weakest ($p = 0.028$) and within-variety dispersion the highest. This result is consistent with the transport of this element, which is mainly xylem-borne and poorly mobile in the phloem, making it sensitive to fruit growth conditions.[5,6] Potassium and magnesium, which are more mobile in the plant,[7] showed a clearer varietal effect ($p = 0.0026$ for Mg; $p = 0.0066$ for K).

The absence of an overall effect of harvest position does not mean that position has no influence: the combined variety × position effect was significant for Mg^{2+} and K^{+}, and large differences appeared for some varieties (e.g. K^{+} for Knt, Ca^{2+} for SL; Table 2). This suggests that the response to position, related for example to light exposure, microclimate or leaf-to-fruit ratio,[8] depends on the variety. However, the very limited number of observations per combination (2 to 3 visible points) does not allow this hypothesis to be tested formally.

The values obtained in this study should be compared with caution to those of food composition tables. For raw mango, the USDA database reports orders of magnitude of about 11 mg Ca, 10 mg Mg, 168 mg K and 1 mg Na per 100 g.[14] The K^{+} and Mg^{2+} contents reported here are markedly lower, and the Na^{+} contents higher. This discrepancy may be due to the matrix analysed, the reference unit or the analytical method; these parameters, which are not specified in the source document, should be checked before interpreting the absolute levels in nutritional terms.

The limitations of the study are: (i) the small number of observations per group, which reduces the power of the non-parametric tests, particularly for pairwise comparisons after adjustment; (ii) the lack of information on soils, fertilisation and irrigation, which govern mineral contents; and (iii) the use of approximate values read from the figures for Tables 2 and 3.

CONCLUSION

The Ca^{2+}, Mg^{2+}, Na^{+} and K^{+} contents of the Senegalese mangoes studied depend significantly on variety, with a common pattern: Kt has the lowest contents and differs from BK and Dr, which are among the richest. Fruit position in the tree has no overall effect, but its combined effect with variety is significant for Mg^{2+} and K^{+}. These results can guide varietal choice for the mineral valorisation of mangoes and call for further studies with more replicates, several growing seasons and data on cultivation conditions.

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