# NATURAL VARIATION IN SIZE AND SOLUBLE SOLIDS CONCENTRATION OF *UAPACA KIRKIANA* FRUIT

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**CHISHIMBA, W. K. & MWANABUTE, N. 2003. Natural variation in size and soluble solids concentration of *Uapaca kirkiana* fruit.** The fruits of *Uapaca kirkiana* (wild loquat) are nutritionally rich in ascorbic acid, mineral constituents and sugars. Therefore, when in season, the fruits are extremely popular in Zambia and other central African countries, where they sell fast along roadside and in markets. The objective of this study was to explore the degree of natural variation in size and soluble solids concentration (SSC) in *U. kirkiana* fruits, and to establish whether a correlation exists between fruit size and SSC. The fruits harvested from natural stands in five districts within three provinces, geographically located between 8° and 18° S of the equator in Zambia, were evaluated for variation in fruit size and SSC. The fruits varied significantly in mean fruit size between some districts. Mean SSC (°Brix) for Mpika (11.31) district were significantly lower than the other four districts, namely, Choma (14.31), Kasama(13.40), Mbala (14.31) and Serenje (14.24). The correlation coefficient between fruit size and SSC did not show any consistent trend.

Key words: Wild loquat - fruit size - *U. kirkiana* - correlation coefficient - hierarchical - nested

**CHISHIMBA, W. K. & MWANABUTE, N. 2003. Perubahan semula jadi dalam saiz dan kepekatan pepejal terlarut buah *Uapaca kirkiana*.** Buah *Uapaca kirkiana* (loquat liar) kaya dengan asid askorbik, bahan galian dan gula. Oleh itu, apabila tiba musimnya, buah ini sangat popular di Zambia dan negara Afrika Tengah yang lain. Ia dijual di sepanjang tepi jalan dan di pasar. Objektif kajian adalah untuk meneroka tahap perubahan semula jadi dalam saiz dan kepekatan pepejal terlarut (SSC) buah *U. kirkiana*, serta untuk mengetahui sama ada wujudnya korelasi antara saiz buah dan SSC. Buah yang diambil daripada dirian semula jadi di lima daerah dalam tiga wilayah yang terletak di antara 8° dan 18° S di Zambia, dinilai untuk perubahan dalam saiz buah dan SSC. Buah berbeza dengan bererti dalam purata saiz buah beberapa daerah. Purata SSC (°Brix) bagi daerah Mpika (11.31) adalah lebih rendah dengan bererti berbanding empat daerah lain iaitu Choma (14.31), Kasama (13.40), Mbala (14.31) dan Serenje (14.24). Pekali korelasi antara saiz buah dan SSC tidak menunjukkan sebarang trend tertentu.

## Introduction

The fruits of *Uapaca kirkiana* (wild loquat), when in season, are extremely popular in Zambia and other Central African countries, where they sell fast along roadside and in markets (Figure 1). The fruits are rich in ascorbic acid, sugars and mineral constituents (Sufi & Kaputo 1977, Saka 1995), and can be processed into jam or fruit squash (Storrs 1979). The fruits may also be processed into a local wine popularly known as "masuku". *Uapaca kirkiana* is a semi-deciduous fruit tree belonging to the Euphorbiaceae family. The fruit tree is widely distributed in the Miombo ecozone of central and southern Africa (White 1962, Mwamba 1995). Although the fruit is wild, it does, however, possess great economic potential as a pomological tree. According to a previous report on fruit character, *U. kirkiana* is known to have three-, four- or five-seeded fruit (Mwamba 1989).

Previous researchers have reported that mature fruit has high starch content which is subsequently converted into simple sugars by enzymatic action (Mehrlich 1971, Veldhuis 1971). The composition of sugar in a given variety will vary from place to place, depending upon the soil, the location and the climatic conditions including light intensity. This variation is not only applicable to sugars, i.e. soluble solids concentration (SSC) and acids but also to mineral constituents. Increased shading due to increased canopy development may lead to reduction in fruit set, fruit size and SSC. Levels of SSC and fruit size are important parameters to small-scale industrialists, who use the fruit to process into jam, wine or fruit squash.

So far, there has been no information about the effect of number of seeds on fruit size and SSC. Therefore, the aim of this study was to explore the degree of natural variation in size and SSC of *U. kirkiana* fruit and to establish whether a correlation exists between fruit size and SSC. The results will help in deciding the material that should be collected when establishing plantations for breeding or commercial purposes.

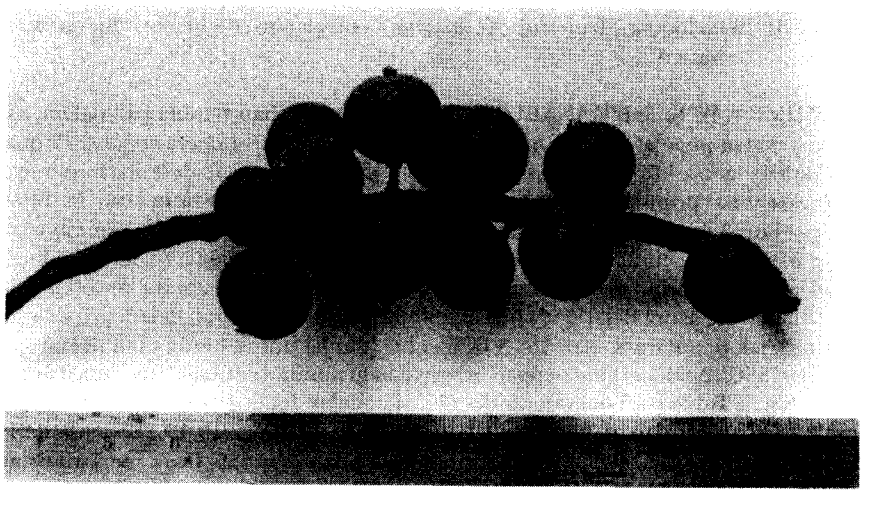


**Figure 1** Fruits of *Uapaca kirkiana*

## Materials and methods

Mbala, Kasama, Mpika, Serenje and Choma districts (Figure 2) were the selected study sites because they have adequate distribution of *U. kirkiana* trees. In addition, these five districts lie approximately along a north-south highway through Zambia, making it easier and cheaper to travel during the study. Since the distribution of trees is not uniform, random route sampling was adopted. Sampling was executed as for a forest setting. A starting point was selected on which no measurements of the variables of interest were taken. From the starting point a compass direction was chosen at random using random numbers. Measurements were taken on the tree found at a distance which was at least 25 m from the starting point. In the event when several trees were found at that distance, one tree was chosen at random. Finally, the sequence of measurements obtained were subjected to the serial test at log zero and log one to select random data.

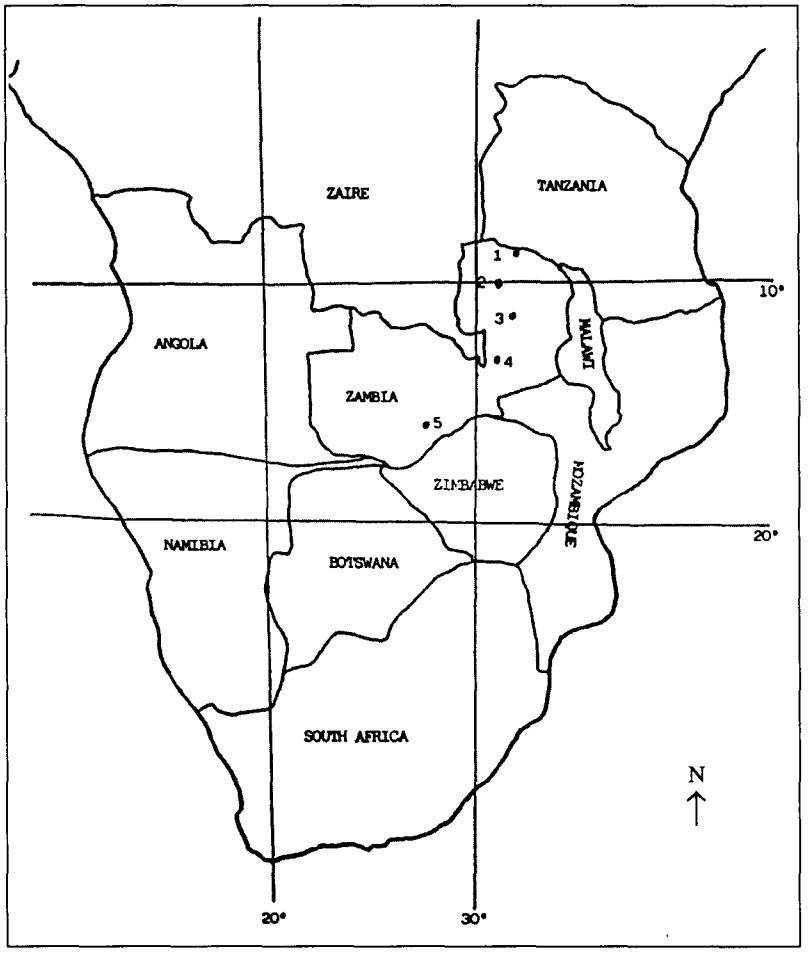



**Figure 2** Location of Zambia and sampled districts. Numbers 1 to 5 are Mbala, Kasama, Mpika, Serenje and Choma districts respectively.

SSC (°Brix) was measured in all fruits sampled from 21 trees per district. Ten fruits were sampled per direction (N, S, E and W), within the crown of a tree. SSC was measured with an Abbe refractometer (Standard 60/70) by squeezing a drop of juice from the fruit pulp. Thereafter, the fruit was split open in order to count the total number of seeds per fruit. The size of the fruit was measured by volume ($cm^3$) displacement in water using a measuring cylinder.

When data were classified according to the number of seeds per fruit, it was found that the most common fruit types were the three- or four- seeded, with the five-seeded being least in occurrence. For this reason, only three- and four-seeded fruit type data were used in the analysis of variance (ANOVA) and computation of correlation coefficients to determine whether the number of seeds had any effect on SSC and fruit size. Due to the nature of the study, and in order to avoid the decline in fruit quality, assessment of SSC was limited to refractometer reading in the field rather than laboratory analysis. The latter would mean fruit must be kept for more than a week during field trips. In order to minimise variation in the level of ripeness, which would have affected the results of SSC, only mature but about to ripen fruits were collected and kept in a warm dark place to ripen within five days.

Since the number of fruits sampled in the western direction was consistently too low in each tree, and in all districts, therefore, this direction was not included in the correlation analysis. Pooled values of fruit size (volume) and SSC from all the other three directions (N, E and S) were used for computing correlation coefficients. To establish whether a correlation exists between SSC and fruit size, six trees were selected at random from each district. From each tree, 10 fruits per direction (N, E and S) were sampled within the tree crown. Only fruits with three- or four-seeds were used in the correlation analysis.

Before the ANOVA was performed, SSC values were arc sin transformed. The analysis of variance on SSC and fruit size was based on a partially hierarchical arrangement of data. The factors were district, direction and tree, with district and direction, and direction and tree within district being crossed. The factor tree was nested within district. Therefore, analysis of variance performed on the data for fruit size and SSC was based on a crossed nested model (partially hierarchical). The first factor was district with the five levels being Choma, Serenje, Mpika, Kasama and Mbala. The second factor was direction with three levels, namely, north, east and south. The third factor was tree with six levels and the replicates were 10 fruits (n) per direction. Using data for SSC and fruit size from three- and four-seeded fruit groups, least significant differences were computed to compare district means of fruit size with SSC. The least significant differences identified categories that contributed to the significant difference at district level. Comparison of two sample means of fruit size from two populations of three- and four-seeded fruits, was also carried out using the *t*-test. All statistical analyses, unless otherwise, were performed using SPSS for MS Windows Release 6.0 (1993).

## Results and discussion

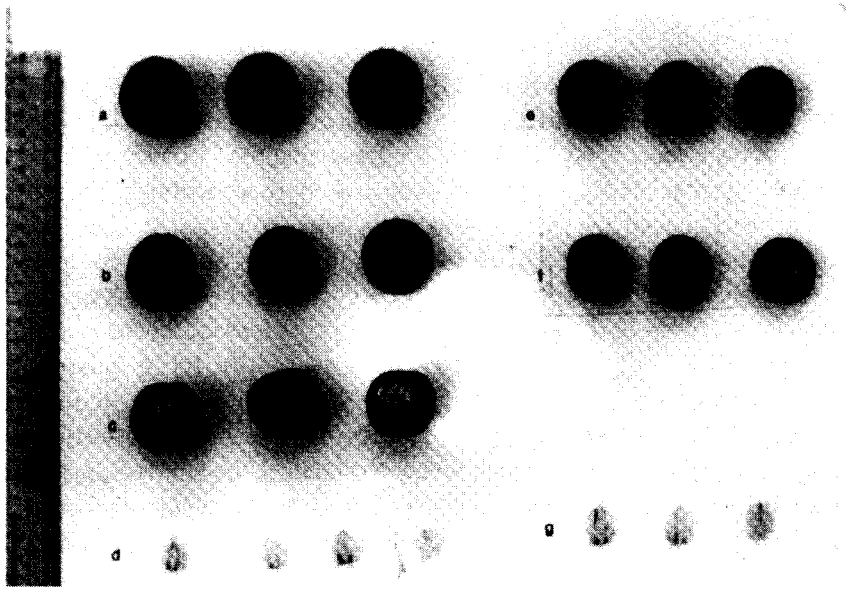
The main factor, tree (within district), was highly significant for both SSC and fruit size. The district factor was also very significant for fruit size but not significant for SSC. Direction was very significant for fruit size and not significant for SSC. For both SSC and fruit size, the interactions in the model (district-direction interaction, and tree-direction interaction within district) were also highly significant. The significances of the interaction terms and the main factors are indications of the effects of geographical locations and positions on direction of fruits within the crown of a tree. Different geographical locations mean different climatic conditions and varying soil conditions, while fruits having different positions on a tree crown get exposed to different levels of light intensities. In short, SSC and fruit size are greatly affected by environmental conditions.

Results of the least significant difference for both three-seeded and four-seeded fruit groups identified categories that contributed to the significant differences at district level. In the case of three-seeded fruit, Mpika (16.08 $cm^3$), Serenje (17.38 $cm^3$) and Mbala (18.28 $cm^3$) belonged to one group which was statistically different from the second group comprising Choma (22.28 $cm^3$) and Kasama (26.90 $cm^3$) (Table 1). As for four-seeded fruit, there were three groups and the most distinctive fruit size was Kasama (30.10 $cm^3$) which was at par with Choma (23.85 $cm^3$) and Mbala (22.5 $cm^3$) but significantly different from Mpika (17.90 $cm^3$) and Serenje (19.00 $cm^3$). It is evident that the volumes of fruits sampled from Mpika and Serenje districts were significantly less in both three-seeded and four-seeded categories than other districts. Results of the least significant difference showed that the mean value of SSC for Mpika was lowest and significantly different from the other four districts (Table 1). Values of SSC from the other four districts were at par.

The *t*-test was not significant, suggesting that there were no real differences in mean fruit size between three-seeded and four-seeded fruits. The differences indicated by the ANOVA lie fundamentally between districts (Table 1). Field observations agreed with the *t*-test because the fewer the seeds in the fruit, the larger the fruit and vice versa (Figure 3).

**Table 1** Variation in mean fruit size and SSC of *Uapaca kirkiana* in five districts

| Province | District | Fruit size ($cm^3$) | | SSC (°Brix) (Three-seeded or four-seeded) |
|---|---|---|---|---|
| | | Three-seeded | Four-seeded | |
| Northern | Mbala | $18.28^{b}$ | $22.5^{ab}$ | $14.31^{b}$ |
| Northern | Kasama | $26.90^{a}$ | $30.10^{a}$ | $13.40^{b}$ |
| Northern | Mpika | $16.08^{b}$ | $17.90^{b}$ | $11.31^{a}$ |
| Central | Serenje | $17.38^{b}$ | $19.00^{b}$ | $14.24^{b}$ |
| Southern | Choma | $22.28^{a}$ | $23.85^{ab}$ | $14.31^{b}$ |
| | LSD | 3.80 | 7.65 | 2.17 |



(a) Mature and unripe fruit of *U. kirkiana* (four-seeded)
(b) Partial cross-section of the skin of a fruit to show four-seeded fruit
(c) Partial longitudinal section of the skin of the fruit to show the inner parts of the fruit
(d) Morphological appearance of the seed from the upper and lower surfaces
(e) Mature unripe fruit of *U. kirkiana* (three-seeded)
(f) Partial cross-section of the skin of a fruit to show three-seeded fruit
(g) Partial longitudinal-section of a fruit to show the inner parts of the fruit

**Figure 3** Morphological features of *Uapaca kirkiana* fruit

The correlation coefficients for the same pair of variables showed no consistent trend. Correlation coefficients for tree 1 and 2 were - 0.90 and 0.67 respectively and were significant at p = 0.05. All other correlation coefficients from the other four trees were non-significant. In locations where SSC was negatively correlated with fruit size (r = - 0.90) it meant that the pair of variables varied antagonistically. Variation was synergistic where the two variables correlated positively (r = 0.67). These results indicate that at some locations, the distribution of SSC and fruit size was bivariate normal, while at other locations it was not. This means that at one location the pair of variables varied in sympathy, while at other locations they varied in opposition. These results also indicate that at some locations, the distribution of SSC and fruit size was bivariate normal, while at other locations it was not.

Indications are, therefore, that SSC depended on a host of other variables, namely, soil and climate, whose presence or absence determined the degree, direction and significance of correlations. These results compare favourably with previous results that were found in similar studies of sugar content (Mehrlich 1971, Veldhuis 1971). The quality of any fruit, particularly with regard to the SSC, is highly dependent on agro-climatic conditions prevailing in a particular growing field. The conditions include soil, light intensity, day and night temperatures,

rainfall, irrigation and season (Mehrlich 1971). Soil moisture and fertility are particularly important in determining fruit size and weight. The variation in SSC as depicted by *U. kirkiana* fruit has also been observed both in temperate and tropical fruits (Mehrlich 1971, Veldhuis, 1971).

Lack of a consistent trend in correlation coefficients between fruit size and SSC indicate that the pair of variables was highly influenced by soil and climatic conditions. Therefore, for domestication purposes, selection of a superior strain should be based on SSC, fruit size, fruit weight and estimated fruit yield. Selection should also take into account the market demand for each strain.

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