# VARIATIONS IN ACHA (*Digitaria* species) GRAIN CHARACTERISTICS

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**Abstract**
*Ten acha accessions (Digitaria sp.) collected from Kaduna (K1, K2, K3, K4 and K5), Nassarawa (NA1 and NA2) and Niger (NI1, NI2 and NI3) States, in the Northern parts of Nigeria were evaluated for their size (length and width) of corticated and decorticated grains and shape, number of nerves on the abaxial and adaxial surfaces of the glumes and variations in seed colour in the Botany Laboratory of Abubakar Tafawa Balewa University, Bauchi, Nigeria. The results showed that (K5) had large grain size averaging 1.47 mm and 1.17 mm in length, and 0.79 mm and 0.75 mm in width for corticated and decorticated grains, respectively. Overall for corticated grains K1 had low grain length, averaging 1.03 mm, while NI3 had low grain width averaging 0.57 mm. However, for decorticated grains low average length and width of 0.83 mm and 0.57 mm were recorded on K4 and NA1, respectively. The grains were elliptical to ovate in shape. The number of nerves on the adaxial surface varied widely from 0-5 in all the accessions, except for K5 that consistently had three (3) nerves. Similarly, the number of nerves on the abaxial glumes of the accessions ranged from 3-8, except for K5 that had five (5) nerves. Of all the accessions only the glumes of the grains from the accession K5 had hairs on their surfaces and margins. All the accessions had glume colour that varied from light brown to dark brown, except K5 that had consistently dark brown colour. The decorticated seed colours across the accessions were glassy white to purple, except K5 that showed uniformly glassy white colour.*

**Keywords:** *Digitaria exilis*, *Digitaria iburua*, acha, grain size, glume, grain shape, grain colour

## INTRODUCTION

Cereals are the most widely cultivated and consumed crops on a global basis and are some of the earliest crops the early man planted (Echendu *et al.*,, 2009). Acha (*Digitaria exilis* (Kippist)Stapf and *Digitaria iburua* Stapf) is a cereal with small coated grains that had played significant role in agriculture and diet of the people of west Africa. It is also locally known as fonio*, fundi, findi,* and hungry rice by the various tribes that populated Wets Africa (NRC, 1996). According to the Food and Agriculture Organization (FAO, 2008) they are regarded as "grain of life" in many communities of West Africa.The white acha (*Digitaria exilis)* is widely cultivated around the West African sub-region,unlike theblack acha (*Digitaria iburua*)that is restricted to northern Nigeria, Benin and Togo (Adoukonou-Sagbadja *et al*., 2007).
Acha is a husked cereal whose grains, after threshing are surrounded by cellulose rich hulls also known as glumes. These grains are ovoid in shape and slightly flattened on the abaxial surface. They are very small in size approximately 1.8 mm in length, and 0.9 mm in width (Cruz and Béavogui, 2011). The color of the grains varies from light brown to dark brown. Eliminating the hulls exposes the naked grain called a caryopsis. They are smaller in size ranging from 1.4 mm to 1.5 mm in length and 0.8 to 0.9 in width (Cruz and Béavogui, 2011). This decorticated grain has a glassy pericarp, white to purple in colour depending on the variety.

Acha has been reported to have considerable potentials in foods and beverages industry (Jideani, 1999). It is well adapted to harsh environments, requires low input for its cultivation and is able to grow on very poor soils without fertilization (Vodouche *et al.*, 2003). Its small grain size and weak stem makes its cultivation and processing cumbersome.

The renewed interest in research and development ofachawithin its area of production and the world at large (Jideani and Jideani, 2011) will require the identification of the variation that exist among the diverse land races currently in cultivation for its genetic improvement.The present study is aimed at evaluating the variations in the grain characteristics of both corticated and decorticated acha collected from three states in Nigeria.

## MATERIALS AND METHODS

Ten (10) acha accessions collected from Kaduna (K1, K2, K3, K4 and K5), Nassarawa (NA1 and NA2) and Niger (NI1, NI2 and NI3) States, in the Northern parts of Nigeria were used for the studies (Table 1). Geographic information on the location where the accessions were collected and their local names are presented in table 1.

**Table 1**: Local names and geographic information of ten (10) acha accessions used in grain studies

| Accession | State | Local Government Area | Town/Village | Local name of accession | Coordinates | Altitude |
|---|---|---|---|---|---|---|
| K1 | Kaduna | Kagarko | Gujeni | Fulu | N 9.47308<br>E 7.37181 | 546 M |
| K2 | Kaduna | Kagarko | KurminJibrin | Ekpeshegwa | N 9.47267<br>E 7.93811 | 765 M |
| K3 | Kaduna | Kagarko | KurminJibrin | Uwun | N 9.47267<br>E 7.93811 | 765 M |
| K4 | Kaduna | Sanga | Nandu-Ngbok | Zayi | N 9.23792<br>E 8.49196 | 526 M |
| K5 | Kaduna | Sanga | Nandu-Ngbok | Andama | N 9.23792<br>E 8.49196 | 527 M |
| NA1 | Nassarawa | Akun Dev. Area/Nassarawa Eggon LGA | Alushi | Aneme | N 8.90774<br>E 8.36988 | 455 M |
| NA2 | Nassarawa | Akun Dev. Area/Nassarawa Eggon LGA | Alushi | Aburu | N 8.90774<br>E 8.36988 | 455 M |
| NI1 | Niger | Bida | Badegi/NCRI | Kure'ep | N 9.06517<br>E 6.09830 | 98 M |
| NI2 | Niger | Bida | Badegi/ NCRI | Churriwe | N 9.06517<br>E 6.09830 | 98 M |
| NI3 | Niger | Bida | Badegi/ NCRI | Ndat | N 9.06517<br>E 6.09830 | 98 M |

Twenty representative grains were randomly selected and viewed under a light microscope using the x40 magnification lens. Observations made were recorded. Photographs of the grain characteristics were taken using Nikon D3300 camera. The sizes of the grains were measured in millimeters using ImageJ application and the data obtained wereanalysed using MS-Excel 2010 Spread sheet and SPSS soft wares.

The soft wares were used to determine mean values, ranges and standard deviation of corticated and decorticated grains of all the accessions. The range and standard deviation was used to ascertain the spread in the variations observed among the traits under consideration. The grain shape was determined using the length to width ratio of the mean values.The numbers of nerves, nerve patterns and the colour of the corticated and decorticated grains were observed and recorded.

**RESULTS AND DISCUSSION**

Seven accessions from Kaduna and Nassarawa states were collected directly from farmers in their respective towns and villages, while those from Niger state were provided by the National Cereals Research Institute (NCRI), Badeggi, Bida (Table 1). The collections from Kaduna and Nassarawa states despite coming from the same Local Government Area (LGA) bear different local names which is a pointer to their distinctness. The collections from NCRI, Badeggi, Bida in Niger state are most likely secondary collections due to the fact that NCRI has the research mandate onacha crop in Nigeria. Acha growing areas in the two states of Kaduna and Nassarawa were found at altitudes ranging from 455 m to 765 m, which contrast sharply with 98 m found in the low land area of Badeggi in Niger state. Acha growing areas in Nigeria are mostly found on the Jos plateau and its surrounding areas, suggesting that achagenotypes in Nigeria does better at high altitude.

The results from corticated grains of acha accessions had length of 1.01±0.01 mm to 1.47±0.08 mm, with K1 having short grain length, while K5 had the long grain length (Table 2). The width of the corticated grains found in the ten accessions started from 0.58±0.10 mm in K1 to as high as 0.79±0.04 mm in K5. This showed that K5 on the whole had large corticated grains compared to the remaining nine accessions. For decorticated grains K4 had low length of 0.83±0.07 mm, while K5 maintained its lead with a length of 1.17±0.04 mm. The accession NA1 had the low value for decorticated grain width amongst the accessions, while K5 out performed all the accessions with a width of 0.75±0.05 mm. Despite K1 having low length and width among all the accessions for corticated grains it turned out with high values for length and width of 0.98±0.08 mm and 0.63±0.12 mm when the glumes were removed. Although there was direct relationship in terms of the length and width of corticated and decorticated grains of acha, especially concerning K5, the same cannot be said of accession K1 whose corticated grains were small, but the decorticated grains turned out to be large. This demonstrated that there is no necessarily a direct correlation in glume length and grain size. The absence of direct relationship between husked anddehusked grain in K1is anexpression of better partitioning of photosynthatesin favour of increased grain production.The standard deviation values generally were as low as ±0.01 mm to as high as ±0.12 mm (Table 2) for corticated and decorticated grain length and width. The accessions with high standard deviations for length and width expressed variations that can be exploited in the improvement of these traits. The decorticated grains of K1 that had high standard deviation value of 0.12mm could be a good population for selection to improve decorticated grain size in acha. The same cannot be said of K5 population that had low standard deviation values. The large decorticated grain size of K5 can be used in crossing programme to generate variability for selection in favour of large decorticated grain size.

The grain shape varied from elliptical and elongate to widely ovate (Table 2). With a length to width ratio of 1.5-2.0 mm K1, K5, NA1, NA2, NI2 and NI3 weresaid to be elliptical and elongate in shape. K2, K3, K4 and NI1 were said to be widely ovate having a length to width ratio of 1.0-1.5 mm (MG101 Archaeobotany in Practice, 2006). Generally, acha accessions from this study had elliptical to ovate decorticated grain shape.

**Table 2**: Length, width, length:width ratio (mean) and shape of corticated and decorticated grains (mm) of ten (10) acha accessions

| Accessions | Corticated mean ± SD* | | Decorticated mean ± SD | | | |
|---|---|---|---|---|---|---|
| | Length | Width | Length | Width | L:W** Ratio | Grain shape |
| K1 | 1.01 ± 0.01 | 0.58 ± 0.10 | 0.98 ± 0.08 | 0.63 ± 0.12 | 1.56 | Elliptical/ elongate |
| K2 | 1.07 ± 0.10 | 0.61 ± 0.09 | 0.89 ± 0.07 | 0.60 ± 0.07 | 1.48 | Widely ovate |
| K3 | 1.24 ± 0.08 | 0.62 ± 0.06 | 0.92 ± 0.07 | 0.62 ± 0.02 | 1.48 | Widely ovate |
| K4 | 1.07 ± 0.12 | 0.62 ± 0.05 | 0.83 ± 0.07 | 0.58 ± 0.04 | 1.43 | Widely ovate |
| K5 | 1.47 ± 0.08 | 0.79 ± 0.04 | 1.17 ± 0.04 | 0.75 ± 0.05 | 1.56 | Elliptical/ elongate |
| NA1 | 1.14 ± 0.09 | 0.61 ± 0.08 | 0.91 ± 0.07 | 0.52 ± 0.08 | 1.75 | Elliptical/ elongate |
| NA2 | 1.13 ± 0.06 | 0.6 ± 0.05 | 0.96 ± 0.06 | 0.59 ± 0.08 | 1.63 | Elliptical/ elongate |
| NI1 | 1.12 ± 0.07 | 0.62 ± 0.07 | 0.88 ± 0.06 | 0.59 ± 0.06 | 1.49 | Widely ovate |
| NI2 | 1.17 ± 0.09 | 0.61 ± 0.05 | 0.88 ± 0.07 | 0.56 ± 0.09 | 1.57 | Elliptical/ elongate |
| NI3 | 1.20 ± 0.07 | 0.57 ± 0.09 | 0.90 ± 0.07 | 0.57 ± 0.08 | 1.58 | Elliptical/ elongate |

*SD = **Standard Deviation; ** L:W = Length:Width**

Majority of the acha accessions had 0-5 nerves on their adaxial surface, with K5 consistently showing three (3) nerves (Table 3; Figure 1). There is variation in the way the nerves were arranged on the diverse forms of upper glume of acha grains within and between the accessions. Across accessions, majority (156 out of 200) of the grains had 2-4 nerves, although some (19 out of 200) had zero nerve, while 18 out of 200 had five (5) nerves. The study established diversity in forms and variation in the number of nerves on the upper glume of acha grains, with the upper glumes mostly showing 2-4 nerves. The upper glume (adaxial) of K5 (Figure 2) is the only accession covered with hairs.

**Table 3**: Number of nerves on the adaxial(upper glume) surface of acha grains and their mean (± SD).

| Accession | Number of nerves | | | | | | N | Mean (± SD)* |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | | |
| K1 | 3 | 6 | 3 | 8 | | | 20 | 1.8 ± 1.15 |
| K2 | | | 1 | 13 | 4 | 2 | 20 | 3.1 ± 0.60 |
| K3 | | 1 | | 11 | 6 | 2 | 20 | 3.4 ± 0.88 |
| K4 | | | 1 | 6 | 5 | 8 | 20 | 4.0 ± 0.97 |
| K5 | | | | 20 | | | 20 | 3.0 ± 0.00 |
| NA1 | 4 | | 4 | 12 | | | 20 | 2.2 ± 1.20 |
| NA2 | 8 | | 2 | 10 | | | 20 | 1.9 ± 1.42 |
| NI1 | | | | 14 | 6 | | 20 | 3.3 ± 0.47 |
| NI2 | 3 | | | 15 | | 2 | 20 | 2.8 ± 1.33 |
| NI3 | 1 | | 1 | 14 | | 4 | 20 | 3.2 ± 1.15 |
| **Total** | **19** | **07** | **12** | **123** | **21** | **18** | **200** | |

***SD = Standard deviation**

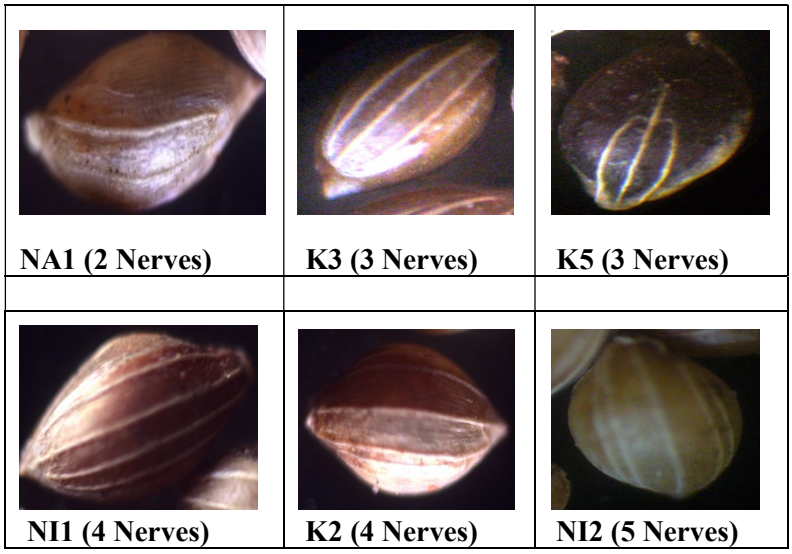


**Figure 1:** Variations in the number and pattern of nerves on the adaxial surface of acha grains of different accessions.

Similarly, the number of nerves on the abaxial (lower glume) surface of the accessions varied from 3-8, except for K5 that had 85% of grains with five (5) nerves (Table 4; Figure 2). Unlike the adaxial surface (upper glume) all the grains observed had nerves on their abaxial (lower glume) surfaces. Majority of the accessions had 4-7 nerves on the abaxial (lower glume) surface. No clear differences in the arrangement of the nerves on the abaxial surface were recognized. The upper glume in K5 was generally smaller in size compared with the lower glume. The abaxial (lower glumes) surfaces of all the accessions were coarser than the adaxial (upper glumes) surfaces. All the accessions had glume colour that varied from light brown to dark brown, except K5 that had consistently dark brown colour (Figure 1, 2). The decorticated grain colours across the accessions were glassy white to purple (Cruz and Béavogui, 2011), except K5 that showed uniform glassy white colour (Figure 3).

**Table 4**: Number of nerves on the abaxial (lower glume) surface of acha grains and their mean (± SD)

| Accession | Number of nerves | | | | | | N | Mean ± SD* |
|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | | |
| K1 | 12 | 4 | 2 | | 2 | | 20 | 3.8 ± 1.28 |
| K2 | | 2 | 3 | 11 | 2 | 2 | 20 | 4.95 ± 1.05 |
| K3 | | | 3 | 8 | 5 | 4 | 20 | 6.5 ± 1 |
| K4 | | 1 | 3 | 3 | 9 | 4 | 20 | 6.6 ± 1.14 |
| K5 | | | 17 | 3 | | | 20 | 5.15 ± 0.37 |
| NA1 | 8 | 2 | 4 | 4 | 2 | | 20 | 4.5 ± 1.47 |
| NA2 | 12 | 2 | 4 | | 2 | | 20 | 3.9 ± 1.33 |
| NI1 | 2 | 8 | 4 | | 2 | 4 | 20 | 5.2 ± 1.77 |
| NI2 | | 2 | 4 | | 12 | 2 | 20 | 6.4 ± 1.23 |
| NI3 | | | 12 | 6 | 2 | | 20 | 5.5 ± 0.69 |
| **Total** | **34** | **21** | **56** | **35** | **38** | **16** | **200** | |

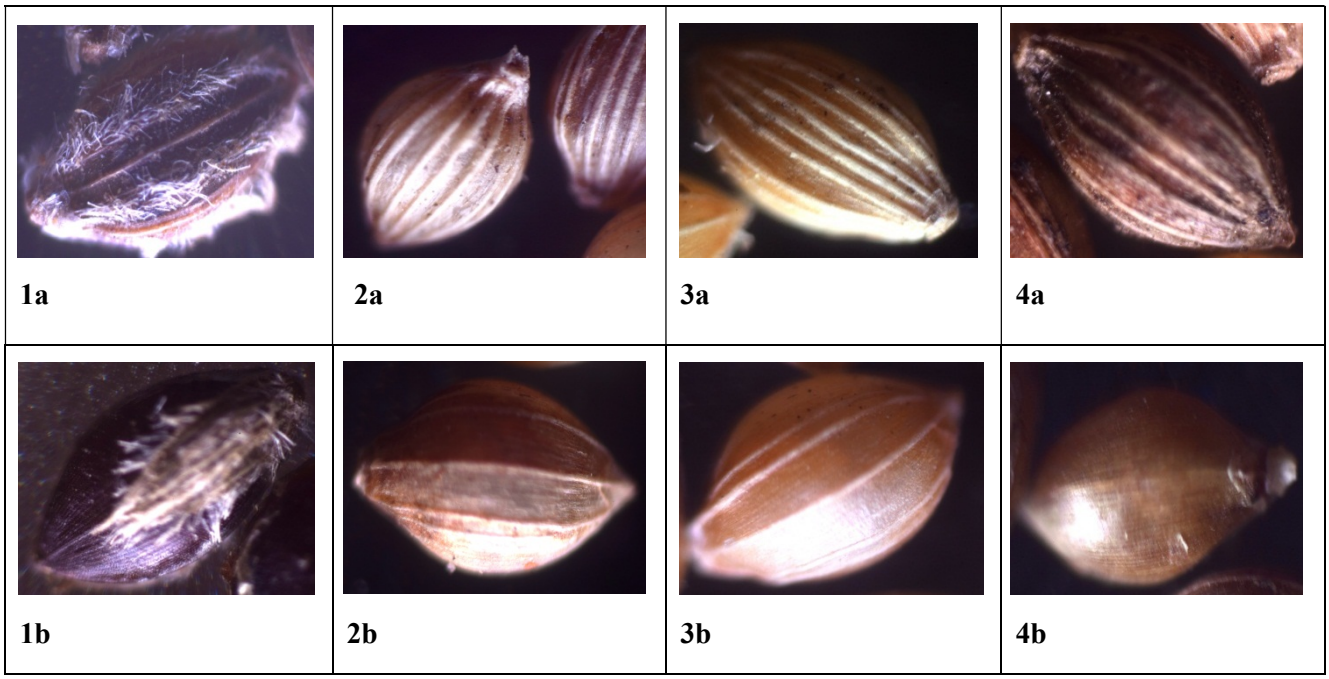


**Figure2**: Variations in the glume colour on the adaxial and abaxial surfaces of acha grains from different accessions. (1a, 2a, 3a and 4a are the abaxial (lower glume) surfaces of accessions K5, K3, NA1 and NI1, while 1b, 2b 3b and 4b are the adaxial (upper glume) surfaces of accessions K5, K3, NA1 and NI1, respectively).

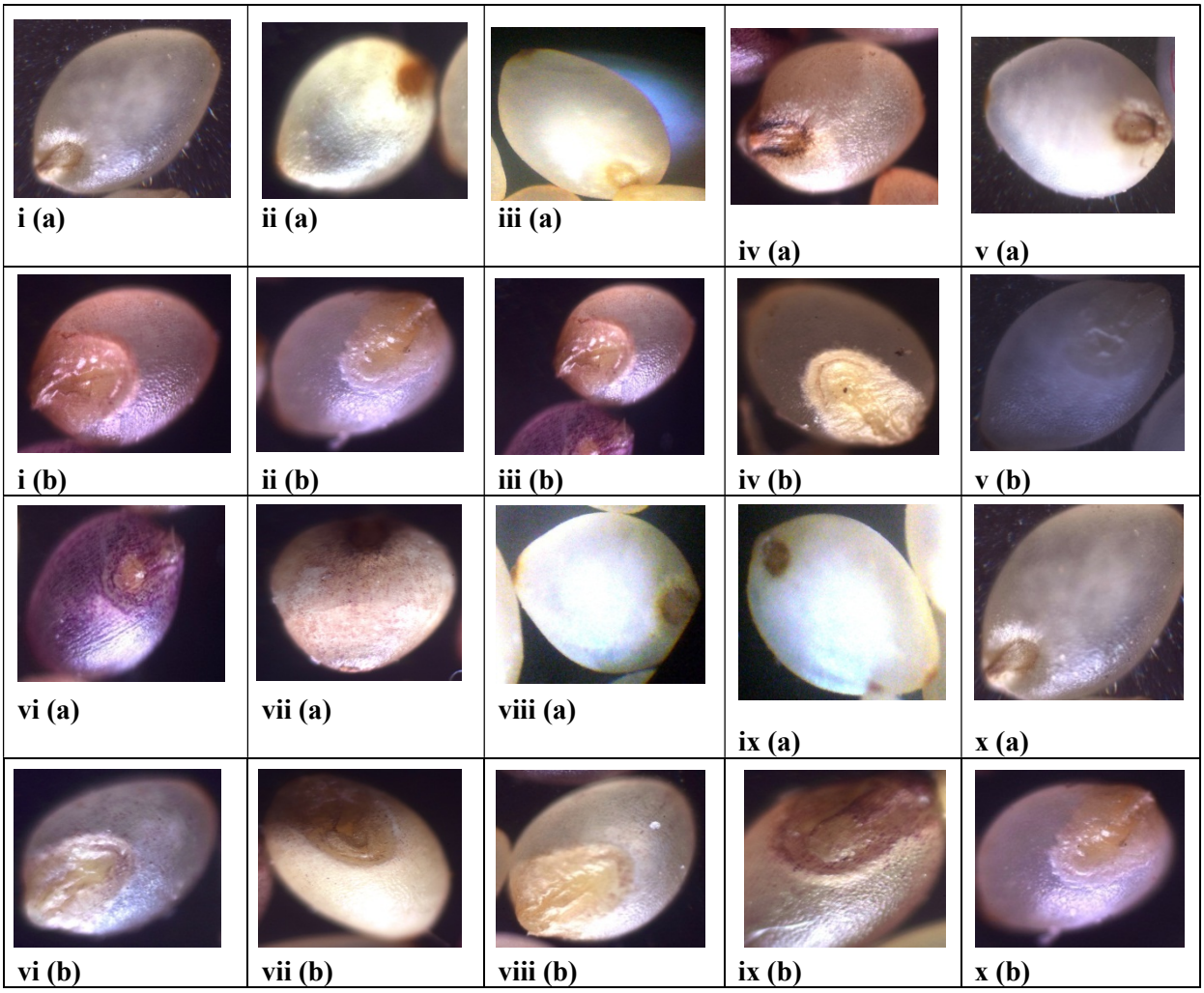


**Figure 3**: Variations in decorticated grain colour of acha from all the accessions. i (a), ii (a), iii (a), iv (a), v (a), vi (a), vii (a), viii (a), ix (a) and x (a) are the adaxial surfaces of K1, K2, K3, K4, K5, NA1, NA2, NI1, NI2 and NI3, while i (b), ii (b), iii (b), iv (b), v (b), vi (b), vii (b), viii (b), ix (b) and x (b) are the abaxial surfaces of K1, K2, K3, K4, K5, NA1, NA2, NI1, NI2 and NI3 respectively.

## CONCLUSION

The studies on the variation in the grains of ten (10) acha accessions revealed diversity in both corticated and decorticated grain sizes as reflected by differences in the length, width and length:width ratio. The accession K5 produced the larger grains of all the accessions with minimal variations within its population. In contrast, accession K1 despite having low length and width among all the accessions for corticated grains it turned out with high values for length and width of 0.98±0.08 mm and 0.63±0.12 mm when the glumes were removed. The K1 population had high standard deviations values that can be utilized for genetic improvement. The grain shape varied from elliptical to widely ovate. Variations were also observed in the number of nerves on the adaxila (upper glume) surface of 2-4, and abaxial (lower glume) surface of 4-7 in all the accessions. K5 expressed minimal variation in terms of the number of nerves on the adaxial surface of 3 and abaxial surface of 5. It is the only accession with hairs on both the

adaxial and abaxial surfaces. The accessions also expressed variation in the colour of both corticated (brown to dark bown) decorticated (glassy white to purplish white) grains.

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