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*Full Length Research Paper*

# Physical and biochemical characteristics of some korarima accessions (*Aframomum corrorima* (Braun) P. C. M. Jansen) collected from major growing regions of southern and southwestern Ethiopia

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**Capsules of korarima collected from four major growing regions of south southwestern Ethiopia at peak harvesting time, November and December 2011 were evaluated for the different physical and biochemical qualities. According to result obtained from analyzing capsules and seeds physical characters significant ($p<0.05$) variations existed in terms of capsule length (CL), diameter and circumference, single fresh capsule weight, number of seeds per capsule, seed to husk ratio, seed length (SL), seed diameter and hundred seed weight. A significant ($p<0.05$) variation was also obtained from seeds quality traits such as volatile oil, oleoresin contents and proximate compositions. The mean values of the capsules and seed physical traits showed that the average CL and SL varied from 4.8 to 6.7 cm and 3.56 to 3.89 cm, respectively among the different samples. Fresh capsule weight ranged from 17.2 to 27.4 g, seed number per capsule varied from 122.6 to 232.8 and hundred seed weight ranged between 1.39 and 2.34 g. The mean values of seed biochemical traits showed that volatile oil content ranged from 0.9 to 3.2 (v/w%) and oleoresin content ranged from 2.2 to 7.8 (w/w%). The results from proximate analysis revealed that the percentage mean values were within a range of 7.4 to 48.4 crude fiber, 1.25 - 2.85 crude fat, 3.08 to 15.38 ash, 6.87 to 7.95 crude protein and 26.12 to 61.01 carbohydrate contents. The overall result show that there is variability in physical and biochemical parameters among korarima samples of different regions. The variation may be linked to varietal, environmental, edaphic factors and/or management practices. The results obtained may contribute for further breeding and quality improvement purposes.**

**Key words:** *Afframomum corrorima*, capsule, seeds, physical and biochemical, quality.

## INTRODUCTION

Korarima (*Aframomum corrorima* (Braun) P. C. M. Jansen) is herbaceous, perennial and aromatic species classified in the monocotyledonous family Zingiberaceae, native to Ethiopia. The plant consists of an underground rhizome, a pseudo stem, and several broad leaves and resembles *Elettaria* species morphologically. Mature korarima can reach a height of 1-2 m. It sets seed after 3-5 years of planting depending on the planting materials used and it continue to bear seeds for a number of decades (Eyob, 2009). The plant is propagated both by seeds and rhizome parts (Ravindran et al., 2002; Girma et al*.,* 2008).

Korarima, also called ‘‘false cardamom’’, spice has been part of daily Ethiopian dish in preparation of curry

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powder for culinary purposes. It is mainly harvested from wildly grown plants in the forests of many places of south and south western parts of Ethiopia. The dried fruit mixture of different clones is sold on almost every Ethiopian market, and is quite expensive, relative to other spices. In the production areas, fresh fruits are sold too, rarely only the seeds (Jansen, 1981). Korarima seeds are used in Ethiopia to flavor all kinds of sauces locally called ‘wot’, for which they are ground and usually mixed with other spices.

Apart from its commercial and nutritional importance korarima is in demand as a variety of ailments by local people. The fruit pulp around the seed is eaten especially before maturity and is chewed as stimulant (Ravindran et al., 2002). It is traditionally used as tonic, carminative and purgative drug. Korarima seeds, pods, leaves, rhizomes and flowers are used in southern Ethiopia as traditional medicine for human and animal ailments caused by unknown agents; and particularly used to treat any part of the animal body upon swelling (Eyob et al*.,* 2008).

Though korarima is indigenous and important cash crop having a good export potential, it has been one of the most mishandled crops which a less research attention has been given. A very few authors have addressed some issues on korariam plant; indigenous practices and farm based biodiversity (Eyob et al*.,* 2009), micro propagation methods (Teffera and Wannakrairoj, 2004, 2006; Eyob, 2009), antioxidant and antimicrobial activities (Eyob et al., 2008). The essential oil yield and compositions from leaves, rhizomes, pods and seeds of was done by Eyob et al*.* (2007, 2008). However, nothing has been reported concerning the physical and biochemical qualities capsule and seed of korariam from different growing regions. A study of physical and biochemical properties of this indigenous crop from different growing regions will give us a range of variability in terms of important quality traits so that further research and improvement becomes easier. On top of that, this will provide information for commercial as well as industrial exploitation of the spice. This study, therefore, investigated variation on the physical and biochemical characteristics of korarima capsules from major growing regions of southern and southwestern Ethiopia

## MATERIALS AND METHODS

### Study area

The samples were collected from four korarima growing administrative zones, Kaffa, Bench Maji, Konta Special woreda and South Omo Zones from Southern and southwestern parts of Ethiopia.

### Sample collection and preparation

Korarima samples were collected from twenty two kebeles of four administrative zones of Southern, Ethiopia. Fully mature red ripe korarima capsules were collected from each area during the peak harvesting time. The collected capsules were transported to Tepi National Spices Research Center (TNSRC) where the drying process was accomplished. Harvested capsules were thoroughly washed with pure water to eliminate impurities such as soil, dirt and other unwanted plant parts. Washed capsules were allowed to drain water for some time. Sun-drying of the samples was done on raised bed made of wire mesh during sunny hours from 10AM to 5PM. The average maximum and minimum temperature at the time of Drying was 29.5 and 15.4ºC, respectively. Frequent mixing up of capsules was done to ensure uniform drying of the samples. Immediately after drying, the samples were removed from the drying material. The samples were taken in triplicate for conducting physical and biochemical quality analyses. The dried capsules were crushed using mortar and pestle and the seeds with the mucilage were separated from the capsules. The seeds were separated from the mucilage by traditional winnowing methods using tray. The dried seeds were then ground at the post-harvest management laboratory at Jimma University College of Agriculture and Veterinary Medicine, Ethiopia (Table 1).

### Laboratory analysis

#### *Physical characteristics*

The physical parameters such as fresh capsule diameter, length of fresh capsules, fresh weight of single capsule, fresh capsule circumference, dry weight of seeds per capsule, seed to husk ratio, hundred seed weight, number of seeds per capsule, seed length, seed diameter, capsule and seed shape indices were taken.

#### *Hydro-distillation of essential oils*

The essential oil extraction was carried out using hydro-distillation method. Samples of korarima were hydrodistilled in a Clevenger type apparatus for 4 h (Eyob et al., 2007). The oils were collected and dried over anhydrous sodium sulphate. Oil yield was estimated on volume by weight (v/w) basis.

#### *Acetone extractable solutes (Oleoresin)*

Oleoresin of korarima seeds was determined by acetone

**Table 1.** List of places and altitudes considered for korarima sampling.

| Sampling sites (kebeles) | Zones/special woredas | Woredas | Altitude (masl) |
|---|---|---|---|
| Michiti | Keffa | Gimbo | 1800 |
| Keja Araba | Keffa | Gimbo | 2100 |
| Bita Chega | Keffa | Gimbo | 1800 |
| Boba Gecha | Keffa | Decha | 1350 |
| Shapa | Keffa | Decha | 2100 |
| Eremo | Keffa | Decha | 1952 |
| Dukara Weshi | Keffa | Chena | 1700 |
| Kuta Shory | Keffa | Chena | 1950 |
| Wana Bola | Keffa | Chena | 1650 |
| Baita | Bench Maji | Shewa Bench | 2350 |
| Golish | Bench Maji | Shewa Bench | 2250 |
| Maz | Bench Maji | Shewa Bench | 2100 |
| Gisu | Bench Maji | Debub Bench | 1725 |
| Gaus | Bench Maji | Debub Bench | 1800 |
| Adisu Zemikn | Bench Maji | Debub Bench | 1750 |
| Gachit | Bench Maji | Menit Goldya | 1900 |
| Girsha | Bench Maji | Menit Goldya | 1650 |
| Kobut | Bench Maji | Menit Goldya | 1625 |
| Metser | South Omo | South Ari | 1500 |
| Zenba | South Omo | South Ari | 1650 |
| Pelpa | South Omo | South Ari | 1750 |
| Seri Shewa | Konta | Konta | 1500 |

extract method using soxhlet apparatus. Thirty grams of ground sample was weighed and put into a paper extraction thimble, a cup made of whatman 1 filter paper. The thimble, containing sample was placed in the container of the extractor. Condenser was fixed on to it. The apparatus was assembled and started the extracting with acetone as solvent. Extraction was extended to 4-6 h. After the process the extract was transferred in to a beaker quantitatively. On a steam bath (Heidolph, rotary evaporator, Germany) the solvent was evaporated completely. When the last traces of acetone were evaporated, the container was placed in a hot air oven at 110±2ºC until two consecutive weightings taken at $1^1/_2$-h intervals did not differ by more than 1 mg (ASTA, 1997).

### Proximate analysis

The samples were determined for their proximate composition of moisture content, crude protein content, crude fat content, crude fiber content and ash content using the method of AOAC (1990). Carbohydrate content was calculated by the difference.

### Statistical analysis

Analysis of variance was done using the General Linear Model procedure of Statistical Analysis Systems (SAS, 2010) version 9.2 to determine the significance of variation among samples. Means of the samples were compared using Least Significant Difference (LSD) test at 5% probability level. The treatment means showing significant differences were separated by using the small letters a to z. Bartlett’s test for homogeneity of variance was done using Minitab 15 (Minitab version 15, Minitab Inc., State College, PA, USA) statistical software to check the validity of the data and transformation of data was carried out for those who failed the test. The mean values of transformed data’s were presented after retransformation was carried out.

## RESULTS AND DISCUSSIONS

### Capsule length, diameter and circumference

The maximum average capsule length (CL) in centimeter was observed in Eremo and Wana Bola samples (6.73) which were statistically at par with Boba Gecha (6.60), Keja Araba (6.51), Dukara Weshi (6.49) and Kuta Shoray (6.22) but significantly superior to the rest of the samples. Samples collected from Maz showed the least (4.81) capsule length. Sample collected from Gisu was the maximum in terms of average capsule diameter (3.39) which was at par with Girsha (3.34) Adisu Zemikn (3.31), Gaus (3.25), Pelpa (3.22), Dukara Weshi (3.13), Kobut (3.12), Boba Gecha (3.11) and Metser (3.11) and followed by Eremo (3.09). Sample collected from Michiti scored the least (2.80) from the others. The observed capsule length and diameter was comparable to the earlier studies of Jansen (1981) and Fissiha (2012) who reported up to ca 6 cm, 6.18 cm long and 3.5 cm, 3.71 cm diameter for mature red korarima capsule, respectively. The maximum capsule circumference was observed in Boba Gecha (11.10) and it was statistically at par with Eremo (10.93), Dukara Weshi (10.83), Kuta Shoray (10.77), Adisu Zemikin (1073), Keja Araba (10.66) and Shapa (10.46) but significantly different from the rest of the samples. Sample from Maz was the least (9.22) in terms of capsule circumference.

## Capsule and seed shape indices

The ANOVA result show that a significant ($p<0.01$) variation was observed both in terms of capsule and seed shape indices of the korarima samples. With regard to capsule shape index, Baita sample significantly different from the others. Sample from Kobut was significantly different from the others except with that of Gachit and Eremo samples whereas Wana Bola was significantly different from Gachit and Kobut but not significantly different from the rest. According to results presented in Table 2 capsule shape index was varied from 2.56 to 1.90. The highest value for capsule shape index was obtained from Kobut which was at par with Gachit (2.36) and Eremo (2.35) but significantly different from the rest. The least index of capsule shape was found from Baita sample. In addition to this, the highest index of seed shape was obtained from Baita (1.43) followed by Michiti (1.35) and Zenba (1.34) whereas Kobut scored the least (1.23). In most of the samples the capsule shape index was greater than 2 (Table 2). Therefore, according to IPGRI (1994) most of the fruits were ovoid shape than Globose. Shape analysis of agricultural products is growing in importance due to many factors including consumers' choices, industrial processing, cultivar description and selection (Costa et al*.,* 2011).

## Fresh capsule weight

A highly significant ($p<0.01$) difference was observed for fresh capsule weight among the samples. Samples from Adisu Zemikn showed the highest fresh capsule weight, (27.44) statistically at par with Gachit (27.32 g), Boba Gecha (25.00 g), Eremo (24.92 g), Girsha (24.39 g), Gisu (24.21 g), Dukara Weshi (23.95 g) and Baita (23.88 g); however, it was significantly superior over the rest of the samples. Samples collected from Kobut and Michiti had the least, 18.59 and 17.22 g, respectively, in respect of fresh capsule weight. In a previous study, Fissiha (2012) found medium (22.52 g) result for fresh weight of red korarima capsule collected from Masha zone. In the present study a high heterogeneous groups was obtained in terms of fresh capsule weight.

## Seed number per capsule

A highly significant ($p<0.01$) variation was observed among the samples in terms of seed number per capsule (Table 2). A significantly higher number of seeds per capsule were obtained in Boba Gecha (232.80) sample followed by Michiti (211.20), Golish (203.00) and Maz (201.20). Maz was at par with Gachit (193.80) in respect of seed number per capsule. On the other hand samples from Shapa, Baita and Metser had the smallest number of seeds per capsule which were counted as 147.60 137.00 and 122.60, respectively. So far no published result has been reported concerning variation in seed per capsule of korarima from different growing regions. However, the present result was much higher than previously reported for 45-60 seed per capsule of korarima (Jansen, 1981). The high variation in seed number per capsule among the korarima samples may give a high advantage so that selection and further improvement can be done through breeding.

## Seed to husk ratio (SHR)

The samples varied significantly ($p<0.01$) in terms of seed to husk ratio (SHR). The highest SHR was observed in Keja Araba (2.76) followed by Bita Chega (2.72), Adisu Zemikin (2.68) Maz (2.61). The lowest ratio of seed over husk was revealed in Eremo (2.07) and Michiti (1.72) samples. In this trait the samples were significantly different from each other except Baita and Girsha samples. In comparable with the current finding, in a previous study Fissiha (2012) reported 2.42: 1 to 3.36: 1 ratio of seed over husk for korarima collected from Masha area.

## Seed length and diameter

A significant ($p<0.05$) difference was observed among the samples on the seed length. The maximum seed length was measured in Gisu (3.89 mm) which was statistically at par with Michiti (3.87 mm), Zenba (3.85 mm), Baita (3.85 mm), Kobut (3.85 mm), Shapa (3.80 mm), Keja Araba (3.79 mm), Seri Shewa (3.79 mm), Wana Bola (3.79 mm), Kuta Shoray (3.76 mm) and Dukara Weshi (3.75 mm) but significantly superior over the rest of the samples. Maz (3.56 mm) and Gachit (3.60 mm) had the minimum seed length. A significant ($p$<0.05) variation was obtained among the samples in terms of seed diameter. The maximum mean of seed diameter in millimeter was found in Gisu (2.97) which was at par with Kobut, Shapa, Eremo, Kuta Shoray, Seri Shewa, Gaus, Keja Araba, Zenba, Boba Gecha, Dukara Weshi and Michiti; however, it was significantly different from the rest of the samples. On the other hand, Girsha and Baita recorded the least with values 2.79 and 2.70mm, respectively. The present result is in agreement with Jansan (1981) and Fissiha (2012) who reported 2-5 and 2.27-5.27 mm diameter for korarima seeds respectively.

## Hundred seed weight

Data on hundred seed weight indicated that there was significant ($p$<0.01) difference among the samples (Table 2). The highest average hundred seed weight was recorded in Keja Araba (2.34 g) sample which was at par with Kuta Shoray (2.34 g) and Eremo (2.32 g) but significantly superior over the rest of the samples. Genotypes and localities as influencing factors in variation of seed weight were reported by Hussain (2011) in *Elaeagnus umbellata* (Thunb) fruit from Rawalakot (Azad Kashmir) Pakistan.

## Biochemical parameters

### *Essential oil*

A significant ($p$<0.01) variation was observed among the samples in terms of essential oil yield (Table 3). The highest average (v/w) percentage of essential oil yield was obtained from Eremo (3.19) and was statistically at par with Pelpa (3.17) but significantly different from the rest of the samples. Lower essential oil yields were recorded for Samples collected from South Bench woreda, Gaus (0.94) kebele than the others. In general the essential oil yield was varying from 3.17 to 0.94 (v/w) among the locations. Variation in yield of essential oil as affected by stage of maturity at harvest and postharvest operations was reported by Fissiha et al. (2014). The result indicated that, the oil yield varied from 2.82 to 5.53% among the samples of various maturity stage and postharvest operations. Based on this, the essential oil yield of korarima samples in the current study can vary further following different post-harvest operations. Hymete et al. (2006) reported the yield of korarima essential oil extracted from dried seeds as 3.77% (v/w). In our study, volatile yields from only two sites, namely Eremo (3.19%) and Pelpa (3.17%) were comparable to the earlier reports, however, the rest of the samples were lower as compared to previous reports. Eyob et al. (2007) reported the essential oil yield from dried seeds of highland korarima. According to the authors, oil yields for seed (4.30%) was higher when extracted from fresh samples compared to dried seeds (3.77%).

### *Oleoresin (w/w %)*

The highest weight by weight percentage of oleoresin content was recorded for sample collected from Pelpa (7.84) followed by Adisu Zemikn (6.87). However, oleoresin content of sample collected from Addisu Zemikin was found at par with Bita Chega (6.78) and Michiti (6.47) but statistically superior ($P$<0.01) over the rest of the samples. Among the samples collected from different locations oleoresin content ranged from 2.19 to 7.83 (w/w%), while the least value was recorded for samples obtained from Gaus. The result obtained is comparable with the previous reports for oleoresin content (4.87 to 9.16%) (Fissiha, 2012).

### *Crude fiber content (%)*

The data presented in Table 3 indicates that there was variation among the samples with regard to crude fiber percentage. Sample from Gachit recorded 48.44 % which was significantly superior over the rest of the samples followed by Gaus (31.84%) and Keja Araba (25.47)**.** On the other hand the least crude fiber percentage was also obtained from Wana Bola sample (7.44%) followed by Girsha (10.87%). All the samples were significantly different from each other in terms of crude fiber content except korarima samples from Michit and Pelpa. Crude fiber content of samples from Gachit (48.44%) and Gaus (31.84%) were somewhat far from the average and resulted in low oil content. Fissiha (2012) reported 22.85% for maximum crude fiber content of korarima seeds sample from Masha zone which was by far lower than the maximum obtained in the present study. However, both small and high fiber content samples are important depending on the end use. Fiber helps in the maintenance of human health and has been known to

**Table 2.** Mean values of physical parameters for capsules and seeds of the korarima samples.

| Samples | CL (cm) | CD (cm) | CSI | CC (cm) | SCW(g) | SPC | SL(mm) | SD(mm) | SSI | HSW(g) | SHR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Michiti | $5.76^{defgh}$ | $2.80^{f}$ | $2.13^{d}$ | $9.75^{hijkl}$ | $17.22^{g}$ | $211.20^{b}$ | $3.87^{ab}$ | $2.87^{abcde}$ | $1.35^{b}$ | $1.39^{i}$ | $1.72^{t}$ |
| keja Araba | $6.51^{ab}$ | $3.03^{cdef}$ | $2.21^{bcd}$ | $10.66^{abcde}$ | $22.41^{bcdef}$ | $188.60^{ef}$ | $3.79^{abcdef}$ | $2.90^{abcde}$ | $1.31^{bc}$ | $2.34^{a}$ | $2.76^{a}$ |
| Bita Chega | $6.11^{bcdef}$ | $2.91^{ef}$ | $2.14^{d}$ | $10.22^{defghi}$ | $20.22^{defg}$ | $166.80^{i}$ | $3.74^{bcdefgh}$ | $2.83^{cdef}$ | $1.32^{bc}$ | $2.22^{cd}$ | $2.72^{b}$ |
| Boba Gecha | $6.60^{ab}$ | $3.11^{abcde}$ | $2.22^{bcd}$ | $11.10^{a}$ | $25.00^{ab}$ | $232.80^{a}$ | $3.71^{cdefgh}$ | $2.87^{abcde}$ | $1.29^{bcde}$ | $2.30^{b}$ | $2.38^{i}$ |
| Shapa | $6.27^{abcd}$ | $2.95^{def}$ | $2.29^{bcd}$ | $10.46^{abcdef}$ | $20.77^{cdefg}$ | $147.60^{k}$ | $3.80^{abcdef}$ | $2.95^{abc}$ | $1.29^{bcde}$ | $2.31^{b}$ | $2.33^{l}$ |
| Eremo | $6.73^{a}$ | $3.09^{bcdef}$ | $2.35^{abc}$ | $10.93^{ab}$ | $24.92^{ab}$ | $167.00^{i}$ | $3.68^{fghi}$ | $2.94^{abc}$ | $1.25^{cde}$ | $2.32^{ab}$ | $2.07^{r}$ |
| Dukara Weshi | $6.49^{abc}$ | $3.13^{abcde}$ | $2.20^{bcd}$ | $10.83^{abc}$ | $23.95^{abcd}$ | $157.40^{j}$ | $3.75^{abcdefg}$ | $2.87^{abcde}$ | $1.31^{bc}$ | $2.22^{cde}$ | $2.20^{o}$ |
| Kuta Shoray | $6.22^{abcde}$ | $3.02^{cdef}$ | $2.26^{bcd}$ | $10.77^{abcd}$ | $22.41^{bcdef}$ | $176.80^{h}$ | $3.76^{abcdefg}$ | $2.92^{abcd}$ | $1.29^{bcde}$ | $2.34^{a}$ | $2.55^{e}$ |
| Wana Bola | $6.73^{a}$ | $3.03^{cdef}$ | $2.15^{cd}$ | $10.39^{bcdefg}$ | $22.56^{bcde}$ | $177.00^{h}$ | $3.79^{abcdef}$ | $2.85^{abcde}$ | $1.33^{b}$ | $2.15^{fg}$ | $2.37^{j}$ |
| Baita | $5.13^{ijk}$ | $3.04^{cdef}$ | $1.90^{e}$ | $9.83^{ghijk}$ | $23.88^{abcd}$ | $137.00^{l}$ | $3.85^{abcd}$ | $2.70^{f}$ | $1.43^{a}$ | $2.12^{g}$ | $2.12^{p}$ |
| Golish | $5.45^{hij}$ | $3.07^{bcdef}$ | $2.12^{d}$ | $9.65^{jkl}$ | $22.23^{bcdef}$ | $203.00^{c}$ | $3.70^{efghi}$ | $2.80^{def}$ | $1.32^{bc}$ | $2.19^{def}$ | $2.12^{q}$ |
| Maz | $4.81^{k}$ | $2.87^{ef}$ | $2.17^{bcd}$ | $9.26^{l}$ | $18.74^{efg}$ | $201.20^{cd}$ | $3.60^{hi}$ | $2.79^{def}$ | $1.29^{bcde}$ | $1.90^{h}$ | $2.61^{d}$ |
| Gisu | $5.74^{efgh}$ | $3.39^{a}$ | $2.28^{bcd}$ | $10.37^{bcdefg}$ | $24.21^{abc}$ | $178.40^{gh}$ | $3.89^{a}$ | $2.97^{a}$ | $1.31^{bc}$ | $2.12^{g}$ | $2.32^{l}$ |
| Gaus | $5.63^{fghi}$ | $3.25^{abcd}$ | $2.26^{bcd}$ | $10.32^{cdefgh}$ | $27.32^{a}$ | $157.00^{j}$ | $3.73^{bcdefgh}$ | $2.90^{abcde}$ | $1.29^{bcde}$ | $2.22^{cd}$ | $2.49^{g}$ |
| Adisu Zemikin | $5.63^{fghi}$ | $3.31^{abc}$ | $2.24^{bcd}$ | $10.73^{abcd}$ | $27.44^{a}$ | $154.40^{j}$ | $3.63^{ghi}$ | $2.85^{bcde}$ | $1.28^{bcde}$ | $2.17^{ef}$ | $2.68^{c}$ |
| Gachit | $5.00^{jk}$ | $2.86^{ef}$ | $2.36^{ab}$ | $9.22^{l}$ | $19.65^{efg}$ | $193.80^{de}$ | $3.56^{i}$ | $2.90^{abcde}$ | $1.23^{de}$ | $1.88^{h}$ | $2.22^{n}$ |
| Girsha | $5.98^{cdefg}$ | $3.34^{ab}$ | $2.15^{cd}$ | $10.31^{cdefgh}$ | $24.39^{abc}$ | $177.40^{h}$ | $3.63^{ghi}$ | $2.79^{ef}$ | $1.30^{bcd}$ | $1.90^{h}$ | $2.12^{p}$ |
| Kobut | $5.47^{ghij}$ | $3.12^{abcde}$ | $2.56^{a}$ | $9.467^{lk}$ | $18.59^{fg}$ | $157.40^{j}$ | $3.84^{abcde}$ | $2.97^{ab}$ | $1.23^{e}$ | $2.10^{g}$ | $1.82^{s}$ |
| Metser | $5.60^{fghi}$ | $3.11^{abcde}$ | $2.17^{bcd}$ | $10.05^{fghij}$ | $21.65^{bcdef}$ | $122.60^{m}$ | $3.71^{defgh}$ | $2.83^{cde}$ | $1.31^{bc}$ | $2.23^{cd}$ | $2.35^{k}$ |
| Zenba | $5.27^{hijk}$ | $3.06^{bcdef}$ | $2.16^{bcd}$ | $10.10^{efghij}$ | $21.06^{cdefg}$ | $165.20^{i}$ | $3.85^{abc}$ | $2.89^{abcde}$ | $1.34^{b}$ | $2.25^{c}$ | $2.28^{m}$ |
| Pelpa | $5.36^{hij}$ | $3.22^{abcd}$ | $2.18^{bcd}$ | $10.43^{bcdef}$ | $21.67^{bcdef}$ | $177.60^{g}$ | $3.71^{cdefgh}$ | $2.84^{bcde}$ | $1.31^{bc}$ | $1.92^{h}$ | $2.47^{h}$ |
| Seri Shewa | $5.63^{fghi}$ | $3.09^{bcdef}$ | $2.23^{bcd}$ | $9.68^{ijkl}$ | $19.81^{efg}$ | $184.80^{gh}$ | $3.79^{abcdef}$ | $2.91^{abcde}$ | $1.30^{bcde}$ | $2.20^{de}$ | $2.52^{f}$ |
| CV (%) | 10.59 | 6.89 | 7.24 | 5.90 | 14.74 | 14.37 | 3.06 | 3.11 | 4.23 | 10.18 | 11.44 |

Values followed by different letters within a column are significantly different $p<0.05$ (lsd's test). *CL: Capsule length, CD: Capsule diameter, CSI: Capsule shape index, CC: Capsule circumference, SCW: Single capsule weight, SPC: Seeds per capsule, SL, Seed length, SD, Seed diameter, SSI: Seed shape index, HSW: Hundred seed weight, SHR: Seed to husk

reduce cholesterol level in the body (Bello et al., 2008). Fiber diets promote the wave-like contraction that move food through the intestine, high fibre food expands the inside walls of the colon, easing the passage of waste, thus making it an effective anti-constipation.

***Crude fat content (%)***

There was a significant ($P<0.01$) variation among the samples regarding the crude fat content (Table 3). Sample from Gachit recorded the higher crude fat content (2.85%) which was at par with Pelpa (2.83) and followed by Shapa (2.65). The crude fat content ranged from 1.25 to 2.85

**Table 3.** Biochemical contents and proximate compositions of dried seeds of the korarima samples.

| Samples | EO* (v/w%) | OC (w/w%) | CFBR (%) | CF (%) | Ash (%) | CP (%) | CH (%) |
|---|---|---|---|---|---|---|---|
| Michiti | $2.16^{c}$ | $6.47^{bc}$ | $18.30^{i}$ | $2.25^{f}$ | $7.73^{f}$ | $7.95^{a}$ | $52.72^{ij}$ |
| keja Araba | $1.36^{fg}$ | $3.25^{j}$ | $25.47^{c}$ | $2.18^{g}$ | $3.70^{o}$ | $7.51^{f}$ | $48.35^{n}$ |
| Bita Chega | $1.63^{d}$ | $6.78^{b}$ | $11.74^{p}$ | $2.50^{d}$ | $6.96^{h}$ | $7.47^{g}$ | $59.02^{c}$ |
| Boba Gecha | $1.46^{def}$ | $4.08^{gh}$ | $24.04^{e}$ | $2.43^{e}$ | $5.35^{k}$ | $7.46^{g}$ | $48.56^{n}$ |
| Shapa | $1.56^{def}$ | $3.96^{ghi}$ | $12.20^{o}$ | $2.65^{b}$ | $7.74^{f}$ | $6.89^{o}$ | $57.91^{d}$ |
| Eremo | $3.19^{a}$ | $4.85^{ef}$ | $13.44^{n}$ | $2.50^{d}$ | $6.21^{i}$ | $7.20^{k}$ | $59.25^{c}$ |
| Dukara Weshi | $2.41^{b}$ | $5.38^{de}$ | $22.17^{f}$ | $1.93^{j}$ | $5.55^{j}$ | $7.63^{e}$ | $50.90^{l}$ |
| Kuta Shoray | $1.46^{def}$ | $3.84^{ghij}$ | $24.30^{d}$ | $2.38^{e}$ | $3.90^{n}$ | $7.41^{h}$ | $50.34^{m}$ |
| Wana Bola | $1.63^{d}$ | $4.86^{ef}$ | $7.435^{u}$ | $2.15^{g}$ | $9.75^{e}$ | $7.46^{g}$ | $61.06^{a}$ |
| Baita | $1.52^{def}$ | $3.67^{hij}$ | $11.40^{r}$ | $2.28^{f}$ | $10.88^{c}$ | $7.50^{f}$ | $55.29^{g}$ |
| Golish | $0.98^{i}$ | $3.18^{jk}$ | $13.90^{l}$ | $2.43^{e}$ | $12.92^{b}$ | $7.31^{i}$ | $50.62^{lm}$ |
| Maz | $1.58^{def}$ | $3.84^{ghij}$ | $11.07^{s}$ | $2.00^{i}$ | $7.72^{f}$ | $7.26^{j}$ | $59.80^{b}$ |
| Gisu | $1.21^{gh}$ | $3.50^{hij}$ | $11.57^{q}$ | $2.00^{i}$ | $4.49^{m}$ | $7.73^{d}$ | $61.21^{a}$ |
| Gaus | $0.94^{i}$ | $2.19^{l}$ | $31.84^{b}$ | $2.38^{e}$ | $3.52^{p}$ | $6.87^{o}$ | $43.03^{o}$ |
| Adisu Zemikin | $1.38^{efg}$ | $6.87^{b}$ | $13.77^{m}$ | $2.58^{c}$ | $10.24^{d}$ | $7.03^{m}$ | $54.60^{h}$ |
| Gachit | $1.08^{hi}$ | $3.37^{ij}$ | $48.44^{a}$ | $2.85^{a}$ | $3.21^{q}$ | $7.80^{b}$ | $26.13^{p}$ |
| Girsha | $1.51^{def}$ | $2.53^{kl}$ | $10.87^{t}$ | $2.15^{g}$ | $15.36^{a}$ | $7.08^{l}$ | $52.16^{k}$ |
| Kobut | $1.11^{hi}$ | $3.59^{hij}$ | $15.30^{k}$ | $2.08^{h}$ | $7.38^{g}$ | $6.90^{o}$ | $55.69^{f}$ |
| Metser | $2.53^{b}$ | $3.70^{ghij}$ | $21.57^{g}$ | $2.43^{e}$ | $4.65^{l}$ | $7.00^{n}$ | $52.92^{i}$ |
| Zenba | $1.60^{de}$ | $5.98^{dc}$ | $18.80^{h}$ | $2.30^{f}$ | $6.96^{h}$ | $7.26^{j}$ | $52.45^{jk}$ |
| Pelpa | $3.17^{a}$ | $7.84^{a}$ | $18.44^{i}$ | $2.83^{a}$ | $3.08^{r}$ | $7.06^{l}$ | $56.43^{e}$ |
| Seri Shewa | $2.15^{c}$ | $4.38^{fg}$ | $16.44^{j}$ | $1.25^{j}$ | $12.91^{b}$ | $7.78^{c}$ | $50.35^{m}$ |
| CV (%) | 37.16 | 4.53 | 14.98 | 14.62 | 25.04 | 4.29 | 14.13 |

Values followed by different letters within a column are significantly different $p<0.05$ (lsd's test). * EO: Essential oil, OC: Oleoresin content, CP: crude protein, CF: Crude fat, CFBR: Crude fiber, CH: Carbohydrate**.**

and the least amount was obtained from Seri Shewa. Although those with low oil content are relegated as a source of oil commercially, they can be recommended as part of weight reducing diets (Bello et al*.,* 2008). In the present study the average crude fat content of the korarima samples was lower than *Aframomum longiscapum* (7.13%) and *Aframomum melegueta* (6.14%) seeds; however, it was comparable with crude fat obtained from *Aframomum sceptrum* which were previously reported by Aliyu et al. (2012), Erukainure et al. (2011) and Ibekwe and Orok (2010), respectively.

***Ash content (%)***

According to the results on Table 3 ash content of the samples ranged from 3.08 to 15.36%. The highest ash content was recorded by Girsha (15.36%) followed by Golish (12.92). Sample from Golish was found at par with Baita (10.88) but significantly different from the rest of the samples. The least ash content was recorded by Pelpa of South Omo (3.08). Most of the korarima samples were found superior over the previously reported ash contents (5.45%) (Fissiha, 2012). The ash content of a sample gives an idea about the inorganic content of the samples from where the mineral content could be obtained (Bello et al*.,* 2008). Samples with high percentages of ash contents are expected to have high concentrations of various mineral elements, which are expected to speed up metabolic processes and improve growth and development (Bello et al*.,* 2008).

***Crude protein content (%)***

The analysis of variance revealed that there existed a significant ($p<0.01$) variation among the different samples in terms of crude protein content. Sample from Michiti registered the highest in protein content (7.95) followed by Gachit (7.80) whereas, Gaus (6.87) had the least with no significant variation with Shapa (6.89) and Kobut (6.90). The protein contents of *Aframomum melegueta*

(Alligator pepper), *Aframomum longiscapum* and *Aframomum sceptrum* seeds were reported by Ibekwe and Orok (2010), Aliyu et al. (2012) and Erukainure et al. (2011) respectively. The average protein content of korarima samples was higher than *Aframomum melegueta* (4.81); however, it was lower than that of *Aframomum longiscapum* (10.38) and *Aframomum Sceptrum.* The variations in crude protein contents of the korarima samples may be accounted to the differences in climatic conditions, edaphic factors and ages of the plants (Edim et al*.,* 2011; Melesse, 2011; Ardabili et al., 2011).

### *Carbohydrate content (%)*

A significant ($p$<0.01) variation was observed among the samples from different locations for carbohydrate content (Table 3). Korarima samples collected from Gisu scored the highest carbohydrate content (61.21) followed by Wana Bola (61.06) and Airemo (59.25). In a wider gap from other samples Gachit was found to be inferior for carbohydrate content (26.13). In general, the carbohydrate content (percentage) was higher in all korarima samples as compared to other proximate compositions regardless of variation among the samples. This finding was supported by Ibekwe and Orok (2010) who found high nitrogen free extract in *Aframomum melegueta* seeds. Similar results also reported by Aliyu et al. (2012) on *Aframomum longiscapum* seeds from Nigeria. In this study a significant variation was obtained among the different locations in terms carbohydrate content since the locations might vary in their ecological natures.

## Conclusion

The present study has revealed that Eremo and Pelpa samples are preferable for essential oil and oleoresin production whereas Wana Bola korarima is preferable for high carbohydrate content. The study result indicated as there is a significant variation in korarima of different climatic regions for physical and biochemical qualities. The variation in capsule and seed physical and biochemical characteristics among korarima samples of different locations could be linked to varietal, environmental (temperature, rain fall etc.), edaphic factors, shade level and management practices.

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