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Physical Properties and Geometric Characteristics of Promising Ethiopian Chickpea (*Cicer arietinum L.*) Varieties

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ABSTRACT: *Chickpea (Cicer arietinum L.) is an important grain legume nutritionally balanced for human consumption. The physical properties of chickpea seeds are important for harvesting, handling, drying, storing, de-hulling, processing, and packaging. This study was carried out to determine the effect of different variety and grown environment on the engineering characteristics and physical properties of 11 released and promising chickpea varieties. Eleven Ethiopian promising chickpea varieties were evaluated for physical properties, engineering properties and soaking test. All physical and geometric properties highly significant at ($p \leq 0.05$) differences were observed almost in all seed varieties in the three different environment locations, these indicating that there was some requirements variation in the processing equipment design. The average geometric diameter mean, hundred seed weight, length, width, thickness, sphericity, aspect ratio, bulk density, true density, porosity, seed volume, seed surface area and moisture content are 7.22 to 8.43mm, 28.11 to 39.72g, 8.76 to 9.82mm, 6.83 to 7.96mm, 6.75 to 7.66mm, 83.10 to 87.13%, 76.85 to 82.92%, 0.32 to 0.48g/ml, 1.22 to 1.46g/cm^3, 25.55 to 36.78%, 161.41 to 261.52, 968.46 to 1326.53 and 10.85 to 12.06%, respectively. The soaking or water absorption of chickpea grain in different time and temperature were showed significant difference among varieties and grown location. Mean diameter showed high positive correlation with that of thickness, seed volume and surface area ($r = 0.99$). Totally as soaking time and temperature increased, the per cent of water absorption of chickpea seed varieties were increased in parallel with different magnitude. The results of this research can be used for design and adjustment of agricultural machines of these different chickpea varieties and recognition and classification of them.*

KEY WORDS: physical properties, Geometric Characteristics, chickpea varieties

INTRODUCTION

Ethiopia chickpea (*Cicer arietinum*) is part of a leguminous family of crops that are rich in protein and pulse content. The major varieties that perform well in the country include Desi and Kabuli. The Desi cultivar is usually sweet and the most popular and widespread in local farms. It features brown, yellow or greenish black colours, all having hard coats. The Kabuli variety comes in a beige colour and can be pea-shaped or round. Its coat is normally light and soft to the touch [1]. Chickpea is a good and cheap source of protein for people in developing countries (especially in South Asia), who are largely vegetarian either by choice or because of economic reasons.

The protein quality is considered to be better than other pulses. Chickpea has significant amounts of all the essential amino acids. Starch is the major storage carbohydrate followed by dietary fibre; lipids are present in low amounts, but chickpea is rich in nutritionally important unsaturated fatty acids like linoleic acid and oleic acid. Chickpea has several nutritional and processing problems, such as the presence of anti-nutrients, prolonged cooking time, and poor digestibility. Its chemical composition is subject to fluctuations, depending on various factors, e.g., cultivar and maturity stage, environment (mostly weather conditions), and agro-ecology. Chickpea is an important ingredient in various dishes and contributes significantly to the basic daily nutritional requirements of a large segment of society in Ethiopia, including used as shiro like lentils, common beans, peas, and faba beans [2].

Variation in chemical composition in pulses might be owing either to intrinsic factors (mainly genetic) or to extrinsic factors such as storage, type of soil, agronomic practices (such as plant density, weeds, or soil fertility), climatic factors (such as rainfall, light intensity, length of growing season, length of day, or temperature) [3]. Information on the physical properties of chickpea is important in the design of equipment used for processing, transportation, sorting, separation, and storage. Furthermore, these properties are required during the processing and handling of agricultural materials to set the operational parameters of the equipment for efficient operations [4,5]. For instance, the size and shape of foods are important physical characteristics that are used in screening, grading, and quality control [6]. Data on volume, density, and porosity are also important for the design of processing, storage of particulate material, determining the power required for pumping, and modelling and design of various heat and mass transfer processes, such as drying, frying, baking, heating, cooling, and extrusion [6]. Bulk density determines the capacity of storage and transport systems, while true density is useful for separation equipment; porosity of the mass of seeds determines the resistance to air flow during aeration and drying of seeds.

The functionality of raw materials is a combination of properties that determine product quality and process effectiveness. These properties are relevant to the mechanization of processing to increase the utilization as a food resource. Current practices including: harvesting, cleaning and processing of this seed depend largely on traditional methods, which are not practical for large-scale production. Moreover, increasing production, reducing crop losses and minimizing seed damage require the designing of efficient handling and processing equipment's. Hence, there is a limited research and knowledge practices on the physical properties, geometric characteristics and soaking characteristics of Ethiopian chickpeas varieties. However, physical properties and geometric characteristics of Ethiopian released and promising chickpea varieties were not well studied. Thus, the objective of this study was to explore physical properties and geometric characteristics of promising Ethiopian chickpea varieties and their dependence on selected varieties, which can help out in the design of handling, processing, and packaging machinery for chickpea production.

MATERIAL AND METHOD

Sample Collection

Eleven chickpeas varieties were collected from Debre Zeit Agricultural Research Centre, Ethiopia and then cultivated at three locations (Deber Ziet (DZ), Minjar (MI) and Chefe Donesa (CD)) in Ethiopia 2011. From eleven chickpea varieties the three (Natoli, Dimtu and Teketaye) varieties are desi type whereas, the other eight chickpeas varieties are kabuli type. All chickpea varieties were planted in three blocks with a RCBD design. Chickpea seeds were collected randomly from each block and pooled together and after seeds were dried in sun. At maturity stage, the grain yield was harvested and brought in to the laboratory for quality parameter analysis. After the seed were collected from each locations, then seeds were cleaned manually by removing any foreign material, damaged and broken seeds, shriveled and insect attacked seeds. All the samples were kept in moisture proof plastic bag placed in air tight tin container at 4^0C.

Notations:-

L- Length (mm)
W- Width (mm)
T- Thickness (mm)
Da- Arithmetic mean diameter (mm)
Dg- Geometric mean diameter (mm)
De- Equivalent mean diameter (mm)
Ds- Square mean diameter (mm)
TD- True density (g/cm^3)
BD-Bulk density (g/ml)
V- Seed volume
Ra-aspect ratio (%)
S- Seed surface area
P- Porosity (%)

100-Seed Weight

100-seed weight of the chickpea accessions was measured on randomly selected 100 seeds and weighing them using a sensitive balance and weight was recorded in grams.

Moisture content

The moisture content can be determined by oven dry method, which is a direct method. Samples from different chickpea cultivars were estimated for their moisture content as per standard methods of analysis (AOAC).

$$MC\ (\%) = (m1-m2)\ /m1*100 \quad (1)$$

Where, m1- initial seed weight, m2- grain weight after oven drying and MC- moisture content

Dimensional Properties

Seed size was measured in millimetres on principal dimensions such as length, width and thickness. Twenty randomly selected seeds from each accession were used to measure length, width and thickness using electronic digital calliper and mean values were calculated. The arithmetic mean diameter (Da), geometric mean diameter (Dg), square mean diameter (Ds), and equivalent mean diameter (De) of the chickpea were determined by using the following equations [7].

$$Da = \frac{L+W+T}{3} \quad (2)$$

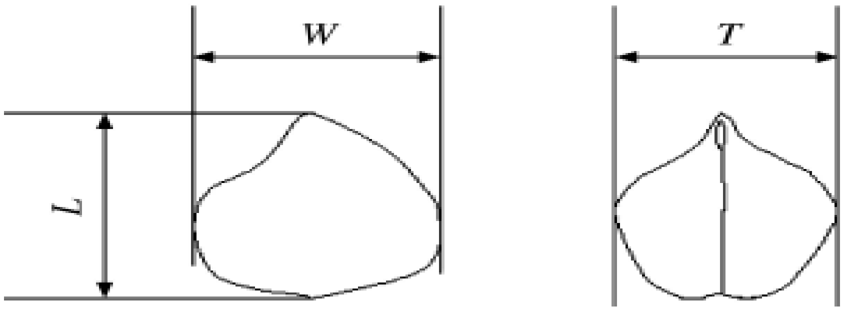

Figure 1. Principal dimensions of chickpea

$$Dg = (LWT)^{1/3} \quad (3)$$

$$Ds = (LW + WT + TL)^{1/2} \quad (4)$$

$$De = \frac{Da + Dg + Ds}{3} \quad (5)$$

The volume (V) and surface area (S) of the chickpea were determined using equations adopted by [8].

$$V = \pi B^2L^2 / 6(2L-B) \quad (6)$$

$$S = \pi B^2L^2 /2L-B \quad (7)$$

Where; $B = (WT)^{1/2}$; L is the length of the seeds; W is the width of the chickpea seeds; T is the thickness of the seeds in mm.

Sphericity

Sphericity defines the ratio of the diameter of a sphere of the same volume as that of the particle and the diameter of the smallest circumscribing sphere or generally the largest diameter of the particle [9].

$$\text{Sphericity} = \frac{\sqrt{\text{volume of the particle}}}{\text{volume of circumdsribed sphere}} = (LWT)^{1/3}\ /L \quad (8)$$

Where, L = largest intercept (length), mm; W= width, mm; T = Thickness, mm.

Aspect ratio

The aspect ratio is defines by the ratio of width of the seeds to the length of seeds into 100. Ra of the chickpea seeds was determined as recommended by using equation:

$$Ra\ \% = W/L * 100 \tag{9}$$

Where, L = largest intercept (length), mm and W= width, mm

Bulk Density and True Density

For determining the bulk density, true density and the porosity of seed a sample size of 100 g was used. Bulk density of the seed was calculated by dividing the weight of each sample on its volume, measured by using a graduated cylinder [10]. True density and volume were determined by toluene solution displacement method [11]. Bulk density and true density were expressed as g/cc at given seed moisture conditions. The porosity was determined as the percentage of densities of bulk seeds [12].

The following formula was used for measuring the porosity (P) which is the ratio of free space between seeds to total of bulk grains:

$$P = \frac{\rho t - \rho b}{\rho t} * 100 \tag{10}$$

Where; ρt is true density, g/mL; and ρb is bulk density, g/mL.

Soaking tests

Ten randomly selected chickpea seeds were weighed, then 200 ml distilled water placed in glass beakers at 20 ^{0}C, 30 ^{0}C and 40 ^{0}C for120 min in triplicate. The amount of water absorption was determined at 15, 30, 60, 90 and 120 min after immersion in the distilled water. The tests were continued at intervals of one hour to reach equilibrium moisture content. The excess water was spilled and the sample removes from the beakers after reaching certain time. A digital chronometer will be used to record soaking duration and a precision electronic balance will be measured weight of soaked sample before and after immersion.

RESULT AND DISCUSSION

Dimensions and size distribution

The effects of Ethiopian chickpea varieties on the size distribution and dimension were presented on Table 1. All dimensional and size distribution properties of the promising Ethiopian chickpea varieties were significant at (p < 0.05) in both varieties and growing locations, which interns indicating that these would require some variation in the processing equipment design. About 72.72% of the chickpea seed have a length ranging from 8.89 to 9.82mm, about 82.82% of the grain seed width ranging from 7.15 to 7.96mm and about 90.91% of the grain thickness ranging from 6.75 to 7.66mm (table 1). The average length, width and thickness of tested chickpea seed varieties 8.57 to 9.82, 6.83 to 7.96 and 6.44 to 7.66 respectively. These dimensional properties of chickpea seed were higher than chickpea grain as reported by Farzad and Alinejat [13]. Similar study were been reported by Konak [14]. From chickpea varieties, varity-19 and from three growing location Deber Ziet were scored the higher in length, width and thickness. Information of the length, width, thickness of the seeds is necessary in determining aperture sizes in the design of seed handling equipment.

The arithmetic and geometric mean diameters of elven promising Ethiopian chickpea varieties were ranged from 7.28 to 8.48 mm and 7.22 to 8.43mm, respectively. The equivalent and square mean diameters of the four improved chickpea varieties were 9.02 to 10.52 mm and 12.56 to 14.64mm, respectively (table 1). Similar with that of length, width and thickness varity-19 have scored the highest in arithmetic, geometric, equivalent and square mean diameters. Deber Ziet location were shows significantly higher values in all arithmetic, geometric, equivalent and square mean diameters from the three growing environments. The mean geometric diameter is useful in evaluation of the projected area of a particle moving in the turbulent or near-turbulent area of an air stream. It is therefore usually investigative of its model of behaviour in air streams, particularly with respect to the ease of separating extraneous materials from the particle during cleaning by pneumatic means [15].

The promising Ethiopian chickpea varieties have a volume, seed surface area and aspect ratio ranged in 161.41to 261.52, 968.46 to 1569.15 and 76.85 to 83.10% respectively (table 1). From elven promising chickpea varieties variety-19 have showed high values in seed volume and seed surface area 261.52 and 1569.15, respectively and the variety Ejere was scored the higher aspect ratio 83.10%. The seed volume did not reflect the seed weight. The lowest and

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Table 1. Physical properties of promising Ethiopian chickpea varieties

Variety	Dg in mm	Da in mm	Ds in mm	De in mm	L(mm)	W(mm)	T(mm)	Volume	Surface area	Ra %
Natoli	7.44±0.26^{e}	7.50±0.26^{e}	12.93±0.46^{e}	9.29±0.33^{e}	8.77±0.25^{e}	6.97±0.24^{f}	6.75±0.31^{e}	177.82±20.37^{e}	1066.95±122.21^{e}	79.38±1.07^{ef}
Ejere	7.62±0.28^{d}	7.66±0.29^{d}	13.23±0.49^{d}	9.50±0.35^{d}	8.76±0.43^{e}	7.27±0.14^{de}	6.95±0.34^{cd}	195.41±20.32^{cd}	1172.47±121.94^{cd}	83.10±2.99^{a}
Teketaye	7.68±0.32^{cd}	7.74±0.33^{d}	13.36±0.57^{cd}	9.60±0.41^{cd}	9.14±0.42^{c}	7.19±0.30^{e}	6.91±0.33^{d}	194.09±23.89^{cd}	1164.56±143.33^{cd}	78.64±2.49^{f}
Hora	7.69±0.38^{cd}	7.75±0.39^{d}	13.37±0.66^{cd}	9.61±0.48^{cd}	9.39±0.41^{b}	7.15±0.31^{e}	6.97±0.33^{cd}	195.17±26.84^{cd}	1171.05±161.04^{cd}	78.36±3.17^{f}
Dhera	7.96±0.28^{b}	8.02±0.28^{b}	13.83±0.48^{b}	9.94±0.35^{b}	9.41±0.42^{b}	7.40±0.20^{c}	7.24±0.25^{b}	216.44±20.37^{b}	1298.67±122.22^{b}	78.71±1.73^{ef}
Arerti	7.22±0.16^{f}	7.28±0.18^{f}	12.56±0.29^{f}	9.02±0.21^{f}	8.57±0.38^{f}	6.83±0.14^{g}	6.44±0.18^{f}	161.41±10.41^{f}	968.46±62.46^{f}	79.85±4.37^{de}
Dimtu	7.80±0.19^{c}	7.87±0.20^{cd}	13.57±0.34^{c}	9.74±0.24^{c}	9.14±0.12^{c}	7.21±0.08^{de}	7.01±0.17^{cd}	199.95±11.36^{cd}	1199.68±68.17^{cd}	76.85±2.97^{g}
Habru	7.73±0.36^{cd}	7.77±0.37^{de}	13.42±0.64^{d}	9.64±0.46^{cd}	8.94±0.50^{d}	7.33±0.27^{cd}	7.05±0.37^{c}	203.12±27.30^{c}	1218.75±163.81^{c}	82.04±2.75^{ab}
DZ-2012-CK-0019	8.43±0.37^{a}	8.48±0.38^{a}	14.64±0.65^{a}	10.52±0.47^{a}	9.82±0.51^{a}	7.96±0.37^{a}	7.66±0.33^{a}	261.52±34.33^{a}	1569.15±205.97^{a}	81.18±3.23^{bc}
Shasho	7.62±0.39^{d}	7.66±0.40^{d}	13.23±0.69^{d}	9.51±0.49^{d}	8.89±0.55^{de}	7.15±0.28^{e}	6.96±0.41^{cd}	193.11±27.87^{d}	1158.65±167.24^{d}	80.64±2.65^{cd}
DZ-2012-CK-0024	7.93±0.31^{b}	7.97±0.31^{bc}	13.78±0.54^{b}	9.89±0.39^{b}	9.11±0.40^{c}	7.55±0.23^{b}	7.27±0.34^{b}	221.09±25.40^{b}	1326.53±152.42^{b}	82.92±2.18^{a}
CV	5.44	5.45	5.44	5.44	6.06	5.15	6.02	6.61	6.61	4.14
Location										
DZ	8.01±0.39^{a}	8.07±0.38^{a}	13.92±0.67^{a}	10.00±0.48^{a}	9.41±0.41^{a}	7.48±0.41^{a}	7.31±0.38^{a}	223.68±35.08^{a}	1342.06±210.49^{a}	79.48±2.38^{b}
Minjar	7.79±0.33^{b}	7.85±0.33^{b}	13.54±0.58^{b}	9.73±0.41^{b}	9.27±0.43^{b}	7.23±0.29^{b}	7.05±0.35^{b}	202.18±25.74^{b}	1213.09±154.43^{b}	78.00±2.59^{c}
CD	7.41±0.29^{c}	7.46±0.29^{c}	12.88±0.50^{c}	9.25±0.36^{c}	8.57±0.37^{c}	7.11±0.30^{c}	6.70±0.27^{c}	179.36±21.80^{c}	1076.18±130.80^{c}	82.98±2.70^{a}
CV	0.70	0.70	1.21	0.87	0.79	0.66	0.63	10.42	62.51	8.11

the highest value, in fact, the highest seed weight corresponds but did not the lowest. Deber Ziet location have shown significance difference in both volume and seed surface area, where as Chefe Donsa location in aspect ratio.

Physical properties

The effects of chickpea varieties and grown location on selected properties of chickpea varieties were presented in Table 2. All determined physical properties of chickpea varieties were showed significant difference ($p < 0.05$) and also except that of moisture content of chickpea seed other selected properties are significantly different in three locations (Deber Ziet, Minjar and Chefe Donsa) (Table 2). Seed moisture content is an important measure of seed quality influencing the physical parameters, seed handling procedures and storage behaviour of seeds in the gene banks. The moisture content of elven chickpea varieties ranged in between 10.85 and 12.06%. According to this study Dhera variety was scored the highest value and the lowest was Ejere variety. The present results show that the moisture content ranges was within those reported by Sastry [16], which the result were ranged from 10.1 to 12.80%. Seed moisture content is an important measure of seed quality influencing the physical parameters, seed handling procedures and storage behaviour of the seeds in gene banks [17]. For food researchers and processors, the amounts of water present in agricultural products are extremely important as they assist in determining certain phases of adaptation and resistance to processing, such as drying, bagging and storing, cooking, and even consumption.

Hundred seed weight of promising chickpea varieties ranges 28.11 to 39.72g. The present result shows that the hundred seed weight of chickpea samples were higher than reported in [16]. The bulk density and true density of chickpea varieties were ranged 0.32 to 0.48gm/l and 1.22 to 1.46g/cm^3. The true densities of different Ethiopian chickpea seed varieties were fairly same as gram which was 1.24 to 1.38 g/mL [13]. True seed density is a component of grain yield that is positively correlated with seed protein content and selection for increased density could provide an efficient way to improve protein content without affecting seed. The density characteristics of the seeds are quite useful in estimating product yield and machine throughput. Bulk density is a useful parameter in determining the size of the container needed for a given weight of seed during seed packaging and storage [18].

The sphericity and porosity among tested chickpea varieties ranged from 83.10 to 87.13% and 25.55 to 36.78%, respectively. The values of sphericity were higher than the corresponding values of gram which had been between 70 and 74% [19]. Since the porosity depends on the bulk as well as true or kernel densities, the magnitude of variation in porosity depends on these factors only. The nearer the sphericity to 1, the higher the affinity ti roll about any of the three-axis, and the closer the ratio thickness to width to 1, the higher the tendency to rotate about the major axis [20]. This propensity (an inclination) to either roll or slide is very important in the design of hoppers and de-hulling machines for the seed since flattest seeds slide more easily than spherical seeds that roll on the structural surface [21]. The higher sphericity of chickpea seed allows more sliding and rolling during seed processing [22]. Ghadge [23] studied the physical properties of chickpea split and identified the importance of sphericity and aspect ratio of the seed seeds in determining the shape of the split.

Table 2. Effects of different chickpea varieties on selected properties of chickpeas

Variety	Moisture (%)	100 seed wt	BD (gm/ml)	TD (g/cm^3)	Sphericity(%)	Porosity (%)
Natoli	10.93^{bcd}	28.11 ± 2.90^{g}	0.37 ± 0.36^{d}	1.46 ± 0.17^{a}	84.83 ± 1.07^{c}	28.32 ± 2.23^{ab}
Ejere	10.85^{d}	31.01 ± 5.30^{e}	0.32 ± 0.39^{f}	1.39 ± 0.18^{bc}	87.03 ± 1.58^{a}	27.60 ± 1.40^{b}
Teketaye	11.31^{b}	29.47 ± 3.98^{f}	0.33 ± 0.37^{f}	1.44 ± 0.20^{a}	84.07 ± 0.87^{c}	30.80 ± 0.36^{ab}
Hora	11.30^{bc}	33.24 ± 4.65^{c}	0.35 ± 0.36^{e}	1.41 ± 0.12^{b}	84.27 ± 1.83^{c}	30.28 ± 1.64^{b}
Dhera	12.06^{a}	34.93 ± 3.88^{b}	0.37 ± 0.36^{d}	1.29 ± 0.21^{e}	84.63 ± 1.16^{c}	36.74 ± 0.25^{a}
Arerti	11.03^{bcd}	28.48 ± 5.28^{g}	0.40 ± 0.31^{c}	1.38 ± 0.08^{c}	84.38 ± 2.69^{c}	26.92 ± 0.53^{b}
Dimtu	11.05^{bcd}	31.38 ± 2.96^{e}	0.43 ± 0.30^{b}	1.46 ± 0.15^{a}	83.10 ± 1.74^{d}	29.36 ± 1.20^{ab}
Habru	11.05^{bcd}	32.39 ± 5.49^{d}	0.42 ± 0.30^{b}	1.32 ± 0.19^{d}	86.48 ± 1.56^{ab}	27.83 ± 1.23^{b}
DZ-2012-CK-0019	11.12^{bcd}	39.72 ± 6.25^{a}	0.43 ± 0.29^{b}	1.22 ± 0.06^{f}	85.88 ± 1.50^{b}	27.66 ± 2.15^{b}
Shasho	11.04^{bcd}	30.04 ± 5.03^{f}	0.48 ± 0.26^{a}	1.39 ± 0.16^{bc}	85.78 ± 1.51^{b}	36.78 ± 1.25^{a}
DZ-2012-CK-0024	10.92^{cd}	33.87 ± 5.19^{c}	0.48 ± 0.26^{a}	1.40 ± 0.17^{bc}	87.13 ± 1.19^{a}	25.55 ± 1.25^{c}
CV	2.05	7.37	2.22	9.36	2.32	3.86
Location						
DZ	11.30^{a}	35.76 ± 4.82^{a}	0.17 ± 0.08^{c}	1.39 ± 0.15^{b}	85.14 ± 1.73^{b}	32.73 ± 12.82^{a}
Minjar	11.18^{ab}	33.99 ± 3.31^{b}	0.20 ± 0.09^{b}	1.22 ± 0.08^{c}	84.01 ± 1.68^{c}	29.13 ± 5.55^{ab}
CD	11.17^{ab}	26.42 ± 2.91^{c}	0.83 ± 0.01^{a}	1.54 ± 0.09^{a}	86.56 ± 1.61^{a}	27.56 ± 8.95^{c}
CV	0.76	1.66	0.09	0.13	9.15	0.46

Soaking Test (Water absorption)

Data on the amount of water absorbed during soaking, in all chickpea varieties and in all heating temperature of soaking water (20, 30 and 40^0C), are illustrated in in figure 2 and shows significance difference at $p<0.05$. This study showed that when the heating temperature of soaking water increased from 20 to 40^0C the water absorption of almost all chickpea seeds were increased significantly with corresponding soaking time. At 15 minutes soaking time the smallest chickpea water absorption differences were observed at 20^0C (Natoli and Dimtu), 30^0C (Natoli and Teketaye) and 40^0C (Natoli and Teketaye) were as the highest chickpea water absorption observed at 20^0C (Shash and variety-24), 30^0C (Shash and Arerti) and 40^0C (Hora and Dhera) (fig.2). These differences were because of seed coat content and thickness of different chickpea varieties were differ, which intern affects water absorption of the chickpea grain. This similar finding with report the seed water content exponentially increases with soaking time at all temperatures [23]. The temperature influenced the rate of water uptake and the time required for maximum absorption, but did not affect the maximum water absorbed. With the process continuing, water absorption decreases until it ceases when the seed attained the equilibrium water content [22].

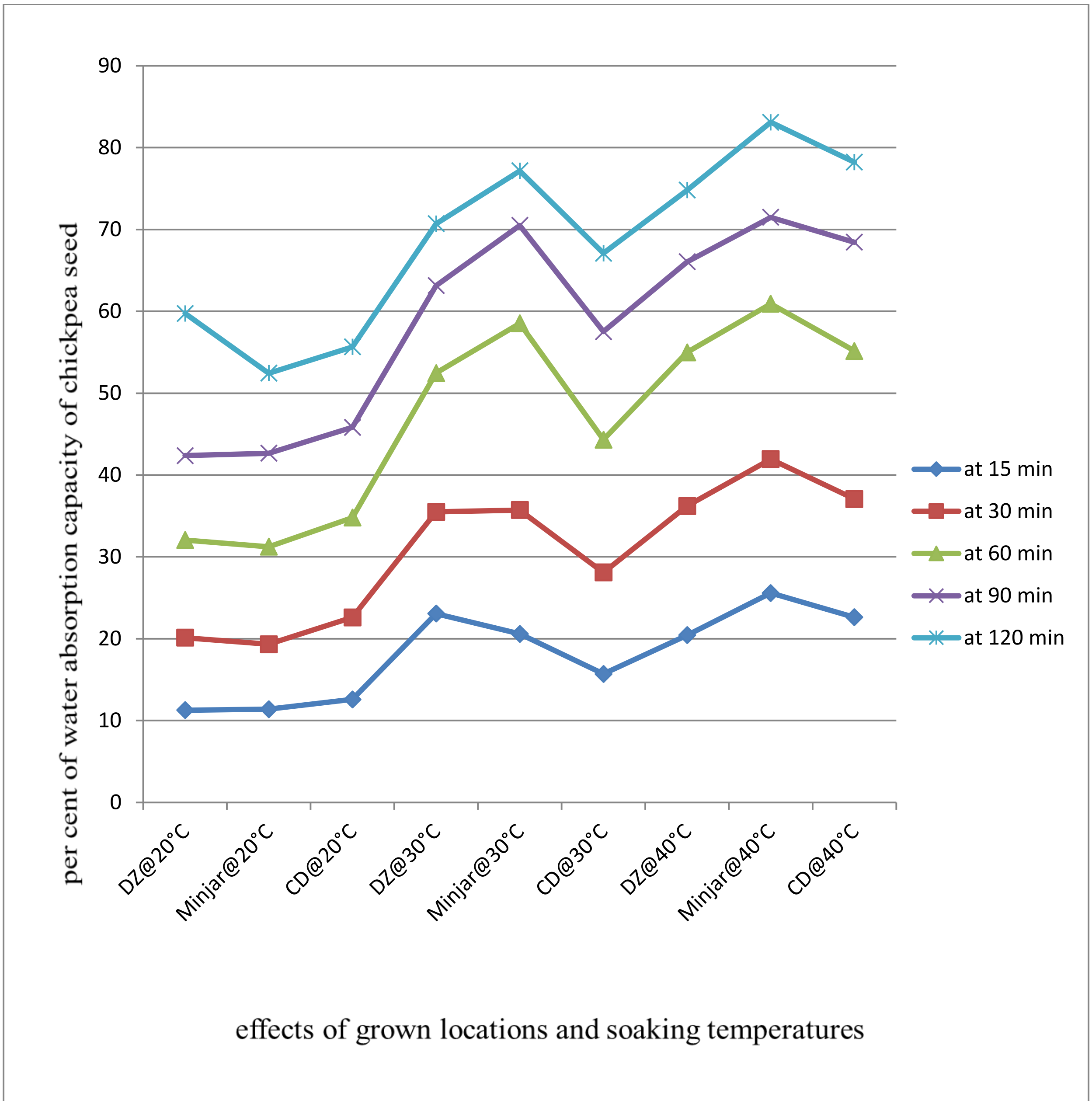

Figure 2. Effects of soaking temperature and time on water absorption of chickpea seed grown location.

Grown location affects significantly ($p<0.05$) the water absorption of different chickpea varieties at different soaking temperature and soaking time (Fig. 3). At 20^{0}C location Derber Diet and Minjar showed the smallest water absorption difference at soaking time 15, 30, 60and 90 minutes, but at 120 minutes Minjar only showed the lowest water absorption. This difference may be from the grown soil and weather difference which they directly affects the quality of the seed and the seed coat of chickpea grains.

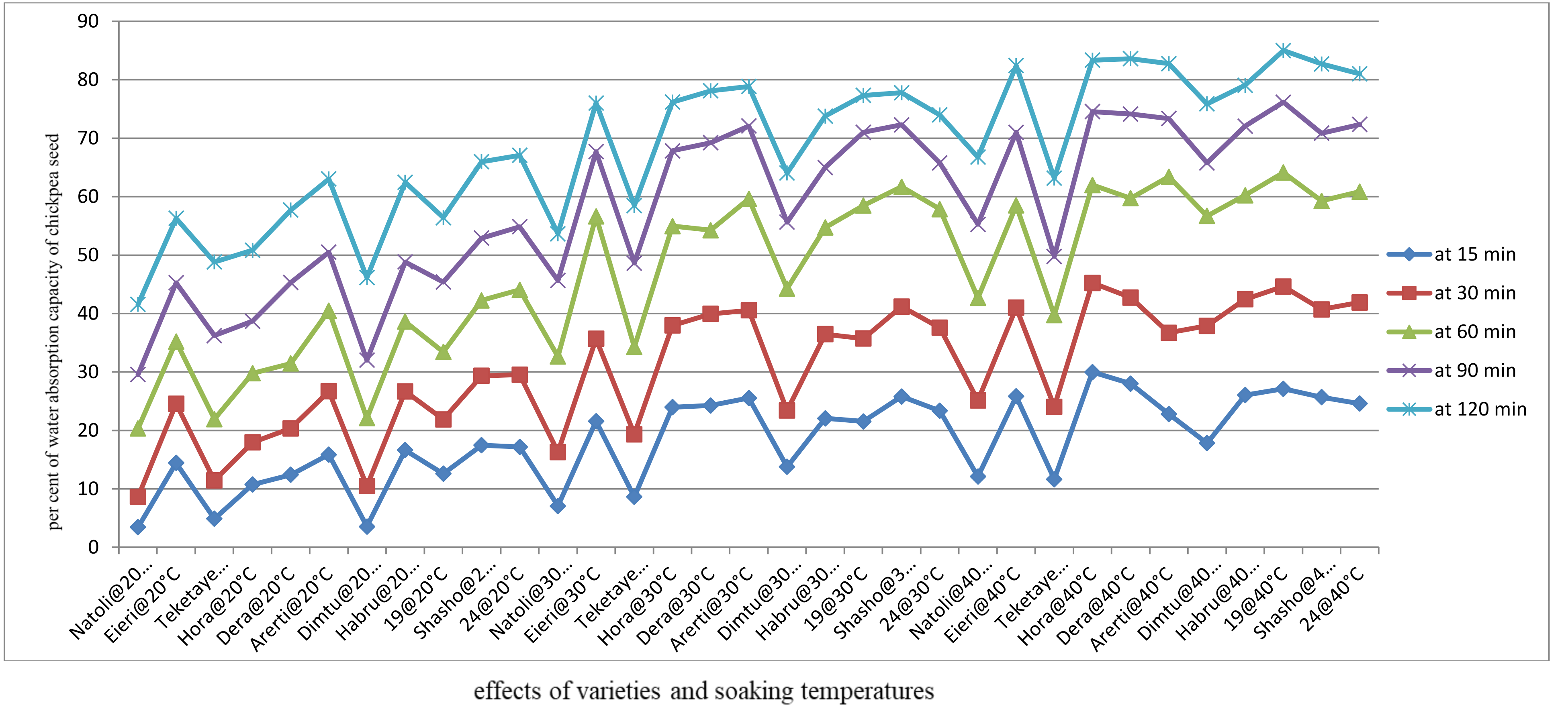

Figure 3. Effects of soaking temperature and time on water absorption of different chickpea seeds varieties

Correlation coefficients for physical properties of chickpea varieties

The correlation coefficients among seed physical properties are presented in Table 3. Seed moisture content of the chickpea had positive and significant correlation with porosity. It positively correlates without significance difference with hundred seed weight, geometric diameter means, seed volume and seed surface area and negatively correlate with bulk density, true density, sphercity and aspect ratio. Since, all the seed samples were dried to lower seed moisture content, the moisture range across seed types was also narrow. Correlation among hundred seed weight and geometric diameter mean, seed volumes and surface area were positively and highly significant. However highly significant negative correlation was observed with true density. Chickpea seed bulk density and true density were negatively correlated without significant difference. But bulk density positively correlated with all physical properties of chickpeas listed in Table 3.

Chickpea true density negatively and significantly correlated with geometric diameter mean, seed volume and surface area, but positively correlated with aspect ratio. Chickpeas sphercity was positively and highly significant correlated with aspect ratio. Sphercity negatively correlated with porosity and positive correlated were observed with geometric diameter mean, seed volume and surface area. Porosity was showed poorly positive correlation with geometric diameter mean, and negatively correlated with seed volume, surface area and aspect ratio. Geometric diameter mean was positively and highly significant correlation with seed volume and surface area but poorly correlated with chickpea seed aspect ratio. Concerning chickpea seed volume relationships with surface area had positive and highly significant. The surface area of chickpea grain was positively correlated with aspect ratio.

	Moisture	HSW	BD	TD	Sphericity	Porosity	Dg	Volume	SA
HSW	0.32								
BD	-0.26	0.24							
TD	-0.54	-0.75**	-0.07						
Sphericity	-0.38	0.27	0.27	0.12					
Porosity	0.67*	-0.02	0.01	-0.33	-0.28				
Dg	0.28	0.94**	0.27	-0.84**	0.23	0.05			
Volume	0.21	0.94**	0.30	-0.80**	0.34	-0.02	0.99**		
SA	0.21	0.94**	0.30	-0.80**	0.34	-0.02	0.99**	0.99**	
Ra	-0.46	0.20	0.23	0.17	0.98**	-0.39	0.14	0.26	0.26

Table 3. Correlation among physical properties of chickpea varieties
Note: *and ** Correlation is significant at the 0.05 and 0.01 level, respectively

CONCLUSION

The present study provides information on physical properties, engineering properties and water absorption or soaking test of elven promising Ethiopian chickpea varieties grown in three different agro-ecologies. The results showed that these all physical properties, engineering properties and water absorption properties were vary among chickpea varieties significantly and the grown environments also showed significant difference except moisture content. The highest water absorption or soaking capacity for all chickpea grain varieties were observed at 90 minutes soaking time and 40^0C soaking temperature. Chickpea varieties grown in minjar locations relatively showed higher percent of water absorption capacity of grains in each soaking time and temperature except that of 30^0C@15 minutes. In conclusion, this paper deals with the physical properties, engineering properties and soaking test properties of improved chickpea, enlarging the knowledge about these varieties and providing useful data for their post-harvest handling and further industrial processing. Further studies should be conducted to explore the moisture-dependent geometric characteristics and engineering properties of these promising Ethiopian chickpea varieties.

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Reference

[1] Shiferaw B., R. Jones; S. Silim, Tekelewold H.; E. Gwata, "Analysis of production costs, market opportunities and competitiveness of Desi and Kabuli chickpeas in Ethiopia," in IPMS (Improving Productivity and Market Success) of Ethiopian Farmers Project Working Paper. 2007, 3,1–48, ILRI (International Livestock Research Institute), Nairobi, Kenya.
[2] Kaur M.; N. Singh; N. Sodhi. Physicochemical, cooking, textural and roasting characteristics of chickpea (Cicer arietinum L.) Cultivars," Journal of Food Engineering. 2005, 6 (9): 511–517, 2005.
[3] Nikolopoulou, D.; Grigorakis, K.; Stasini, M.;Alexis, M. N.; Iliadis,K. Differences in chemical composition of field pea (Pisumsativum) cultivars: Effect of cultivation area and year. Food Chem. 2007,103:847-852.
[4] Khansa, A. P.; Bintoro, N. The Influence of Types and Moisture Contents of Coffee Beans (Coffea Sp) on Sphericity and Geometric Means Diameter. IOP Conference Series: Earth and Environmental Science. 2021, 653 (1). DOI: 10.1088/1755-1315/653/1/012017.
[5] Adebowale, A. R. A.; Sanni, L. O.; Owo, H. O.; Karim, O. R. Effect of Variety and Moisture Content on Some Engineering Properties of Paddy Rice. J. Food Sci. Technol. 2011, 48(5), 551–559. DOI: 10.1007/s13197-010-0173-3.
[6] Serpil, S.; Servet Gulum, S. Size, Shape, Volume, and Related," in Size, Shape, Volume, and Related Physical Attributes. Phys. Prop. Foods. 2006, 1–37.
[7] Heidarbeigi, K.; Ahmadi, H.; Kheiralipour, K.; Tabatabaeefar, A. Some Physical and Mechanical Properties of Khinjuk. Pakistan J. Nutr. 2009, *8*(1), 74–77. DOI: 10.3923/pjn.2009.74.77.
[8] Baryeh, E. A.; Mangope, B. K. Some Physical Properties of QP-38 Variety Pigeon Pea. *J. Food Eng.* 2002, *56*(1), 59–65. DOI: 10.1016/S0260-8774(02)00148-6.
[9] Sahay, K. M.;K. K. Singh. Unit operations of agricultural processing. Vikas Publishing house Pvt. Ltd, New Delhi. 1994, 7-8.
[10] Ayman H; Amer Eissa; MA Mohamed; H Moustafa; Abdul Rahman; Alghanna O. Moisture dependent physical and mechanical properties of chickpea seeds. *Int. J. Agric. Biol. Eng. 2010*, 3: 70-83.

[11] Mohamed, M. A. Geometric changes caused by moisture content on some physical properties of lentil seeds. Menoufiya Journal of Agricultural Research. 2005, 30(5): 1275-1294.
[12] Jha N.S. Physical and hygroscopic properties of makhana. *J. Agric. Eng. Res.* 1999,72: 145–150.
[13] Farzad Jaliliantabar;Alinejat Lorestani. Physical properties and effect of loading orientation on the mechanical properties of black chickpea. Agric Eng Int: CIGR Journal. 2012, 14(3): 230－235
[14] M. Konak; K. C¸ arman; Aydin C. Physical Properties of Chick Pea Seeds. Bio-systems Engineering. 2002, 82 (1), 73–78 doi:10.1006/bioe.2002.0053.
[15] Seyed Mohammad Taghi Gharib-Zahedi, Seyed Mohammad Mousavi, Manochehr Hamedi and Amin Taheri Garavand. Determination of Some Physical, Mechanical, Chemical and Thermal Attributes of Black Seed (*Nigella oxypetala Boiss.).* International Agricultural Engineering Conference, Bangkok, Thailand. 2009, 7 – 10 December, (IAEC Ref. No. 197).
[16] Sastry D. V., H. D. Upadhyaya; Srinivas T. R. Variation for seed physical and hydration properties of chickpea (Cicer arietinum L.) mini core collection and their relevance to conservation and utilization. Plant Genetic Resources. 2019, 1–14 doi: 10.1017/S1479262119000030.
[17] Sharma, V.; Das, L.; Pradhan, R. C.; Naik, S. N.; Bhatnagar, N.; Kureel, R. S. Physical Properties of Tung Seed: An Industrial Oil Yielding Crop. Ind. Crops Prod. 2011, 33(2), 440–444. DOI: 10.1016/j.indcrop.2010.10.031.
[18] Gursoy S.; Guzel E. Determination of physical properties of some agricultural grains. Research Journal of Applied Sciences, Engineering and Technology.2010, 2: 492–498.
[19] Dutta, S. K.;V. K. Nema; R. K. Bhardwaj. 1988. Physical properties of gram. Journal of Agricultural Engineering Research. 1988, 39(4): 259-268.
[20] Akaaimo, D. I.; Raji, A. O. Some Physical and Engineering Properties of Prosopis Africana Seed. Biosyst. Eng. 2006, 95(2), 197–205. DOI: 10.1016/j.biosystemseng.2006.06.005.
[21] Adewumi, B. S.; Ijadunola, I. O.; Oladimeji, J. A.;S. Kosemani T. Determination of Some Physical Properties and Terminal Velocity of Locust Beans of Parkia Specie (Parkia Biglobosa). Sci. Eng. Perspect. 2015, 10, 1–8.
[22] Sayar S.; Turhan M.; Gunasekaran S. Analysis of chickpea soaking by simultaneous water transfer and water-starch reaction. J. Food Eng. 2001,50, 91-98.
[23] Cristina Patane; Elisa Iacoponi; Salvatore Raccuia A. Physicochemical characteristics, water absorption, soaking and cooking properties of some Sicilian populations of chickpea (Cicer arietinum L.), International Journal of Food Sciences and Nutrition. 2004, 55:7, 547-554, DOI: 10.1080/09637480400015836.