

Traditional Use of Legume Seeds for Weighing Gold in India

Raghava S. Boddupalli*

Retired Scientist, # 19, Sri Purushottama Nilayam, 16th Cross Road,
5th Main Road, N. N. Farm, Sanjayanagar, Bangalore.

(Received 16 September 2019; revised 01 June 2020)

Abstract

In world history, grains and seeds were chosen for weighing gold, silver and other precious gemstones. The selection of these seeds as weight-stones is due to their elegant uniformity. As mentioned in the vedas, gold was weighed using *guñja* or ratti seeds in ancient India because these seeds are fairly constant in weight. This article intends to highlight (i) traditional usage of three legume plant seeds viz. ratti, coral and carob as weights and measures (ii) weighing systems followed in India, and (iii) descriptions of botanical features of these legume species.

Key words: Carob seed, Coral seed, Gold weighing, Legume seeds, Ratti, Weight-stone.

1 Introduction

The history of weights and weighing devices in ancient India dates back to the vedic period. *Yajurveda* described the usage of *kṛṣṇala*, the seed of *Abrus precatorius* (*guñja*), as a unit of measurement for weight. In the sense of a weight, it occurs in the *Yajurveda Samhitā* such as *Taittirīya Samhitā* (2-3-2, || *Śatakṛṣṇalām niravapat* ||), *Maitrāyaṇī Samhitā* (2-2-20), *Kāthaka Samhitā* (11-4) and later in the *Taittirīya Brāhmaṇa* [1-3-6 (7), || *Kṛṣṇalam kṛṣṇalam vājasṛdbhyaḥ prayacchati* ||]. According to *Manusmṛti* (8-134c and 8-135c), the weight of one *māṣa* (bean) is equated to five *kṛṣṇalas* of gold or two *kṛṣṇalas* of silver (Macdonell and Keith 1912). A gold currency was evidently beginning to be known as far as definite weights of gold are mentioned. Thus a weight, *aṣṭā-prūḍ*, occurs in the *Taittirīya Samhitā* [3-4-1(4), || *Aṣṭāprūddhiranyam dakṣiṇāṣṭāpadī* ||] and *Kāthaka Samhitā* (11-1, 13-10). The golden *śatamāna*, weight of a hundred *kṛṣṇalas* is found in the vedic texts– *Taittirīya*

Samhitā [2-3-11(45), 6-6-10(37)], *Kāthaka Samhitā* (11-1, 13-10), and *Śatapatha Brāhmaṇa* [5-5-5(16), 7-7-2-(13), 9-1-4]. This was used as a standard weight of silver coins in ancient India between 600–200 BCE (Mukherjee 2012, pp. 411–413).

The ancient Indian name for a balance was *tulā*, which is still in use in modern times. The literary evidence of it can be gleaned from the vedic scriptures of *Vājasaneyya Samhitā* (30-17), *Śatapatha Brāhmaṇa* [9-2-7(33)] and *Āpastamba Sūtra* (v.II Pt. I & II 6 & 9). It is also mentioned in the *Aṣṭādhyāyī* of Pāṇini (4-4-51). Sanskrit writers freely conceded its claim to the title of Balance or Scales seed and termed it as *tulabīja* or *tulavīja*.

2 History of weights and measures

The first weight was not fashioned by man but by nature. Weights and measurements have been an essential system in human life since the dawn of civilization. The history of weighing devices in ancient India, on the basis of evidence provided by archaeological artifacts, literature, numismatics, sculptures and paintings have been

reported by (Cunningham 1891, Bhandarkar 1921, pp. 76–128; Sircar 1968, pp. 48–73; Sharma and Bharadwaj 1989; Kenoyer 2006, pp. 258–266; Vahia and Yadav 2007; Iwata, 2008). In order to weigh small amounts precisely, small objects of consistent size and weight were needed. Hence, grains and seeds of plants were chosen for their elegant uniformity. The grains of wheat and barley and the seeds of mustard, poppy, black gram, green gram, ratti and coral seeds were used to weigh gold, other precious metals and stones in India. Of these, only ‘ratti’ (*guñja*) seeds were used consistently throughout India. It is the smallest measure of weight in India; 1 ratti = 1.875 grains and 1 gram = 15.4 grains = 8.23 ratti (McIntosh 2008). In the countries of Middle-East, Europe and the USA, the seeds of carob tree (*Ceratonia siliqua*) were used as weights. The ancient Indian system of weights by Manu is provided in the Table 1.

2.1 Weights during Indus Valley Civilization

During the Harappan period, a series of graduated cubical weights were introduced (Figure 1). It has been suggested that the basis for the weight system was the ‘ratti’, equivalent to a 128th part of the Harappan basic unit or just over 0.1 grams. The smallest unit weighs 0.865 grams. At this part of the weight scale, each unit is double the weight of the one before (Kenoyer 2006; McIntosh 2008, p.441). The ‘ratti’ is still used in India as a jeweler’s weight and was the basis, for the weight standards of the first Indian coins in the 7th century BCE, among other things.

The first documented coinage is deemed to start with the *purāṇa* coins issued between the 7th–6th century BCE and the 1st century CE. These coins are otherwise called punch-marked coins because of their manufacturing technique (Figure 2a&b). Mostly made of silver weighing 560 grains, these bear symbols, each of which was punched on the coin with a separate punch (Figure 3a&b). These were in circulation during the centuries long before the beginning of the Christian era. Sanskrit writers such as Manu and Pāṇini, and the Buddhist Jātaka stories have made mention of these coins. This class of coins was also frequently mentioned as *kārṣāpaṇa*, derived from the word *kārṣa*. Literary records mention *kārṣāpaṇas* of gold, silver and copper (Bhandarkar 1921, Sircar 1968, pp. 48–73 and McIntosh 2008, p. 441). The gold-*kārṣāpaṇa* was also known as *suvarṇa* and *niṣka*, whereas the silver one was called *purāṇa* or *dharāṇa* (Table 1) and likewise, the cop-

per *kārṣāpaṇa* bore the popular designation of *paṇa*. The weight of the coins was indicated by the Indian authorities as that of the *raktikā* or *kṛṣṇala* (ratti) seeds (Table 2). The use of the ratti seed as the basis for the weight system may explain the endurance of the weight system through the period after the decline of the Indus civilization, when weights themselves disappeared.

2.2 Ratti Seeds (*Abrus precatorius*)

The seeds of *Abrus precatorius* have been used throughout history in a variety of roles. Due to their uniform size and weight, they are known as ratti, and were used as weights for weighing gold and silver. The genus name *Abrus* in Latin means ‘graceful’ and it refers to its beautiful flowers (Figure 4b). The species name *precatorius* expresses ‘entreaty’ or supplication and is prayerful. Earlier, these seeds were imported from India for use in Europe for making rosaries. The seeds are nearly globular, hard, red, and glossy, with a large black spot at one end.

A ratti is a traditional Indian unit of measurement for mass. They are very similar in weight. Based on the nominal weight of a ratti seed, it measures approximately 1.8 or 1.75 grains (Cunningham 1891, Bhandarkar 1921, Sircar 1968, pp. 48–73, McIntosh 2008, p. 441 and Mukherjee 2012, pp. 411–413). It has now been standardized as 0.1215 gram. In olden times, Indians used ratti seeds to generally measure gold. In another study, a sample of 200 ratti seeds from southern Ghana had an average weight of 0.074 grams, determined by an electric precision balance. The seeds varied between 0.068 and 0.079 grams but when used in groups of half a dozen or more gave an average of around 0.074 grams. Their weight remained almost constant over a period of several months (Garrard 1980, p. 232). Even in this case, it averages about 0.122 gram per seed.

Raktikā is the Sanskrit name for a unit weight corresponding to the weight of a single *guñja*/ratti seed (roughly corresponding to 1/8th of a gram), according to the *Ṣoḍaśāṅgahṛdayam* (classic treatise on Āyurvēdic literature). The different weight-units and their relation to one another and along with their corresponding values in parentheses are provided in Table 3.

Table 1 Ancient Indian system of weights (*Manusmṛti*, 8-134a, 8-134c, 8-135a, 8-135c, 8-136a and 8-137a).

Silver			
2 ratti	=	1 māṣaka	
32 ratti	=	16 māṣaka	= 1 kārṣāpaṇa or dharaṇa or purāṇa
320 ratti	=	160 māṣaka	= 10 dharaṇa or purāṇa
Gold			
5 ratti	=	1 māṣaka	
80 ratti	=	16 māṣaka	= 1 suvarṇa
320 ratti	=	64 māṣaka	= 4 suvarṇa = 1 pala, or niṣka
3200 ratti	=	640 māṣaka	= 40 suvarṇa = 10 pala, or niṣka = 1 dharaṇa

(Kṛṣṇala is colloquially known as 'ratti')

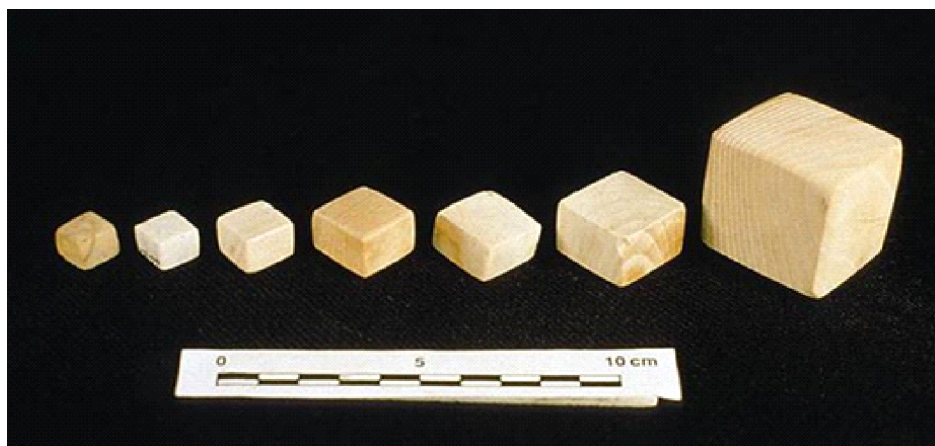


Figure 1 A series of graduated cubical weights from Harappan period. The smallest weighs 0.865 grams. At this part of the weight scale, each unit is double the weight of the one before (cubical chart weights from Allahdino, Sindh).



Figure 2 (a) Punch-marked silver-kārṣāpaṇa (purāṇa) square coin, (b) Rare punch-marked gold-kārṣāpaṇa (suvarṇa) round coin.



Figure 3 Punch-marked Coins –(a) *Purāṇa/s* or punch-marked coins (circa 600 BCE, circa 300 CE), (b) Ancient silver bent bar - silver *śatamāna* coin (circa 600 BCE).

Table 2 Different denominations of *kārṣāpaṇa* (‘Arhiya’ section of *Aṣṭādhyāyī* by Pāṇini).

2 ratti	=	0.0625 <i>kārṣāpaṇa</i> or <i>māṣa</i>
4 ratti	=	0.125 <i>kārṣāpaṇa</i> or <i>dvimāṣa</i>
8 ratti	=	0.25 <i>kārṣāpaṇa</i> or <i>pada</i>
16 ratti	=	0.5 <i>kārṣāpaṇa</i> or <i>ardha</i>
24 ratti	=	0.75 <i>kārṣāpaṇa</i> or <i>tripada</i>
32 ratti	=	1 <i>kārṣāpaṇa</i> or <i>paṇa</i> or <i>dharaṇa</i> or <i>purāṇa</i>
48 ratti	=	1.5 <i>kārṣāpaṇa</i> or <i>adhyardha</i>
64 ratti	=	2 <i>kārṣāpaṇa</i>
Other denominations mentioned		
12.5 ratti	=	1 <i>sana</i>
40 ratti	=	1 <i>vimastika</i>
60 ratti	=	1 <i>trimastika</i>
100 ratti	=	1 <i>śatamāna</i>

Table 3 Different weight units used in ancient India (Source: Wisdom Library - Āyurvēda and Botany).

<i>Guñjā (Raktikā)</i>	=	1 seed of <i>Guñjā</i>
8 <i>raktikā</i>	=	1 <i>māṣa</i> (1 gram)
10 <i>māṣa</i>	=	1 <i>karṣa</i> (10 grams)
2 <i>karṣa</i>	=	1 <i>śukti</i> (20 grams)
2 <i>śukti</i>	=	1 <i>pala</i> (40 grams)
2 <i>pala</i>	=	1 <i>prasṛta</i> (80 grams)
2 <i>prasṛta</i>	=	1 <i>kuḍava</i> (añjali) (160 grams)
2 <i>kuḍava</i>	=	1 <i>śarāva</i> (320 grams)
2 <i>śarāva</i>	=	1 <i>prastha</i> (640 grams)
4 <i>prastha</i>	=	1 <i>āḍhaka</i> (Pātra) (2.56 Kgs)
4 <i>āḍhaka</i>	=	1 <i>droṇa</i> (10.24 Kgs)
4 <i>droṇa</i>	=	1 <i>droṇī</i> (40.96 Kgs)
100 <i>pala</i>	=	1 <i>tulā</i> (4 Kgs)

2.3 Coral Seeds (*Adenanthera pavonina*)

Another leguminous tree of Caribbean origin, called 'jumbie bead' produces brilliant red, shiny seeds that are remarkably similar in general appearance to pharmaceutical tablets (Figure 5d). An individual seed has a constant weight of about four grains (0.26 gram). In early times, they were known as Circassian seeds and were used by goldsmiths throughout Asia as a standard measure for weighing gold, silver and diamonds. Renowned botanist Edred Corner (1940) states that in India, the coral seeds (*Adenanthera pavonina*) have been used as units of weight for fine measures of gold throughout the recorded history because the seeds are known to be almost identical in weights to each other. Indeed, the Malay name for the tree, 'saga', has been traced to Arabic for 'goldsmith' (Gardner *et al.* 2011).

Adenanthera pavonina seeds were experimentally validated and described that they were used as weight-stone for quantification of gold in jewelry shops in the traditional system in Manipur. These seeds are locally called as '*changing maru*'. In the traditional practice, one '*tola*' (equivalent to 11.664 grams in weight) is composed of four '*suns*'; one '*sun*' is composed of 24 '*changing maru*'; one '*changing maru*' is one seed of *A. pavonina*, which is regarded as equivalent to a standard weight of 0.122 grams. The weight of 96 seeds (4x24) is equivalent to one '*tola*' (Singh *et al.* 2003).

2.4 Carob Seeds (*Ceretonia siliqua*)

The seeds of carob tree (*Ceretonia siliqua*) were used to weigh gold and precious stones in Rome, Greece, Great Britain and other European countries, USA and the Middle East. In today's international gold market, the name 'carat' is used to value gold, silver, diamonds and other precious gems. The *carat*, a unit of mass for gemstones, and of purity for gold, takes its name, indirectly, from the Greek word for carob seed, *keration*. There appears to be a long history of a weight carrying a name associated with carob and with a mass close to that of a single carob bean. For example, the ancient Greeks had a small weight, the '*kerat*', while the '*siliqua*' (from the Latin for carob) is the smallest sub-division (1/1728) of the Roman pound (Smith 1870). Incidentally, the measure of gold purity— also called the *carat* (UK English) or *karat* (US English) – is derived from the time of the Emperor Constantine when a new gold coin was struck at 72 to the Roman pound, meaning that each coin weighed 24 *siliquae* or *carats*. While the exact modern equivalents of ancient weights are of course unknown, various methods such as weighing ancient coins, give widely accepted values for the *siliqua* in the range of 189–192mg (Smith 1870). According to the Oxford English Dictionary (OED 1989) the word '*carat*' first appeared in 1555 but its weight varied from place to place prior to its standardization at 200mg in 1907 (Zhengzhang 1991). The carob seed is considered to have been used as a standard weight unit and 24 seeds weighed one Byzantine gold coin. However, the differences in the weight of the carob seeds was experimentally validated and found that they are no more consistent in mass than a lot of other seeds (Turnbull 2006).

3 Weighing systems in Indian subcontinent

Before the introduction of metric system, the Indian weighing system can be divided into the following three periods:

3.1 Indian regional period system

During pre-Akbar period (before 1556 CE), weights system varied from region to region, commodity to commodity, and rural to urban areas. The weights were based on

the weight of various seeds. Weights were made of iron or stone. Balance (*tulā*) with two pans of different sizes was used for weighing different quantities. The early unit was a grain of wheat or barleycorn, used to weigh the precious metals, silver and gold. Larger units preserved in stone standards were developed and used as units of mass.

The amalgamated scheme of the weights of India in 1528 CE, prior to Sher Shah's intervention, has been preserved in the text of the Emperor Babar's memoirs, and the simplified version was provided by Thomas (1864 and 1874) and is presented in the Table 4.

3.2 Akbar period system (1556–1605)

Akbar realized a need for a uniform system in the country. He elected the barleycorn seed as a unit for measurement of weight (Thomas 1874 and Iwata 2008, pp. 2254–2255). Unfortunately, this did not replace the existing system. Instead, it just added another system. Weight nomenclature that was prevalent in India before 1833 till the introduction of metric system is presented in Table 5.

3.3 Colonial period system (1612–1947)

British people entered India as traders. They used weight of wheat berries as a standard and accepted barleycorn seeds as a unit 'grain' for weighing gold, same as Akbar. The grain, $\frac{1}{5760}$ th of the troy pound, is traditionally the weight of a barleycorn (Harris 1907, p. 396). Before the development of the modern strains of wheat and barley, the ratios 3 barleycorns = 4 grains of wheat, 4 grains of wheat = 1 carob seed (*Ceratonia siliqua*) were used. The weights were based on the weight of various seeds (especially the wheat berry or ratti). Since the weights of the cereal seeds (wheat and barleycorn) are highly variable due to the presence of moisture, it is a convention rather than an absolute law.

The British made an effort to achieve uniformity in weights and measures. They minted coins using wheat berry seed as the standard. Eventually, British introduced their own system for weighing gold (troy ounce) and commodities [pound/cwt (centum weight)/ton]. In 1956, the Government of India passed the Standards of Weights Act, which came into effect in 1958. This allowed *tolā/seer/maund* system to coexist with pound/cwt/ton system (Table 6).

4 Botanical descriptions of legume species

Seeds of the three legume plants that were used in weighing gold and other precious stones belong to the family Fabaceae. Here below are the botanical descriptions of these plants:

4.1 *Abrus precatorius* Linnaeus (Ratti)

This legume species is found in tropical regions. The deciduous creeper is native to tropical Asia and commonly found all over India, up to 1,000 meters high. It is also cultivated in countryside. However, it grows in most warm, humid climates all over the world such as in the Caribbean Islands and Florida. This shrub is also cultivated in the Egypt. It is a perennial climbing shrub, twines around trees, shrubs, and hedges. Leaves are stipulate, even-pinnate; Leaf rachis to 11 cm long; Leaflets 12-16 pairs, oblong; Raceme shorter than leaves. Flowers fascicled, few, calyx sparsely pubescent; Corolla whitish-pink; Pod thick, hard, wrinkled; Seeds adhere to pods, brilliant red, with a black base and a white basal hilum, no fracture lines (Figure 4a,b,c,d).



Figure 4 Ratti (*Abrus precatorius* L.) - (a) Climbing shrub in flowering, (b) Inflorescence close up, (c) Dehiscent legumes with attached seeds, (d) Seeds close up. ¹

¹The red seeds have small jet black spot at the base, in which is the point of attachment called the hilum (white in colour) due to which it

Table 4 Weights system of the Indian regional period (from Babar’s memoirs, p. 332).

8 ratti	=	1 māṣa		
32 ratti	=	4 māṣa	=	1 tang
40 ratti	=	5 māṣa	=	1 miṣkāl
96 ratti	=	12 māṣa	=	1 tola
1344 ratti	=	168 māṣa	=	14 tola = 1 sīr
53760 ratti	=	6720 māṣa	=	40 sīr = 1 mann
			=	12 mann = 1 māni
			=	100 māni = 1 mināsah

Table 5 Weights system used in India before 1833.

4 chāwāl (grain of rice)	=	1 dhān (weight of one wheat berry)	
4 dhān	=	1 ratti	= 1.75 grains = 0.11339825 gram
8 ratti	=	1 māṣa	= 0.9071856 gram
12 māṣa	=	96 ratti	= 1 tola = 180 grains = 11.66375 gram
80 tolās	=	1 seer	= 870.89816 gram
40 seers	=	1 maund	= 8 paseri = 37.32422 kilogram
1 chattānk	=	4 kancha	= 5 tolā
1 pāv	=	2 adh-pāv	= 4 chattank = ¼ seer
1 seer	=	4 pāv	= 16 chattank = 80 tolā = 933.1 grams
1 paseri	=	5 seer	
64 dhān (wheat berries)	=	45 jau (barleycorns)	

Table 6 Weights system used during British colonial period.

5760 grains	=	1 troy pound
1 troy pound	=	12 troy ounce
1 troy ounce	=	480 barleycorn
	=	120 carat
	=	31.1034768 gram
3.75 troy ounce	=	10 tola
1 barleycorn	=	64.79891 milligram
1 wheat berry	=	45.561732 milligram
3 barleycorns	=	4 wheat grains
4 wheat grains	=	1 carob seed

In 1878, the troy pound was abolished.

Common Names: *Raktika*, *Guñja* (Sanskrit); *Ratti*, *Ganchi*, *Gunchi*, (Hindi); *Chunhali*, *Kunch* (Bengali); Indian liquorice, Crab’s Eye, Indian bead (English); *Guriginja*, *Gurivenda* (Telugu); *Gurugunji*, *Gulganji* (Kan-

has earned names such as coral bead and crab’s eyes (Figure 4d)

nada); *Kunni*, *Kunnikuru* (Malayalam); *Gundumani*, *Kuntumani* (Tamil); *Ganji*, *Chanothi*, *Gunja* (Gujarati); *Chanoti*, *Gunchi*, *Gunja* (Marathi); *Gunja*, *Runji* (Oriya); *Liluwani*, *Raturmani* (Assamese); *Labrigunchi*, *Ratak* (Punjabi).

Botanical Citation: *Abrus precatorius* Linnaeus, Syst. Nat. ed. 12, 472, 1767; Baker in Hooker f., Fl. Brit. India 2: 175. 1876; Cooke, Fl. Bombay, 1: 359 (382), 1902; Duthie, Fl. Gangetic Pl. 1: 262. 1903; Gamble, Fl. Madras, 349 (247), 1918; Verdcourt, Kew Bull. 24: 240. 1970; Sanjappa, Legumes of India 74. 1992.

4.2 Adenantha pavonina Linnaeus (Coral seeds)

It is widely grown in several countries in the world. It occurs up to sub-Himalayan tract ascending 1200 m altitude. It grows wild in Andaman Islands, Assam, Arunachal Pradesh, Tamil Nadu, Maharashtra, Karnataka, Uttar Pradesh and across the country. It is a large deciduous tree, 11–16 m tall, bark grey, leaves bipinnate, alternate



Figure 5 Coral seed tree (*Adenanthera pavonina* L.) - (a) Tree in flowering, (b) Inflorescence close up, (c) Legume fruits with concave impressions of seeds inside (d) Seeds close up. Red seeds look like pharmaceutical tablets.

and leaflets 5–8 pairs. Flowers bisexual; Calyx 5-lobed; Corolla 5-toothed, pale yellow; Stamens 10, free; Pods spirally coiled after dehiscence; Seeds 8-15, hard-coated, lens-shaped, brilliant scarlet in color, adhere to pods, seed coat smooth, shiny, bony, very hard, generally no fracture lines (Figure 5).

Botanical citation: *Adenanthera pavonina* Linnaeus, Sp. Pl. 384. 1753; Hooker, Flora of Brit. India, 2: 287. 1878; Gamble, Fl. Pres. Madras, 1: 418. 1919 (Fig. 5).

Common names: *Tamraka* (Sanskrit); *Baragunchi* (Hindi); Coral seed tree, Barricari seed tree, Circassian seed tree, Jumbie bead, Redwood tree (English); *Bandigurivinda* (Telugu); *Manjuti*, *Chenna kai*, *Manjatti kai* (Kannada); *Aanaikkundumani* (Tamil); *Mandakaincha* (Oriya).

4.3 *Ceratonia siliqua* Linnaeus (Carob seeds)

It is native to Cyprus, Egypt, Israel, Jordan, Lebanon, Libya, Saudi Arabia, Syrian Arab Republic, Tunisia and Turkey. Exotic to Algeria, Argentina, Australia, Chile, Croatia, France, Greece, India, Indonesia, Italy, Malta, Mexico, Morocco, Pakistan, Portugal, South Africa, Spain, United States of America, Venezuela and Yugoslavia (former). It is an evergreen tree growing up to 15 m tall. The leaves are compound; leaflets 2–4 pairs, shiny; flow-



Figure 6 Carob tree (*Ceratonia siliqua* L.) - (a) Entire tree, (b) Inflorescence close up, (c) Matured legume fruits in clusters, (d) Seeds close up.

ers in racemes, small, red, hermaphrodite; pods foot-long, curved, rich in sugar; seeds obovate, brown in colour, contain useful gum known as tragasol (Figure 6).

Botanical Description: *Ceratonia siliqua* Linnaeus, Sp. Pl. 2: 1026. 1753.

Common Names: *Al-kharoubah*, *Kharrub* (Arabic); *Garrover*, *Algarrobo*, *Garrofero* (Spanish); *Garrover*, *Garrofer* (Catalan); St. John's bread, Locust bean, Carob tree, Carob bean (English); *Caroubier* (French); *Karubenbaum*, *Johannisbrotbaum* (German); *Charaoupi* (Greek); *Kharnub* (Hindi); *Carrubo* (Italian); *Gelenggang* (Malay); *Chiao-toushu* (Mandarin); *Alfarrobeira* (Portuguese); *Chum het tai* (Thai); *Charnup* (Turkish); *Carob tree*, *Locust bean*, *Chocar* (trade name).

5 Conclusion

Weights and measurements have been an essential part of human life. Seeds/grains as a unit of measure and the 'tulā' as a weighing device were first described in vedas. Various grains and seeds were used to weigh gold, other precious metals and stones. The ratti seeds as unit of measurement for mass gained importance due to its uniform size and weight. The coral seeds were also used as weight-stone for quantification of gold in jewelry shops in the traditional system in India. The seeds of carob tree were used to weigh gold and precious stones in Rome, Greek,

Great Britain and other European countries, the USA and the Middle East. The modern word 'carat' owes its derivation to the carob tree, which was used by Arab jewelers to weigh precious metals and stones.

Weighing system in India dates back to Indus Valley people for trade and valuation of goods for tax. Uniform polished stones used as weight setting standard were based on the unit ratti which later on became weight standards for minting the first Indian coins, known as the *kārṣāpaṇa* or punch-marked coins. These were of different monetary denominations based on the metal used, viz. gold (*suvarṇa* or *niṣka*), silver (*purāṇa* or *dharāṇa*) and copper (*paṇa*) coins. A *śatamāna*, (hundred measures) weight of hundred ratti seeds was used as a standard weight of silver coins in ancient India between 600–200 BCE. With the decline of the Indus civilization, the weights themselves disappeared but the ratti seed as the basis for the weight has endured the test of time and used even till today. Chronologically weighing system in India can be summarized into three systems of (i) regional (*ratti*, *māṣa* and *tolā*); (ii) Akbar (wheat berry and barley-corn) and (iii) colonial (troy ounce, pound/cwt/ton). The current metric system came into existence due to the Standards of Weights Act from 1958.

The progression of units generally followed westward direction, where the units of Middle East empires found their way to Greece, Rome, Gaul and Britain mostly as a result of trade and conquest. In the course of development of units a number of systems were adopted. Two systems extensively used are the CGS (centimeter, gram and second) and MKS (meter, kilogram and second). These two are historically distinguished as– (a) an evolutionary system, such as the British Imperial, which grew more or less haphazardly out of custom, and (b) a planned system, such as the International System of Units (SI; *Système Internationale d'Unités*), universal in use by the world's scientific community and by most nations.

Bibliography

- [1] Bhandarkar D. R. *Lectures on Ancient Indian Numismatics*, University of Calcutta, Calcutta, 1921.
- [2] Corner E. J. H. *Wayside Trees of Malaya*, Vol. I, pp. vii + 770, Vol. 2, pp. ii + 228, Government Printing Office, 1940 (1988 reprint edition), ISBN 967-99906-0-5.
- [3] Cunningham A. *Coins of Ancient India: From the Earliest Times Down to the Seventh Century A. D.*, Quaritch, B., London, 1891.
- [4] Gardner S., Sidisunthorn P. and May L. E. *Heritage Trees of Penang*, Areca Books, Penang, 2011, ISBN 978-967-5719-06-6.
- [5] Garrard T. F. *Akan Weights and the Gold Trade*, *Legon History Series*, A. A. Boahen, (General Editor), London, Longman, 1980.
- [6] Harris M. D. *The Coventry Leet Book: or Mayor's Register*, Part 1, Early English Text Society series 134, Kegan Paul, Trench, Trübner & Co., London, 1907.
- [7] Iwata S. Weights and measures in the Indus valley, In, *Encyclopaedia of the History of Science, Technology, and Medicine in Non-Western Cultures* (2nd edition), Helaine Selin (ed.), Springer, 2008, ISBN 978-1-4020-4559-2.
- [8] Kenoyer J. M. Indus valley civilization, *Encyclopedia of India* (vol. 2), Stanley Wolpert (ed.), Thomson Gale, 2006, ISBN 0-684-31351-0.
- [9] Macdonell A. A. and Keith A. B. *Vedic Index of Names and Subjects* (Vol I & II), Indian Texts Series, First Edition, Motilal Banarsidass, New Delhi, 1912.
- [10] McIntosh J. *The Ancient Indus Valley: New Perspectives*. ABC-CLIO, 2008, ISBN 1576079074, 9781576079072.
- [11] Mukherjee B. N. Money and social changes in India (up to c. AD 1200), In: Saiyid Zaheer Husain Jafri (ed.), *Recording the Progress of Indian History*, Symposia Papers of the Indian History Congress, 1992-2010, Primus Books, 2012, ISBN 978-93-80607-28-3.
- [12] *Oxford English Dictionary*. Oxford University Press, Oxford, UK, 1989.
- [13] Singh H. B., Jain A. and Singh R. S. Seeds of *Adenantha pavonina* Linn. used as weight-stone for weighing gold in the traditional system: a nature's substitute, *Indian Journal Traditional Knowledge*, 2.3 (2003): 289–291.

- [14] Smith W. *Dictionary of Greek and Roman Antiquities*, Little, Brown & Company, Boston, MA, USA, 1870.
- [15] Thomas E. Ancient Indian weights, *The Numismatic Chronicle and Journal of the Numismatic Society*, Published by the Royal Numismatic Society, New Series 4, 1864, pp. 40–58.
- [16] Thomas E. *Maesden's Numismata Orientalia*. Part I, Ancient Indian Weights, Trubner & Co., 57 and 59, Ludgate Hill, London, 1874.
- [17] Turnbull L. A., Luis S., Toni M., Joan R. and Andy H. Seed size variability: from carob to carats, *Biology Letters*, 2.3 (2006): 397–400.
- [18] Sharma V. L. and Bharadwaj H. C. Weighing devices in ancient India, *Indian Journal History of Science*, 24.4 (1989): 329–336.
- [19] Sircar D. C. *Studies in Indian Coins*, Motilal Banarsidass Publishers, New Delhi, 1968, ISBN: 978-81-208-2973-2.
- [20] Vahia M. N. and Yadav N. Harappan weights, *Puratattva* 37 (2007): 213–217.
- [21] Zhengzhang T. On the origin of the carat as the unit of weight for gemstones, *Chinese Journal of Geochemistry*, 10 (1991): 288–294.