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Moisture Dependent Properties of Onion Neck and Leaf for Different Varieties of Harvested Onion Bulbs

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ABSTRACT

The study was conducted during December, 2024–May, 2025 for period of six month, at Department Agricultural Process Engineering, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India to determine the moisture dependent properties of harvested onion neck and leaves for four different varieties. The four important varieties of onion were selected for study such as Nashik red, Bhima raj, Red china and Bhima super. The properties such as diameter of onion neck, moisture content of onion neck, force required to cut onion neck, tallest length of leaf and number of leaves were studied for selected variety in two categories i.e. freshly harvested and cured onions. The diameter of onion neck for all studied varieties were range from 11.37±1.53 mm–17.68±1.70 mm for freshly harvested and 7.37±1.53 mm–10.94±1.40 mm for cured onions. Moisture content of onion neck for all studied varieties ranged from 68.35±5.37%–77.55±2.89% for freshly harvested and 5.37±0.64%–6.01±1.07% for cured onions. The force required to cut onion neck for all studied varieties ranged from 108.27±45.83 N–170.84±22.03 N for freshly harvested and 74.36±25.25 N–171.90±78.58 N for cured onions. The tallest length of leaves for all studied varieties ranged from 386.78±47.93 mm–598.78±48.48 mm for freshly harvested and 186.64±38.83 mm–386.78±48.48 mm for cured onions. Number of leaves for all studied varieties ranged from 7.14±1.18–10.20±1.76 for freshly harvested and 3.48±1.55–6.68±1.70 for cured onions.

KEYWORDS: Neck diameter, leaves length, cutting force, moisture content

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Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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1. INTRODUCTION

Onion (*Allium cepa* L.) is a globally significant vegetable, cultivated for its culinary and medicinal properties (Teshika et al., 2019). It is one of the important crop considered in vegetable and spices commodity. In India onion consumed almost every day in every house (Ahmed et al., 2022). It is seasonal in production, but required round the year (Dabhi and Patel, 2017). The world acreage of onion has doubled during the last one decade. India ranks second in onion production in the world, which acquires 6% of the market share in the total production of vegetables in India (Ahmed et al., 2022). The country had produced 242.12 lakh tonnes of onion in the 2023–24 crop year (Anonymous, 2025a).

The quality and storage potential of onion bulbs are influenced by various factors, among which moisture content plays a pivotal role (Hatem et al., 2014). The neck of the onion bulb is highly susceptible to moisture variations. Inadequate curing of the neck area can lead to increased moisture retention, creating favourable conditions for fungal infections such as Botrytis neck rot. This disease manifests as water-soaked areas near the neck, progressing to softening and browning of the scales, and can result in significant post-harvest losses (Nischwitz and Dhiman, 2013).

Research indicates that moisture content significantly affects the physical properties of onion bulbs (Abhayawick et al., 2002). For instance, studies have shown that as moisture content increases, parameters such as bulk density, true density, porosity, and angle of repose also increase, while the coefficient of friction changes, influencing the ease of handling and processing (Pragalyaashree and Kailappan, 2014). Additionally, the mechanical properties, including the shear force required to cut the neck, vary with moisture content, which is crucial for mechanical de-topping processes (Wozniak et al., 2023).

Different onion varieties exhibit distinct responses to moisture variations. For example, the Pusa Red variety has been observed to have higher density and different frictional properties compared to other varieties, which can affect its suitability for various processing methods. Furthermore, the curing process, which involves drying the neck and outer scales of the bulb, is influenced by moisture content (Gorreapti et al., 2017). Proper curing is essential to reduce moisture levels, thereby enhancing storage life and reducing susceptibility to diseases such as neck rot (Anonymous, 2025b).

The onion harvesting operation includes digging, lifting, curing, cutting the necks to separate onions from the foliage, cleaning and grading of bulbs, shed curing and storage (Patel and Nath, 2020). Onion neck cutting also known as de-topping is time consuming and labour intensive operation (Karate et al., 2025). One of the main reasons for low productivity is the low level of mechanization and less technology utilization.

Machine for cutting root and shoot is not available in India and imported machines are expensive and an Indian farmer cannot afford such high price. Farmers incur financial loss because of non-availability of manpower (Chaudhary et al., 2016). For design of such machines it is necessary to have knowledge of properties of onion neck and leaves (Bahnasawy et al., 2004). Therefore, the study was undertaken to determine the moisture depend properties of onion neck and leaf of harvested onion for four different varieties. The important varieties of onion were selected for study such as Nashik red, Bhima raj, Red china and Bhima super. The properties of onion neck and leaves like diameter of onion neck, moisture content of onion neck, force required to cut onion neck, tallest length of leaf and number of leaves were studied for selected varieties in two categories i.e. freshly harvested and cured onions.

2. MATERIALS AND METHODS

The study was conducted during December, 2024–May, 2025 for period of six month, at Department Agricultural Process Engineering, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India. The properties of onion neck and leaves for selected four varieties was measured in two category i.e. freshly harvested and cured onion bulbs (Figure 1). For freshly harvested onion bulbs properties were measured immediately after harvesting and for cured onion bulbs properties were measured after curing process. For curing of onion bulbs the freshly harvested onion bulbs was kept in shade for curing for 15 days (Sharma et al., 2020).

The harvested onion bulbs of varieties Nashik red, Bhima

(a) (b)

Figure 1: Categories of harvested onion bulbs (a) freshly harvested and (b) cured onion bulbs

raj, Red china and Bhima super procured from the farmer's field and sorted clean and non-damaged onion bulbs of equal size for study. Total fifty number of onion bulbs of each variety selected for study and different properties of onion neck measured.

2.1. Diameter of onion neck

The diameter of neck of both freshly harvested and cured onion bulbs was measured using digital Vernier calliper having least count of 0.01 mm (Figure 2). The diameter of neck measured for two different direction and average of

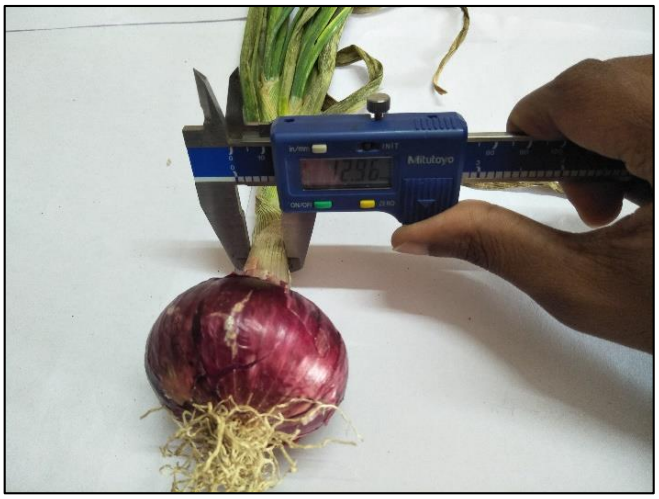


Figure 2: Measurement of diameter of onion neck

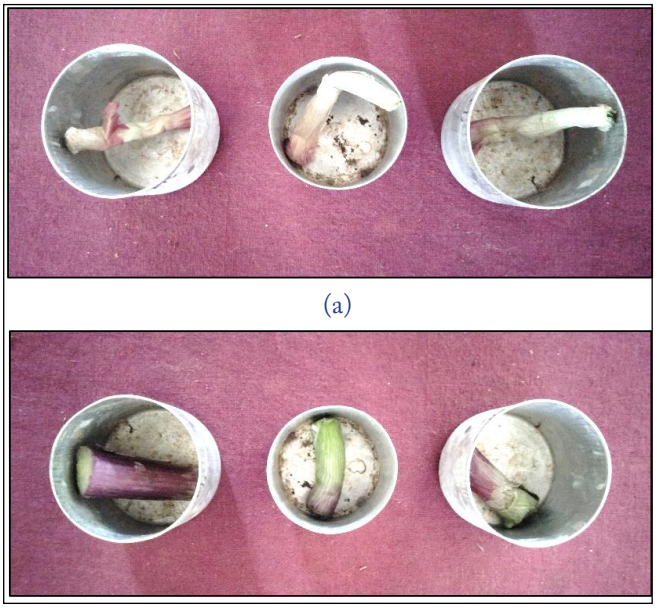
both considered as diameter of neck of onion bulbs.

2.2. Moisture content of onion neck

Moisture content of onion neck measured using standard moisture content measurement procedure using hot air oven method. The neck portion of onion bulbs separated form onion bulbs as shown in Figure 3 and weighted initially as W_1 before drying using precision weighing balance. Weighted onion neck portion dried in ventilated hot air oven at 55°C till constant weight observed. After drying neck portion of onion weighted again as W_2. The moisture content of neck of onion bulb measured using following equation (Ambrose, 2020).

2.3. Force required to cut onion neck

Forced required to cut onion neck measured using texture analyser of Stable Micro Systems, United Kingdom, machine model number TA-HD plus. The onion bulbs with neck kept below the cutting probe and cutting probe allowed to cut neck of onion bulbs as shown in Figure 4. The forced required to cut the neck and graph of forced vs time obtained from texture analyser was recorded. The Knife or Guillotine blade selected as cutting probe for texture analyser with 500 kg load cell. The pre-test speed, test speed and post-test speed of probe were maintained 10 mm s^{-1}, 0.2 mm s^{-1} and 10 mm sec^{-1}, respectively.



(a)

(b)

Figure 3: Samples for determination of moisture content of onion neck for (a) cured and (b) freshly harvested onion bulbs

2.4. Tallest length of leaf

The tallest length of leaf of onion bulbs were measured using measuring scale. The onion bulb with leaves placed on horizontal surface and tallest leaf selected and length measured from onion bulb portion to tip of leaf.

2.5. Number of leaves

The number of leaves of both freshly harvested and cured onion bulbs were measured by counting number of leaves attached to onion bulb.

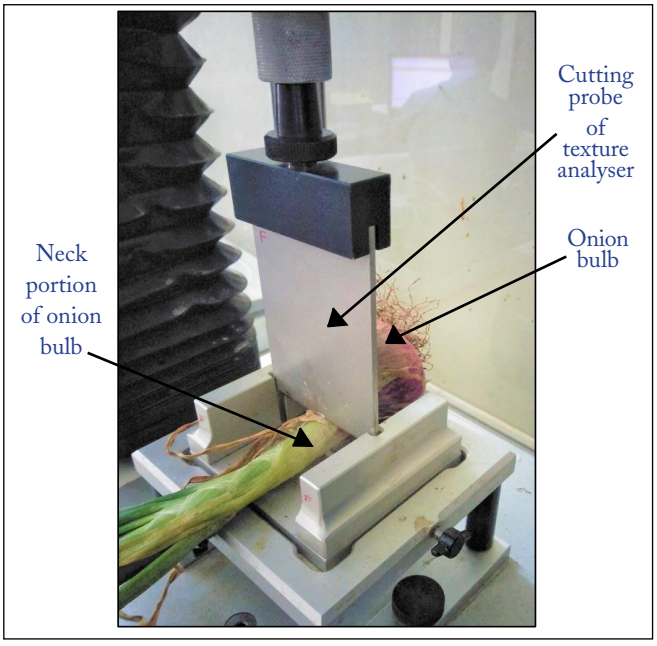


Figure 4: Measurement of force required to cut onion neck using texture analyser

3. RESULTS AND DISCUSSION

The moisture depending properties of onion neck and leaves for selected varieties such as Nashik red, Red china, Bhima raj and Bhima super were studied. The details of studied properties discussed in following sections.

3.1. Diameter of onion neck

The diameter of neck of onion bulb of varieties Nashik red, Bhima raj, Red china and Bhima super were observed in range between 15.15 mm–7.36 mm, 15.44 mm–7.61 mm, 22.79 mm–14.08 mm and 15.43 mm–2.41 mm respectively, for freshly harvested onion bulbs and 10.15 mm–2.36 mm, 11.69 mm–5.69 mm, 13.60 mm–7.18 mm and 14.32 mm–9.01 mm respectively, for cured onion bulbs. The average values of diameter of onion neck for all varieties shown in Table 1. It was observed that for freshly harvested onion bulbs values for onion neck diameter found to be higher than cured onion bulbs. The necks of freshly harvested onion bulbs have water content in it therefore the tissue of plant swallow during freshly harvested condition result in large neck diameters, whereas in case of cured onion bulbs water content in neck was removed during curing process therefore the neck got shrink and reduced in size result in small neck diameters. The diameter of neck observed are close accordance with the finding of Kumari and Kumar, 2017 for onion cultivar Agrifound light red for 90 days after transplant and for cured onions.

Table 1: Average values of diameter and moisture content of onion neck for selected varieties of onion bulbs

	Varieties	Diameter of onion neck (mm)±SD	Moisture content of onion neck (%)±SD
Freshly harvested onion bulbs	Nashik red	11.37±1.53	77.55±2.89
	Bhima Raj	12.46±1.51	73.70±6.44
	Red china	16.08±2.40	72.21±1.41
	Bhima Super	17.68±1.70	68.35±5.37
Cured onion bulbs	Nashik red	7.37±1.53	6.01±1.07
	Bhima Raj	7.73±1.19	5.88±0.79
	Red china	10.76±1.30	5.51±0.39
	Bhima Super	10.94±1.40	5.37±0.64

3.2. Moisture content of onion neck

The average values of moisture content at neck portion of onions for selected varieties are shown in Table 1. Moisture content of onion neck for Nashik red, Bhima raj, Red china and Bhima super varieties were observed in range between 81.38%–73.16%, 76.73%–64.07%, 73.36%–70.64% and 72.54%–62.30% respectively, for freshly harvested onion bulbs. The result observed were in accordance with result were reported by Patricia et al., 2025 for Galmi Violet Variety of onion. Moisture content at neck portion for Nashik red, Bhima raj, Red china and Bhima super varieties were observed in range between 7.21%–4.65%, 7.05%–5.37%, 5.59%–4.66% and 6.12%–4.68% respectively, for cured onion bulbs. The similar results for moisture content was observed by Barman et al., 2015 for garlic stem for small, medium and large size bulbs. It was observed that freshly harvested onion neck having higher moisture content than the cured onion bulbs. The neck of freshly harvested onion bulbs contain higher moisture content because onion plant intact with soil and getting moisture from soil before harvesting. In cured onion bulbs curing process evaporates moisture from leaves resulting in reducing moisture content of neck.

3.3. Force required to cut onion neck

The average values of force required to cut neck of onion varieties are shown in Table 2. The force required to cut neck of onion bulbs for Nashik red, Bhima raj, Red china and Bhima super varieties were observed to be in range between 229.2 N–25.72 N, 258.73 N–117.78 N, 210.7 N–125.39 N and 151.07 N–91.22 N respectively, for freshly harvested onion bulbs and 265.41 N–61.93 N, 137.99 N–23.5 N, 383.23 N–71.67 N and 171.28 N–111.43 N respectively, for cured onion bulbs. Forced required to cut onion neck for freshly harvested onion bulbs was observed higher than cured onion bulbs. The freshly harvested onion observed large size of neck diameter which required higher amount of force to cut neck whereas cured onion bulbs observed smaller size of neck diameter which required less amount of force to cut neck. The observation of force required to cut onion neck found in accordance with Kumawat and Raheman, 2023 and Yang et al., 2022 for Pusa Red and Red Hydrangea variety of onion, respectively.

3.4. Tallest length of leaf

The average values of tallest length of leaf of onion varieties

Table 2: Average values of force required to cut neck and tallest length of leaf for selected varieties of onion bulbs

	Varieties	Force required to cut neck (N)	Tallest length of leaf (mm)
Freshly harvested onion bulbs	Nashik red	108.27±45.83	386.78±47.93
	Bhima Raj	140.84±46.29	534.38±119.94
	Red china	147.07±26.39	534.28±67.20
	Bhima Super	170.84±22.03	598.78±48.48
Cured onion bulbs	Nashik red	74.36±25.25	186.78±47.93
	Bhima Raj	134.48±45.83	197.86±46.78
	Red china	139.05±22.03	186.64±38.83
	Bhima Super	171.90±78.58	386.78±48.48

are shown in Table 2. The tallest length of leaf for Nashik red, Bhima raj, Red china and Bhima super varieties were observed in range between 527 mm–300 mm, 704 mm–42 mm, 686 mm–431 mm and 741 mm–510 mm respectively, for freshly harvested onion bulbs and 327 mm–100 mm, 363 mm–112 mm, 296 mm–121 and 529 mm–298 mm respectively, for cured onion bulbs. The tallest length of leaves for freshly harvested onion bulbs observed higher than cured onions. The texture of freshly harvested onion leaves were observed to be firm which help to maintain original length of leaves in handling which developed onion plant during growing period. In curing process the moisture from onion leaves get evaporated and form fragile texture of leaves. During handling of such cured onion bulbs breakage of onion leaves observed resulting shorter leaves length. The result obtain for tallest length of leaves for freshly harvested and cured onions were in accordance with Nayak et al., 2016 for Nasik Red cultivar and Nour et al., 2020 for onion Beheri red variety, respectively.

3.5. Number of leaves

The Average number of leaves for selected varieties of onion bulbs are shown in Table 3. Number of leaves for Nashik red, Bhima raj, Red china and Bhima super varieties were observed in range between 10–5, 10–5, 14–5 and 13–7 respectively, for freshly harvested onion bulbs and 7–2, 8–1, 9–3 and 10–4 respectively, for cured onion bulbs. Freshly harvested onion bulbs was found to be higher number of leaves than cured onion bulbs. Leaves of freshly harvested onion bulbs were green and firm. Since number of leaves developed during growing period was same during harvesting resulting higher number leaves observed for freshly harvested onion bulbs. Less number of leaves observed for cured onion bulbs because during the curing process moisture of onion leaves reduced resulting dried and fragile formation of leaves. During handling of such cured onion bulbs causes breakage of bulb leaves consequently reducing number of leaves for cured onion bulbs. The findings for number of leaves of onion bulbs are similar with Kumari and Kumar, 2017 for onion cultivar Agrifound light red for 90 days after transplant and for cured onions.

Table 3: Average values of number of leaves for selected varieties of onion bulbs

	Varieties	Number of leaves
Freshly harvested onion bulbs	Nashik red	7.22±1.15
	Bhima Raj	7.14±1.18
	Red china	10.20±1.76
	Bhima Super	9.68±1.70
Cured onion bulbs	Nashik red	4.22±1.15
	Bhima Raj	3.48±1.55
	Red china	5.20±1.58
	Bhima Super	6.68±1.70

4. CONCLUSION

Moisture dependent properties of onion neck and leaves were studied for selected onion varieties like Nashik red, Bhima raj, Red china and Bhima super. Diameter of neck, moisture content of neck, force required to cut onion neck, tallest length of leaves, Number of leaves were range from 11.37 mm–17.68 mm, 68.35%–77.55%, 108.27N–170.84N, 386.78 mm–598.78 mm, 7.14–10.20, respectively for freshly harvested onion bulbs and 7.37 mm–10.94 mm, 5.37%–6.01%, 74.36N–171.90N, 186.64 mm–386.78 mm, 3.48–6.68, respectively for cured onion bulbs.

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