Determination of Post-harvest Losses of Quinoa at Different Stages of Handling at Saling Gewog, Mongar District

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ABSTRACT

Quinoa (Chenopodium quinoa) is a nutrient-dense cereal crop that has been introduced in Bhutan in recent years. There is no data in Bhutan on post-harvest handling losses of quinoa, and literature from other countries are limited. This study was conducted in Saling Gewog under Mongar District to assess the losses of quinoa at different post-harvest handling stages like field drying after harvest, threshing, and drying after threshing and also to determine weight losses during storage and de-husking. Field drying loss of 1.4% and threshing loss of 2.3% with a total handling loss of 3.7% was recorded in Lingmethang. Field drying loss was 6.5% and threshing loss was 3.4% with a total handling loss of 9.9% in Yongkola while in Tzenzebi, the total handling losses increased to 14.7% including field drying loss of 7.1% and threshing loss of 7.6% with a significant difference in losses between these locations with a P-value < 0.000 for both the field drying after harvest and for threshing. Weight losses during drying were 3.4%, 4.7% and 5% for quinoa samples from Lingmethang, Tzenzebi and Yongkola respectively (P < 0.005). Losses during storage and de-husking of quinoa were determined only for the quinoa samples from Lingmethang. Weight loss at the end of three months of storage was very minimal at 0.2%. A large quantity of quinoa (19.2 %) was lost as husk during the de-husking process. Interventions from the relevant agencies are needed to improve the techniques on field drying, threshing and storage practices to reduce post-harvest losses of quinoa in Bhutan.

Keywords: *Quinoa; Post-harvest losses; Weight loss*

1. Introduction

Quinoa (*Chenopodium quinoa*) is an annual herbaceous plant belonging to the family Amaranthaceae. It is a pseudo-cereal crop with a broadleaf plant and starchy dicotyledonous seeds (Sharma, Chandra, Dwivedi, & Parturkar, 2015). Its origin is believed to be from the Central Andes in South America (Martínez, Fuentes, & Bazile, 2015). Quinoa is said to be a nutrient-dense cereal crop and is promoted as high nutritional food in many countries around the world (Gamboa, Van den Broeck, & Maertens, 2018). Quinoa has been recognized by the Food and Agriculture Organization (FAO) as a strategic crop that can contribute to global food security because of its

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high nutritional quality, genetic variability, adaptability to adverse climate and soil conditions, and low production cost (FAO, 2011; Parra, Rohringer, Garcia-Molano, & Ortiz-Gonzalez, 2020).

In Bhutan, quinoa was introduced in 2015 from Peru by the Department of Agriculture with support from FAO with an objective to diversify crops and the current cropping systems, and to enhance the food and nutritional security of the Bhutanese people (Katwal, Wangdi and Giri, 2019). In Bhutan, quinoa production was estimated to be 9 tons from 70 acres of harvested area with an average yield of 132 kg/acre in 2017 (DoA, 2017).

The maturity of quinoa depends on the variety and altitude at which it is grown. In high altitude areas (above 1200 masl), the maturity takes 120 to 150 days after sowing while 170-180 days are required for longer duration varieties to mature. In the warm areas below 1200 masl, the quinoa crop matures much faster (Katwal, 2018). Quinoa crops are sun-dried or made into bundles and hung by the ceilings immediately after harvest for drying. It should be dried properly for easy threshing. Well-dried quinoa grains can be put in polypropylene bags or plastic bins and stored in a cool and dry room. Milling or de-husking can be done manually using a locally made de-husking device used in villages to de-husk rice and millet or mechanically using a de-husking machine. Only the well-dried quinoa should be used for milling (Katwal, 2018).

Any nation needs to carry out studies on post-harvest losses of crops to determine how much food is lost after harvest before reaching the consumers and at what stages the major losses occur for the particular food crops. Accurate data on post-harvest losses of crops at different stages of handling can be beneficial for policymakers and relevant organizations to make appropriate interventions to help reduce food losses. This would ensure that the food that has been produced after putting so many inputs reaches the market to feed the growing global population.

According to the Food and Agriculture Organization (2015) of the United Nations, 1.5 billion tons of food are wasted or lost per year. The food losses and wastes amount to roughly US$680 billion in industrialized nations and US$310 billion in developing countries (FAO, 2015). It was revealed that post-harvest loss of cereal in Sub-Saharan Africa ranged between 5-40 % with an estimated value of around $4 billion while losses of cereal crops in the developing countries are estimated to be as high as 25% of the total production (Zorya et al., 2011).

Since its introduction in the country, no studies have been conducted on post-harvest losses of quinoa and currently, no data are available on its losses at the different stages of post-harvest handling operations. Even at the global level, the reports and data on post-harvest losses of quinoa at different stages of handling are either too little or not available. This study was conducted at Saling Gewog under Mongar district to determine post-harvest losses of quinoa at different stages of handling to compare the post-harvest losses at different locations and to assess the weight losses of quinoa during post-harvest storage.

2. Materials and Method

2.1. Survey area and data collection

The data on post-harvest losses of quinoa were collected from Tshenzebi (1400 masl), Yongkola (1500 masl), and the Agriculture Research and Development Sub-Centre (ARDSC), Lingmethang (650 masl) research field under Saling Gewog, Mongar district in the month of January 2020. The variety used in this study was 'Amarilla Saccaca' that is extensively promoted and cultivated in the Lingmethang locality. The post-harvest operations in this study were practiced as described by (Katwal, Wangdi, & Giri, 2019). The post-harvest losses of quinoa during field drying after harvest, threshing operations, and drying (after threshing) were carried out with five replications in each location. Post-harvest weight changes (post-harvest weight losses) were recorded after storage and de-husking for the quinoa samples harvested from only ARDSC Lingmethang, and no studies were carried out to determine the losses during storage and de-husking for the samples from Yongkola and Tsenzebi since there was no budget allocation to procure quinoa from farmers.

2.2. Determination of weight losses during field drying after harvest

Quinoa plants were harvested from 2 × 2 m^2 plots and dried on a tarpaulin sheet for four consecutive days within the field in the sun. At the end of the drying period, the fallen quinoa grains were collected from tarpaulin and weighed. The sum of weights of grains fallen on the tarpaulin during drying and grains that did not fall during the drying operation constituted the total grain weight of the sample. This procedure was replicated five times in each location. The field-drying losses were calculated using the formula:

$$Field\ drying\ loss\ (\%) = \frac{Weight\ of\ fallen\ grains}{Total\ weight\ of\ grains}\ x\ 100 \qquad (1)$$

2.3. Determination of weight losses during threshing operation

A tarpaulin sheet was spread around the normal threshing area and grains that fell outside the threshing area were collected and weighed after threshing. The sum of weights of grains from within and outside the threshing areas constituted the total grain weight of the sample. The threshing losses were calculated using the formula:

$$Threshing\ losses\ (\%) = \frac{Weight\ of\ grains\ fallen\ outside\ of\ the\ normal\ threshing\ area}{Total\ weight\ of\ grains}\ x\ 100 \qquad (2)$$

2.4. Determination of weight (moisture) losses during drying after threshing

The threshed quinoa samples were weighed and dried in the sun for two consecutive days before storage. After the completion of drying, the samples were again weighed and the difference in weight after drying was calculated using the formula:

$$Weight\ loss\ (\%)\ during\ drying = \frac{Weight\ before\ drying - Weight\ after\ drying}{Weight\ before\ drying} x100 \qquad (3)$$

2.5. Determination of weight losses during storage

At Lingmethang, five kilograms of dried quinoa were stored at ambient temperature store for a period of three months and changes in weight of sample were recorded monthly. The storage trial consisted of five replications. The difference in weight during each storage month was calculated as follows:

$$Weight\ loss\ (\%)\ during\ storage = \frac{Initial\ weight\ of\ grains - Final\ weight\ of\ grains}{Initial\ weight\ of\ grains} x100 \quad (4)$$

2.6. Determination of weight loss during milling (de-husking)

Five samples of dried and stored quinoa with five replicates were weighed before and after de-husking to find the differences in weight. De-husking was carried out using a quinoa de-husking machine. The weight loss was calculated as follows:

$$Weight\ loss\ (\%) after\ de - husking = \frac{Weight\ before\ de\text{-}husking - Weight\ after\ de\text{-}husking}{Weight\ before\ de\text{-}husking} x100 \qquad (5)$$

2.7. Data analysis

Microsoft Excel was used for basic calculations and plotting graphs. The data were analyzed using SPSS software version 21.0. The recorded data were analyzed by one-way ANOVA and the significance of treatment means were compared using Duncan's test or independent samples *t*-test ($P < 0.05$).

3. Results and Discussion

At the Agriculture Research and Development Sub-Centre, Lingmethang, the field drying and threshing losses of quinoa were 1.4 % and 2.3 %, respectively with a total handling loss of 3.7 % (Table 1). The total handling losses were 9.9 % at Yongkola (field drying- 6.5 % and threshing- 3.4 %) while the total handling losses were 14.7 % at Tsenzebi (field drying-7.1 % and threshing- 7.6 %). The average field drying and threshing losses from the above three places were 5.0 % and 4.4%, respectively that constituted a total handling loss of 9.4%. The weight losses during drying after threshing were 3.4 %, 5 % and 4.7 % for quinoa from Lingmethang, Yongkola and Tsenzebi respectively (Table 1).

The lowest post-harvest losses recorded from ARDSC Lingmethang was assumed to be due to good production and post-harvest management practices, while higher losses at farmers' field in

Yongkola and Tsenzebi could be due to the lack of or poor technical know-how on post-production handling and management operations. The higher losses in these areas could also be due to the harvest of quinoa before the maturity stage since farmers generally have minimal knowledge of maturity indices of newly introduced crops. The differences in altitude of these places could have resulted in different maturing stages of crop and contributed to the difference in losses during the post-harvest operations (Katwal, 2018).

Table 1. Losses (%) of quinoa at different post-harvest handling stages by locations.

Locations	Weight losses (%)		
	Field drying (after harvest)	**Threshing**	**Drying (after threshing)**
Lingmethang	1.4 ± 0.0^{c}	2.3 ± 0.1^{c}	3.4 ± 0.4^{b}
Yongkola/Thridangbi	6.5 ± 0.0^{b}	3.4 ± 0.1^{b}	5.0 ± 0.3^{a}
Tsenzebi	7.1 ± 0.2^{a}	7.6 ± 0.3^{a}	4.7 ± 0.2^{a}
Mean	5.0	4.4	4.4
P-value	0.000	0.000	0.005

Mean values within the columns with different superscripts are significantly different between locations for each post-harvest operation at $P < 0.05$ by Duncan's test (mean ± standard error, n=5).

Table 2. Field drying and threshing losses of quinoa at Lingmethang.

Post-harvest operations	Weight loss (%)
Field-drying	1.4±0.0
Threshing	2.3±0.7
t (8)	-10.8
P-value	0.000134

Independent samples *t*-test by SPSS version 21 (n = 5, mean ± standard error).

There was a statistically significant difference ($P = 0.000134$) between field drying and threshing losses of quinoa harvested in Lingmethang (Table 2). In Lingmethang, weight loss (change in weight) during storage for three months was very minimal at 0.2 % while the change in weight during drying was slightly higher at 3.4%. The major weight loss of quinoa occurred during de-husking with 19.2 % as shown in Table 3. The de-husking data indicates that 19.2 % of quinoa is lost as husk and other associated waste during de-husking. Storage and de-husking trials were not carried out for the samples from Yongkola and Tsenzebi.

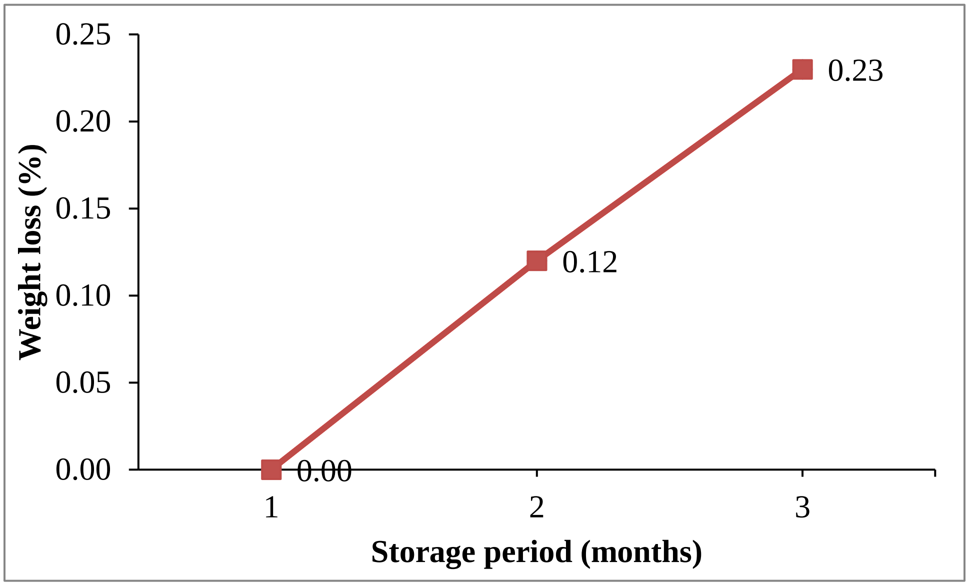
The change in weight during storage was very small as shown in Figure 1. No weight change was recorded until one month after storage, and it reached just 0.12 % and 0.23 % after storing for two and three months respectively.

Table 3. Weight loss (%) during different post-harvest handling operations for the quinoa at ARDSC, Lingmethang.

Post-harvest operations	**Weight losses (%)**
Drying	3.4 ± 0.4^{b}
Storage	0.2 ± 0.1^{c}
De-husking	19.2 ± 0.5^{a}
p-value	< 0.000

Duncan's test for weight loss respectively by SPSS version 21 (n=5, mean ± standard error). Means in the same column with different superscripts are significantly different between post-harvest operations.

Figure 1. Quinoa weight losses (%) during the three months storage period in Lingmethang.



4. Conclusion

The quantity of post-harvest handling losses differed among the places. The lowest handling loss was recorded at Lingmethang while higher losses were recorded both at Yongkola and Tsenzebi. The mean field drying and threshing losses from these three locations were 5.0 % and 4.4 %, respectively with a total handling loss of 9.4 %. In Lingmethang, change in weight during drying and storage was minimal, while weight loss during de-husking was high and significantly different from drying and storage.

Wastage of food through post-harvest losses not just translates into human hunger but also results in lesser revenue generation for the growers (FAO, 2013, 2020). Overall, the post-harvest handling loss of quinoa in Mongar district is not alarming currently but care should be taken to minimize further losses to help achieve food security in the country. It is recommended to train farmers and relevant stakeholders on the post-harvest management of quinoa in the country to reduce the losses during post-harvest handling and operations of quinoa. It is also recommended to carry out similar studies in other quinoa-growing areas of the country to further validate the findings of this research.

Acknowledgement

The authors thank the management and staff of the Agriculture Research and Development Sub-Centre, Lingmethang, and farmers involved in this study for providing support during the data collection from their fields. We also thank the staff of the National Post Harvest Sub-Centre, Lingmethang who helped us in the collection of field data.

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