Assessment of Harvesting and Post-harvest Handling Practices on Organically Grown Cloves and Black pepper in Tawa Ward, Morogoro

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Abstract

Post-harvest management of spices is crucial in minimizing losses and upholding quality and safety along the value chain. This study assessed harvesting and post-harvest handling practices of clove and black pepper organically grown in Tawa Ward, Morogoro; to establish the quality compromising stages. A total of 107 clove and black pepper farmers were interviewed using a semi-structured questionnaire to assess harvesting, drying and storage practices. Thirty-four spice samples from 34-randomly selected farmers were collected in airtight bags for moisture content determination. Data were statistically analyzed using IBM SPSS Statistics, version 20. Farmers in this study practice mixed farming, and handpicking harvesting to manageable amounts of spices (<100 kg/year). Spice drying is done on the ground by 80% of the farmers. Poor storage methods, mixing spice batches and attempts to treat spoiled spices were noticed as critical points that could compromise final quality. More than 46% of black pepper farmers acknowledged post-storage treatment of spoiled and contaminated spices including rubbing spices with cooking-oil and blanching. Such treatments along with higher moisture contents were related to farmers' unawareness on post-harvest management. Moisture content of the final dried spices ranged from 23.9-14.8 (clove) and 13.8-10.1 (black pepper) indicating that farmers are struggling to achieve the recommended moisture content of 12% as per TZS 357:2012 and TZS 30:2013. This study calls for interventions of improving farmer's knowledge and making use of simple but effective methods; like drying of spices on raised platforms and use moisture meter to determine the final level of dryness.

Keywords: Spice harvesting, drying, spice storage, clove, black pepper, spice quality

Introduction

Clove and black pepper are among the high value spices. Black pepper nicknamed 'king of spices' (Hammouti *et al.,* 2019) and Clove, 'a champion spice' (Milind and Deepa, 2011) are among the most ancient and valuable spices of the world used for culinary, pharmaceutical and perfumery purposes (Hussain *et al.,* 2017; Takooree *et al.,* 2019).

The clove of commerce is the dried aromatic fully grown unopened flower buds of the clove tree *(Syzigium aromaticum)* belonging to the family *Myrtaceae*. (Thangaselvabai *et al.,* 2010). Black pepper is a product of the mature fruits of *Piper nigrum* L., a perennial woody evergreen climber. Under cultivation, pepper vines are trailed on supports and may attain a height of 20 m or even more (Ravindran and Kallupurackal, 2012). In the study area, Tawa Ward; Jatropha curcas, Jackfruit, Kapok and Grevilea trees are used as trellising material for black pepper. In some few cases big rocks, mango and coffee trees are also used to support the crawling of black pepper while clove trees do need crawling support during growth.

Tawa Ward is found along the Uluguru Mountains within Matombo Division of Morogoro rural District. Altitude and weather of Tawa Ward favor growth of various spices including vanilla, cloves, black pepper, cardamom, cinnamon and turmeric. Majority of spice growers in this area are small-scale farmers and are considered to grow spices organically by default (ITC, 2014; Mbiha *et al.,* 2008).

In a workshop for 'participatory action research design'that was conducted at SUA on December 2017, spice farmers from Tawa ward elaborated their quality concerns regarding cloves and black pepper. Spice farmers mentioned to have been experiencing color change, decrease in weight and presence of white dust during storage of spices especially black pepper. Information on any quality parameter including moisture content was missing because they had never subjected their sample for any laboratory analysis. Therefore, this study assessed the harvesting and post-harvest handling practices performed by these farmers in order to establish the quality compromising stages. Final moisture content of the spices that are ready for storage and distribution was selected as a major indicator of the spice quality. Data generated in this study will assist in the crafting of intervention processes.

The quality of clove and black pepper highly depends on maturity of harvested seeds, drying methods and storage conditions (Ravindran, 2017). Current status of spice value chain in Tanzania indicate that spices are dried without monitoring the moisture content during the process as well as the final moisture content, sales are done on undefined packaging without sorting and grading, and purchase and export is still monopolized by middlemen traders (ITC, 2014). Limited studies regarding spice handling have been carried out focusing on small-scale farmers in Tawa ward Morogoro, hence the rationale of this study.

Materials and method

Harvesting and post-harvest concepts explained in this study are based on information obtained during field visits at the study area. The core of the study based on already existing well-structured focus groups. Total of 30 clove farmers, 77 black pepper farmers and 3 spice middlemen traders were directly involved in this study from five among the eight villages of Tawa Ward. The participants were interviewed, and their post-harvest handling practices were closely observed.

Study area and study population

This study was conducted in Tawa Ward that is within Morogoro rural District. Location coordinates and altitudes of the visited sites are shown in Appendix 1. Clove and black pepper farmers from five villages within Tawa Ward formed a study population. The selected villages had existing focus groups. Total number of famers who were assessed during this study is shown in Table 1.

Table 1: Clove and Black pepper farmers involved in this study

WARD	VILLAGES	FOCUS GROUP NAMES	NUMBER OF FARMERS N=107	
			Clove farmers	**Black pepper farmers**
Tawa	Uponda	Hapa kazi tu	0	17
	Kisarawe	Upendo	9	17
	Milawilila	Ningendole	6	10
	Kifindike	Tupendane	6	12
	Tawa	Twaweza	9	21
		Total farmers	**n=30**	**n=77**

Study design

Participatory Action Research (PAR) design was used in this study involving farmers from Tawa Ward, researchers from Sokoine University of Agiculture (SUA) and

an NGO known as Sustainable Agriculture Tanzania (SAT). Spice farmers elaborated their quality problems through SAT who organized researchers from SUA to address them. Also, this study involved survey and laboratory analysis.

Assessment of harvesting and post-harvest handling practices

Semi-structured questionnaires were used to collect qualitative data from 107 spice farmers. The data collected was on regular post-harvest practices performed by farmers. Drying practices and storage facilities were also assessed against the prepared checklist.

Sampling and moisture content determination

A total of 34 spice samples, each weighing between 250-400gm were randomly collected from interviewed farmers and kept in aseptic sachets. Samples were categorized according to their availability (Table 2). Collected samples were immediately kept in air-tight plastic bags, and carried within cool boxes to the laboratory. Moisture content of each collected sample was analyzed within 24 hours after collection. At the laboratory, the samples were then frozen at -10°C prior to grinding.

Table 2: Sampling categories

	Fresh/Immediately harvested	Final dried samples				Total
		Stored ≤ 1 month	Stored 3 months	Stored 6 months	Stored 1 year	
Cloves	4	3	3	3	0	n= 13
Black pepper	4	0	11	0	6	n= 21
						N=34

Spice frozen samples were ground by using a laboratory blender and sieved across a mesh of 1mm diameter prior to analysis. To minimize moisture loss samples were ground while frozen and very little amount of sample was added in a blender each time to prevent heat generation during grinding that could melt the samples (Nielsen, 2010).

Moisture content was determined using an automated moisture measuring instrument (IR35M-000230V1, Denver Instrument Germany) where 2 grams of powdered sample was kept in a moisture meter at temperature of 105°C. The moisture meter uses infrared heat (up to 130°C) to heat a coil that generates heat toward a sample. The heat removes all moisture contained in the sample. The calibrated machine is an automatic moisture analyzer which displays the percentage moisture of the sample that had been calculated by using weight difference between the initial sample and the heated sample.

Data analysis

Descriptive statistics such as frequencies and percentages characterizing the respondents were computed using Statistical package for the social sciences-IBM SPSS version 20.0. Also, for laboratory data, One-Way ANOVA was done, and results were expressed as means ± standard deviation.

Results and discussion

Demographic information

Demographic information of the assessed spice farmers is shown in Table 3; indicating that clove and black pepper farming in Tawa Ward is dominated by elder male with primary education.

Farming characteristics of clove and black pepper farmers in Tawa

Farm size and total annual harvest of the two spices is shown in Table 4 below. Mixed crop farming is practiced by more than 96% of clove farmers and more than 97% of black pepper farmers. They mix clove or black pepper trees with both spice and non-spice crop within the same farm space. Mixed cropping system is mentioned to be a common practice among spice farmers in Tanzania (ITC 2014; Reyes *et al.,*

Table 3: Demographic details

Demographical item	Descriptions	Clove farmers n=30	Black-pepper farmers n=77
		Percentage of respondents	
Sex	Female	23.3	32.5
	Male	76.7	67.5
Educational level	Not attended school	10	7.8
	Primary education	80	88.3
	Secondary education	10	3.9
Age (years)	21-30	20	18.2
	31-40	20	29.9
	40-50	33.3	31.1
	above 50	26.7	20.8

2009). More than 90% of all farmers reported to face pest problems prior to harvesting whereas 50% of them said that they take no measure to solve the problem. The rest mentioned to use garlic and chili powder sprays to minimize pest infestations.

Harvesting

During harvesting, matured spices are manually handpicked from their tress. Farmers in Tawa uses bamboo stick ladders for climbing trees hosting the respective spice plants with matured and ready to harvest spices. A farmer climbs up the bamboo ladder carrying a woven bag across his shoulder for collecting harvested spices as shown in Plate 1. In Tawa, harvesting of black pepper takes place in two seasons;

Table 4: Farm size and total annual harvest of clove and black pepper expressed in percentage of total samples

	Farm size (hectors)		Total harvest (kg/ hector/year)		
Size	>2	2-4	> 50	50-100	<100
Percentage	79.4	20.6	50	47.1	2.9

Harvesting and post-harvest handling of clove and black pepper in Tawa

A summary of handling practices assessed in this study is shown in Table 5.

Table 5: Summary of post-harvest practices assessed in this study expressed in percentage of the total samples in each spice

Spices	POST HARVEST PRACTISES										
	Drying method		Storage equipment			Storage time				Mixing with previous batch	
	On the Ground	On Raised platform	Nylon sack	Sisal sack	Plastic bucket/ Metal pot	One month	Three months	Six months	One year	Yes	No
Clove	84.6	15.4	46.2	23.1	30.8	38.5	38.5	23.0	0.0	0.0	100.0
Black pepper	90.5	9.5	61.9	28.6	9.5	42.9	33.3	0.0	23.8	47.6	52.4

minor harvesting season (June-August) and major harvesting season (December-January). Locals at Tawa call the minor harvesting season of black pepper 'Mdegeta' (meaning a little harvest in Luguru language) because the harvesting yields are three times less the major harvesting season. Only 9.1% and 13.3% of black pepper and clove farmers reported harvest more than 100kg/hector/year. More than 40% of farmers harvest between 10-40 kg per hector per year.

Drying

Drying is done by spreading the harvested spices on mats that are spread directly to the ground. Local mats used during drying are locally known as 'bushera' (made of woven straws), 'kitanga' (made of dried leaves), 'mkeka' (made of plastic pipes) and nylon sheaths as elaborated in Plate 1. Only 20% and 7.8.% of clove and black pepper farmers uses raised platforms for drying spices. Drying is often carried out under unclean environments; at the open sun in the homestead hence the spices become vulnerable to contamination due to dust and livestock. Similar observation is reported in ITC report, (2014).

Spice farmers in Tawa use the following indicators to determine if spices are well dried.

- Color change. All interviewed farmers say color change is the initial indicator of dried spices. They claimed to be experienced enough to relate intensity of color change to level of dryness. But color change itself is not a sufficient indicator of proper drying.
- Pressing by hands and breaking with the teeth. Hand pressing of dried spices to confirm level of dryness has been reported by 63.4% and 44.1% of clove and pepper farmers. Properly dried black pepper is expected to be hard enough to resist tooth penetration. In this study, 26% and 13.3% of interviewed clove and black pepper farmers said they combine this method with color change to decide if the spices are well dried.
- Sound. Dried cloves are expected to produce sound of a dry stick when broken. For black pepper farmers lift a hand full of dried black pepper and pour them down, if they produce a sound similar to the sound of poured dried rice then they are satisfied with the drying condition. Conducted interviews revealed that 20.8% of black pepper farmers rely on this method of deciding level of dryness.

Moisture content

Farmers in this study are required to dry spices from moisture content of above 60% to 12% (Table 6). Moisture content of samples collected during this study show that local methods of detecting moisture content could be accurate on black pepper than cloves.

Table 6: Moisture content of fresh and dried sample compared to TBS standard

Moisture content (%)	Fresh-harvested sample	Dried samples	TBS standard for dried samples (max %)
Clove	60.291±9.176 (n=4)	18.87±3.36 (n=9)	12 TZS 357:2012
Black pepper	68.146±2.968 (n=4)	11.44±1.09 (n=17)	12 TZS 30:2013

Storage and post-storage handling

Farmers reported that middlemen contact them immediately after harvesting to purchase their produces at cheaper price. Storage of spices for longer storage time is common among middlemen than farmers. Middlemen collect and store spices before selling in bulk. Three middlemen who were visited during this study have a selected storeroom for keeping spices throughout the year whereas individual farmers store spice in their kitchens or living and bedrooms. Storage of spices for less than three months was reported by more than 60% of both clove and black pepper farmers. About 5% of black pepper farmers store their produces for more than one year. Stored spices are kept in sisal/plastic woven bags, buckets or metal pots *(sufuria)* depending on their quantities.

When interviewed, more than 90% of black pepper farmers mentioned that spices do spoil during storage. Despite the average moisture content of dried and stored black pepper in this study being within acceptable limit of TBS standards, the spices are reported to be highly susceptible to fungal spoilage than clove (de Castro *et al.,* 2016). Farmers in this study decide to throw away spoiled spices depending on the extent of visible spoilage and contamination. Only 16.9% of the farmers, who experience spice spoilage, reported to discard them. Others, 27.3% among them admitted mixing spoiled batch with the new unspoiled batch prior to selling, while more than 46% of pepper farmers mention to treat spoiled spices before selling them at cheaper prices. Home-based treatments include rubbing spoiled spices with cooking oil to remove discoloration; blanching, washing with cold water and re-drying in the sun were mentioned to be applied.

Quality compromising stages

Drying

Spice farmers at Tawa practice open sun-drying which increases the chances of spoilage and contamination (Akyoo and Lazaro 2008; Akbulut and Durmus 2009). Once spices are contaminated during drying, other handling practices may also cause additional contamination. Farmers used simply visual approaches and lack reliable tools to decide level of spice dryness. In this study the average moisture content on dried and stored spices were 18.87±3.36 for cloves and 11.44±1.09 for black pepper.

Storage

Storage environment were exposed to be critical in compromising safety and quality of stored spices. When interviewed, more than 89% and 96% of pepper and clove farmers acknowledged cleaning storage places before storing spices. However, observation of the most storage facilities revealed poor hygienic condition and roof leakage as indicated in Plate 1. Both farmers and middlemen store spices with other nonfood materials at the same storage space. Farmers store spices in their living and bedrooms while middlemen use storage facilities for multiple crops storage. This may cause cross contamination. Code of hygienic practice for spice and aromatic herbs recommends appropriate clean and dried storage conditions (CAC/RCP 42-1995). Also, storage facility should contain proper equipment to control temperature, ventilation and relative humidity levels: inaccessible from the activities of insects, pests, rodents, birds, livestock, domestic animals and other biotic factors (Das and Sharangi, 2018; UNIDO and FAO 2005). None of that was observed among Tawa spice farmers.

Mixing of spice batches during storage

More than 48% of interviewed farmers said that new batch of spice can be harvested and dried before finishing selling or using the previous batch. Mixing the two batches and either continue to store or sell them while mixed together, was admitted by 23 and 27% clove and pepper farmers. Spice mixing is also common among middlemen. Middlemen buy spices in small amount from various farmers and collect them together in a single bag without isolation or means of knowing if they were previously contaminated.

Post storage treatment

Presence of undesirable changes during storage such are: rise in moisture content (sweating of spices), change in color, breakage of spices into dust, loss of spice original pungency and gain of foul smell, was a challenge explained by farmers in this study. Farmers handle such changes by applying home-based tricks including rubbing with cooking oil, blanching, washing and re-drying. Post storage treatment of spices after spoilage is admitted and explained by more than 46% of black pepper farmers. Maintaining the color of dried spices for marketing is the major concern by spice farmers and middlemen in Tawa. Treatments applied to maintain color after contamination and spoilage indicate that farmers have very little knowledge on maintenance of spice quality and safety.

Farmers knowledge on safety of spices and how customers perception influence quality practices

This study also assessed farmers' knowledge on the causes of spices spoilage and how the customer perception influence quality of the sold spices. Only 70% and 62% of clove and black pepper farmers admitted knowing about the existence of organic farming standards despite the training from SAT. All interviewed farmers said that they did not know that there are standard guiding quality and safety of spices. All clove farmers and 87% of pepper farmers acknowledged inadequate drying as the major cause of spoilage during storage. Unawareness of proper post-harvest management and the safety standards among the interviewed farmers calls for an intervention to ensure spice safety and quality.

More than 93% of spice farmers' customers are middlemen. They approach the farmers earlier and during harvesting season. Middlemen do not ask if the spices are grown organically, hardly ask about the storage time and only complain about quality when there is visible color change, hand felt moist and obviously seen dirt. Such trend influence farmer's safety practices. This study observed that intervention to improve spice quality at the study area should also involve middlemen.

Conclusion

This study provides further evidence that small scale farmers of spices are struggling on the post-harvest management. Drying is still done on the ground. There is no scientific method in Tawa village that is used to determine moisture content of spices. Storage is done under unhygienic environment, and grading is influenced by customers who are more concerned of weight than quality. Therefore, this study recommends simple but effective interventions to farmers, which include drying of spices on the raised and covered platforms (solar driers) to minimize risks of contamination. Since, electricity is available in Tawa Ward, farmers can make use of moisture meter to determine moisture content of dried spices. Storage places should be cleaned, well arranged, ventilated and without moisture fluctuation. Farmer's organization in focus groups will make a good starting point toward achieving the recommended interventions.

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References

Akbulut A. and Durmus A. (2009). Thin layer solar drying and mathematical modeling of mulberry. *International Journal of Energy Resource*. 33:687–695

Akyoo, A. and Lazaro, E. (2008). The Spice Industry in Tanzania: General Profile, Supply Chain Structure, and Food Standards Compliance Issues. DIIS Working Paper no 2007/8. DIIS. Denmark

de Castro, G.L.S., de Lemos, O.F., Tremacoldi, C.R., Moraes, F.K.C., dos Santos, L.R.R., and Pinheiro, H.A. (2016). Susceptibility of in vitro black pepper plant to the filtrate from a *Fusarium solani* f. sp. piperis culture. Plant Cell, Tissue and Organ Culture (PCTOC), 127(1), 263-268.

Das, A., and Sharangi, A.B. (2018). Post-Harvest Technology and Value Addition of Spices. In Indian Spices (pp. 249-276). Springer, Cham.

Hammouti, B., Dahmani, M., Yahyi, A., Ettouhami, A., Messali, M., Asehraou, A., and Touzani, R. (2019). Black Pepper, the "King of Spices": Chemical composition to applications., *Arabian Journal of Chemical and Environmental Research,* 6(1), 12-56.

Hussain, S., Rahman. R., Mushtaq, A., and Belaskri, A.E. (2017). Clove. A review of a precious species with multiple uses. *International Journal of Biological Chemistry,* 11, 129-133.

International Trade Centre (ITC) (2014). Tanzania spices sub sector strategy. Trade Impact for Goods. Geneva. 68 pp.

Mbiha E.R., Ashimogo G.C., Marwa N. and Akyoo A. (2008) Prospects for Organic Agriculture in Tanzania- SAFE Policy Brief No. 5: In: A series of Policy Briefs

from the SAFE programme -Standards and Agro-Food Exports: Identifying Challenges and Outcomes for Developing Countries.

Milind, P., and Deepa, K. (2011). Clove: a champion spice. *International Journal of Research in Ayurveda and Pharmacy*, 2(1), 47-54.

Neielsen, S.S. (2010). Food Analysis Laboratory Manual. Fourth edition, Springler US Publishing, ISBN

Ravindran P.N. and Kallupurackal J.A. (2012). Black pepper, Woodhead Publishing Limited, India.

Ravindran, P.N. (2017). The Encyclopedia of Herbs and Spices. CABI.

Reyes, T., Quiroz, R., Luukkanen, O. and de Mendiburu, F. (2009). Spice crops agroforestry systems in the East Usambara Mountains, Tanzania: growth analysis. Springer Science+Business Media B.V.

Takooree, H., Aumeeruddy, M.Z., Rengasamy, K.R., Venugopala, K.N., Jeewon, R., Zengin, G., and Mahomoodally, M.F. (2019). A systematic review on black pepper (*Piper nigrum* L.): From folk uses to pharmacological applications. Critical reviews in food science and nutrition, 59(sup1), S210-S243.

Thangaselvabai, T., Kennedy, R.R., Joshua, J.P., and Jayasekar, M. (2010). Clove (*Syzigium Aromaticum)* The Spicy Flower Bud of Significance-A Review. Agricultural Reviews, 31(1).

APPENDICES

Appendix 1: Study location

Table 7: Location description of the study area

WARD	VILLAGE	LATITUDE	LONGITUDE	ALTITUDE
TAWA	Uponda	07° 01.207' S	037° 46.637' E	218m
	Kisarawe	07° 00.755' S	037° 44.340' E	374m
	Milawilila	06° 59.758' S	037° 44.738' E	377m
	Kifindike	07° 02.367' S	037° 45.210' E	380m
	Tawa-center	07° 00.921' S	037° 43.878' E	395m

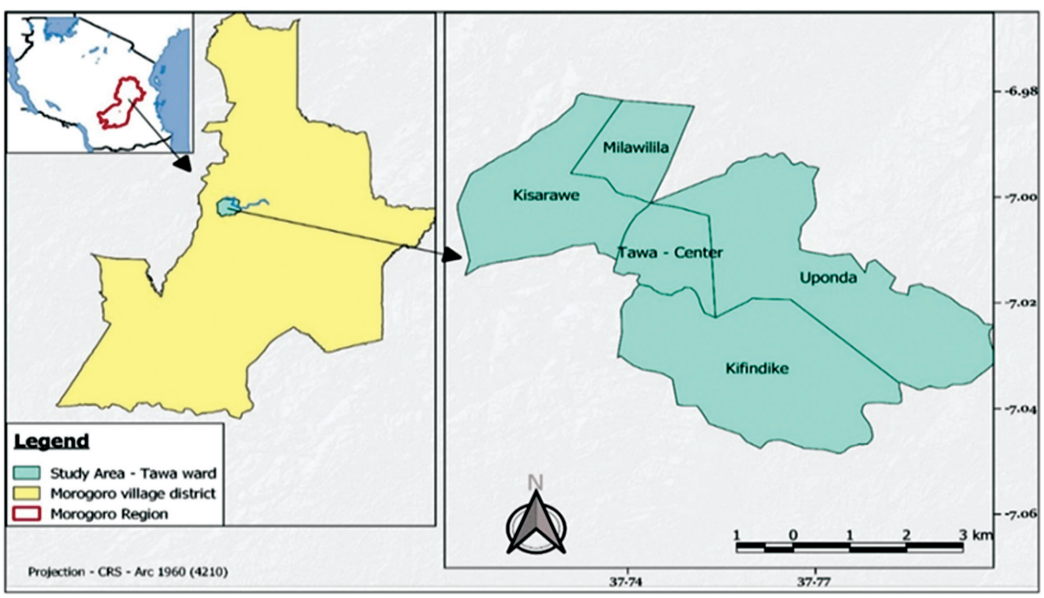

Plate 1: Pictorial description of the study area- Tawa Ward

Plate 2: Harvesting (a), drying (b) and Storage (c) of spices in Tawa Ward