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Research paper

Post-harvest handling practices and associated food losses and limitations in the sweetpotato value chain of southern Ethiopia

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ABSTRACT

Household food insecurity is a chronic problem in Ethiopia; the situation is being exacerbated by high population growth rates and recurring droughts in the country. The interest to address post-harvest value chain (VC) constraints leading to food losses has increased significantly to provide adequate nutrition to the growing population. In this study, mapping of sweetpotato VC not only quantifies the degree of losses but establish links between distinct VC constraints and respective food losses and limitations. Harvest and handling at farm level and shelf life issues at distribution were identified as vulnerable hot-spots of the sweetpotato food losses. Apart from physical and biological factors, demand and supply mismatch during the main harvest season at the wet markets leads to food (up to 25%) and economic losses (33–75%) followed by deficiencies in the lean season. A multi-stakeholder cooperation is required to mitigate food losses, which can have a high impact on the nutritional and financial status of the producers, market operators, and the consumers.

1. Introduction

Starchy roots and tubers such as Ethiopian banana (*Ensete ventricosum*), potato (*Solanum tuberosum*), sweetpotato (*Ipomoea batatas*) and taro (*Colocasia esculenta*) are the second most important source of daily dietary intake in Ethiopia following cereals [1]. Sweetpotato is the most important tropical root crop in the country, especially in the densely populated southern and southwestern parts of the country [2]. The Ethiopian national sweetpotato production has quintupled in the last decade, making it the 4th largest producer globally after China, Nigeria and Tanzania [3]. Sweetpotato is attractive to small-scale resource-poor farmers as it provides more carbohydrates per hectare than any other crop and has an ability to endure in poor soils and dry conditions [4,5]. The importance of sweetpotato as a source of β-carotenoids, ascorbic acid, and anthocyanins have also been widely recognized and promoted [6–8]. Because of these unique features sweetpotato is classified as a typical food security crop. In the semi-arid plains of East Africa, sweetpotato is sometimes called '*Cilera Abana* – protector of the children' which is a reflection of its crucial role in fighting malnutrition [9].

Being perishable and poorly handled in developing countries such as Ethiopia sweetpotato roots may suffer significant post-harvest losses along the value chain (VC). Current global estimates suggest that 45 up to 54% of roots and tubers are spoiled post-harvest in sub-Saharan Africa (SSA) [10,11]. A recent meta-analysis by Affognon et al. [12] provides a staggering 45–69% loss for sweetpotato. The distinct causes and magnitude of such losses depend on the particular conditions prevailing in specific locations. Many recent studies raised this concern and demanded location specific detailed information regarding the scale and nature of these losses [10,12–14]. The most recent global effort towards bringing the issue of food loss in the forefront was the release of United Nations sustainable development goals (SDG). SDG-12.3 targets a reduction of 50% in per capita global food loss at retail and consumer level by 2030 and propose the requirement to multiply efforts towards reduction of losses at production and supply stages.

Food security in Ethiopia is still a critical issue, 25–35% of the country's population is undernourished [15]. Reduction in food losses and food waste is one of the sustainable solutions to enhance future food availability [13,16,17]. Little information is available from the country about the post-harvest handling practices and associated food losses, despite Ethiopia being the fourth largest producer of sweetpotato. In a review Jones et al. [18] highlighted that information from Ethiopia on sweetpotato post-harvest handling practices, storage and magnitude of losses is almost nonexistent.

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Table 1
Damage classes at farm and market levels.

Code	Damage class	Definition[a]
UD	Undamaged	Root is whole, and there is no mechanical injury apart from the breaking point from the vine.
LD	Lightly damaged	Roots are not whole and carry one small cut other than the breaking point from the vine.
SD	Severely damaged	Roots are not whole and carry more than one cut, apart from breaking point from the vine.
PD	Pest damage	Roots which are infested by the pest, visual identification by looking at the holes present on the surface due to weevil attack.

[a] Skinning injuries were ignored at retail and wholesale level as 100% of the roots were found to be affected by skinning and minor bruising.

In the course of this study, a diagnostic survey was carried out during the main harvest season along the sweetpotato VC in southern Ethiopia. The objective was to capture the current status of the post-harvest VC from harvest to retail, identify the key actors and their respective roles, and quantify food losses. The principal focus was to assess how much, where and when food losses occur and what the main causes and types of these losses are.

2. Materials and methods

2.1. Study location

The SNNPR (Southern Nations, Nationalities, and Peoples' Region) borders Kenya in the south and southwest, and South Sudan in the west. It is one of the most rural regions of Ethiopia, with an estimate of 90% rural inhabitants. The region constitutes 52% of the total land allocated for sweetpotato production at the national level. The Sidama and Wolayita zones are the centers of sweetpotato production in SNNPR, contributing 72% of the total regional production [1]. Hawassa and Sodo main markets and Addis Ababa market (*markatu*) were the key markets visited to track commercial consignments of sweetpotato roots. Hawassa is the capital city of SNNPR and about 275 km south of the national capital Addis Ababa. Sodo is the central administrative town of Wolayita zone located 150 km southwest of Hawassa and 312 km south of the national capital. According to the Ethiopian national census of 2007, the population of Hawassa and Sodo towns was 157,139 and 76,050 respectively. However, current estimate suggests that the population of these cities may have grown two fold since then mainly due to rural-urban migration. The cities represent the urban centers of the respective zones, with literacy rates of 72.5 and 88.7%, and economic activity rates of 52.2 and 58.9% for Sodo and Hawassa respectively [19]. The geographical location and elevation of Hawassa and Sodo are 038° 28′ E, 07° 03′ N, 1694 m and 037° 44′ E, 06° 49′ N, 1854 m respectively. The rainfall pattern in the study area is bimodal, with a short rainy season in March and April and the long second rainy season from June to mid-October.

2.2. Definitions and system boundaries

Maintaining a consistent definitional framework and clearly stating the system boundaries are keys to compare food losses results to existing studies and measuring future developments against the current status. Throughout this study the FAO definitional framework of food loss and system boundaries was followed [20], where food loss is referred as *'decrease in quantity or quality of any substance (processed, semi-processed or raw) which originally was intended for human consumption'*. Four boundaries which were selected for this study were *agricultural production (during harvest); post-harvest handling and storage (during packaging, transportation); processing (industrial or domestic processing) and distribution (wholesale and retail)*. Food waste is referred as the food loss occurring at consumption stage, which is a major problem in developed countries [10,13]. Therefore, food waste was not considered during this study.

2.3. Damage assessment

After conducting a preliminary investigation at the farm and wholesale stages, four classes of the damages was conceptualized (refer to Table 1).

2.4. Field survey and measurement

A survey (semi-structured questionnaires) and field measurements (direct weighing/counting) were conducted for the assessments at retail, wholesale and farm levels. An upstream approach of stakeholder identification was used starting from the retail level. All the sweetpotato retailers in Hawassa and Sodo markets were interviewed. Retailers were asked to provide the contact of wholesalers delivering sweetpotato roots to them. Similarly, information from wholesalers was obtained to reach collectors and subsequently the farmers. The primary sweetpotato supplier *woredas* (sub-regional administrative units) to the selected urban markets and the respective *kebeles* (smallest administrative units) which were surveyed during the study are illustrated in Table 2. In total 61 VC actors were interviewed including 30 farmers, and 31 traders (19 retailers, nine collectors, and three wholesalers). Background characteristics of VC actors are presented in Tables 3 and 4.

2.5. Trials at market conditions

Freshly arrived sacks (weighing ∼110 kg) at the wholesale level were procured for shelf life (keeping quality) trials at market conditions during the month of March at Hawassa main market. The consignment was a day old harvest and had traveled a distance of 35 km (Kebele: *Mesinkala)* by mini-truck involving loading and unloading activities (please refer to Fig. 1 for transition points and approximate delays for Hawassa market). All the roots suffered skinning injuries. For in-sack keeping quality trials, 30 sweetpotato roots were kept in polypropylene bags, representing the marketing situation. The purpose was to investigate critical quality deterioration during marketing rather than long-term storability. Rees et al. [21] clearly distinguish between long term storage (>3 months) and shelf life (keeping qualities during marketing ranging 2–3 weeks). A period of 4 weeks was considered to represent the maximum length of time fresh roots may stay in the marketing stage. Two sets of bags with three replicas each were prepared. Set one (unsorted) constitutes an imitation of the commercial sack with all the different classes of roots (UD, LD, SD, PD) in the same proportion as it was identified at the wholesale level. Another set (sorted) of bags with only undamaged (UD), lightly damaged (LD) and severely damaged roots (SD) was prepared after sorting the original commercial sack to analyze the effect of injury type on weight loss and rotting. Weight loss and surface rotting were observed weekly, and at the end of the 4th week, all the roots were cut vertically and horizontally to detect the types of infection. *'Sweetpotato DiagNotes: A Diagnostic Key & Information Tool for Sweetpotato problems'* was used for identification of rotting and responsible microorganism [22].

Retail conditions were categorized into three types: shade (S), semi-shade (SS) and no shade (NS). S retail: roots are placed under