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Traditional maize post-harvest management practices amongst smallholder farmers in Guatemala

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ABSTRACT

Much of the maize that is produced in Guatemala is planted, harvested and handled via subsistence-oriented agricultural practices, strongly connected to Mayan heritage. This post-harvest assessment study was done to characterize the current practices used in the region of Huehuetenango, Guatemala, in order to identify the different grain handling practices in the region as well as possible factors contributing to post-harvest losses of maize. A total of 280 families representing 14 rural communities were surveyed through interviews. Survey revealed that most (88%) of interviewed farmers prefer to dry the maize cobs after harvest by laying them in stacks exposed to direct sunlight. After drying, harvested maize is stored until consumption along with purchased maize kernels from the market. Among storage practices, 62% of surveyed families store the maize as shelled kernels; while 38% store it on cobs. When storing shelled maize, bags are the preferred containers among 81% of farmers, while only 14% use metal silos. Among farmers who stored maize on cobs, 74% use the *tapanco* as the preferred storage structure. Forty-one percent of farmers indicated storing the maize for at least 4 months. During the storage time, 61% of farmers perform grain quality checks once a week. Moreover, 65% perform pest control during storage; however, in most cases, the control is not preventive but corrective. For 49% of farmers, the main cause of loss between harvest and consumption is the mishandling of grain moisture, leading to insect and fungal infestation. With this data, it was possible to identify diverse maize harvesting, drying, storage and consumption practices within the studied communities. Understanding the traditional post-harvest practices will help better design intervention steps to improve these practices and to increase food security and food safety for smallholder farmers in the Guatemalan Highlands.

1. Introduction

The majority of agriculture in the highlands of Guatemala is devoted to the culture of maize and beans. Wheat, squash and a few other vegetables are also grown on small farms (Williams and Menegazzo, 1988) mostly due to their attractive market value (Hamilton, 2005; Reardon et al., 2009), but also for being less labor intensive (Immink and Alarcon, 1993). Of these, maize is considered a staple crop for Guatemala's population (Argueta, 2013), even more so for low income households (Van Etten and Fuentes, 2004). In this country, this crop averages an annual production of 1.7 million metric tons (USDA, 2014). More than half of Guatemala's maize is consumed as tortillas, at approximately 170 kg per capita per year (Kenneth and Kiple, 2000; Schmidt et al., 2012). Besides this, several other Guatemalan dishes are based largely on maize, which also happens to be a very susceptible commodity to fungal contamination (Appell et al., 2009).

Fungi thrive in relatively low moisture environments compared with bacteria, which make grains, and more specifically maize, a perfect niche. This is further exacerbated when poor handling and storage conditions allow access to pests and/or promote moisture migration to the seed. Given that certain fungi can produce harmful compounds to humans and other animals, their presence becomes of concern. The toxicity of these compounds, known as mycotoxins,

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is dependent on several parameters such as dosage, chemical structure, length of exposure, and affected organism, among others (Bryła et al., 2013; Cornell University, 2015). Depending upon the dose, the effects of food-borne mycotoxins can be acute, with symptoms of severe illness appearing rapidly. At lower doses fungal toxins show long term chronic effects on health, including the induction of cancer, and immune deficiency (FAO, 2016). Previous work in the lowlands of Guatemala indicate an incidence of mainly fumonisin but also aflatoxin, mycotoxins produced by fungi in the genera *Fusarium* and *Aspergillus*, respectively, acting synergistically or individually. Health problems attributed to these mycotoxicoses in the region include neural tube defects, stunting and hepatocellular carcinoma (Torres et al., 2015, 2007).

Previous findings by the International Maize and Wheat Improvement Center, known by its Spanish acronym as CIMMYT, revealed that for a significant part of the western highlands of Guatemala food production is of subsistence; agricultural assets are generally very small and rural properties are highly fragmented (CIMMYT, 1981). It is in such rural regions where people have limited economic resources that a larger maize consumption is more noticeable (Torres et al., 2007), therefore even low levels of mycotoxin contamination could pose a substantial health risk to this population. Moreover, the lack of financial support results in limited technical knowledge and tools (Immink and Alarcon, 1993) for appropriate grain handling practices, among which proper storage and drying equipment stand out. Many of the farmers in the highlands of Guatemala use rudimentary and empirical techniques where little technology is involved. Consequently the present work aims to evaluate such conditions to better understand their potential role and impact on maize quality and safety.

This study took place in Huehuetenango, Guatemala. This department lies in the northwestern corner of Guatemala. Geographically, it is bounded to the north and west by Mexico, to the east by the department of Quiché and to the southeast by the department of Totonicapán. This region is largely mountainous with a total area of approximately 7500 square kilometers (~2900 mi^2) (Baepler, 2016). More specifically, the townships of Chiantla and Todos Santos Cuchumatán, of the Huehuetenango department were subject to investigation.

Understanding the different traditional maize-handling practices performed in the Highlands of Guatemala will help elucidate their potential influence on the class of maize produced, sold or consumed, as well as its safety and shelf-life. Additionally, data would guide the choice of better intervention steps, if necessary, to decrease smallholder farmers' maize spoilage and post-harvest losses, and ultimately increase the food security and safety of the region.

2. Materials and methods

2.1. Sampling method

Households located in communities or settlements known as landscapes, villages, towns, cities, etc. from Todos Santos and Chiantla were randomly selected. The sample size (n = 267 households) obtained from community conglomerates was determined using the following equation (Chow et al., 2007):

$$n = \frac{\left(Z_{\alpha/2}\right)^2 * p(1-p)}{d^2}$$

Where,

- $Z_{\alpha/2}$: 1.962, confidence level at 95%. Two-tail test.
- p: ratio, 0.50. The variance of the indicators measured as a proportion reaches a maximum point as they approach 0.50, ensuring an adequate sample size.
- 1−p: probability of failure. Complement of the event.
- d: accuracy or acceptable error limit. In this case 6% (0.06).

Possible losses of study subjects for various reasons (data loss, abandonment, no answer) was also taken into account with a sample increase. The adjusted sample size ($n_{adj} = 280$) was determined as follows (Pérez et al., 2013):

$$n_{adj} = n\left(\frac{1}{1-R}\right)$$

Where,

- R: proportion of expected losses, 5% (0.05) is expected.

These 280 households were distributed between Chiantla (35.7%) and Todos Santos (64.3%). Although Todos Santos' population and terrain are the smaller of the two, the selection of the sample is proportionately greater due to its variations in altitude.

2.2. Community selection

The communities were selected based on their altitude and maize production chain (producers or purchasers). Communities were divided in three groups depending upon the altitude: type C: altitude from sea level until 1500 masl (meters above sea level), type B: between 1500 and 2700 masl, and type A: above 2700 masl.

Farmers having land available to plant and harvest maize (producers) were designated “Chain 1” farmers; while farmers who didn't have land and thus rely on purchasing maize were identified as “Chain 2” farmers. With 20 families per community, 14 communities were covered in this study: 9 from Todos Santos, 5 from Chiantla.

2.3. Surveying process

Two hundred and eighty families from the 14 communities of Todos Santos and Chiantla, townships of Huehuetenango in Guatemala, were surveyed between May and August 2014. The survey consisted of 80 questions in order to get acquainted with household composition, practices related to agriculture and grain handling, community organization, level of technical education, hygiene and health. Only results related to maize agriculture, harvest, grain handling and storage are included in the present article. Unless otherwise noted, farmers' answers to questions were referred to the 2013–2014 harvest season.

Before the actual interviewing of the different households, the interviewers selected for the survey were properly trained. At the end of such trainings, interviewers demonstrated having knowledge and understanding of the study objectives, mastering the survey instrument to be used (i.e. ballots), having an impartial interview technique, knowing the areas the study comprised, logistics and contact with community, route plan, among others. In addition, interviewers spent a day of work in the field to validate their skills and mastery over the instruments.

This validation was performed with people in the community of Taluca from the township of Chiantla. This community was not selected to participate in the study, however it showed similar characteristics to those that were. Several consultations between post-harvest scientists and SHARE (Self Help And Resource Exchange), the NGO providing field personnel, resulted in the refined survey instrument and procedures to be followed.