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ORIGINAL ARTICLE

Gender differentials in value addition and lean season market participation in the grasshopper value chain in Uganda

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Abstract

Gender gaps in agrifood value chains are manifested in differential access to and control of productive resources, upgrading activities, market participation, farm productivity and food security among women and men. These gender gaps threaten economic development in sub-Saharan Africa. With low-resource requirements, edible insects have emerged as a promising agrifood value chain with income opportunities for women and men. However, it is not clear how gender gaps are manifested in the participation in value addition and lean season market of the edible insect value chain with a potential to improve household welfare. In this paper, we analyse the gender gaps of retailers' participation in value addition and lean season market in the grasshopper value chain in Uganda. Multivariate probit and tobit models are used in the empirical analyses. We find that women are 15% more likely to participate in primary value addition. However, there are no gender gaps in the participation in secondary value addition and the lean season market. The study also shows that grasshopper business is an important source of income for many retailers. Therefore, the development of the grasshopper value chain, especially the aspects of value addition and lean season market, could contribute to gender equality and improvement of livelihoods of women and men.

KEYWORDS

Agrifood sector, edible insect value chain, food security, gender gap, upgrading strategies, value addition

1 | INTRODUCTION

Gender equality is seen as 'the means and the end'[1] of development (Duflo, 2012). Gender gaps, reflected in differential access to agricultural inputs, cultivation of cash crops, financial inclusion, market participation and farm productivity, threaten economic development in sub-Saharan Africa (SSA) (UN Women et al., 2015). In various agrifood value chains, especially for staple foods, previous studies (Gebre et al., 2019, 2020; Marenya et al., 2016; Quisumbing et al., 2021) on gender gaps have mainly focused on the production nodes of the value chains. For example, Marenya et al. (2016) and Gebre et al. (2020)

showed that there were gender gaps in market participation in the maize sector in Ethiopia, with women being net buyers and men net sellers. Both studies attributed the gender gaps in market participation to structural differences in resource endowments. In Kenya, Kihiu and Amuakwa-Mensah (2020) reported that enhancing women and men access to organised agricultural markets improved their dietary outcomes, but the effect on women was twice as great as that on men. In Uganda, Mugisha et al. (2019) found that there were gender differences in yields of improved and local groundnut varieties—with a higher proportion of male plot managers (63%) reporting higher yields on average than that of female plot managers (44%). Differences in labour input and variety type were found to be the main factors contributing to the gender gap in yield. Kilic et al. (2015) found that female-managed plots were on average 25% less productive in Malawi. A recent study by Quisumbing et al. (2021) showed women in Malawi, Benin, the Philippines and Bangladesh had lower participation in agricultural value chains, which they attributed to cultural and context factors. Malapit et al. (2020), on the contrary, found that women and men were equally empowered in Abaca, coconut seaweed and swine value chains in the Philippines. In the gender literature, there is limited empirical evidence of gender gaps at the retail node of the agrifood chains, particularly for niche and underutilised food commodities such as edible insects.

Interest in edible insects has been increasing as the integration of edible insects into existing food systems is crucial for sustainable and resilient food systems (van Huis, 2016). The argument is based on the economic potential of edible insects referring to the creation of business opportunities, nutritional benefits and environmental friendliness (van Huis, 2016). Edible insect production requires less resources in terms of land, energy, water and capital investments compared with livestock-based protein production. Edible insect production is also associated with lower emission of greenhouse gases than crop and livestock production, thereby contributing to environmental sustainability (van Huis & Oonincx, 2017). Edible insects are rich in proteins, vitamins and minerals, which are required for human body growth and development (Araújo et al., 2019; Nowak et al., 2016). For example, Christensen et al. (2006) concluded that consumption of edible insects such as ants and termites could be a strategic way to address iron and zinc deficiency in East Africa. Kipkoech et al. (2017) and Kinyuru et al. (2021) concluded that farmed crickets can be incorporated as ingredients in children food to improve nutrition. Evidence from Alemu, Olsen, Vedel, Kinyuru, et al. (2017) suggested that there is a market for bread made with cricket flour in Kenya. Demand for edible insects, especially grasshoppers, was found to exceed supply (mainly due to seasonality) with higher prices than meat, making them a promising business opportunity (Odongo et al., 2018). These potentials of edible insects accentuate their capacity to contribute to sustainable food and nutrition security in SSA, where malnutrition, in particular protein deficiency, is prevalent (FAO et al., 2021).

In Uganda, for example, edible insects such as grasshoppers (*Ruspolia differens*) are a delicacy and consumed by most people in the central part of the country. Grasshoppers play an important role in household nutrition security as they contain essential nutrients such as proteins, vitamins (provitamin A, E, C, B2, B3 and B9) and minerals (iron, zinc and calcium) (Ssepuuya et al., 2017; Ssepuuya et al., 2019). However, grasshoppers are not domesticated but harvested in the wild when they are abundant annually in two periods, which are referred to as seasons in this paper. Though Odongo et al. (2018) found overall low levels of value addition in Uganda and Burundi, the seasonality and the high perishability create an opportunity for value addition through processing to reduce spoilage and ensure supply during the lean season. In this paper, lean season refers to the period where there is limited or no supply of grasshoppers from the wild. Nevertheless, participation in value-adding activities and lean season marketing at the retail node of the grasshopper value chain has not been studied. Moreover, as processing of edible insects has low barriers to entry, a nuanced understanding of how contextual factors affect women's and men's participation can contribute to assessing the potential of edible insect value chain development for achieving the sustainable development goal of gender equality. However, there is lack of evidence on gender gaps and how contextual factors affect women's and men's participation in activities at retail node of the edible insect value chain, especially grasshoppers. Instead, studies on edible insect sector focus on mass production of edible insects (Ssepuuya et al., 2018), nutritional composition (Kinyuru, 2020; Ssepuuya et al., 2019), consumer behaviour towards insect foods (Alemu & Olsen, 2019; Alemu, Olsen, Vedel, Kinyuru, et al., 2017; Alemu, Olsen, Vedel, Pambo et al., 2017) and a few studies on marketing of edible insects (Agea et al., 2008; Odongo et al., 2018).

In this context, our paper aims to contribute to expanding the knowledge on edible insect value chains by analysing gender gaps of retailers' participation in value addition and the lean season market in the grasshopper value chain in central Uganda. We also analyse contextual factors that influence female and male retailers' decisions to participate in value addition and the lean season market, as well as the intensity of participation using multivariate probit and tobit models, respectively. By providing empirical evidence of gender gaps in product upgrading

at retail nodes in the edible insect value chain, the paper contributes to expanding the literature on gender gaps in the agrifood value chains, which mostly focuses on marketing (Gebre et al., 2019, 2020; Marenya et al., 2016) and productivity gaps (Kilic et al., 2015; Mugisha et al., 2019) of staple foods at the production nodes. Moreover, the empirical findings on contextual factors affecting women's and men's engagement in product upgrading also build upon on recent studies by Quisumbing et al. (2021) and Malapit et al. (2020) who found gender empowerment disparities in agricultural commodity processing and trading, but did not evaluate contextual factors contributing these disparities.

The paper is organised as follows. Section 2 provides an overview of the grasshopper value chain in Uganda. Section 3 describes the methodology applied to achieve the research objectives. The descriptive results are presented in Section 4, while the econometric results are shown in Section 5. The discussion of key results is provided in Section 6, and the last section presents conclusions and policy implications.

2 | AN OVERVIEW OF THE GRASSHOPPER VALUE CHAIN IN UGANDA

Grasshoppers (*Ruspolia differens*) are consumed as a delicacy by people in central Uganda in East Africa (Odongo et al., 2018). Linked to rainfall patterns, there are two seasons: April–May and November–December. The volume of grasshoppers traded is higher in the November–December season than the April–May season. The main actors in the grasshopper value chain are collectors, wholesalers, retailers and consumers (Figure 1). Financial institutions, associations, transporters and health services[2] are also involved in the chain to provide support services to the main actors. The collectors are located in peri-urban and rural communities in central Uganda, particularly in Masaka District. Grasshoppers are harvested with specially designed local tools such as barrels, roofing sheets, high-voltage electric wires, electric bulbs and capacitors (Okia et al., 2017).[3] Odongo et al. (2018) reported that a collector can harvest and sell an average of up to 70 bags (about 100 kg each) daily during the peak season. Grasshopper collectors are categorised into commercial and subsistence collectors (Odongo et al., 2018). Subsistence collectors gather grasshoppers in small quantities and sell them either to wholesalers or retailers or directly to consumers in their communities (Odongo et al., 2018). They harvest grasshoppers in large quantities and sell them to wholesalers and retailers in rural and urban areas.

Wholesalers pack and transport grasshoppers from collection points in rural areas to various markets in urban areas. Some wholesalers process grasshoppers by removing the wings and legs, which we call as plucking in this paper. The plucked grasshoppers are washed and fried in cooking oil. Wholesalers sell fried grasshoppers to retailers, while others store and sell them for sale in the lean season market. Retailers purchase grasshoppers from wholesalers or directly from collectors (Figure 1). Retailers include street and market vendors who sell grasshoppers to consumers in various forms of value addition, namely unplucked, plucked, fried, dried or boiled. Unplucked grasshoppers are raw grasshoppers, that is the non-value-added product, with wings, legs and antenna. However, it is common practice for most retailers, especially those in urban centres to purchase fresh unplucked grasshoppers from wholesalers. Some retailers process raw grasshoppers by plucking, frying or

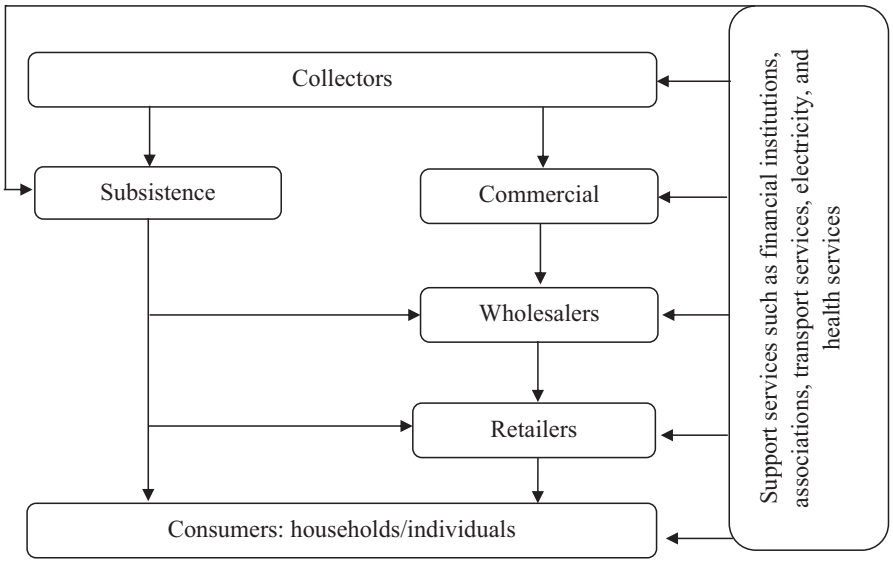

FIGURE 1 Grasshopper value chain in Central Uganda. Source: Modified and adapted from Odongo et al. (2018)

drying them, while others stock processed grasshoppers for the lean season, where there is virtually no supply of raw grasshoppers. During this lean season (that is between January to March and July to October), prices for value-added grasshoppers are higher than during the peak season. Major challenges faced by traders in the grasshopper value chain in central Uganda include lack of standardisation and processing technology, seasonality, high market fees and short shelf life of grasshoppers (Odongo et al., 2018; Okia et al., 2017).

3 | MATERIALS AND METHODS

3.1 | Conceptual framework

Most gender studies in agriculture are based on the conceptual approaches of household and intrahousehold production models (Duflo & Udry, 2004; Kanbur & Haddad, 1994; Udry, 1996), women empowerment (Alkire et al., 2013; Malapit et al., 2020; Quisumbing et al., 2021), livelihood and asset approach (Quisumbing et al., 2015). These approaches derive their conceptual foundation from the concept of 'gendered economy', which refutes the notion of gender neutrality of the economy and points to gender biases in the economy (Elson, 1993). This paper is positioned within the concept of a 'gendered economy', expecting gender gaps in the grasshopper value chain. We use individual retail business owners as a unit of analysis and not from the household or intrahousehold perspective. Such an approach to analysing the existence and correlates of gender gaps parallels the concepts of gender as a means and end of development as detailed in Duflo (2012).

Gender dynamics play an important role in transforming agricultural value chains (Quisumbing et al., 2021), as women and men have different roles at various nodes of the chain (UN Women et al., 2015). The extent to which women and men participate at different nodes in the chain is influenced by contextual factors (Quisumbing et al., 2021). In this paper, we consider women's and men's involvement in value addition at the retail node of the grasshopper value chains. We regard value addition as product upgrading strategy. Humphrey and Schmitz (2002, p. 1020) define product upgrading as 'moving into more sophisticated product lines (which can be defined in terms of increased unit values)'. We focus on two levels of value addition: primary and secondary at the retail node of the grasshopper value chain. Primary value addition involves increasing only the market value of raw grasshoppers by the removal of wings, legs and antennae, which is termed as plucking. Secondary value addition entails enhancing the market value of raw grasshoppers and extending the shelf life through frying and drying.

There are limited empirical studies on contextual factors influencing women's and men's participation in upgrading activities at the retail level, especially for edible insect value chains. Hence, we rely on previous studies (Adeyonu et al., 2017; Donkor et al., 2018; Khoza et al., 2019; Kuwornu et al., 2014; Musyoka et al., 2020) from various agrifood value chains such as maize, cassava, sweet potato and mango, especially the aspect of upgrading activities (e.g. roasting, drying, grinding, slicing and blending) at the production nodes to support our conceptual framework. The nature of these value chains may differ from each other and from insect value chains. However, the value-adding activities carried out in these chains similar. In particular, roasting and drying in cassava, maize and mango are similar to those in the grasshopper value chain. Hence, the factors that influence farmers' participation in value addition in these value chains are also likely to affect retailers' decision to engage in value addition in the grasshopper value chain.

Based on previous studies from different agricultural value chains, we conceptualise that women's and men's decision to upgrade is likely to be influenced by contextual factors categorised as market locations, socioeconomic, institutional, transactional, communication technology and transport assets, and processing and managerial factors as shown in Figure 2. The location of the markets[4] where women and men operate can influence their decision to upgrade. For example, we expect retailers in markets located in Kampala Central Division to upgrade compared with those in other markets. Kampala Central Division is characterised by a high concentration of business offices, many lorry stations and high-income consumers, making it a strategic location for selling value-added grasshoppers.

In this paper, we expect socioeconomic factors such as age, education, labour availability and monthly income to be significantly correlated with women's and men's decision to participate in value addition and the lean season market. Donkor et al. (2018) showed that older farmers were less likely to participate in value addition at the production node of the cassava value chain in Nigeria. Hence, we expect that older women are more likely to engage in value addition and lean season market than older men. Women have limited economic opportunities (Duflo, 2012; Quisumbing et al., 2021) and might consider value addition and lean season market as an opportunity to earn an income that also corresponds to the traditional roles in food preparation. Musyoka et al. (2020) found that off-farm income positively correlated with mango farm-level value addition in Kenya. Similarly, Kuwornu et al. (2014) showed that education and household income showed a significant positive association with food crop farmers' decision to diversify into agro-processing activities in Ghana. However, we expect that educated or

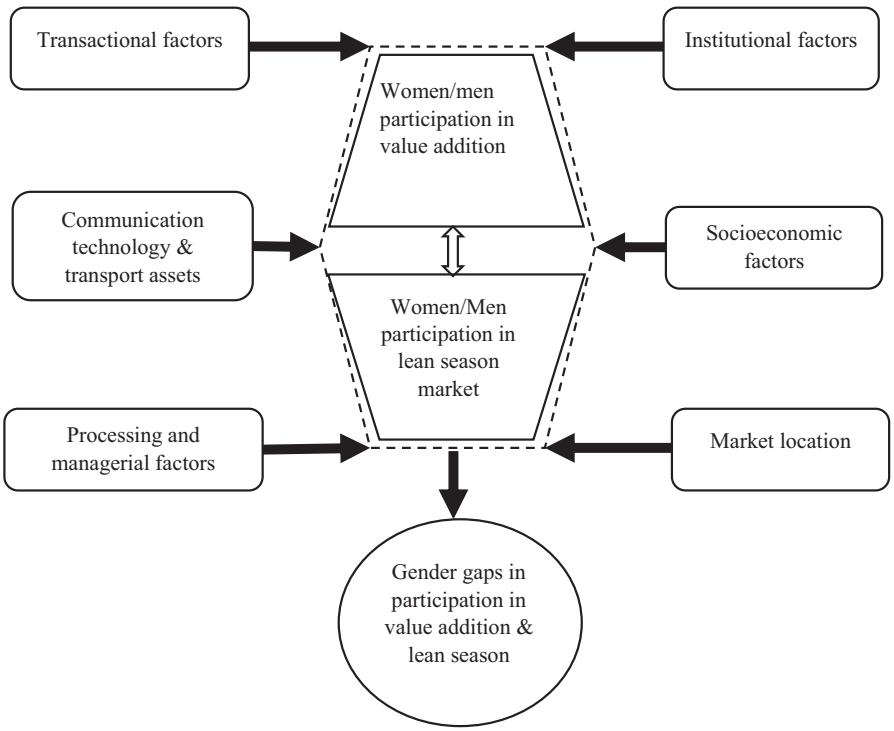

FIGURE 2 Conceptual framework. Source: Authors' design

high-income women and men are less likely to participate in value addition and the lean season market because they might have better opportunities elsewhere and therefore have higher opportunity costs. Labour was found to be positively correlated with mango farm-level value addition in Kenya (Musyoka et al., 2020) and participation in agro-processing in South Africa (Khoza et al., 2019). Based on these previous studies, we hypothesise that the availability of affordable labour might encourage women and men to participate in value addition and the lean season market. Upgrading strategies such as value addition is labour-intensive (Donkor et al., 2018) and labour availability enables them to process raw grasshoppers.

Based on previous studies (Donkor et al., 2018; Musyoka et al., 2020, Adeyonu et al., 2017), we expect institutional factors such as membership of an association and the use of credit to be positively correlated with women's and men's participation in value addition and the lean season market. Membership of association was found to positively influence participation in value addition among cassava (Donkor et al., 2018) and sweet potato farmers in Nigeria (Adeyonu et al., 2017). Associations through collective action can provide members with financial support and relevant information related to value addition (Donkor et al., 2018; Adeyonu et al., 2017). We therefore expect women and men membership of association to be positively correlated with their participation in value addition and lean season market in the grasshopper value chain. Donkor et al. (2018) found that access to credit was positively associated with cassava farmers' participation in value addition in Nigeria. In addition, Musyoka et al. (2020) showed a positive relationship between the amount of credit received and participation in mango farm-level value addition in Kenya. Based on these previous studies, we expect the use of credit to be positively correlated with men and women participation in value addition and lean season, as these activities require capital investment. Credit helps retailers with limited capital to overcome liquidity constraint and increase their capital, which can be invested in value addition.

We also hypothesise that transactional factors such as record-keeping, access to information on the market price of grasshopper products and transport costs will be correlated with women's and men's decision to participate in value addition and the lean season market. Donkor et al. (2018) reported that record-keeping increased farmers likelihood of participating in value addition in the cassava value chain in Nigeria, as better farm records enable them to make informed decision. Following Donkor et al. (2018), we expect record-keeping or access to information on the market price of grasshoppers to be positively associated with women's and men's participation in value addition and the lean season market. Evidence from Ater et al. (2018) showed that high transport costs limited maize farmers' ability to engage in value addition in Nigeria. Similarly, we expect transport costs to be negatively correlated with women's and men's participation in value addition and the lean season market, as high transport costs increase overall production costs and reduce profit margins. Kuwornu et al. (2014) showed that ownership of assets increased food crop farmers' likelihood of diversifying

into agro-processing activities in Ghana. Similarly, we hypothesise that women's and men's ownership of communication technology (radio and television sets) and transport assets (vehicle and motorbike) will increase their probability of participating in value addition and the lean season market.

Processing and managerial factors such as access to information on processing of grasshoppers are expected to be positively correlated with women's and men's participation in value addition and the lean season market while lack of storage facility, lack of business skills and poor working conditions at market will discourage women and men to engage in value addition and the lean season market. Men and women who have access to information on grasshopper processing are likely to be aware of the benefits of value addition, such as long shelf life, high market value and the possibility of selling the products in the lean season when prices are higher. These advantages could encourage retailers to participate in value addition and take advantage of the lean season. For the storage of value-added grasshoppers, men and women need storage containers. Retailers without such a facility cannot engage in value addition as they cannot store the value-added products. This hypothesis is supported by previous studies reporting that lack of processing (Ater et al., 2018) and storage (Musyoka et al., 2020) facilities discouraged farmers in Nigeria and Kenya, respectively, from participating in value addition. Compared with men, women are likely to face to storage constraint as they have fewer resources to acquire storage containers. Acquiring entrepreneurial skills enables retailers to make informed decisions about participating in value addition and lean season markets. Women tend to have low entrepreneurial skills compared with men (Brixiova et al., 2020; Siba, 2019), which affects their ability to make better decisions in their business. Many retailers, especially women, do not have a permanent place to sell their grasshoppers, so they sell at lorry stations and busy roads, which is risky. These poor working conditions can discourage them from investing further in value addition.

In addition, we hypothesise a positive correlation between participation in value addition and the lean season market for women and men. The correlation between value addition and lean season market is bidirectional. That is, the decision to engage in value addition is positively correlated with lean season market, while participation in lean season market in turn positively influenced participation in value addition. For instance, value addition through drying and frying reduces perishability of the grasshopper products and increases their shelf life, which enables women and men to sell their products during the lean season. On the contrary, value-added grasshopper products attract higher prices in the lean season due to shortage of supply. This price incentive tends to encourage women and men to fry or dry their raw grasshoppers so that they participate in the lean season market.

Lastly, we hypothesise gender gaps in participation in value addition and the lean season market, favouring women at the retail node of the grasshopper value chain. The reason is that processing activities such as plucking, frying and drying are considered women's activities and are an essential part of meal preparation, which is mainly done by women (UN Women et al., 2015). These activities are also time-consuming and involve high opportunity costs, especially for men. Women, who typically have limited economic opportunities (Alkire et al., 2013; Duflo, 2012; Quisumbing et al., 2021; UN Women et al., 2015), resort to value-adding activities and the lean season market as a way to earn an income to support their families.

3.2 | Empirical estimation strategy

Studies have employed methods such as the Blinder–Oaxaca (B-O) decomposition to examine gender gaps in market participation (Gebre et al., 2020; Marenya et al., 2016). This approach allows researchers to analyse how gender differences in access to resources and returns from resource mobilisation affect gender gaps (Gebre et al., 2020). However, our sample is not balanced when disaggregated into gender group and further divided into participation and non-participation in value addition and lean season market. For this reason, we apply multivariate probit and Tobit regression models and simply compare the conditional predicted probabilities of participation in value addition and lean season market between women and men. A multivariate probit model is applied to jointly analyse retailers' correlates of participation in value addition and the lean season market, whereas a multivariate tobit model is used jointly analyse correlates of retailers' intensity of participation in value addition and the lean season market. The multivariate probit model allows us to account for the non-mutually exclusive binary choices of participating value addition and the lean season market and interdependence between the choices. The multivariate tobit model enables us to consider the joint decision regarding the quantities of raw grasshoppers being processed and the quantities of processed grasshoppers allotted to be sold during lean season. For example, the retailer's decision to participate in secondary value addition, notably by frying, is highly dependent on the decision to pluck, as grasshoppers are plucked before frying. Likewise, a retailer involved in secondary value addition has a higher tendency to participate in the lean season market. The data set is disaggregated according to the retailers' gender; hence,

we estimate different models for women and men using the same variables.

We start our empirical analysis with the specification of the multivariate probit model. Based on the conceptual framework, we express that female and male retailer's decision to engage in primary and secondary value addition is correlated with contextual factors such as retailers' market location, socioeconomic, institutional, transactional, communication technology and transport assets, and processing and managerial factors. Besides the decision to participate in value addition, female and male retailers decide whether to store value-added grasshoppers to sell during the lean season. This decision is also influenced by the contextual factors. Following Cappellari and Jenkins (2003), a reduced form of the multivariate probit regression is given as:

$$V_{ijk}^{*} = \varpi_{jk} X_{ijk} + \varepsilon_{ijk}, \quad j = 1, \ldots, J; k = 0(\text{male}), 1(\text{female}) \tag{1}$$

$$V_{ijk} = 1 \text{ if } V_{ijk}^{*} > 0 \text{ and } 0 \text{ otherwise}$$

where V_{ijk}^{*} denotes jth latent dependent variable. V_{ijk} denotes a set of dependent variables under investigation related to ith retailer. The dependent variables include participation in primary and secondary value addition and the lean season market. X_{ijk} is a vector of contextual factors related to ith retailer for jth choice. The descriptions of the contextual factors are presented later in Table 1. ϖ_{jk} is a set of parameters to be estimated, and $\varepsilon_{ijk}, (j = 1, \ldots, J)$ are the error terms distributed as multivariate normal, each with a mean of zero, and variance–covariance matrix $\mathbf{V}$, where $\mathbf{V}$ has values of 1 on the leading diagonal and correlations $\rho_{jk} = \rho_{kj}$ as off-diagonal elements (Cappellari & Jenkins, 2003).

As indicated in Equation (1), two separate multivariate probit models are estimated for female and male retailers. The parameters in the multivariate probit model are estimated using the simulated maximum-likelihood method (Cappellari & Jenkins, 2003). We compute gender gaps in the participation of value addition and the lean season market as the mean differences between female and male retailers' predicted probabilities of participating in value addition and the lean season market:

$$\Delta\text{Gap}_1 = p_{1\text{F}} - p_{1\text{M}} \tag{2}$$

$$\Delta\text{Gap}_2 = p_{2\text{F}} - p_{2\text{M}} \tag{3}$$

$$\Delta\text{Gap}_3 = p_{3\text{F}} - p_{3\text{M}} \tag{4}$$

where ΔGap_1, ΔGap_2 and ΔGap_3 are the gender gaps related to the participation in primary value addition, secondary value addition and the lean season market, respectively. $p_{1\text{F}}$ and $p_{1\text{M}}$ are the predicted probabilities of female and male retailers' engagement in primary value addition, respectively. $p_{2\text{F}}$ and p_{2M} represent the predicted probabilities of female and male retailers' participation in secondary value addition, respectively. p_{3F} and $p_{3\text{M}}$ are the predicted probabilities of female and male retailers' participation in the lean season market, respectively. These predicted probabilities are estimated from Equation (1). We use the independent t-test to validate if the gender gaps are statistically different from zero. The appropriateness of the multivariate probit model is validated using the likelihood ratio test (LR test) to check the null hypothesis that no correlations exist among the error terms, $\rho_{12} = \rho_{13} = \rho_{23} = 0$. The rejection of this hypothesis implies that the application of the multivariate probit model is suitable in our context.

We operationalise the intensity of participation in value addition as quantities of primary and secondary value-added grasshoppers being processed. Quantities of secondary value-added grasshoppers allotted for lean season market sales are used as an indicator of the intensity of participation in the lean season market. Quantities of the value-added grasshopper products being processed and quantity-stored for the lean season market are censored since there are some retailers who sell only raw grasshoppers and do not participate in the lean season market. These decisions are made simultaneously; hence, we apply the multivariate tobit regression model in the analysis. Following the specifications of Lee (1993), the reduced form of multivariate tobit model is given as:

$$Y_{ijk}^{*} = \varpi_{jk} X_{ijk} + \xi_{ijk}, k = 0(\text{male}), 1(\text{female}) \tag{5}$$

$$Y_{ijk} = \text{Maximum}\left(Y_{ijk}^{*}, 0\right) = \begin{cases} Y_{ijk}^{*}, \text{if } Y_{ijk}^{*} > 0 \\ 0, \text{ if } Y_{ijk}^{*} \leq 0 \end{cases}, \quad k = 0(\text{male}), 1(\text{female}) \tag{6}$$

where Y_{ijk}^{*} indicates a set of unobservable dependent variables. Y_{ijk} indicates the observable dependent variable. $j = 1$ (the quantity of raw grasshoppers plucked), 2 (the aggregated quantity of grasshoppers dried or fried) and 3 (quantity of the value-added grasshoppers stored for lean season market in 2020). X_{ijk} are the contextual factors, which are already defined below in Equation 1. ξ_{ijk} are the error terms, which are assumed to be multivariate normally and independently distributed with zero mean, variance $(\sigma_{1k}^2, \sigma_{2k}^2, \sigma_{3k}^2)$ and correlation $(\rho_1^2, \rho_2^2, \rho_3^2, \rho_{12}, \rho_{13}, \rho_{23})$ (Lee, 1993). ρ_{12} represents the correlation between the errors term of primary and secondary value-adding activities. ρ_{13} denotes the correlation between the errors for the primary value addition and the lean season market participation, whereas ρ_{23} indicates the correlation between the error terms of the secondary value addition and the lean season market participation. The

TABLE 1 Summary statistics of female and male retailers

Variables	Description	Female retailers $N = 295$ (59%)		Male retailers $N = 205$ (41%)		Mean difference	*t*-value
		Mean	SD	Mean	SD		
Location dummies							
Kampala Central Division	1 if retailer is selected from Usafi, Nakasero, Kamwokya, and Old Taxi Park markets	0.23	0.42	0.14	0.35	0.09**	2.49
Rubaga Division	1 if retailer is selected from Busega and Nateete markets	0.26	0.44	0.07	0.26	0.19***	5.56
Makindye Division	1 if retailer is selected from Ndeeba, Katwe and Kibuye markets	0.28	0.45	0.20	0.40	0.08**	1.99
Kawempe Division	1 if retailer is selected from Kalerwe market	0.04	0.19	0.09	0.29	−0.05***	−2.58
Mukungwe Division	1 if retailer is selected from Nyendo market	0.18	0.38	0.30	0.46	−0.13***	−3.34
Buwunga Division	1 if retailer is selected from Masaka Central market	0.01	0.12	0.19	0.39	−0.18***	−7.28
Socioeconomic factors							
Age	Age of retail business owner	34.76	10.11	29.48	9.84	5.29***	5.58
Education	Number of years of formal education	8.29	3.42	8.31	3.47	−0.02	−0.08
Labour constraint[a]	1if retailer that perceives high cost of labour negatively affect their grasshopper business growth and 0 otherwise	0.39	0.49	0.32	0.47	1.44	0.06
Monthly income	Income generated from non-grasshopper business per month (100,000Ugx)	4.06	9.36	3.09	3.04	0.97	1.43
Institutional factors							
Membership of association	1 if retailer is a member of association and 0 otherwise	0.64	0.48	0.52	0.50	0.12***	2.70
Credit	1 if retailer used credit to support grasshopper business and 0 otherwise	12.40	13.76	13.73	26.32	−1.33	−0.29
Transactional factors							
Record-keeping	1 if retailer keeps records of grasshopper business activities and 0 otherwise	0.40	0.49	0.39	0.49	−0.02	0.33
Access to market price information	1 if retailer has access to information on market price of grasshopper products and 0 otherwise	0.77	0.42	0.70	0.46	0.07*	1.90
Transport costs	Costs of transporting grasshoppers from purchasing point to selling point per week (100,000Ugx)	0.20	0.24	0.16	0.22	0.04**	2.31

TABLE 1 (Continued)

Variables	Description	Female retailers $N = 295$ (59%)		Male retailers $N = 205$ (41%)		Mean difference	*t*-value
		Mean	SD	Mean	SD		
Communication technology and transport assets							
Radio	1 if retailer owns a radio set and 0 otherwise	0.74	0.44	0.83	0.74	−0.10**	−2.52
TV	1 if retailer owns a TV set and 0 otherwise	0.80	0.40	0.71	0.45	−0.10**	−2.38
Vehicle	1 if retailer owns a vehicle and 0 otherwise	0.02	0.13	0.03	0.17	−0.01	−0.92
Motorbike	1 if retailer owns a motorbike and 0 otherwise	0.03	0.18	0.12	0.33	−0.09***	−3.84
Processing and managerial factors							
Access to information on processing	1 if retailer has access to information on processing of grasshoppers and 0 otherwise	0.17	0.37	0.23	0.42	−0.06*	−1.77
Storage constraint	1 if retailer perceives that their lack of storage facility negatively affects their grasshopper business growth and 0 otherwise	0.30	0.46	0.26	0.44	0.04	0.45
Business skill constraint	1 if retailer perceives that their lack of business skills negatively affects their grasshopper business growth and 0 otherwise	0.40	0.49	0.36	0.48	0.04	1.07
Poor working conditions[b]	1 if retailer perceives that poor working conditions at market negatively affects their grasshopper business growth and 0 otherwise	0.45	0.50	0.41	0.49	0.05	1.09

Note: *, ** and *** represent 10%, 5% and 1% statistical significance, respectively. Ugx represents Ugandan Shillings. 1USD = 3669.22 Ugx as at 20 December 2020.

Source: Authors' computations.

[a]During the peak season, the demand for labour to pluck raw grasshoppers is high and wages increase accordingly. Retailers were asked to indicate the level of severity in which high labour costs negatively affect their grasshopper business growth. We used a 4-point severity scale: not severe, less severe, severe and very severe. We coded severe and very severe as 1 and the rest as 0. This coding also applies to storage constraint, business skill constraint and poor working conditions.

[b]Poor working conditions refer to the working conditions at markets. Most retailers do not have a permanent place to sell their grasshoppers but sell on busy roads and lorry stations, where their safety can be compromised. The environment in most markets is unhygienic, which can lead food safety issues. Retailers were asked if such conditions affect negatively affect their grasshopper business growth.

parameters in Equations (5) are estimated simultaneously using the simulated maximum-likelihood approach (Trivedi & Zimmer, 2005).

3.3 | Grasshopper retailer survey

We used cross-sectional data collected from randomly selected grasshopper retail business owners in Kampala and Masaka districts in central Uganda collected in December 2019 grasshopper major season. A multistage cluster sampling technique was employed in the study. First, Kampala and Masaka districts in central Uganda were purposively chosen because they are well known for the trading of large volumes of grasshoppers. Second, ten major markets (Busega, Katwe, Old Taxi Park, Ndeeba, Kalerwe, Nateete, Kamwokya, Kibuye, Nakasero and Usafi) known for grasshopper trading were selected from Kampala district and two markets (Nyendo and Masaka Central) from Masaka district.

Kampala district has five administrative divisions: Kampala Central, Rubaga, Kawempe, Makindye and Nakawa. Usafi, Nakasero, Kamwokya, and Old Taxi Park markets are located in Kampala Central Division, Busega and Nateete markets are in Rubaga Division, Ndeeba, Katwe and Kibuye markets are in Makindye, and Kalerwe market is in Kawempe Division. Kampala Central Division is a central business hub in Kampala district. Compared with other divisions in Kampala district, Kampala Central Division is characterised by high concentration of many business offices and lorry stations, and has many high-income consumers. This makes Kampala Central a strategic place to establish any kind of business. Katwe market in Makindye Division serves as a whole hub, where most retailers from other market purchase their raw grasshoppers, while Busega market in Rubaga Division is one of the largest retail grasshopper markets in Kampala district. Masaka district is a rural district with nine subcounties or divisions, namely Mukungwe, Katwe-Butego, Kimaanya-Kyabukuz, Kabonera, Nyendo-Ssengyange, Bukakata, Buwunga, Kyanamukaaka and Kyesiiga. Nyendo market is located in Mukungwe subcounty and Masaka Central Market in Buwunga subcounty. In Masaka district, most retailers buy raw grasshoppers from Nyendo market.

The lists of the traders in these markets were not available; hence, a sampling frame of 1250 retailers was generated (see Table A1 in the Appendix A1) from the 12 selected markets with the help of local research assistants. The research assistants visited the selected 12 markets in November 2019 in the beginning of the second grasshopper season in Uganda and recorded the names of retailers selling grasshoppers in the markets. The research assistants also asked the retailers to provide names and contacts of other traders who also sold grasshoppers in the same market. The target population comprised all grasshopper retailers in the 12 selected markets. The composition of the sampling frame based on the selected markets is presented in Table A1 (see the Appendix A1). With the known population size, we applied the formula[5] of Yamane (1967), which yielded a representative sample size of 303. We increased the number of questionnaires administered by 40% due to anticipated low response. In total, we interviewed 500 owners of retail grasshopper business in the selected markets. Once the sample size was determined, we computed the subsamples for districts based on their share in the targeted population. Sixty-nine per cent of retailers in the sample frame (1250) were in Kampala district and 31% in Masaka district. Based on these proportions, we computed 343 retailers for Kampala and 157 retailers for Masaka. We also computed the proportions of each market in the subpopulations and randomly selected the number of traders accordingly from the subsamples. A structured digital survey questionnaire was designed using KoboToolbox to collect relevant information from the grasshopper retailers in Uganda. Six enumerators were recruited and trained for the data collection using the KoboToolbox mobile application.

4 | DESCRIPTIVE RESULTS

4.1 | Characteristics of retailers

The retailers' descriptive statistics disaggregated by gender are shown in Table 1. The survey data show that female traders constitute the majority (59%) of the total sample, with the rest (41%) being male. This result indicates female dominance in the grasshopper retail business in Central Uganda. This result is contradictory to that of Odongo et al. (2018) who reported that 86% of the traders (where the majority are retailers) of grasshoppers in Iganga district of Uganda were men. However, the gender distribution of Odongo et al. (2018) may not reflect the population characteristics as the respondents were purposively selected through snowball method. In our paper, respondents were selected randomly and the gender distribution reflects the population characteristic. Moreover, our result is consistent with that of Donkor et al. (2022) who reported that women dominated at the processing and retail nodes of the cassava value chain in Oyo State, Nigeria. We find that there are statistical differences between the proportions of men and women located in different markets (Table 1). In Kampala District, there are more women in the markets in Kampala Central (Usafi, Nakasero, Kamwokya and Old Taxi Park markets), Rubaga (Busega and Nateete markets) and Makindye

(Ndeeba, Katwe and Kibuye markets) Divisions, while more men are in the Kawempe Division (Kalerwe market). The markets in Mukungwe (Nyendo market) and Buwunga (Masaka central market) divisions of Masaka District have more male retailers than female retailers. In general, the mean age of retailers shows that most of them are young.

There are significant differences between the genders of retailers on a number of characteristics, including membership of groups, the cost of transporting grasshoppers, ownership of communication (radio and television sets) and transport (motorbikes) assets, and access to processing information. Compared with male retailers, more female retailers are members of associations and have more access to information, but few own communication and transport assets. Women's better access to grasshopper processing information could be explained by the fact that women are involved in food preparation (UN Women et al., 2015) and seek information on food preparation with which they are not familiar. Women's lower access to communication and transport could be related to the fact that women are more likely to invest their incomes in household food consumption than in asset acquisition (Quisumbing et al., 2015).

4.2 | Male and female retailers' participation in value addition and lean season market

The results on male and female participation in value addition and the lean season market are presented in Table 2. The participation of female retailers in value addition is higher (87%) than that of male retailers (73%) (Table 2).

For both male and female retailers, participation in primary value addition is higher than in secondary value addition. While more female retailers are involved in primary value addition, there is no gender-specific pattern in the participation of secondary value addition and lean season market, as well as the quantities of grasshoppers processed into primary and secondary products (Table 2). On average, female retailers stored 295.10 kg more dried grasshoppers than male retailers. Table 3 shows summary statistics of price differences between seasons and grasshopper products. We find large price differences between raw grasshoppers and value-added grasshopper products. In particular, secondary value-added products tend to be sold at higher prices than primary value-added product and raw grasshoppers. The result also shows that retailers get higher prices for the sales of secondary value-added products in the lean season than those in the peak season.

5 | ECONOMETRIC RESULTS

The multivariate probit results on the factors influencing female and male participation in value addition and the lean season market in Central Uganda are shown in Table 4. In Table 5, we present results from the multivariate tobit models. The results of the multivariate probit and tobit models for the pooled sample are presented in Tables A2 and A3 in the Appendix A1. The chi-square statistics of the likelihood ratio (LR) test of pooling are statistically significant at the 1% level (Tables 4), implying that disaggregating the data based on gender is more appropriate than pooling the data and incorporating gender as a dummy variable. Also, using the LR test, we tested the assumption of no correlation ($\rho_{12} = \rho_{13} = \rho_{23} = 0$) between the error terms associated with the value addition and lean season market models for the gender groups in the multivariate probit and multivariate tobit models. In both models, the chi-square statistics from the LR test are statistically significant at the 1% level, thereby rejecting the null hypothesis that there is no correlation among the error terms (Tables 4 and 5). This evidence shows that correlation exists between retailers' participation in value addition and the lean season market justifying the appropriateness of the application of multivariate probit and multivariate tobit models. Moreover, Wald's chi-square statistics from the multivariate probit model of gender group are statistically significant at the 1% level, implying that the covariates incorporated in the models jointly correlate with retailers' participation in value addition and the lean season market (Tables 4 and 5).

5.1 | Factors influencing female and male participation in value addition and lean season market

We incorporate the locations (i.e. the administrative divisions of Kampala and Masaka districts) of retailers' markets in the models. We find that all location-specific dummies significantly positively correlate with female and male participation in primary and secondary value addition, except Kawempe and Buwunga Divisions for male participation in primary value addition and female participation in secondary value addition, respectively. For the lean season market participation, only Rubaga and Kawempe Divisions show a significant negative correlation for women and men, respectively (Table 4).

As expected, age correlates positively with female participation in primary value addition but negatively correlates with male participation in secondary value addition. The perceived labour constraint positively correlates with male

TABLE 2 Value addition and lean season market participation among the gender groups

Variables	Description	Female retailers $N = 295$ (59%)		Male retailers $N = 205$ (41%)		Mean difference	t-value
		Mean	SD	Mean	SD		
Participation in value addition							
Overall value addition	1 = plucking or frying or drying	0.87	0.34	0.73	0.45	0.14***	4.01
Primary value addition	1 = plucking of raw grasshoppers	0.74	0.44	0.59	0.49	0.15***	3.65
Secondary value addition	1 = frying or drying of grasshoppers	0.54	0.50	0.50	0.50	0.04	0.99
Frying	1 = frying of grasshoppers	0.52	0.50	0.49	0.50	0.03	0.57
Drying	1 = drying of grasshoppers	0.09	0.28	0.04	0.19	0.05**	2.03
Quantities processed and sold (kg/week)							
Plucking	Plucked grasshoppers	298.68	46.11	294.39	872.52	4.29	0.06
Frying	Fried grasshoppers	53.41	122.21	59.17	163.69	5.76	−0.45
Drying	Dried grasshoppers	4.63	19.23	3.90	40.09	0.73	0.27
Lean season market participation[∞]							
Lean season market	1 = if plans to participate in lean season market in 2020	0.29	0.45	0.30	0.46	−0.01	−0.22
Fried grasshoppers	1 = if retailer stores fried grasshoppers for lean season	0.24	0.43	0.24	0.43	0	0
Dried grasshoppers	1 = if retailer stores dried grasshoppers for lean season	0.02	0.14	0.04	0.15	−0.02	−1.25
Quantity stored for lean season (kg)							
Fried grasshoppers	Quantity of fried grasshopper stored for lean season	57.33	180.55	90.64	175.48	−33.31	−1.05
Dried grasshoppers	Quantity of dried grasshopper stored for lean season	393.84	231.40	98.74	157.87	295.10**	2.64

Note: [∞] The data set was collected in the December peak season, when value-added grasshoppers allotted for lean were not sold. *, ** and *** denote 10%, 5% and 1%, respectively. SD denotes standard deviation. 1USD = 3669 Ugx as at 20 December 2020. Source: Authors' computations.

TABLE 3 Price differences between seasons and grasshopper products

	Lean season[∞]		Peak season			
Prices per kg (Ugx)	**Mean**	**SD**	**Mean**	**SD**	**Mean difference**	**t-value**
Raw grasshoppers			7503	2157		
Plucked grasshoppers			15,001	2973		
Fried grasshoppers	63,876	17,264	39,258	5571	24,618***	21
Dried grasshoppers	54,365	14,194	28,046	5525	26,318***	9
Price differences between grasshopper products in the peak season (Ugx/kg)						
Plucked and raw grasshoppers			7498***	27		
Fried and raw grasshoppers			31,755***	65		
Dried and raw grasshoppers			20,543***	34		
Fried and pluck grasshoppers			24,257***	67		
Dried and pluck grasshoppers			13,046***	21		
Fried and dried grasshoppers			11,211***	11		
Price differences between value-added grasshopper products the in lean season						
Fried and dried grasshoppers			9511**	2		

Note: [∞]The prices for the lean season are price expected by retailers. The data set was collected in the December peak season, when value-added grasshoppers allotted for lean were not sold. *, ** and *** denote 10%, 5% and 1%, respectively. SD denotes standard deviation. 1USD = 3669 Ugx as at 20 December 2020.
Source: Authors' computations.

and female participation in primary and secondary value addition, respectively.

Membership of association is positively correlated with female participation in primary value addition, whereas for men, it is positively associated with secondary value addition and negatively related to the lean season market participation. Use of credit is positively correlated with men' participation in primary value addition but negatively correlates with their participation in the lean season market.

Access to information on market price of grasshopper products is positively associated with female participation in the lean season market. Record-keeping has a significant positive correlation with female participation in primary value addition. Transport costs have a significant positive correlation with female participation in the lean season market and male participation in primary value addition.

The ownership of a radio set significantly negatively correlates with only female participation in primary value addition. However, the ownership of a television positively correlates with female participation in primary value addition and the lean season market, while it positively correlates with male participation in primary value addition and in the lean season market. The ownership of a vehicle shows a significant positive correlation with female participation in primary value addition and the lean season market, as well as with male participation in lean season market (Table 4). Owning a motorbike correlates negatively with male participation in secondary value addition.

Access to information on grasshopper processing significantly positively correlates with only female participation in secondary value addition and the lean season market. The perceived storage constraint is negatively related to female and male participation in the lean season market, as well as female participation in secondary value addition. The perceived business skill constraint shows a significant positive correlation with only female participation in primary value addition. While perceived poor working condition is significantly negatively correlated with female participation in secondary value addition and the lean season market, it is significantly positively related to male participation in secondary value addition (Table 4).

TABLE 4 Multivariate probit estimates of retailers' participation in value-adding activities and lean season market

	Female						Male					
	Primary value addition		Secondary value addition		Lean season market		Primary value addition		Secondary value addition		Lean season market	
Variables	**Coeff**	**SE**	**Coeff**	**SE**	**Coeff**	**SE**	**Coeff**	**SE**	**Coeff**	**SE**	**Coeff**	**SE**
Location dummies (Kampala Central = base category)												
Rubaga	0.96***	0.25	−1.45***	0.27	−0.81***	0.24	1.53***	0.51	−3.14***	0.63	−0.92	0.64
Makindye	0.82***	0.25	−1.26***	0.27	0.03	0.23	0.76***	0.35	−2.30***	0.46	−0.50	0.36
Kawempe	0.99*	0.49	−1.59***	0.49	−0.06	0.53	0.05	0.47	−3.01***	0.59	−1.24**	0.55
Mukungwe	1.16***	0.30	−1.22***	0.29	0.05	0.25	0.62*	0.33	−2.20***	0.43	0.04	0.29
Buwunga	5.42***	0.39	−0.36	0.62	0.53	0.61	1.51***	0.37	−1.31**	0.47	0.21	0.37
Socioeconomic factors												
Age	0.02*	0.01	−0.01	0.01	0.00	0.01	−0.01	0.01	−0.05***	0.01	−0.02	0.01
Education	−0.03	0.03	0.05	0.03	0.04	0.03	0.01	0.03	−0.03	0.03	0.00	0.03
Labour constraint	0.33	0.21	0.71***	0.20	0.38*	0.20	0.75***	0.24	−0.33	0.26	0.05	0.23
Asinh (monthly income)	−0.04	0.03	0.02	0.03	0.04	0.03	−0.04	0.03	−0.01	0.03	−0.05	0.03
Institutional factors												
Credit	0.07	0.21	−0.03	0.20	0.22	0.19	0.46*	0.25	0.02	0.26	−0.46*	0.25
Association	0.45**	0.19	−0.06	0.18	−0.12	0.17	−0.03	0.21	−0.05	0.25	0.28	0.23
Transactional factors												
Market price information	0.27	0.21	0.13	0.21	0.61***	0.19	−0.37	0.23	−0.38	0.23	−0.42*	0.23
Record-keeping	0.65***	0.21	−0.01	0.19	−0.07	0.18	0.07	0.21	−0.04	0.23	−0.18	0.22
Asinh (transport costs)	0.00	0.02	0.03	0.02	0.04**	0.02	0.05**	0.02	0.02	0.03	0.01	0.02
Communication technology and transport assets												
Radio	−0.52**	0.23	0.28	0.21	0.15	0.21	0.03	0.28	0.07	0.28	−0.19	0.27
TV	0.52**	0.24	0.09	0.22	0.53**	0.24	0.57**	0.23	0.34	0.25	0.46*	0.26
Vehicle	4.43***	1.24	−1.20**	0.59	1.72**	0.71	0.33	0.61	0.65	0.60	1.13**	0.56
Motorbike	−0.66	0.45	−0.56	0.51	−0.09	0.46	−0.55	0.33	−0.71*	0.42	−0.38	0.38

TABLE 4 (Continued)

	Female						Male					
	Primary value addition		Secondary value addition		Lean season market		Primary value addition		Secondary value addition		Lean season market	
Variables	**Coeff**	**SE**	**Coeff**	**SE**	**Coeff**	**SE**	**Coeff**	**SE**	**Coeff**	**SE**	**Coeff**	**SE**
Processing and managerial factors												
Information on processing grasshoppers	0.17	0.27	1.12***	0.31	1.02***	0.23	0.07	0.27	0.06	0.29	0.29	0.25
Storage constraint	0.07	0.23	−0.49**	0.22	−0.93***	0.25	−0.20	0.28	−0.15	0.26	−0.65**	0.27
Business skill constraint	0.45*	0.24	0.21	0.22	0.40	0.22	−0.07	0.29	−0.15	0.31	0.44	0.32
Poor working condition	−0.26	0.26	−0.69***	0.24	−0.98***	0.25	0.04	0.29	0.77**	0.33	−0.05	0.33
Constant	−0.92	0.64	0.29	0.59	−2.35***	0.66	−0.46	0.78	3.48***	0.75	0.69	0.74
Diagnostic statistics												
$\rho_{21} = \rho_{31} = \rho_{32} = 0$	68.58***						31.51***					
ρ_{21}	0.36***	0.09					0.58***	0.12				
ρ_{31}	0.33***	0.09					0.48***	0.10				
ρ_{32}	0.87***	0.05					0.37***	0.13				
LR test of pooling: chi-square$^{\infty}$	132.14***											
Wald chi-square	1552.32***						247.06***					
Log likelihood	−379.88						−279.63					
Observation	295						205					

Note: *, ** and *** represent 10%, 5% and 1% statistical significance, respectively. LR denotes likelihood ratio. Coeff indicates coefficients. SE denotes robust standard errors. The standard errors were estimated using the robust estimation approach. Annual income and transport cost were transformed into sine inverse hyperbolic. $^{\infty}$The LR test of pooling was performed with the expression: $\mathrm{LR} = -2\left(\mathrm{LL_P} - \left(\mathrm{LL_M} + \mathrm{LL_F}\right)\right)$; where $\mathrm{LL_P}$ denotes the pseudo-log-likelihood values from the pooled results presented in Tables A2 and A3, $\mathrm{LL_M}$ denotes pseudo-log-likelihood values from the multivariate probit and tobit models related to male retailers, whereas $\mathrm{LL_F}$ denotes the pseudo-log-likelihood values related to the female models. Asinh represents inverse hyperbolic sine transformation. Source: Authors' computations.

TABLE 5 Multivariate tobit estimates of intensity of retailers' participation in value addition and lean season market

	Female						Male					
	Quantity of primary value-added product		Quantity of secondary value-added product		Quantity of value added stored for lean season market		Quantity of primary value-added product		Quantity of secondary value-added product		Quantity of value added stored for lean season market	
Variables	**Coeff**	**SE**	**Coeff**	**SE**	**Coeff**	**SE**	**Coeff**	**SE**	**Coeff**	**SE**	**Coeff**	**SE**
Location dummies (Kampala Central = base category)												
Rubaga	3.83***	0.72	−3.11***	0.81	−3.16***	0.95	7.78***	2.08	−7.05***	2.30	−3.48	2.89
Makindye	3.59***	0.69	−2.04***	0.77	0.18	0.94	4.81***	1.74	−4.93***	1.23	−2.87*	1.55
Kawempe	3.37***	1.15	−3.17	2.13	−3.09	2.91	0.44	2.42	−8.76***	2.07	−5.38**	2.15
Mukungwe	4.21***	0.76	−2.90***	0.85	−0.30	1.10	3.55**	1.69	−4.60***	1.11	−0.60	1.25
Buwunga	7.00***	1.06	1.00	2.00	0.71	1.92	1.17	1.81	−1.41	0.95	0.01	1.49
Socioeconomic factors												
Age	0.03	0.02	−0.04	0.03	−0.01	0.04	−0.04	0.05	−0.16***	0.05	−0.05	0.05
Education	−0.01	0.07	0.11	0.09	0.21	0.11	0.03	0.14	−0.01	0.13	−0.03	0.14
Labour constraint	1.30**	0.51	2.99***	0.67	0.73	0.83	4.11***	0.91	−0.41	0.90	0.14	0.93
Asinh (monthly income)	0.00	0.08	0.14	0.08	0.14	0.11	−0.19	0.11	0.05	0.13	−0.24**	0.11
Institutional factors												
Credit	0.99**	0.48	−0.22	0.67	0.84	0.75	2.42**	1.03	0.23	0.90	−2.22**	1.11
Association	0.86*	0.48	−0.42	0.63	−0.34	0.78	−0.94	0.91	0.57	0.76	1.58*	0.89
Transactional factors												
Market price information	0.18	0.54	−0.28	0.71	1.47	0.90	−1.15	1.05	−2.29***	0.74	−1.84*	0.96
Record-keeping	1.49***	0.46	0.05	0.64	0.07	0.73	−0.71	0.88	−0.06	0.79	−0.69	0.91
Asinh (Transport costs)	0.00	0.05	0.07	0.06	0.17**	0.08	0.15	0.10	0.18**	0.09	0.08	0.10
Communication technology and transport assets												
Radio	−1.53***	0.53	0.78	0.78	0.78	0.92	0.06	1.26	1.76	1.02	−0.12	1.19
TV	0.82	0.59	0.47	0.81	2.36*	1.28	0.69	1.00	0.85	0.95	2.39**	1.09
Vehicle	2.01**	1.02	−2.72	3.36	3.57*	1.86	3.41**	1.68	5.03***	1.95	3.78**	1.86
Motorbike	−0.63	1.40	−2.78	1.70	0.45	2.19	−0.23	1.68	−3.56**	1.67	−2.20	1.68

TABLE 5 (Continued)

	Female						Male					
	Quantity of primary value-added product		Quantity of secondary value-added product		Quantity of value added stored for lean season market		Quantity of primary value-added product		Quantity of secondary value-added product		Quantity of value added stored for lean season market	
Variables	**Coeff**	**SE**	**Coeff**	**SE**	**Coeff**	**SE**	**Coeff**	**SE**	**Coeff**	**SE**	**Coeff**	**SE**
Processing and managerial factors												
Information on processing grasshoppers	0.18	0.66	4.91***	0.82	3.00***	0.86	1.14	1.14	0.54	0.89	1.16	1.04
Storage constraint	−0.27	0.51	−1.25	0.76	−2.58***	0.99	−0.54	1.10	−0.75	0.92	−3.27***	1.07
Business skill constraint	1.29**	0.60	0.00	0.83	2.03**	0.87	0.10	1.17	−1.38	1.08	1.05	1.28
Poor working condition	−0.63	0.65	−2.19***		−3.97***	0.93	−0.83	1.17	2.19**	1.08	0.61	1.28
Constant	−2.02	1.52	0.49	1.91	−9.70***	2.69	−0.69	3.31	5.32**	2.44	2.46	2.91
Diagnostic statistics												
$\rho_{12} = \rho_{13} = \rho_{23} = 0$	55.16***						11.45**					
ρ_{21}	0.11	0.07					0.004	0.10				
ρ_{31}	0.14	0.09					0.33***	0.10				
ρ_{32}	0.57***	0.07					0.14	0.11				
LR test of pooling: chi-square	168.54***											
Wald's chi-square	454.49***						485.44***					
Log likelihood	−1418.67						−903.29					
Observation	295						205					

Note: *, ** and *** represent 10%, 5% and 1% statistical significance, respectively. Coeff indicates coefficients. SE denotes robust standard errors. LR denotes likelihood ratio. The standard errors were estimated using the robust estimation approach. All dependent variables, annual income and transport cost were transformed into sine inverse hyperbolic to reduce skewness of these variables and deal with associated outliers. The choice of this transformation is based on the fact that the dependent variables for the multivariate tobit have many zero values. Hence, sine inverse hyperbolic transformation has been recommended over natural logs (Bellemare & Wichman, 2019). Source: Authors' computations.

TABLE 6 Gender gaps in value addition and lean season market participation

	Female retailers		Male retailers			
Outcome variable	Mean	Standard deviation	Mean	Standard deviation	Mean difference (Gender gaps)	t-value
Primary value addition	0.74	0.21	0.59	0.26	0.15***	7.1
Secondary value addition	0.54	0.28	0.50	0.34	0.04	1.4
Lean season market participation	0.31	0.25	0.29	0.22	0.02	0.8

Note: ** and *** denote 5% and 1%, respectively. Source: Authors' computations.

5.2 | Factors influencing the intensity of female and male participation in value addition and lean season market

We find that all location-specific dummy variables show a significant positive correlation with the intensity of female participation in primary value addition, but for men, Rubaga, Makindye and Mukungwe Divisions show a significant positive correlation. Rubaga, Makindye and Mukungwe Divisions significantly negatively correlate with female participation intensity in secondary value addition, while Makindye Division significantly negatively correlates with male participation intensity in secondary value addition and the lean season market. While only Rubaga is significantly and negatively correlated with the intensity of female participation in the lean season market participation, Makindye Division shows a significant negative correlation with the intensity of male participation in the lean season market (Table 5).

The age of male retailers significantly negatively correlates with the intensity of participation in secondary value addition. We find that the perceived labour constraint is significantly positively correlated with the intensity of female and male participation in primary value addition, but it significantly positively correlates with only female participation intensity in secondary value addition. Monthly income shows a negatively significant correlation with the intensity of male participation in secondary in the lean season market (Table 5).

The use of credit shows a significant positive correlation with the intensity of female and male participation in primary value addition, but it shows a significant negative relationship with the intensity of male participation in the lean season market. Membership of association significantly positively correlates with female and male intensity of participation in primary value addition (Table 5). We also observe a significant negative relationship between access to market price information and male participation intensity in secondary value addition and the lean season market. Record-keeping shows a significant positive relationship with female intensity of participation in primary value addition. Transport costs are significantly positively correlated with the intensity of female participation in the lean season market and male participation in secondary value addition.

Female ownership of a radio set significantly negatively correlates with the intensity of participation in primary value addition. However, ownership of a television set significantly positively correlates with the intensity of female and male participation in the lean season market (Table 5). The ownership of vehicle shows a positive significant correlation with the intensity of female participation in primary value addition and the lean season market, while it is positively correlated with the intensity of male participation in primary and secondary value addition and in the lean season market. However, the ownership of a motorbike significantly negatively correlates with the intensity of male participation in secondary value addition.

Access to information on grasshopper processing has a significant positive relationship with the intensity of female participation in secondary value addition and the lean season market. Perceived storage constraint shows a significant negative correlation with the intensity of female participation in the lean season market, whereas it shows a significant negative relationship with the intensity of male participation in the lean season market. The perceived business skill constraint shows a significant positive relationship with female intensity of participation in primary value addition and the lean season market, while it has a significant positive relationship with the intensity of male participation in secondary value addition (Table 5).

5.3 | Gender gaps in participation in value addition and lean season market

To check robustness of our models, we specified the multivariate probit models by including only those contextual factors that are statistically significant at 10% and predicted the gender gaps to test how sensitive our gender gap estimates to different model specifications. The result is presented in Table S1. The result shows that the gender

gaps from the different model specifications remain unchanged, implying that our gender gap estimates are not sensitive to model respecification. It also shows the robustness of the models applied. Table 6 shows comparisons of the predicted probabilities of participation in value addition and the lean season market. The mean differences represent gender gaps in primary value addition, secondary value addition and the lean season market participation. We find the gender gap in primary addition participation to be 0.15 (Table 6), which is statistically significantly different from zero at the 1% level. This gender gap indicates that on average, women are 15% more likely than men to engage in primary value addition. However, we find no statistically significant difference in the gender gaps for the participation in secondary value addition and the lean season market participation (Table 6). Overall, men and women have higher probability to participate in value addition than in the lean season market (Table 6).

6 | DISCUSSIONS

Our results show that value-added grasshoppers, notably secondary value-added products, are priced higher than non-value-added products. In addition, secondary value-added products fetch higher prices in the lean season compared with selling the same products in the peak season. This suggests that retailers who sell during the lean season are more likely to generate higher returns. This result is consistent with the observation made by Odongo et al. (2018) that grasshopper products are sold at higher prices in the lean season. Despite these high possible economic returns from secondary value addition and lean season markets, retailers' participation remains low. This may be due to the interaction of contextual factors such as location-specific, socioeconomic, institutional, transactional, communication technology and transport assets, and processing and managerial factors. Compared with men, women's participation in value addition is higher in case of primary value addition and equal in terms of secondary value addition and the lean season participation, suggesting the importance of grasshopper value chains as a livelihood option for women. This finding is consistent with the evidence of women's higher participation in the informal sector in Uganda (Dawa & Namatovu, 2015; Langevang et al., 2012; Namatovu et al., 2018). After accounting for the contextual factors, we find that women are more likely to participate in primary value addition than men, confirming our initial hypothesis. The observed gender gap could be explained by social norms related to gender roles. Processing activities such as plucking can be regarded as female activities in Uganda. In addition, women are constrained by domestic activities (UN Women et al., 2015) and have lower opportunity costs, so they may consider primary value addition as an opportunity to generate an extra income. In contrast, women and men are equally likely to participate in secondary value addition and the lean season market. We also find a strong positive correlation between value addition and participation in the lean season market for both women and men, suggesting that value addition provides an opportunity for retailers to participate in the lean season market where they receive higher prices. Women and men can also be incentivised by the higher prices during the lean season to add value to their raw grasshoppers to benefit from such a great opportunity. Our findings on the gender gaps in value addition and lean season market participation at the retail node of the insect value chain add to the existing literature on gender gaps (Gebre et al., 2019, 2020; Marenya et al., 2016) in various agrifood value chains that mainly focus on staple foods at the production level of the chains.

The result shows that women and men earn similar income from non-grasshopper and grasshopper enterprises. On average (median), women and men earn annual incomes of $654.09 and $545.07, respectively from non-grasshopper businesses (Table A4). The median income from grasshopper business in the peak season is $2595.37 for women and $2459.82 for men (Table A4). We find that the median income of women and men from the grasshopper business (during the peak season of 8 weeks) is four times higher than their annual income from other businesses. Income from grasshopper business accounts for 80% of the total annual income (income from grasshopper and other businesses) for women and 82% for men (Table A4). This result indicates that grasshopper business in Uganda is an important source of income for women and men, particularly the youth.

Econometric estimates based on cross-sectional data such as ours may have endogeneity problems; therefore, the results should be interpreted with caution. We find female and male participation and intensity of participation in value addition and lean season market do vary with location-specific variables, socioeconomic, institutional, transactional, communication technology and transport assets, and processing and managerial factors. We focus our discussion on the key policy variables. We identify spatial patterns in male and female participation and the intensity of participation in value addition and lean season market. The findings show that male and female retailers in markets located Kampala Central Division are less likely to participate in primary value-adding activities but more likely to engage in secondary value-adding activities and the lean season market, compared with the other five divisions. A similar pattern is observed in the intensity of participation in value addition and the lean season market. Kampala Central Division is a business hub with

many corporate offices, numerous trading activities and large lorry stations, making it a strategic location for the sale of secondary value-added grasshoppers that can be readily eaten as snacks.

While older women are more likely to participate in primary value addition, older men are less likely to engage in secondary value addition and have lower intensity of participation in secondary value addition. This result could imply that older women, in particular, have limited economic options and resort to primary value addition to earn income. In contrast, older men might perceive secondary value addition as a female activity and be reluctant to engage in such activities. This result is consistent with Donkor et al.(2018) who reported that older farmers were less involved in value addition in the cassava value chain in Nigeria. Women with higher monthly income generated from non-grasshopper business tend to intensify their participation in the lean season market, while men with higher monthly income generated from non-grasshopper business per year are less likely to participate in the lean season market and intensify their participation. This result may reflect a higher opportunity cost of time devoted to the grasshopper value chain, especially for men with higher incomes.

The results show that women and men who use credit to support their grasshopper business are more likely to intensify their participation in primary value addition. With credit, women can invest in primary value addition by hiring people to pluck their grasshoppers for them. This result corroborates with previous studies that found a significant positive correlation between value addition and access to credit among cassava farmers in Nigeria (Donkor et al., 2018) and mango farmers in Kenya (Musyoka et al., 2020). In contrast, men who use credit are less likely to intensify participation in the lean season market. Men are more likely to invest their loans in primary value addition and sell in the peak season because they can generate returns to immediately repay their loan as most loans have a short repayment period. Men would therefore avoid investing such loans in the lean season market where they have to wait for some time to reap the returns and repay the loan.

Women and men who are members of association are more likely to participate in primary value addition. This result is supported by empirical findings from the cassava and potato value chains in Nigeria, where Donkor et al. (2018) and Adeyonu et al. (2017) showed that farmers' membership of association increased their probability of processing their raw cassava tubers and potatoes, respectively. Collective action through associations enables women and men with limited resources to receive support in the form of finance and even assistance with plucking of grasshoppers from female group members. Moreover, women who keep records of their grasshopper business are more likely to engage in primary value addition. This result is consistent with Donkor et al. (2018) who found that record-keeping was positively associated with cassava farmers' decision to participation in value addition in Nigeria. Record-keeping provides female retailers with knowledge to make an informed decision on product upgrading, as they can understand how product upgrading through primary value addition has affected their returns.

Women with access to information on the market prices of grasshopper products are more likely to participate in the lean season market. However, men with access to such information are less likely to engage in secondary value addition and less likely to intensify their participation in lean season market. This may be because men have other economic opportunities besides the grasshopper business compared with women. Based on the market information gathered, they might consider participating in the lean season market as having a higher opportunity cost. Women, on the contrary, have limited livelihood opportunities and are attracted to the lean season market, which is associated with higher prices.

In addition, increasing transport costs tend to increase their likelihood of participating in primary value addition and the intensity of participation. This is contrary to the finding of Ater et al. (2018), showing that high transport costs deterred maize farmers from engaging in value addition in Nigeria. The reason for this unexpected result is related to the distance of retailers' market and the place where they purchase their grasshoppers (see Table S3). For example, in Kampala district, most retailers purchase their grasshoppers from Katwe market in Makindye Division. Kampala Central and Kawempe Divisions, where many retailers engage in value addition, are slightly further away from Katwe market. Therefore, transport costs for retailers in Kampala Central and Kawempe Divisions are higher than in other markets closer to Katwe market.

Women who own a television set are more likely to participate in primary value addition and the lean season market and also intensify their participation in the lean season market. Similarly, men who own a television set have a higher probability to engage in primary value addition and the lean season market and to intensify their participation in these activities. Our result is consistent with evidence by Donkor et al. (2018) who reported that ownership of a TV set increased the proportion of cassava tubers processed by farmers in the cassava value chain in Nigeria. During the peak grasshopper season, some TV stations in Uganda broadcast activities including value addition at grasshopper markets, highlighting the importance of value addition. Retailers with a television set are likely to retrieve relevant information on value addition and the lean season market to make an informed decision.

This is supported by our result that women access to information on processing of grasshopper is positively associated with their participation and intensity of participation in secondary value addition and the lean season market. The sources of information include social media (television and radio), other traders, and personal observations (Table S2).

We also find that women who perceive that their lack of storage containers negatively affects their grasshopper business have a lower probability to engage in secondary value-adding activities and the lean season market and intensify their participation in these activities. This result is consistent with Musyoka et al. (2020) that lack of storage facilities discouraged mango farmers from engaging in value addition in Kenya. Storage containers are needed to store value-added grasshoppers for the lean season market. Retailers with the perception that their lack of storage containers affects their grasshopper business are already aware of its negative implication. However, these female retailers may not have the finance to purchase storage containers to enable them store value-added grasshoppers for lean season. They may therefore prefer to sell the raw grasshoppers instead of processing them. Women who perceive that the poor working conditions at markets negatively affect their grasshopper business are less likely to participate in primary and secondary value-adding activities, whereas men with the same perception are more likely to participate in secondary value addition. Grasshopper retailers, particularly women, do not have a permanent premise to run their grasshopper business and therefore mostly sell at busy roads and lorry stations (Odongo et al., 2018; Okia et al., 2017). Such places are unsuitable for selling since the retailers' safety may be compromised. These challenges may dissuade retailers from investing in secondary value-adding activity and participating in the lean season market. However, despite perceived poor working conditions, they are more likely to participate in secondary value-adding activities. Male retailers may have kiosks where they can sell value-added grasshoppers during the lean season. These results highlight the need to support women and men with storage containers to enable them to store value-added grasshoppers for the lean season market, where they can receive higher prices.

7 | CONCLUSIONS AND POLICY IMPLICATIONS

We conclude that while there is gender gap in the participation of primary value addition, there are no gender gaps in the participation of secondary and lean season market at the retail node of the grasshopper value chain. The study findings of higher prices for value-added grasshopper products and incomes from grasshopper business constitute the highest proportion of the total income for women and men. This result shows that developing the grasshopper value chain, especially at the retail node, can improve food security and livelihoods of women and men. This underlines the urgent need to prioritise grasshopper value chain development, especially the value addition and lean season market aspects, in Uganda's Vision 2040 to 'transform Ugandan society from a peasant to modern and prosperous country within 30 years' (GoU, 2007). The study also concludes that different contextual factors influence women's and men's participation in value addition and lean season market; hence, it is important to develop the insect value chain in a gender-sensitive way to address the needs of women and men.

We recommend intensifying socioeconomic research and education on edible insect value chains to gain more insights on how to develop the chain to inclusively benefit young women and men. The creation of awareness through education on benefits of value addition and lean season market participation should be intensified among men and women, particularly in urban centres where probability to participate in value addition is lower. Provision of support in the form of storage containers to women and men will enable them to store value-added grasshoppers for lean season markets, which are associated with higher prices. The study findings show that despite perceived poor working conditions, women and men tend to participate in value addition. Hence, creating enabling working environment through construction of permanent market facility would in the long run motivate women and men to participate in value addition. Further, supporting women with affordable loans with flexible terms of payment will enable them to overcome financial constraints associated with participation in value addition. The study findings also indicate the need to train women on business management practices such as proper record-keeping to improve their managerial skills. Improved managerial skills will trigger higher participation and intensity of participation in value addition.

We recommend further research in understanding the grasshopper value chain, especially at the retail level. More importantly, increased participation in grasshopper markets depends on consumer acceptance and utilisation of value-added grasshopper products. Therefore, future research needs to analyse consumer preferences for different value-added grasshopper products to generate adequate knowledge to inform retailers and other entrepreneurs and investors on which value-added products are most preferred by consumers. This will trigger further development of grasshopper products to make them more available in the lean season. Another area for further research is to

analyse how intrahousehold resource allocation can affect women's and men's participation in the grasshopper value chain, as this aspect was not considered in our study.

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CONFLICT OF INTEREST

The authors have stated explicitly that there are no conflicts of interest in connection with.

DATA AVAILABILITY STATEMENT

The data related to this paper are available upon request.

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ENDNOTES

[1] https://www.sustainablegoals.org.uk/gender-equality-means-end/

[2] Retailers reported that grasshoppers use their legs to scratch them when plucking and also emit chemicals that cause skin burns and rashes. Hence, they seek medical support from hospital.

[3] See Okia et al. (2017) for the full description of how the harvesting of grasshoppers is done.

[4] Further details of the market locations where retailers were selected are presented later in Section 3.3.

[5] $n = N / (1 + N(e)^2)$. n = sample size, N = population, e = margin of error (0.05).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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APPENDIX A

TABLE A1 Sample frame and selection of respondents

Markets	Target population	Selected retailers	Proportion of selected from target population
Kampala District	857	343	69
Busega	180	72	14
Katwe	178	71	14
Old Taxi Park	125	50	10
Ndeeba	80	32	6
Kalerwe	75	30	6
Nateete	52	21	4
Kamwokya	50	20	4
Kibuye	50	20	4
Nakasero	47	19	4
Usafi	20	8	2
Masaka Districts	393	157	31
Nyendo	285	114	23
Masaka central	108	43	9
Total	1250	500	100

Authors' construction (2020).

TABLE A2 Multivariate probit estimates of retailers' participation in value addition and lean season market

	Primary value addition		Secondary value addition		Lean season market	
Variables	**Coefficient**	**SE**	**Coefficient**	**SE**	**Coefficient**	**SE**
Location dummies (Kampala Central = base category)						
Rubaga	1.03***	0.23	−1.56***	0.23	−0.78***	0.23
Makindye	0.83***	0.20	−1.34***	0.21	−0.15	0.19
Kawempe	0.35	0.30	−1.92***	0.35	−0.81**	0.39
Mukungwe	0.93***	0.20	−1.35***	0.21	0.02	0.20
Buwunga	1.73***	0.28	−0.39	0.30	0.29	0.27
Socioeconomic factors						
Females	0.51***	0.15	0.42***	0.15	0.18	0.16
Age	0.01	0.01	−0.02***	0.01	−0.01	0.01
Education	−0.01	0.02	0.02	0.02	0.04*	0.02
Labour constraint	0.52***	0.16	0.30**	0.15	0.17	0.15
Asinh (monthly income)	−0.05**	0.02	0.00	0.02	−0.01	0.02
Institutional factors						
Credit	0.15	0.16	0.06	0.15	−0.03	0.16
Association	0.23*	0.14	0.00	0.14	0.12	0.14
Transactional factors						
Market price information	−0.06	0.16	−0.13	0.16	−0.01	0.16
Record-keeping	0.39***	0.14	0.05	0.14	−0.10	0.14
Asinh (transport costs)	0.02	0.01	0.03**	0.01	0.03**	0.01
Communication technology and transport assets						
Radio	−0.26	0.17	0.23	0.17	0.05	0.18
TV	0.40***	0.15	0.18	0.16	0.45**	0.18
Vehicle	0.33	0.47	−0.48	0.38	1.13***	0.46
Motorbike	−0.57**	0.28	−0.57**	0.30	−0.33	0.31
Processing and managerial factors						
Information on processing grasshoppers	0.10	0.19	0.63***	0.20	0.51***	0.18
Storage constraint	−0.12	0.17	−0.35**	0.16	−0.78***	0.19
Business skill constraint	0.22	0.18	0.15	0.17	0.51***	0.18
Poor working condition	−0.10	0.19	−0.17	0.18	−0.45**	0.19
Constant	−0.75*	0.44	0.99**	0.46	−1.05**	0.50
Diagnostic statistics						
$\rho_{21} = \rho_{31} = \rho_{32} = 0$	81.80***					
ρ_{21}	0.38***	0.07				
ρ_{31}	0.32***	0.09				
ρ_{32}	0.58***	0.07				
Wald chi-square	296.54***					
Log likelihood	−729.34					
Observation	500					

Note: *, ** and *** represent 10%, 5% and 1% statistical significance, respectively. LR denotes likelihood ratio. SE denotes robust standard errors. The standard errors were estimated using the robust estimation approach. Asinh represents inverse hyperbolic sine transformation. Source: Authors' computations.

TABLE A3 Multivariate tobit estimates of intensity of retailers' participation in value adding activities and lean season market

	Quantity of primary value-added product		Quantity of secondary value-added product		Quantity of value-added product stored for lean season market	
Variable	**Coefficient**	**Standard error**	**Coefficient**	**Standard error**	**Coefficient**	**Standard error**
Location dummies (Kampala Central = base category)						
Rubaga	4.54***	0.74	−3.58***	0.79	−3.53***	1.00
Makindye	4.04***	0.68	−2.51***	0.69	−0.58	0.81
Kawempe	1.76	1.12	−5.40***	1.51	−4.88***	1.96
Mukungwe	4.04***	0.68	−2.51***	0.69	−0.58	0.81
Buwunga	4.05***	0.70	−3.04***	0.65	−0.26	0.86
Socioeconomic factors						
Females	1.40***	0.50	2.15***	0.53	0.53	0.68
Age	0.01	0.02	−0.09***	0.03	−0.03	0.03
Education	0.04	0.06	0.04	0.07	0.13	0.08
Labour constraint	2.40***	0.46	1.58***	0.54	0.60	0.66
Asinh (monthly income)	−0.11*	0.06	0.07	0.07	−0.02	0.08
Institutional factors						
Credit	1.17**	0.48	0.07	0.55	−0.37	0.64
Association	0.39	0.45	0.06	0.49	0.49	0.62
Transactional factors						
Market price information	−0.28	0.50	−1.29**	0.52	−0.39	0.70
Record-keeping	0.81*	0.43	0.19	0.48	−0.36	0.59
Asinh (transport costs)	0.04	0.04	0.12**	0.05	0.15**	0.07
Communication technology and transport assets						
Radio	−0.99*	0.53	1.11*	0.61	0.61	0.79
TV	0.53	0.51	0.65	0.59	2.04**	0.81
Vehicle	2.01**	0.80	0.29	1.70	2.32*	1.23
Motorbike	−0.59	0.99	−2.74**	1.28	−1.32	1.38
Processing and managerial factors						
Information on processing grasshoppers	0.39	0.58	3.15***	0.57	1.99***	0.67
Storage constraint	−0.53	0.49	−1.04*	0.59	−2.90***	0.75
Business skill constraint	0.86	0.56	0.03	0.67	1.90***	0.74
Poor working conditions	−0.65	0.60	−0.72	0.69	−2.21***	0.78
Constant	−2.08	1.34	1.47	1.54	−4.17**	2.06
$\rho_{21} = \rho_{31} = \rho_{32} = 0$	52.57***					
ρ_{21}	0.07	0.06				
ρ_{31}	0.22***	0.06				
ρ_{32}	0.40***	0.06				
Wald chi-square	556.37***					
Log likelihood	−2402.23					
Observation	500					

Note: *, ** and *** represent 10%, 5% and 1% statistical significance, respectively. LR denotes likelihood ratio. The standard errors were estimated using the robust estimation approach to correct heteroscedasticity. Source: Authors' computations.

TABLE A4 Comparison of incomes from grasshopper business (peak season) and non-grasshopper business

Variable	Currency	Women ($N = 210$)			Men ($N = 106$)		
		Median	Mean	SD	Median	Mean	SD
Income from grasshopper business/season (8 weeks or 2 months)	Ugx	9,523,999	11,600,000	9,403,138	90,525,741	11,800,000	10,200,000
	USD	2595.37	3161.43	2562.71	2459.82	3215.94	2779.88
Total annual income from non-grasshopper businesses	Ugx	2,400,000	4,062,049	12,500,000	2,000,000	2,572,825	2,602,542
	USD	654.09	1107.06	3406.72	545.07	701.19	709.29
Total annual income (grasshopper and non-grasshopper)	Ugx	12,600,000	15,600,000	15,800,000	12,100,000	14,400,000	10,400,000
	USD	3433.97	4251.58	4306.09	3297.70	3924.54	2834.39
Annual income shares of grasshoppers (%)		80	71	27	82	74	24
Daily income from grasshopper business (USD)		7.11	8.66		6.74	8.81	
Daily income from non-grasshopper business (USD)		1.79	3.03		1.49	1.92	
Daily total income (USD)		9.56	11.87		9.03	10.75	

Income from grasshopper business represents the profit generated grasshopper business in the peak season. The profit was calculated as difference between the total revenue generated from the sales of grasshopper products and the associated total cost. The total revenue was computed by multiplying the quantities (kg) of grasshopper products (raw grasshoppers, plucked, fried and dried) sold by their respective prices per kg. The total costs were sum of the cost items such as transport costs (costs of transporting products from purchasing points to sale points), product costs, and value addition costs (plucking, drying, frying). On average, retailers sold grasshoppers for 8 weeks (2 months) in the peak season. 1USD = 3669.22 Ugx as at 20 December 2020.USD = US dollars, Ugx = Ugandan shillings and SD = standard errors. Some outliers have been excluded from the computations. These include observations with negative profits and observations with profits greater than 5 million. Nineteen women had loss between 1800 Ugx and 7million Ugx, and 61 had profits between 5 million Ugx and 14 million. Five men had loss between 1800 and 167,000 Ugx, and 40 had profits between 5 million Ugx and 58 million. Source: Authors' computations.