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Exploring gender differences in trait preferences among groundnut value chain actors in northern Ghana

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Abstract

Assessing gender differences in trait preferences of groundnut value chain actors can influence the effectiveness of crop breeding programs, the adoption of developed technologies, and policy interventions. However, there is limited evidence to support decisions that meet end users' demands, given that most studies do not disaggregate trait preferences by sex and age. We use a stated preference method to characterize the preferences and willingness to pay (WTP) for various attributes of improved groundnut varieties by male and female youth and older adults in the different segments of the groundnut value chain. The results indicate heterogeneity in preference and WTP for production, market, and nutrition attributes of groundnut across supply chain actors. The results showed that gender is not a unifying factor in respondents' WTP, revealing dissimilarities among youth and older adults of the same sex group. Our findings suggest that groundnut breeding programs must prioritize production, market, and nutrition attributes based on gender needs to speed up the process of adoption, commercialization, and utilization of groundnut.

Keywords Discrete choice experiment, Random parameter logit, Groundnut supply chain actors, Willingness to pay, Ghana

Introduction

Groundnut or peanut (*Arachis hypogaea*) is an important global food and oilseed crop. Given its ability to improve soil fertility through atmospheric nitrogen fixation, the crop is often intercropped or rotated with cereals. At the Global level, groundnut is cultivated on 27.66 million ha, with an annual production of 43.98 million tons [1, 2]. The leading producers of groundnut in the world are India (21%), China (16%), Nigeria (10%), and Sudan (8%) [1, 2]. In some developing countries, groundnut contributes about 25–60% of the small-scale farmer's income. It is estimated that, at the farm level, at least 23% of households in developing countries are employed in groundnut production [3].

In Ghana, a total of 6,764.73 tons of groundnut were produced between 1999 and 2016 [4]. Within this period,

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the highest annual groundnut production of 530.9 tons was recorded in 2010. In the same year, Ghana ranked fifth in Africa and tenth in the world in terms of quantity of unshelled groundnut produced [5]. However, in 2019 Ghana recorded total production area and production volume of 40,3447 ha and 535,685 tonnes, respectively [5]. Undoubtedly, groundnut is one of the most profitable and predominant legume crops cultivated by smallholder farmers in northern Ghana. Northern Ghana contributes close to 80% of the national output of groundnut [4]. Groundnut production in the region is characterized by low, erratic and poorly distributed rainfall, high incidence of pests and diseases, and relatively low adoption of improved varieties. Several factors such as lack of credit, access to improved varieties, lack of consistent information about the attributes of the varieties contribute to the low adoption [6]. Therefore, any insights on farmer- and market-preferred traits based on gender disaggregation, along with an identification and prioritization of production constraints, can enhance the rate of adoption of improved varieties among farmers and other value chain actors [1].

In northern Ghana, 90% of farming families cultivate peanuts, wherein women play major roles in its production, marketing and processing [7]. The constraints women face in peanut cultivation are low productivity, low remuneration, poor agricultural marketing systems, and limited access to financial services [8]. Beyond low productivity is the underpinning of patriarchal systems and other socio-cultural and institutional factors that pose huge challenges to women's access to production resources [9]. Majali [10], finds that tradition and cultural norms are the major challenges that limit the access of women to agricultural input, thereby leading to the invisibility of women in agricultural development. Strengthening the agri-food system requires a greater focus on identifying and addressing the different needs, dissimilarities, constraints, and opportunities of rural women (being mindful of intersectional elements, such as age, education, wealth status, religion, geography, etc.) in program designs and policies to ensure outcomes, such as empowerment, enhanced productivity, equity and higher rates of economic growth for all. Agricultural policies and programming in Ghana presently do not focus on peanuts, which do not even make the list of top eight crops [11] despite its potential of contributing to the economies of the improvised northern regions by reducing poverty amongst women and youth through reinforcing food and nutritional security. Therefore, there is the need, among others, for the groundnut breeding programme in Ghana to collaborate with partners to develop varieties that perform well under farmer conditions with desirable farmer traits around yield, postharvest, nutritional, and processing qualities. The ability of breeding programmes to incorporate farmer-preferred traits will improve the probability of adoption and consequent household welfare indicators, such as food security [12].

Farmers consider a couple of factors before deciding to adopt a variety. They may even choose not to adopt a variety, even though it may be high yielding. Farmers tend to grow varieties that respond well to their production constraints, meet their consumption preferences and are marketable [13]. Male and female farmers can choose to either grow the same or different crop varieties under the same or varied farm and farmer conditions. Male and female farmers tend to have different trait preferences when they face different constraints, have different production and consumption roles and responsibilities as well as different production goals. Female farmers tend to prefer traits that guarantee food security, such as early maturing, low input requirement, easy to process and easy to store [12, 14]. Male farmers often focus on production and marketing-related variety characteristics [14]. Regardless of gender, food insecure and poor farm families tend to place more premium on food quality traits when compared to food secure and wealthy households [15].

Knowledge of the trait characteristics preferred by male and female actors in the value chain can enable the development of new varieties with a greater potential for adoption and commercialization. Even though breeding programs are increasingly recognizing the need to consider gender differences in trait preferences and incorporate them in their research activities [12], there is still a need to identify gender dimensions of trait preferences and their implications for further improving breeding programs.

Preferences for groundnut traits have been well-documented in Africa. Using a participatory rural appraisal approach to assess farmers' preferred groundnut traits, Banla et al. [16] found that pod yield and size were the preferred traits. Daudi et al. [2] identified medium-to-large grain size and tan and red seed color as the main farmer and market-preferred groundnut traits. In Nigeria and using a participatory varietal selection, Motagi et al. [17] found that resistance to pests and diseases, early maturity, pod yield, oil yield, haulm yield, pod and kernel features, and drought tolerance are the important groundnut traits to the farmers. A study by Florkowski and Kolavalli [18] reported that buyers of groundnut prefer color, kernel size, and oil content. Ndjeunga et al. [19] identified leaves color, maturity, number of pods, pod size, constriction, pod yield, pod filling and taste as the most important attributes of groundnut in Mali. In Niger, farmers ranked color of the leaves, the number of pods per plant, pod filling, pod beak, and pod yield as the most

important groundnut attributes [19]. However, there is limited evidence on gender preference elicitation across the groundnut supply chain actors. A comprehensive assessment of gender preferences of groundnut traits and its incorporation in crop breeding programs will enhance uptake, commercialization, and utilization.

Changes in climate, agro-ecology and socioeconomic conditions results in transformations in farming and food systems. The use of crop varieties with varied traits is one option that farmers employ to adapt to these changing conditions [14]. The main objective of this study is to define the traits of groundnut cultivars preferred by male and female actors of the groundnut value chain that would inform the development of market-driven product profile. We quantify the various attributes of interest to the groundnut value chain actors and estimate their willingness to pay (WTP) for improved and quality groundnut. Value chains are seen to subsume inclusiveness as a means of attaining a far-reaching social transformation [20]. The literature on the development of value chains has underscored the importance of assessing the contribution and ability of women and recently youth to benefit from their involvement in the different value chain nodes. However, literature on the intersectional analyses of gender in groundnut production in general is very limited or nonexistent to the best of our knowledge. Our study bridges this knowledge gap and contributes to the understanding of varietal choice and preferences of actors occupying the diverse segments of the groundnut value chain based on intersectionality. Intersectionality do not only attend to the identities of individuals, but the social structures and institutions through which individuals, groups express their needs, pursues their interests and the experience of inequalities are reproduced across different social categories and strata. Therefore, this study will significantly contribute to the literature on value chain development and crop participatory breeding programs.

The rest of the paper is structured as follows: "Methodology" section describes the methodology, while "Conceptual and econometric model" section presents the conceptual and empirical model. "Results of the study" section presents and discusses the empirical results and "Conclusion and policy implications" section provides the concluding remarks.

Methodology

2.1 Research setting

The research satisfied all the ethical concerns leading to a waiver for the requirement for approval. This study employed survey data of groundnut value chain actors in Guinea and Sudan Savannah agro-ecological zone of Ghana consisting of Northern, Savannah, North East, Upper East, and Upper West regions. Agriculture is predominantly the main source of income for most of the inhabitants [21, 22]. The major crops grown are maize, sorghum, millet, rice, soybean, groundnut, and cowpea. Groundnut is mostly cultivated by smallholder farmers under rain-fed conditions. Figure 1 presents the map of the study area showing the location (districts) of the sampled groundnut value chain actors. Northern Ghana is characterized by a high incidence of poverty which has been consistently higher than the national average since 2005/2006 [23]. The Upper West Region recorded the highest poverty rate among all the 10 regions in Ghana followed by Northern, and Upper East regions [23].

The groundnut value chain actors consist of seed and grain producers, traders (wholesalers and retailers), processors (small scale and large-scale), and consumers. The data captured information on groundnut production, commercialization, and consumption for the 2019/2020 cropping season in 10 districts within northern Ghana. Seed producers are broadly categorized as individual and community certified seed producers. The sampled traders comprise of wholesalers/aggregators and retailers. Wholesalers are individuals or organizations who buy large quantities of groundnut from different sources to sell to processing firms or regional markets. Retailers are traders (largely dominated by women) who engage in smaller volumes of groundnut trade and sell directly to individual consumers. Processors are individuals or private firms that buy groundnut from traders or directly from farmers and transform it into a final product to sell. Consumers are individuals who buy groundnut and or groundnut products from farmers, traders, and processors for consumption.

Sampling technique

Different sampling methods were used in the selection of the groundnut value chain actors. The sampling[1] procedure followed a multi-stage sampling technique to select the respondents across the groundnut value chain in the Guinea and Sudan Savannah agro-ecological zones. Table 1 shows the distribution of sampled seed growers, producers, traders, processors, and consumers across the regions. The study relied on purposive and snowball sampling techniques to sample 178 seed growers due

[1] The sampling frame consists of all groundnut value chain actors in northern Ghana consisting of Northern, Savannah, North East, Upper East, and Upper West regions. The zone is made up of 52 districts with 26 in Northern, 15 in Upper East and 11 in Upper West regions. For more details on the major groundnut producing districts, refer to the Ministry of Food and Agriculture (MoFA), (2017). Agriculture in Ghana Facts and Figures, 2016. Statistics, Research and Information Directorate (SRID) of MoFA, Accra. https://new-ndpc-static1.s3.amazonaws.com/CACHES/PUBLICATIONS/2016/04/16/AGRICULTURE-IN-GHANA-Facts+and+Figures-2010.pdf.

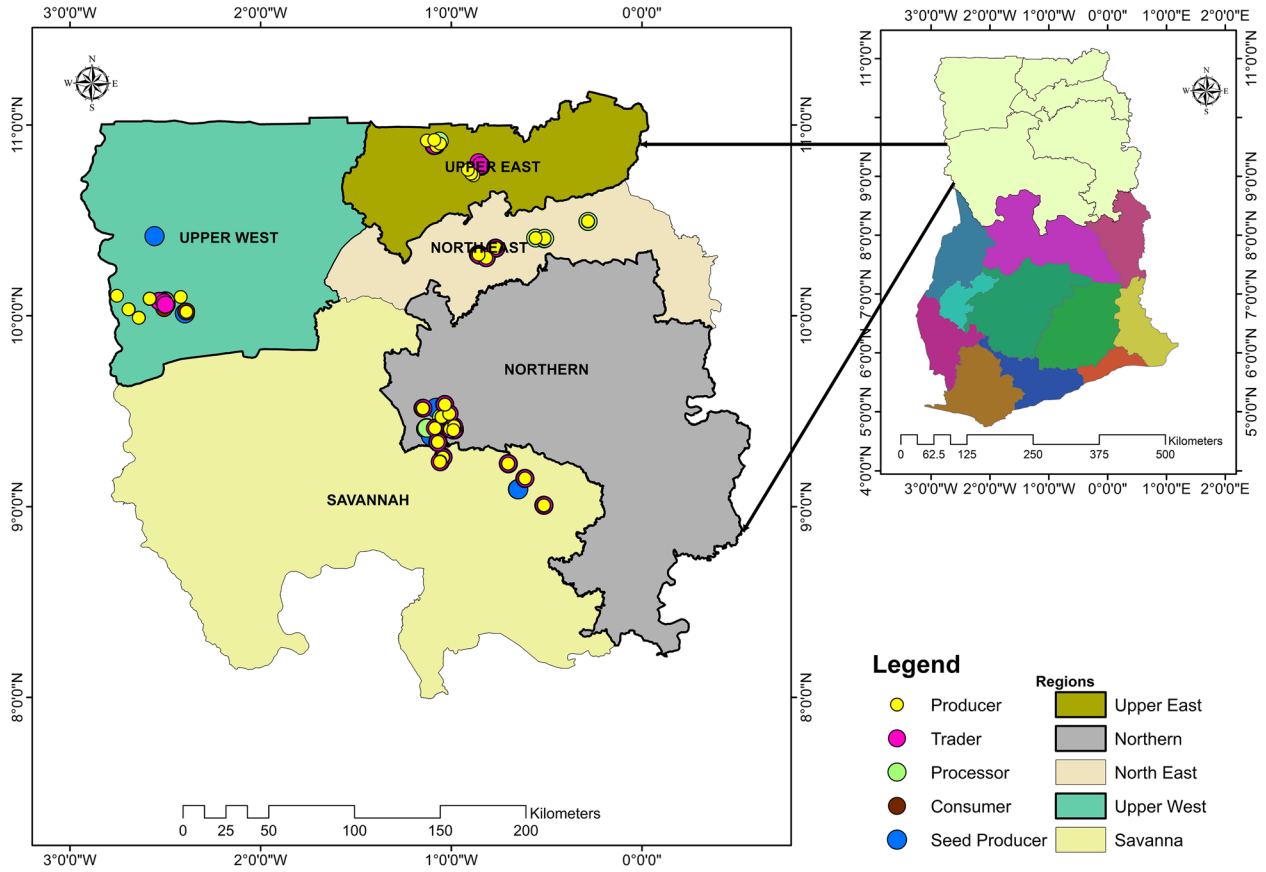


Fig. 1 Administrative map of northern Ghana

Table 1 Distribution of sampled traders by region

Region	Seed Producers	Producers	Traders	Processors	Consumers
Northern	120	108	20	18	20
Savannah	24	108	20	18	20
North East		108	20	18	20
Upper East		109	20	18	20
Upper West	34	107	20	18	20
Total	178	540	100	90	100

to limited number of groundnut seed producers in the Guinea and Savannah agroecological zones of Ghana. The sampling of groundnut producers combined both purposive and simple random sampling techniques to select 540 farmers. In the first stage, two districts were purposively selected from each of the five regions in northern Ghana based on the quantity of groundnut produced and the active presence of groundnut value chain actors. In the second stage, six communities were purposively selected from each of the selected Districts based on accessibility and gender distribution. Within the selected communities, 18 groundnut producers were randomly selected from a list of groundnut producers. In all, 540 groundnut producers were selected from 36 communities in the 10 districts. Sampling of the traders (wholesalers or aggregators, and retailers) followed a three-stage process. In the first stage, the study employs purposive sampling to select the same districts and communities as in the case of the farmers. The second stage involves stratified sampling approach, where the traders were stratified into three strata within the District where each stratum accommodate a specific trader type. In the third stage, a

Table 2 Groundnut attributes preferred by groundnut value chain actors

No	Producers	Traders	Processors	Consumers
1	Yield	Oil content	Oil content	Color
2	Maturity	Size	Size	Nutrition
3	Disease resistance	Debris	Color	Texture
4	Ease of harvest	Grain storability	Grain storability	Flavor
5	Price	Price	Price	Price

simple random sampling technique was employed to sample 100 traders within the three strata. A total of 90 processors were successfully sampled from 10 Districts and 29 communities following the same sampling procedure for the traders. Finally, the study employed purposive and random sampling techniques to sample 100 consumers across the sample districts.

Data for the study

The study relied on primary data captured with both structured and unstructured questionnaire. Trained enumerators were deployed to the field to interview the sampled groundnut value chain actors. A reconnaissance survey was conducted, and the feedback generated from the analysis was used to update the questionnaire and the method of interview. The interviews were conducted in the local language to ensure high response rate. Data captured by the survey questionnaire include actor demographic information (gender, age, education, household size, economic active members, religion, and tribe), access to social amenities, landholding and management practices, knowledge of improved groundnut varieties, agronomic and socio-economic constraints in production and utilization of groundnut, varietal preferences, household assets, income and expenditures (food, health, education, housing, consumer goods and durables), and disruptions in the groundnut value chain due to COVID-19 pandemic.

The individual interviews were completed with a choice survey which captured the actors' varietal preferences and key groundnut traits. Following Lusk and Shogren [24], choice experiment allows the researcher to estimate the demand for new products or technologies if the transaction of the goods or technology is non-existent. In a choice experiment, researchers stimulate market and production settings by presenting individuals with a hypothetical scenario from which respondents make multiple decisions with several alternatives in a choice set. Each scenario includes two or three alternatives defined by several attributes that take on different levels. Respondents choose their preferred alternative from the alternatives provided. The identified attributes were obtained from the survey result, consultation with the groundnut breeders, trade experts, and focus group discussion. Table 2 shows the selected attributes of groundnut cultivar per value chain segment considered for the choice experiment. The outcome of the literature search, FGD, and experts' consultations revealed that yield, maturity, disease resistance, ease of harvesting, and price are the most important attributes of groundnut among farmers. Traders have higher preferences for oil content, size, clean grains, the longevity of storage and price, while processors prefer oil, size, color, grain storability, and price. But consumers have high preferences for color, nutrition (protein), texture, flavor, and price.

Design of choice sets

Table 3a–d shows a summary of the attributes and the levels of the attributes used in the choice experiment. The OPTEX procedure in SAS was used to establish the optimal experimental design using the attributes and levels. The study used a D-optimal design with a modified Federov search algorithm with a full-factorial design constituting the candidate set. Fewer attributes in a choice set allow farmers to make an actual choice by eliminating the tendency to ignore one or more of the attributes in the experiment, referred to as attribute non-attendance (ANA) [25]. The producer choice sets were structured into nine blocks, while the traders, processors, and consumers were structured into 10, six, and 10 blocks, respectively. Each participant of the choice experiment was randomly assigned to a block and provided with three independent choice sets.

Figures 2, 3, 4, 5 show an example of a choice set scenarios presented to the sampled groundnut value actors with illustrations to accommodate different levels of literacy among the participants and to support making an informed choice. The choice set scenarios were administered to the respondents privately to allow for independent decision-making.

Conceptual and econometric model

Conceptual framework

The Lancastrian consumer theory serves as the underlying theoretical framework in estimating the marginal value of various attributes of good or new technology [26]. The study assumes that groundnut value chain actors make decision on the choice of improved groundnut varieties to maximize their subjective expectation of utility subject to their budget and socioeconomic constraints. We assume that the subjective expected utility of a value chain actor i choosing a groundnut trait j (EU_{ij}) is specified as

Table 3 a Farmer attributes and levels used in the choice experiment. b Traders' attributes and levels used in the choice experiment. c Processors' attributes and levels used in the choice experiment. d Consumers' attributes and levels used in the choice experiment

Attribute	Levels			Preference/Description
	1	2	3	
a				
Yield	Low	High		Average production (in 47 kg) harvested per hectare for cultivating planting a specific groundnut variety. Most farmers prefer high yield to low yield
Maturity	Early	Medium	Late	The period between planting and harvesting. Early-maturing variety is mostly preferred
Disease resistance	Resistance	Tolerant	Susceptible	The extent to which the groundnut plant can withstand, tolerate or resist all forms of diseases. Disease resistance is preferred over tolerance and susceptibility
Ease of harvest	Easy	Difficult	Very difficult	Uprooting of the groundnut pods from the soil is tedious especially when the soil moisture is low. The level of effort in harvesting is directly proportional to the cost. Most farmers will prefer a groundnut variety that is easy to harvest
Price	GH₵90	GH₵130	GH₵170	The amount of money the farmer earns by selling 47 kg of harvested unshelled groundnut. The average market price for unshelled groundnut is GH₵130 per 47 kg
b				
Oil content	Very low	Low	High	The amount of oil per grain. Most traders prefer high to very low and low
Size	Small	Big		The size of the grain is directly related to the quantity required to fill a bag. Traders have mixed preferences for size, though the big size is mostly preferred. Larger grains yield higher levels of meal and oil per ton of raw material
Debris	Clean	Not clean		Stone-free groundnut is preferred. Groundnut with stones affects the crushing and drying process and may lead to damaged equipment and the discoloration of grains
Grain storability	Short	Medium	Long-term	The storability measures the period for which the grains can be stored. Most of the traders prefer a groundnut variety with long duration of storage to take advantage of high price beyond harvest
Price	GH₵90	GH₵130	GH₵170	The amount of money the trader earns by selling 47 kg of harvested unshelled groundnut. The average market price for unshelled groundnut is GH₵130 per 47 kg
c				
Oil content	Very low	Low	High	The amount of oil per grain. Most traders prefer high to very low and low
Size	Small	Big		The size of the grain is directly related to the quantity required to fill a bag. Traders have mixed preferences for size, though the big size is mostly preferred. Larger grains yield higher levels of meal and oil per ton of raw material
Color	Tan	Red	Brown	Tan is a preferred color among most processors. Most of the processors perceive the tan color as healthy grain and attracts buyers
Grain storability	Short	Medium	Long-term	The storability measures the period for which the grains can be stored. Most of the processors prefer a groundnut variety with long duration of storage to ensure that the grain value is not discounted
Price	GH₵90	GH₵130	GH₵170	The amount of money the processor earns by selling 47 kg of harvested unshelled groundnut. The average market price for unshelled groundnut is GH₵130 per 47 kg
d				
Color	Very low	Low	High	Tan is a preferred color among most processors. Most of the processors perceive the tan color as healthy grain and attracts buyers
Nutrition	Low	Medium	High	The nutrition content of a variety represents the essential plant-based source of protein and vitamins, minerals, and plant compounds. Most of the consumers interviewed prefer high protein groundnut variety
Texture	Smooth	Medium	Crunchy	The texture represents the smoothness or coarseness of the groundnut paste. The choice of the preferred texture depends on the end-use of the groundnut paste. In terms of soup preparation, most of the consumers prefer smooth paste, while the crunchy is preferred when used as bread spread
Flavor	Sweet	Salty	Natural	The flavor represents the taste of the groundnut paste. Most consumers prefer the natural flavor for food preparation
Price	GH₵90	GH₵130	GH₵170	The amount of money the consumer spent in buying 47 kg of harvested unshelled groundnut. The average market price for unshelled groundnut is GH₵130 per 47 kg

1 US$ = GHS5.37 (Bank of Ghana, 2020)

Please check (√) the option (A, B or C) that you would most likely to choose

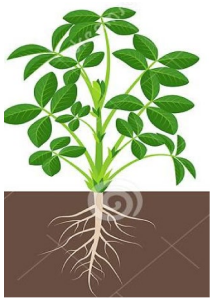
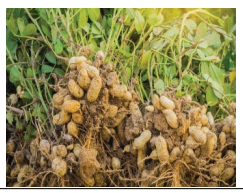
Attributes	Option A	Option B	Option C
Yield	Low 	High 	Do not like neither option A nor option B (Opt-out)
Maturity period	Medium (110 days) 	Late (120 + days) 	
Disease resistance	Resistant 	Susceptible 	
Ease of harvesting	Easy 	Difficult 	
Price per bag (47 kg)	GHS170	GHS90	
I will choose…	☐	☐	☐

Fig. 2 Example of choice set presented to a farmer

$$EU_{ij} = V\left(X_j, Z_{ij}\right) + \varepsilon_{ij} \quad (1)$$

where X_j is a vector of groundnut attributes associated with alternative j (yield, maturity, color, size, nutrition, texture, flavor, storability, and price); Z_{ij} is a vector interaction between actor-specific characteristics (socioeconomic characteristics) and choice variables; ε_{ij} is the random error term that is unobserved by the researcher. We postulate that given a choice set of groundnut traits packages H containing G alternatives, a rational groundnut value chain actor i chooses alternative j, if the subjective utility from choosing j is greater than any other alternative g:

Please check (√) the option (A, B or C) that you would most likely to choose

Attributes	Option A	Option B	Option C
Oil Content	High 	Low 	Do not like neither option A nor option B (Opt-out)
Size	Big 	Small 	
Foreign matter	Clean (Sorted) 	Not clean (Not sorted) 	
Grain storability	Medium  **6 months**	Short  **3 months**	
Price per bag	GHS130	GHS170	
I will choose…	☐	☐	☐

Fig. 3 Example of choice set presented to a trader

$$EU_{ij} > EU_{ig} \rightarrow V_{ij} + \varepsilon_{ij} > V_{ig} + \varepsilon_{ig}\ \forall j \neq g; j, g \in H \tag{2}$$

where EU_{ij} is the sum of a deterministic or observable component (V_{ij}) and the error term (ε_{ij}). Due to the random error component, the expected utility (Eq. 2) is expressed as a probability function as

$$P(j) = P\left(V_{ij} + \varepsilon_{ij} > V_{ig} + \varepsilon_{ig}\right)\forall j \neq g; j, g \in H \tag{3}$$

$$P(j) = P\left(\varepsilon_{ig} - \varepsilon_{ij} < V_{ij} - V_{ig}\right) \tag{4}$$

Following Train [27] with the assumption that the errors are independently and identically distributed, the choice probability is expressed:

$$P(L_i = j) = \frac{X_j\vartheta + Z_{ij}\theta}{\sum_{g=1}^{G}\exp(X_j\vartheta + Z_{ij}\theta)} g = 1, \ldots, G, g \neq j \tag{5}$$

where L_i indicates the choice the groundnut value chain actor makes, and ϑ and θ are parameters to be estimated.

Econometric model

We employed the conditional logit (CL) and the random parameter logit (RPL) models to estimate groundnut value chain actors' preferences for attributes of a groundnut improved variety. The RPL is preferred over the CL model given that the CL model relies on the Independence of Irrelevant Alternatives (IIA) assumption [28]. The study assumes that the value chain actors

Please check (√) the option (A, B or C) that you would most likely to choose

Attributes	Option A	Option B	Option C
Oil Content	Low 	High 	Do not like neither option A nor option B (Opt-out)
Size	Small 	Big 	
Color	Red 	Tan 	
Grain storability	Short  **3 months**	Short  **3 months**	
Price per bag	GHS90	GHS90	
I will choose…			

Fig. 4 Example of choice set presented to a processor

are heterogeneous and their preferences for production, market, and nutrition attributes may also be heterogeneous. A more frequent way of evaluating preference heterogeneity is the estimation of the RPL model that allows random taste variation within a sample based on a specified distribution [29]. The probability function specification for the RPL can be found in Train [30].

In this study, we specify an explicit model for the subjective utility following Krah et al. [31] and Asrat et al. [32], where key socio-economic characteristics enter the utility framework through interaction with the attributes. The subjective expected utility of a groundnut value chain actor i choosing groundnut trait j is specified as

$$EU_{ij} = \beta\prime X_{ij} + \delta\prime P_{ij} + \varphi_i\prime X_{ij} + \lambda\prime Z_{ij} + \varepsilon_{ij} \quad (6)$$

where X_{ij} is the attribute vector (previously defines) excluding the price attribute, β are the associated coefficients to be estimated for each of the groundnut traits of the value chain actors including an alternative specific constant (ASC); δ is the marginal utility of money; φ are actors-specific random terms that capture preference heterogeneity in the attribute; λ are the associated coefficients on the interaction terms (Z) to be estimated; ε_{ij} is the random error term that is identically and independently distributed (IID) extreme value [30].

Estimation of tradeoffs that groundnut value chain actors make is performed in both the preference and willingness to pay (WTP) space.[2] In the interest of brevity,

[2] Refer to Waldman et al. [33] for more exposition on model estimations of attributes tradeoff in either preference or willingness to pay space.

Please check (√) the option (A, B or C) that you would most likely to choose

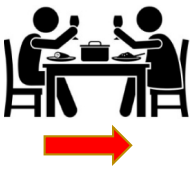
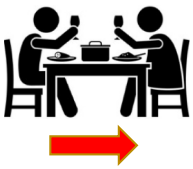
Attributes	Option A	Option B	Option C
Color	Red 	Tan 	Do not like neither option A nor option B (Opt-out)
Nutritional value	Low 	Low 	
Texture	Smooth/fine 	Medium 	
Flavor/taste	Natural 	Sweet 	
Price per bag	GHS130	GHS90	
I will choose…	☐	☐	☐

Fig. 5 Example of choice set presented to a consumer

we reported the results of the estimations using the preference space, while the box plot is used to report on the willingness to pay results. For this study, we specify the random parameters corresponding to the attributes to vary with a normal distribution. A normal distribution of the random parameters is the most common assumption, although in principle any of the distributions expected to fit the estimated parameters can be chosen [7]. For the price attribute, we use the lognormal distribution. Fitting a loguniform distribution will lead to a break down in the estimator given that a negative price coefficient is forced to be positive. This is resolved by computing a new variable (*PRS*) which is negative of the price variable (i.e., $PRS = -price$). The RPL is estimated using simulated maximum likelihood with 1000[3] Halton draws.

Despite the robustness of the estimation method, we acknowledge that farmers may overstate or underestimate their WTP compared to prices in a retail market and especially conducting such a study within an experimental auction setting.

[3] This is based on the recommendation by Bhat [34].

Table 4 a Socio-demographic characteristics of sampled seed grower—continuous variables. b Socio-demographic characteristics of sampled producers—continuous variables. c Socio-demographic characteristics of sampled traders—continuous variables. d Socio-demographic characteristics of sampled processors—continuous variables. e Socio-demographic characteristics of sampled consumers—continuous variables

	Youth		Older Adults		Pooled		Difference
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	
a							
Age	30	5	46	8	40	11	16.76***
Female adult	3	2	3	2	3	2	− 0.16
Female children	3	2	3	2	3	2	0.24
Male adult	3	2	3	2	3	2	− 0.01
Male children	3	2	2	2	3	2	− 0.39
Household size	11	7	11	6	11	6	− 0.32
Years of education	2	4	1	3	2	3	− 0.87
Farming experience (years)	8	5	18	9	14	9	9.19***
Years of farming groundnut	7	3	12	7	10	6	5.14***
Groundnut share income	53	25	50	25	51	25	− 3.66
Observation	66		112		178		
	Pooled		Youth		Older Adults		Difference
Variable	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	
b							
Age	41	12	29	4	48	10	18.74***
Years of education	8	3	8	3	7	2	− 2.25***
Female adult	3	2	3	2	3	2	− 0.12
Female children	3	2	3	2	3	2	− 0.30
Male adult	2	2	2	2	2	2	0.08
Male children	3	2	3	2	3	2	− 0.23
Household size	10	6	11	7	10	6	− 0.56
Farming experience (years)	15	10	8	4	19	11	11.72***
Years of farming groundnut	11	8	6	3	13	9	7.37***
Groundnut share income	50	26	55	27	47	25	− 7.31***
Observation	540		195		345		
c							
Age	41	10	30	4	46	7	16.54***
Years of education	8	3	8	3	8	3	0.51
Female adult	3	2	3	2	3	2	− 0.13
Female children	3	2	3	2	3	2	0.58*
Male adult	2	2	2	1	3	2	0.29
Male children	3	3	3	2	3	3	1.25
Household size	10	6	9	6	11	7	− 2.08**
Years of trading groundnut	11	8	6	4	14	8	8.08***
Observation	100		32		68		
d							
Age	47	13	30	5	50	10	19.72***
Years of education	1	3	3	4	1	2	− 0.03
Female adult	3	1	3	2	3	1	0.08
Female children	2	2	2	2	2	2	0.31
Male adult	2	2	2	2	2	2	− 0.51
Male children	2	2	3	2	2	1	− 0.15
Household size	9	4	9	5	9	4	− 2.67***

Table 4 (continued)

Variable	Pooled		Youth		Older Adults		Difference
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	
Years of processing groundnut	13	11	6	3	16	11	9.67***
Observation	106		28		78		
e							
Age	37	12	28	5	46	9	18.31***
Years of education	10	4	9	3	11	4	0.40
Female adult	3	2	3	1	3	2	0.23
Female children	3	2	3	2	3	1	0.09
Male adult	3	2	3	2	2	2	0.11
Male children	3	2	3	2	3	2	0.83
Household size	10	6	10	6	11	5	− 0.70
Observation	100		32		68		

Difference = mean (older adult) − mean (youth)

***, ** and * indicates significance at 1%, 5%, and 10%, respectively

Results of the study

Socio-economic characteristics of the groundnut value chain actors

Table 4a shows that the sampled seed growers are 40 years of age on average and have a household size of 11 consisting of three female adults, female children, male adults, and male children, respectively. A seed grower in our sample has 14 years of experience in farming and 10 years of experience in groundnut seed production. On average, the seed growers have spent 2 years in formal education and generate 51% of their income from groundnut production. The demographic information did not change much irrespective of the gender disaggregation except for years of farming, years of farming experience in groundnut production, and groundnut share income. The youth seed growers generate 2% more income from groundnut production relative to the older adults. The Welch test shows a statistically significant differences in the age, farming experience, and years of experience in groundnut farming between the youth and older adult groundnut seed producers.

The socio-economic profile of the sampled producers presented in Table 4b indicates that the sample is relatively young (41 years) with 8 years of formal education and household size of 10. The household composition is made up of three female adults, female children, and male children, respectively, and two male adults. On average, the sampled producers have been farming and producing groundnut for 15 years and 11 years, respectively. The average income share due to groundnut is 50%. Based on gender disaggregation, the results indicate that the youth farmers generate 8% more of their farm income from groundnut relative to the older adult. The household size of the sampled youth producers is one more than the older adult producers. Despite the high experience of older adults in groundnut farming, it does not translate to an increase in the share of income accrued from groundnut production. Several observable (farm size, land productivity, use of improved seed, good pant spacing, etc.) and unobservable factors (motivation, ingenuity, entrepreneurial ability, etc.) may be accounting for this phenomenon. The Welch test shows a statistically significant differences in the age, years of education, farming experience, years of experience in groundnut farming, and share of income from groundnut between the youth and older adult groundnut producers.

Table 4c highlights the socio-economic characteristics of the sampled traders. The results show that the average age of the sampled traders and years of formal education is 41 years and 8 years, respectively. Hence, the traders are relatively young; with the right policy framework, these traders can be retained in the trading business for more than three decades. The household composition is made up of three female adults, female children, and male children, respectively, and two male adults. The sampled traders have been trading in groundnut for 11 years on average. Comparatively, the older adult traders have relatively higher household members (11) than the youth groundnut traders (nine). In terms of years of education, there is no difference between male and female youth and the older adult counterparts. The Welch test shows a statistically significant differences in the age, number of female children, household size, and years of groundnut trading between the youth and older adult groundnut traders.

The socio-economic profile of the sampled processors in Table 4d indicates that processors are relatively young (47 years) with 1 year of formal education and household size of nine. A sample processor household consists of three female adults, two female children, male adults,

Table 5 RPL estimates for choice of groundnut traits by supply chain actors

Variables	Producers Coefficient (Std. error) (1)	Traders Coefficient (Std. error) (2)	Processors Coefficient (Std. error) (3)	Consumers Coefficient (Std. error) (4)
ASC	− 2.475***	− 1.979***	− 1.655***	− 1.084
	(0.577)	(0.588)	(0.391)	(1.186)
Price	− 3.496***	− 3.736***	− 4.148***	− 4.267***
	(0.080)	(0.269)	(0.247)	(0.296)
Yield (1 = low)	− 1.096***			
	(0.167)			
Maturity2 (1 = medium)	− 0.143			
	(0.207)			
Very low oil content		− 0.030	− 1.811**	
		(0.687)	(0.490)	
Maturity3 (1 = late)	− 1.147***			
	(0.207)			
Disease resistance 2 (1 = tolerance)	− 0.280			
	(0.186)			
Low oil content		− 0.109	− 0.061	
		(0.665)	(0.402)	
Disease resistance 3 (1 = susceptible)	− 0.567**			
	(0.274)			
Small grain size		− 1.566*	0.588	
		(0.899)	(0.394)	
Easily harvest 2 (1 = difficult)	− 0.772***			
	(0.266)			
Short grain storability		− 1.186*	0.002	
		(0.607)	(0.434)	
Medium grain storability		− 0.206	− 0.015	
		(0.718)	(0.430)	
Easily harvest 3 (1 = very difficult)	0.066			
	(0.219)			
Red grain			0.549	− 0.230
			(0.434)	(0.609)
Brown grain			0.346	0.525
			(0.458)	(0.548)
Low nutritional value				− 1.586***
				(0.547)
Crunchy texture				0.812
				(0.560)
Salty flavor groundnut paste				0.557
				(0.581)
Non-random parameters				
Age	0.023* (0.013)			0.005 (0.025)
Gender (1 = male)	− 0.131 (0.247)			0.616 (0.702)
Household size	0.030 (0.227)			
Farming experience	− 0.020 (0.173)			
AEA	− 0.674** (0.286)			
Training	0.026 (0.284)			
Education	0.001 (0.030)			− 0.021 (0.057)

Table 5 (continued)

Variables	Producers Coefficient (Std. error) (1)	Traders Coefficient (Std. error) (2)	Processors Coefficient (Std. error) (3)	Consumers Coefficient (Std. error) (4)
Household size				− 0.097* (0.056)
Standard deviations				
ASC	0.117	0.109	1.217	0.216
	(0.169)	(0.217)	(1.580)	(0.448)
Price	0.036	1.191***	1.644	0.060
	(0.117)	(0.269)	(3.566)	(0.462)
Yield (1 = low)	0.447			
	(0.499)			
Maturity2 (1 = medium)	1.173***			
	(0.452)			
Very low oil content		2.724***	0.865	
		(0.953)	(0.578)	
Maturity3 (1 = late)	1.624***			
	(0.380)			
Disease resistance 2 (1 = tolerance)	0.705			
	(0.566)			
Low oil content		0.235	0.636	
		(0.763)	(0.473)	
Disease resistance 3 (1 = susceptible)	3.372***			
	(0.444)			
Small grain size		2.683**		
		(1.161)		
Easily harvest 2 (1 = difficult)	1.833***			
	(0.370)			
Short grain storability		1.618	0.210	
		(1.138)	(0.841)	
Medium grain storability		3.371**	0.170	
		(1.577)	(0.610)	
Easily harvest 3 (1 = very difficult)	0.748			
	(0.618)			
Red grain			0.169	1.329*
			(0.546)	(0.807)
Brown grain			1.014	1.288
			(0.750)	(0.793)
Low nutritional value				0.713
				(1.906)
Crunchy texture				0.433
				(1.246)
Salty flavor groundnut paste				2.071**
				(1.033)
Observations	1620	900	1080	900
AIC	2768.0	324	334	309
Log likelihood	− 1358.99	− 148	− 149	− 136

ASC indicates alternative specific constant; ***, ** and * indicates significance at 1%, 5%, and 10%, respectively

and male children, respectively. The sampled processors have been processing groundnut for 13 years on average. Comparatively, the older adult processors are 20 years older than the youth processors. The implication of the wide age differential indicates that agricultural development programs that aim at sustaining the groundnut value chain must specifically target, encourage, and support the youth to take up more critical roles in the line of processing. The results of the Welch test revealed a statistically significant differences in the age, household size, and years of groundnut processing between the youth and older adult groundnut processors.

Table 4e shows that the sample consumers are 37 years on average and have a household size of 10 consisting of three female adults, female children, male adults, and male children, respectively. On average, the sampled consumers have spent 10 years of formal education. Comparatively, there is a wide age differential between the youth and older adult consumers. In terms of education, older adult consumers have 3 years of education more than the youth consumers.

Preferences and willingness to pay for groundnut attributes

The results of the random parameter logit (RPL) are presented in Table 5. The variant forms of the RPL for estimating preferences of the supply chain actors (producers, traders, processors, and consumers) is based on the Akaike Information Criterion (AIC) and the standard deviations.

Producers (column 1) consider yield (i.e., low vs. high), maturity (i.e., late vs. otherwise), disease resistance (i.e., susceptible vs. otherwise), and harvesting (i.e., difficult vs. otherwise) as important attributes in the selection of improved groundnut varieties. The size (i.e., small vs. big) of groundnut is not statistically significant. Comparatively, the magnitude of the coefficient on price attribute is large and significant relative to all the other attributes indicating that many producers incur more disutility from being offered a relatively low price per bag of groundnut variety. The alternative specific constant is significant and relatively high magnitude. The significance of the ASC indicates that farmers believe that the utility of not adopting improved groundnut variety is lower than that of adoption. The result implies that most of the producers gain more utility from adopting groundnut variety with high yield, early maturing, resistance to diseases, and easy to harvest.

Relative to high yielding cowpea varieties, producers are less likely to adopt groundnut varieties with low yields. Producers generally associate higher disutility with low-yielding groundnut varieties. Improved crop varieties that guarantee high yield are more likely to be adopted. The finding is consistent with Asrat et al. [32] who find that yield stability is an important attribute for farmers' choice of crop varieties. The coefficient and sign on the "maturity" attribute indicate that producers prefer early and medium maturing groundnut varieties compared to late-maturing varieties. Producers associate higher disutility with late maturing groundnut varieties relative to early and medium maturing groundnut varieties. Northern Ghana is characterized by one major rainy season with long dry spells, thus, a variety that is early maturing will be highly preferred. Early maturing groundnut varieties allow producers to escape drought and diseases and pests' infestation from the field. Worku et al. [35] observed that maize farmers in East Africa (i.e., Kenya, Uganda, Tanzania and Rwanda) that were involved in the participatory selection of varieties rated early maturity, germination and yield as the three most important traits that they desire in hybrids. Producers in Burkina Faso chose earliness as one of their most important sorghum traits. Whereas tolerance refers to the capacity of plants to withstand drought at any stage of the season, earliness allows plants to mature before the onset of drought [36].

Compared to the disease resistant groundnut varieties, producers are less likely to adopt groundnut variety that is susceptible to diseases. The sampled producers associate higher disutility with groundnut varieties that are susceptible to diseases. A groundnut variety that is highly resistant to diseases is likely to reduce the overall production and labor costs and guarantee some level of output at the time of harvest. Relative to groundnut varieties that are easily harvested, producers associate high disutility with varieties that are difficult and very difficult to harvest. Harvesting of groundnut is relatively expensive and the cost is extremely high during of harvest time especially when the rains delay. In such circumstances, producers tend to dig rather than uproot with the hands which is likely to damage the pod and affect the seed vigor.

The non-random parameters are included in the RPL model to account for a portion of the variation in the preference heterogeneity among the sampled producers. The results indicate that older producers are more likely to compromise on the preferred attributes of the groundnut varieties relative to the young producers. The result is consistent with the a priori expectation as relatively young producers are more dynamic and willing to innovate and take calculated risks that are likely to improve their welfare [37]. Producers who have access to extension services are less likely to compromise on the preferred groundnut attributes. Information received from agricultural extension agents enables producers to

make informed production decisions on the adoption of improved groundnut varieties. Second, information reduces the uncertainty associated with new improved crop varieties.

With respect to the traders (column 2), grain size (i.e., small vs. big) and grain storability (i.e., short vs. otherwise) are important attributes when buying groundnut. Comparatively, the magnitude of the price coefficient is large and significant relative to all the other attributes indicating that many traders gain more disutility from being offered a relatively low price per bag of groundnut variety. The alternative specific constant is significant with a relatively high magnitude. The significance of the ASC indicates that traders believe that the utility of buying groundnuts that do not have the preferred traits is lower than utility derived from buying groundnuts that have preferred traits. The result implies that the traders, prefer the status quo (quality groundnut) relative to the other options (1 and 2). This indicates that most of the traders gain more utility from purchasing groundnut with high oil content, big grain size, long storage duration, and clean grains.

Traders associate negative preference for small grain size and short duration of grain storage, and by doing so are discounting the prices paid to farmers with increasing levels of the negative attributes. Comparatively, the discounting of a groundnut variety with small grain size is relatively higher than groundnut grain variety with short duration storability. Relative to big grain size, traders are less likely to buy groundnut grains with small size, though they do not reject the small grain size groundnut. Traders associate higher disutility with small grain size groundnut. Compared to long-duration storability of the groundnut grains, traders are less likely to purchase groundnut grains that have short-duration storability. The result indicates that the traders associate higher disutility with short duration groundnut variety. The results imply that both the production and market attributes must be considered in breeding decision to enhance uptake by producers and commercialization by the other value chain actors (traders and processors).

The significance of the standard deviation of the oil content attribute indicates that some proportion of the traders prefer groundnut variety with high oil content, while others prefer very low oil content. Similarly, the significance of the standard deviation on the grain size suggests that there is a sub-sample of the traders that prefer small grain size relative to the big grain size. While the sampled traders largely prefer groundnut varieties with long storage duration, there is a subset of the traders that prefer groundnut varieties with medium storage duration. In summary, the results indicate heterogeneity in the preferences of the attributes presented to the traders, thus the groundnut breeding program must incorporate both the feedback of the different subsample of the population to make an informed decision regarding the trade-offs among the attributes.

Processors (column 3) consider oil (i.e., very low vs. otherwise) as an important attribute when buying groundnut for processing. Comparatively, the magnitude of the price coefficient is large and significant relative to all the other significant attributes indicating that many processors gain more disutility from being offered a relatively low price per bag of groundnut variety. The alternative specific constant is significant with a relatively high magnitude. The significance of the ASC indicates that processors believe that the utility of not buying quality groundnut is lower than purchasing quality groundnut. The result implies that the processors, prefer the status quo (quality groundnut) relative to the other options (1 and 2). This indicates that most of the processors gain more utility from purchasing groundnut with high oil content, big grain size, long storage duration, and tan-colored grains.

In reference to the RPL model and consistent with our theoretical predictions, the results show that most of the processors associate high utility to groundnut grains with high oil content. The insignificance of the other attributes suggests that processors are indifferent on the attributes of grain size, color, and storability. The indifference in the grain size attribute is confirmed by the significance of the standard deviation which suggests that there is a subsample of the processors who prefer small and big grain size. Therefore, the result is likely to be capturing a portion of the processors that have high preferences for oil and indifferent about the other attributes.

Consumers (column 4) consider nutritional value (i.e., low vs. otherwise) as the important attribute in the selection of quality groundnut or groundnut product. Comparatively, the magnitude of the coefficient on price attribute is large and significant relative to all the other attributes indicating that many consumers gain more disutility from being offered a relatively higher price per bag of groundnut. The alternative specific constant is significant indicating that consumers gain more utility from purchasing groundnut with tan-colored grain, high nutritional value, smooth and natural flavor.

The significance of the nutrition variable suggests that consumers gain more utility from consuming groundnut or any form of groundnut product (especially paste) that has high nutritional value. The result suggests that consumers are more willing to buy high nutritious groundnut and groundnut products from sellers irrespective of the other attributes. This connotes the need to prioritize nutrition in the groundnut breeding pipeline decision

without neglecting other important attributes preferred by the other actors within the groundnut value chain. Given that consumers are at the downstream of the value chain, it is important to prioritize their preferences. The non-random parameters are included in the RPL model to account for a portion of the variation in the preference heterogeneity among the sampled consumers. The results indicate that large household size is more likely not to compromise on the preferred attributes of the groundnut or product relative to small household size.

The significance of the standard deviations of the color and flavor indicate preference heterogeneity in the selection between color and flavor. The results suggest that while some of the consumers prefer red color grain, others prefer the tan grain color groundnut. Similarly, while a proportion of the consumers prefer salty flavor groundnut paste, there is a subsample of the consumers that prefer the natural flavor (not salty). The heterogeneity in consumers' preferences must be considered and incorporated in setting breeding objectives. The information regarding the heterogeneity will also guide traders in identifying the segment of the population with high and low preferences for quality groundnut given that traders do not reject non-quality grain but rather discount the price.

Heterogeneity analysis on WTP based on gender

Figure 6 shows the gender-disaggregated distribution of producers' WTP for each attribute of improved groundnut varieties using a box plot. Across all the categories of the producers (WTP distribution of -200 to 200), the female youth had the lowest distribution of WTP (-100 to 150). This indicates that the female youth were more considerate with their stated WTP values relative to the older adult producers. Across all the gender categories, yield had the narrowest distribution and positive. The results indicate that producers, irrespective of gender were willing to pay below GHS50 (US$9) for a bag of groundnut with a low yield attribute. Compared to the market value (US$23) of a bag of groundnut, the results suggest that farmers discount the yield by 39%; revealing that producers have a high preference for a high yield groundnut attribute.

With respect to maturity, female youth and older adults associate both positive and negative WTP for medium maturing groundnut varieties. Comparatively, the number of male youth and older male adults that associate a negative WTP for medium maturing groundnut varieties is smaller than their female counterparts. Except for the female older adults, all the other categories associate high positive WTP for a groundnut variety that is medium yielding. The results indicate that most of the producers prefer early maturing groundnut varieties, though a few prefer the medium maturing variety. The result is consistent with the significance of the standard deviation on maturity. Similarly, all the farmers associate positive WTP for late-maturing groundnut varieties.

In reference to disease resistance, producers associate both positive and negative WTP for susceptibility to disease. The distribution is wider for the female youth and followed by male older adult. The distribution for female older adult and male youth are almost the same. For all categories, majority of the farmers associate positive WTP for susceptibility. Comparatively, the older female adults recorded the lowest proportion of farmers associating negative WTP for a groundnut variety that is susceptible to diseases. Comparing the mean values, the results suggest that the females discount the price of a groundnut variety that is susceptible to disease more than the males (i.e., females mean WTP is below the zero line). However, among the female categories, a relatively large proportion of the female youth associate positive WTP above the mean value compared to the older female adults.

Except for the female youth, all the other categories of the farmers recorded a narrow distribution of WTP for harvesting. Our results suggest all the farmers in our sample associate negative WTP for a groundnut variety that is difficult to harvest. Comparatively, the female youth reported the lowest price discounting for a groundnut variety that is difficult to harvest. However, male older adults reported the highest price discounting for a groundnut variety that is difficult to harvest. The value of the mean WTP indicates that on the average, farmers are willing to pay US$18 for a groundnut variety that is high yielding, early maturing, and disease resistance but difficult to harvest. Harvesting is labor intensive and costly to the farmers thus a variety that is easily harvested is more preferred to a variety that is either difficult or very difficult to harvest.

Figure 7 shows the distribution of traders' WTP for each of the groundnut attributes presented to the traders. The distribution of the WTP for each of the attributes is wide for the youth relative to the older adults. The older adult traders discount the price of the less preferred attributes more than the youth traders. However, both category of traders recorded positive mean WTP for a groundnut variety that is associated with short duration of storage. In terms of sex disaggregation, the figure depicts a wide variation in WTP across traders for grain size and medium storage duration among male traders. A relatively large proportion of the male traders discount the small grain size and medium storage duration attributes compared to the female traders. Comparatively, female traders have higher preferences for groundnut

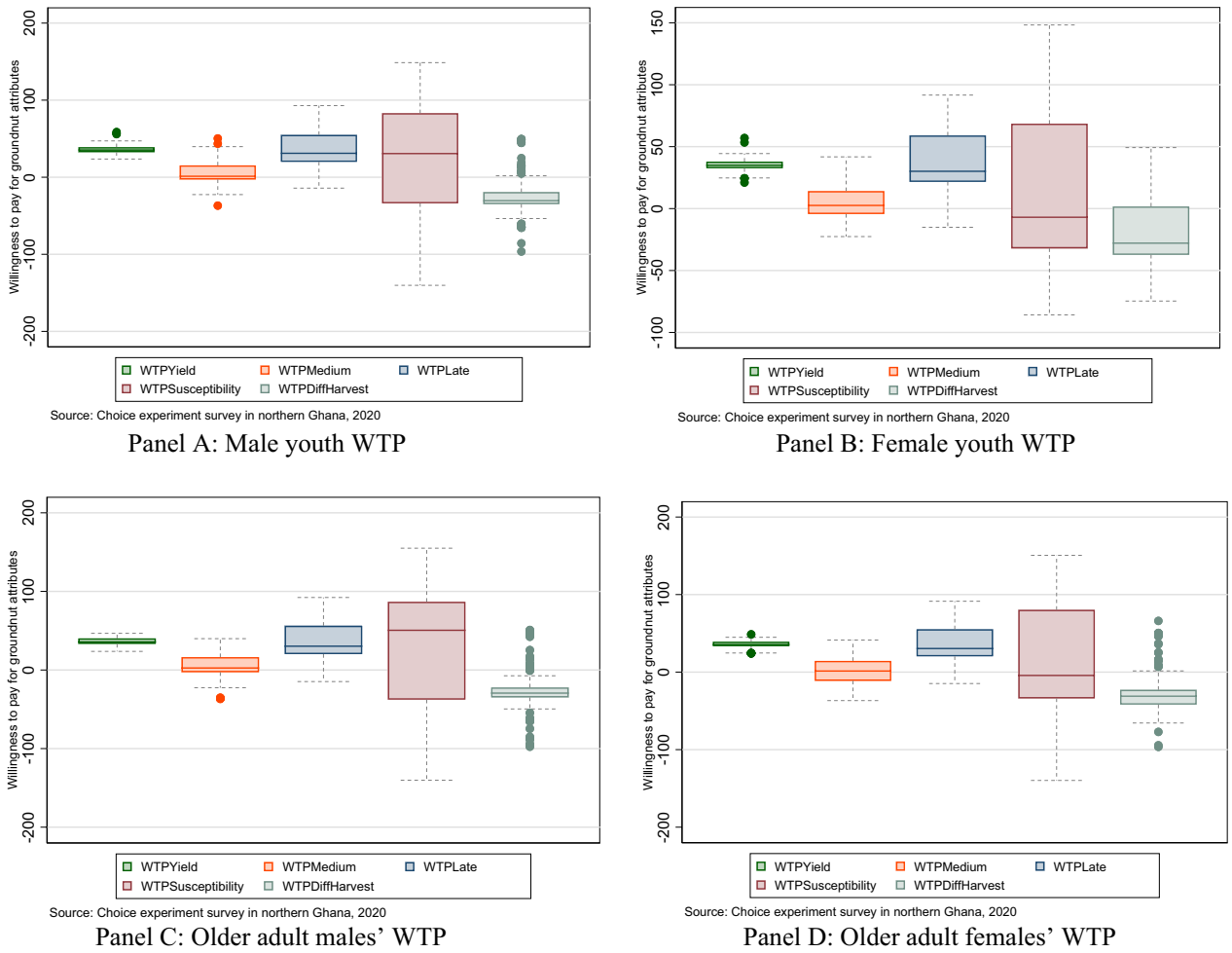


Fig. 6 Distribution of producers'WTP for groundnut key traits

with high oil content than the male traders. Understanding the dynamics of preferences within the context of gender and sex is necessary for an effective breeding program that will enhance effective targeting and uptake by the population.

Figure 8 shows the distribution of the processors' WTP for each of the groundnut attributes presented to the processors. The skewed sex distribution of the processors does not allow for the computation of the WTP based on sex. When disaggregated by age, the distribution of the WTP for each of the attributes is wide for the youth relative to the older adults. The older adult processors discount the price of the less preferred attributes more than the youth processors. The results show that the youth processors have relatively higher positive WTP for groundnut with low oil content than the older adult processors. Understanding the dynamics of preferences with an intersectionality lens is necessary for an effective and inclusive breeding program to reinforce the targeting and subsequent incorporation of a wider diversity of users of the breeding products in the population.

Figure 9 shows the distribution of the consumers' WTP for each of the groundnut attributes. The distribution of the WTP for color and nutrition attributes is wider for the youth consumers relative to that of the older adult consumers. The distribution of the WTP for the flavor attribute is the same across consumer types. However, the proportion of youth consumers above and below the mean WTP for flavor is the same. In contrast, the proportion of the older adult consumers below the mean WTP for salty flavor groundnut attribute is higher than those above the mean WTP. In terms of sex disaggregation, the figure depicts a wider variation in the male consumers' mean WTP for red color groundnut grains and salty flavored groundnut paste compared to the female consumers.

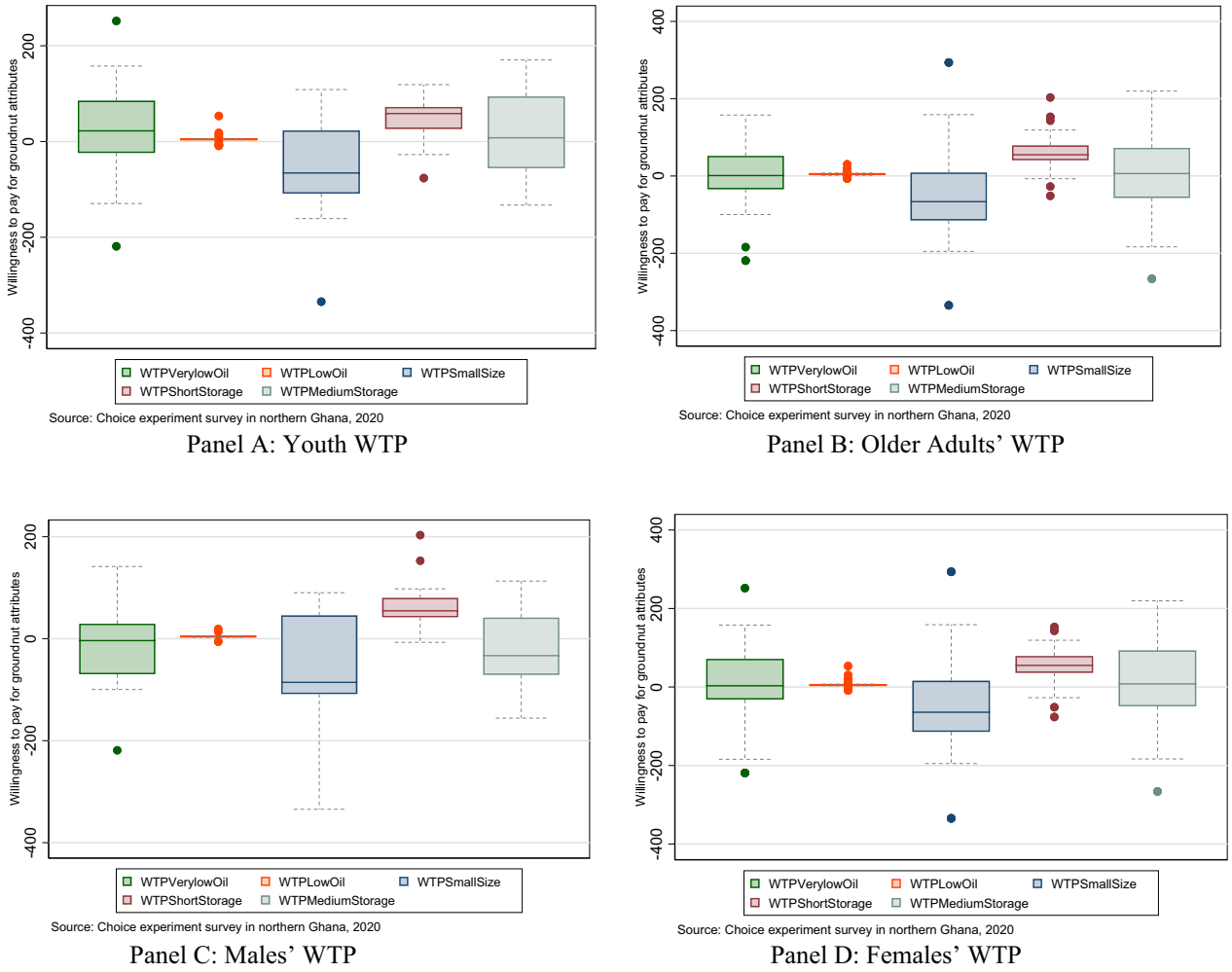


Fig. 7 Distribution of traders'WTP for groundnut key traits by gender and sex

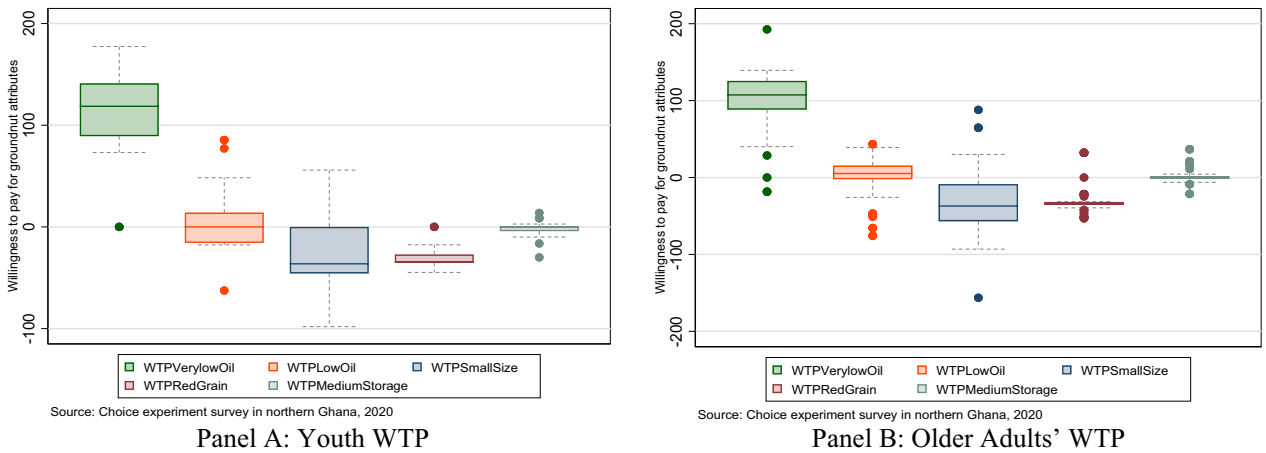


Fig. 8 Distribution of processors'WTP for groundnut key traits by gender

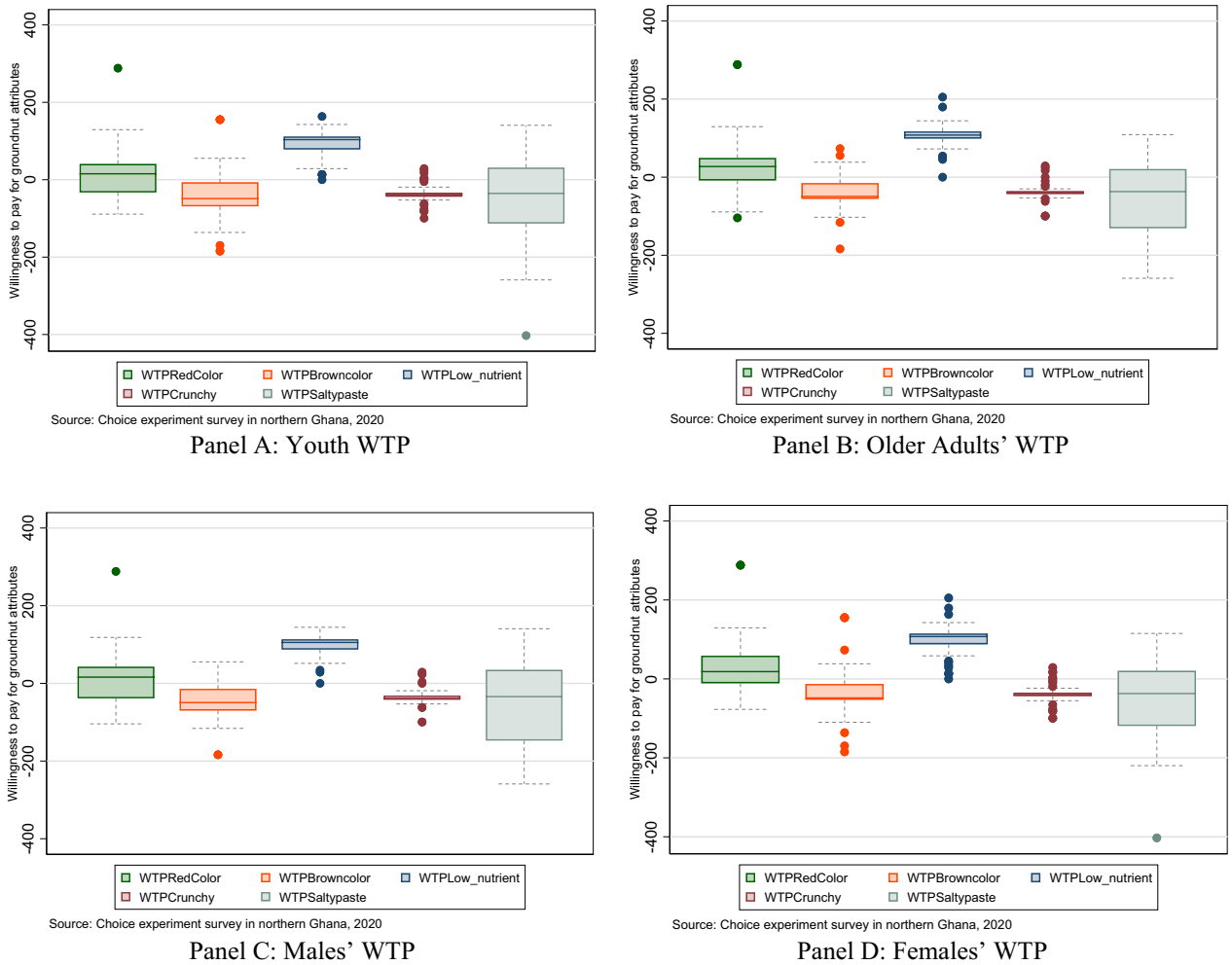


Fig. 9 Distribution of consumers'WTP for groundnut key traits by gender and sex

Conclusion and policy implications

Developing improved and gender-sensitive crop technologies through a holistic trait preferences elicitation among value chain actors is necessary to enhance crop breeding programs, adoption, productivity, utilization, and food security. This study elicited groundnut traits preferred by men and women in the different segments of the groundnut value chain including seed out-growers, producers, grain traders, processors and consumers.

Results of the choice experiment indicates that producers associate high utility to high yield, early maturing, disease resistance, and a groundnut variety that is easy to harvest. Traders associate negative preference for small grain size and short duration of grain storage, and by doing so are discounting the prices paid to farmers with increasing levels of the negative attributes. Consistent with our theoretical predictions, most of the processors associate high utility to groundnut grains with high oil content. Consumers gain more utility from consuming groundnut or any form of groundnut product (especially paste) that have high nutritional value. We find gender heterogeneity in terms of the groundnut trait preferences among the value chain actors. In terms of the WTP, the women were more conservative than the men. Discounting of off-traits were mixed for both men and women and adults and youth. The novelty of the study is the disaggregation of the trait preferences based on the age cohort (youth and adult) which indicate that while adults were more conservative in their WTP, the youth were more liberal.

The results of the study have four main implications: (1) breeding for improved groundnut varieties must consider the gender differences in production, nutrition and market attributes to enhance uptake by farmers and utilization and commercialization by other value chain actors (traders, processors, and consumers). This requires a more holistic approach based on gender disaggregation to speed up the adoption process and utilization of the

technology in a sustainable manner; (2) Research institution must effectively collaborate with the Ministry of Food and Agriculture to improve farmers' access to newly developed improved groundnut seed that meets the needs of different segments of the value chain through the subsidy program under the "Planting for Food and Jobs Program"; (3) Given that the youth are more risk-loving in terms of their WTP, development organizations can specifically engage and train them as agents of technology dissemination; (4) Eliminating of information asymmetry characterizing groundnut commercialization through improved access to market information can lead to market efficiency, where farmers can clearly target their buyers depending on the quality of their grains given that traders do not reject grains that are of low quality but rather discount the price. Nevertheless, it is important to have adequate information about the preferences of the downstream users of the grains.

The main limitation is the scope of the study. The study is limited to northern Ghana, although groundnut is also produced in the southern part of Ghana. In view of this, the findings from our study can only hold in countries with similar agroecology as pertains to northern Ghana. Despite these limitations, the study has provided essential insights on how gender disaggregated trait preference elicitation improves crop breeding programs.

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Author contributions
All persons who meet authorship criteria are listed as authors, and all authors certify that they have participated sufficiently in the work to take public responsibility for the content, including participation in the concept, design, analysis, writing, or revision of the manuscript. Furthermore, each author certifies that this material or similar material has not been and will not be submitted to or published in any other publication before its appearance in the Social Indicators Research. The Conception and design of study, acquisition of data, analysis and/or interpretation of data, drafting the manuscript, revising the manuscript critically for important intellectual content, and Approval of the version of the manuscript to be published was carried out by JOY, EM, PME, DSA, GM, and HD.

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Availability of data and materials
The data sets for the current study are available from the lead author on reasonable request.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
The purpose of this study has been explained to me. After understanding the research objectives, I agree to participate in the survey and give my consent for audio, photo and video recording during the survey. I understand that my responses would be used and or shared when and if necessary for research purposes mainly, without revealing my identity. I understand that my participation is voluntary, and I am free to or not answer any question and or withdraw from participation in the interview at any time. However, I know that the information, knowledge and views I would share would make a significant contribution toward improving agricultural research and development. All information obtained is confidential.

Competing interests
The authors declare that they have no competing interests both financial and non-financial.

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