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Market preferences for cowpea (*Vigna unguiculata* [L.] Walp) dry grain in Ghana

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Cowpea is an important crop in Ghana, serving as a major source of calories and high-quality protein for many people. An understanding of market preferences is necessary when targeting research and breeding efforts. This study makes use of data from 562 samples of cowpea dry grain collected from 91 markets across Ghana, analyzed using the hedonic model framework, to determine implicit prices of characteristics, including seed coat color, pattern, texture, the location of purchase, the gender of the vendor, seed size, and seed quality. The results indicate that market location and seed size are the most important characteristics regarding pricing. Improvements in infrastructure to facilitate transport of goods and dissemination of varieties with increased seed size could improve incomes for the smallholder farmers in Ghana who produce cowpea.

Key words: Characteristic value, consumer demand, hedonic pricing, seed coat, *Vigna unguiculata*.

INTRODUCTION

Cowpea (*Vigna unguiculata* [L.] Walp) (Fabaceae) is a warm-season legume, most often consumed as a grain, but also as a vegetable in the form of immature pods and leaves (Boukar et al., 2018). Cowpea is a versatile crop, with high drought and heat tolerance (Boukar et al., 2018). In Ghana, cowpea is grown across the country, with the areas of greatest production in the Northern Plains. The majority of production is by smallholder farmers, often as an intercrop with maize or millet (Ehlers and Hall, 1997). Ghanaian production of cowpea has been increasing: from 2013 to 2016 the volume of production increased from 200,404 to 206,378 metric tons per year (Ministry of Food and Agriculture, 2016). Early maturing varieties have been developed and disseminated by breeding programs to fill the "hunger gap" between June and August, between when farmers have sown their seeds but have not yet brought in the harvest (Fatokun et al., 2002).

Cowpea is a cash crop for small-holder farmers and a vital source of income, meaning that growing cultivars with more valuable characteristics could lead to increased income (Samireddypalle et al., 2017). However, for breeders to know which traits to target, it is necessary to determine those which are most desired by consumers. Seed coat color, pattern, and texture traits are important consumer-related traits in cowpea.

Previous research has shown that consumers make qualitative decisions about the acceptability, quality, and

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presumed taste of a product based on appearance and color (Jaeger et al., 2018; Simonne et al., 2001). Consumer preference for different cowpea seed coat traits varies across locations, with different seed coat traits desired in different places and for different uses: for example, lack of color for use as flour or solid brown for use as whole beans (Langyintuo et al., 2003; Mishili et al., 2009).

A major cowpea pest is the bruchid (*Callosobruchus maculates* [F.]) (Coleoptera: Bruchidae), a post-harvest pest, which infests stored grains and bore holes in the seeds. It is understood that consumers prefer seeds with lower levels of damage and expect discounted prices for damaged seeds (Langyintuo et al., 2004; Mishili et al., 2009). Until recently, most farmers did not have access to adequate storage methods and so regularly sold their product for low prices directly after harvest (Murdock and Baoua, 2014). The lack of proper storage resulted in high levels of infestation and lower quality seeds, with the number of holes in seeds available on the market increasing from the time of harvest in September (Langyintuo et al., 2004). To address the issues of bruchid infestation the Bean/Cowpea Collaborative Research Support Program developed the triple bag technology known as Purdue Improved Cowpea Storage (PICS) which can protect seeds at low cost (Murdock and Baoua, 2014). It has recently been reported by Ibro et al. (2014) that 64% of cowpea in the West African countries of Burkina Faso, Niger, and Nigeria was stored in hermetic containers, including PICS bags, which reduce the incidence of infestation. Similar levels of adoption in Ghana might also be expected.

The consumer goods characteristics model, a hedonic pricing model, is a linear model for estimating consumer demand for specific traits based on quality which was developed by Ladd and Suvannunt (1976). Using the model, it is possible to determine the implicit value of the attributes of a good. This model is widely applicable and has been used to analyze prices of a wide variety of goods, including ecosystems (Czembrowski and Kronenberg, 2016), cloud computing services (Wu et al., 2018), used cars (Prieto et al., 2015), and origin country of imported meat (Hussein and Fraser, 2018). Previous analyses of the characteristics of cowpea dry grain and how those relate to price have been done within and comparing between African countries (Faye et al., 2004; Langyintuo et al., 2004; Mishili et al., 2009; Mundua et al., 2010). However, those which have included Ghana have only examined markets either in the north (Langyintuo et al., 2004) or south (Mishili et al., 2009) of the country. To date, no country-wide analysis of market preferences has been performed for Ghana. While it has been reported that cowpea is transported from inland production regions of West Africa to coastal regions (Langyintuo et al., 2003), the effects of such movement on consumer prices have not been examined. In this study, market preferences of Ghanaian consumers for cowpea dry grains are examined to determine which traits have the greatest implicit values.

MATERIALS AND METHODS

Sample and data collection

562 samples of cowpea were collected from 91 markets distributed across the ten regions of Ghana in July and August 2018 (Figure 1). In each region, samples were purchased from vendors in local markets where consumers purchase cowpea for end-use consumption. At the time of purchase, the location, gender of the vendor, and price paid were noted. During July and August 2018, the exchange rate was about 4.80 Ghanaian Cedi (GHS) to 1.00 United States Dollar (USD). In the lab, the price per kilogram of the purchased seed was determined and seed coat characteristics including color, pattern and texture were noted. Color was defined by the presence of a pigment in the seed coat, including black, brown, red and purple. Pattern was defined by how the observed pigmentation was distributed on the seed coat, including eye, solid coat, speckled, and mottled, among others. Three 100-seed subsamples were taken from each sample. In these subsamples, 100 seed weight and number of holes per 100 seeds were noted. For analysis, the average of the three values was used, rounded to the first decimal place. Due to mixtures in the seeds purchased, for analysis the most prevalent seed coat traits (>75% of seeds in the sample) were used as when collectors reported the type of seed purchased they ignored traits held only by a minority of the sample. To determine the latitude and longitude of each market, Google Maps (maps.google.com) was used.

Hedonic analysis framework

Implicit values of the observed characteristics of seeds were analyzed through the use of a hedonic analysis framework, originally developed by Ladd and Suvannunt (1976). For this analysis, a simplified equation used by Langyintuo et al. (2004) and Mishili et al. (2009) was used, which takes the form of:

$$P_C = \sum_{j=1}^{m} X_{Cj}\,\beta_{Cj} + \epsilon$$

where P_C is the price of cowpea, X_{Cj} is the quantity of cowpea characteristic *j*, β_{ij} is the regression coefficient (implicit price) of characteristic *j*, and ϵ is a normally distributed random error. Analysis was done using the linear regression function in R. Tested factors included seed coat color, pattern, and texture, seed weight, infestation levels, purchase location, and vendor gender.

RESULTS

Range of characteristics

The full range of characteristics of the collected samples can be found in Table 1. Across Ghana, there is high variability in 100 seed weight, ranging from 7.3 g to 40.1 g, with a mean of 17.4 g and a standard deviation of 6.4 g. The number of bruchid holes per 100 seeds ranged

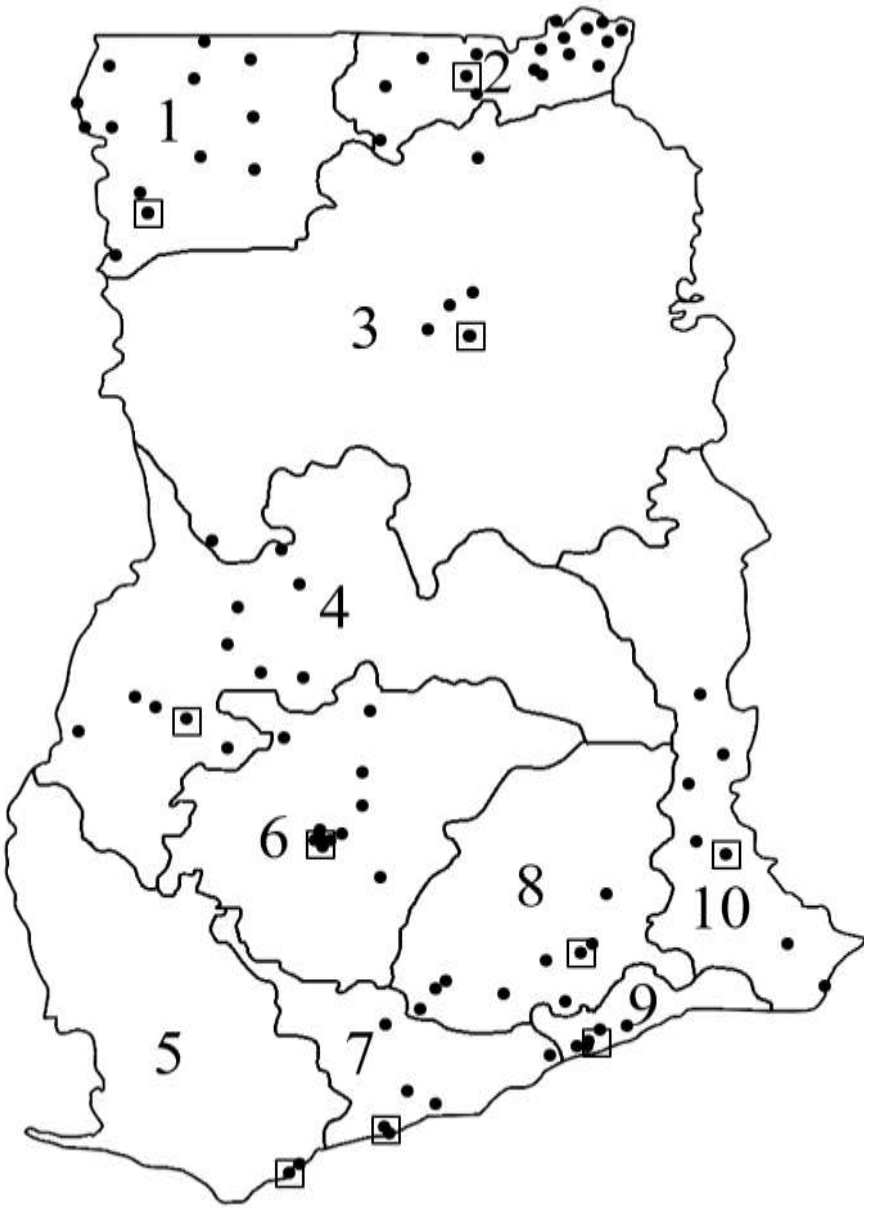

Figure 1. Location of markets at which samples were purchased. Black dots indicate market locations. Squares indicate regional capitol city locations. Map available from Wikimedia Commons. 1 = Upper West, 2 = Upper East, 3 =Northern, 4 = Brong Ahafo, 5 = Western, 6 = Ashanti, 7 = Central, 8 = Eastern, 9 = Greater Accra, 10 = Volta.

from 0 to 69.0, with a mean of 6.3 and a standard deviation of 3.4. The price per kilogram of seeds ranged from 1.8 Ghanaian Cedis (GHS) to GHS 23.3, with a mean of GHS 6.1 and a standard deviation of GHS 2.7. The most expensive sample, from Nsawam market in the Eastern region is most likely an outlier. The next most expensive sample had a price per kilogram of GHS 18.7. Most cowpea vendors were women. Of those samples for which the vendor's gender was recorded 95.9% (493) were sold by women and 4.1% (21) were sold by men. The most common pattern was the presence of an eye, which was in 66.7% (375) of the samples, followed by 19.8% (111) of the samples with a solid coat, 5.5% (31) with a speckled coat, 4.1% (23) with a mottled coat, and 3.9% (22) with other seed coat patterns. Seeds which had a clearly defined eye and additional pigmentation were considered as having an eye pattern for this analysis. 69.8% (392) of the samples had rough seed coats, 30.2% (170) had smooth seed coats. 49.3% (277) had black coloring, 15.8% (89) had brown coloring, 7.1%

Table 1. Statistics of quality and price metrics of cowpea in Ghana.

Region	#Samples	100 seed weight (g)		# holes / 100 seeds		Price	Vendor
		Average	σ	Average	σ	Average	(GHS/kg) σ (F/M/NR)
Ashanti	77	17.4 (8.9-29.6)	5.5	3.2 (0-23.7)	4.0	5.9 (4.0-10.3)	1.4 75/2/0
Brong Ahafo	83	16.2 (8.5-37.1)	6.1	6.3 (0-50.7)	2.2	5.2 (2.9-8.1)	1.3 79/4/0
Central	35	19.9 (9.6-40.1)	7.0	6.5 (0-33.7)	8.6	6.9 (3.7-18.7)	3.4 31/4/0
Eastern	80	19.6 (9.5-36.4)	7.5	5.8 (0-41.0)	7.8	7.3 (2.3-23.3)	3.5 62/3/15
Northern	55	15.3 (7.3-29.8)	5.7	1.0 (0-11.7)	2.2	5.4 (2.6-8.5)	1.4 55/0/0
Greater Accra	38	19.6 (9.3-35.1)	6.7	2.9 (0-15.3)	3.8	11.0 (7.8-17.5)	2.6 30/8/0
Upper East	75	16.4 (9.0-30.1)	4.6	1.7 (0-21.7)	3.2	5.4 (3.1-12.4)	1.7 75/0/0
Upper West	52	15.1 (9.2-29.1)	5.1	5.8 (0-30.3	3.8	4.3 (1.8-12.7)	2.2 19/0/33
Volta	47	18.2 (8.7-35.9)	6.5	5.4 (0-69.0)	10.9	5.7 (2.6-9.7)	1.5 47/0/0
Western	20	20.2 (10.5-38.8)	9.8	4.6 (0-15.7)	3.9	5.1 (3.6-9.5)	1.6 20/0/0
Ghana	562	17.4 (7.3-40.1)	6.4	6.3 (0-69.0)	3.4	6.1 (1.8-23.3)	2.7 493/21/48

The ranges of values are in parentheses. Mean weight and number of holes per 100 seeds values are averaged from three subsamples of a market sample. All values are rounded to the nearest single decimal. GHS = Ghana Cedi, F = female, M = male, NR = not recorded.

(40) had red, brown, and purple coloring, 6.9% (39) had red and brown coloring, 6.9% (39) had red and purple coloring, 1.1% (6) had purple coloring, and 0.4% (2) had purple and brown coloring. The remaining 70 samples consisted of mixed seeds of various colors and so were considered missing data to avoid biasing the analysis.

Hedonic pricing

The hedonic pricing indicates that 26% of price variability of cowpea in Ghanaian markets is due to the tested characteristics. Table 2 shows the effects of different characteristics. Table 3 shows the analysis of variants table. All price effects are relative to a rough black seed with an eye pattern sold by a female vendor. The most significant effects were market location, seed weight and vendor gender, with a minor effect by the seed coat pattern. Prices decreased by GHS 0.33 per degree north and GHS 0.90 per degree west. For larger seeds, consumers were willing to pay an additional GHS 0.09 for each gram increased per 100 seeds. Seed coat color, pattern, and texture traits were not significant except for a seed with the mottled pattern, for which consumers were willing to pay an additional GHS 2.07. The price for seeds purchased from a male vendor was increased by GHS 1.78. The effects of number of bruchid holes per 100 seeds, seed coat color, the eye pattern, the speckling pattern, and texture were not significant.

DISCUSSION

The price of cowpea was uniform across all markets, with a mean price of GHS 6.1 per kg and a standard deviation of GHS 2.7. However, this finding was skewed by the much higher prices from the Greater Accra Region, which had an average price of GHS 11.0, a 75% increase over the country-wide average. The increased price in the capitol follows the trend reported by Mishili et al. (2009), but the difference is much more marked. The higher prices parallel the higher cost of living in general in Accra compared to other parts of the country (”Cost of living” 2018), as well as the fact that cowpea is not produced in the area and so the supply must be imported. During the collection period, it was noted by author Ira A. Herniter that street food in Accra cost twice as much compared to other locations, including both major cities like Kumasi,

Table 2. Estimated coefficients for cowpea seeds.

Coefficient	Estimate	Std. Error	t value	Pr(>|t|)	Significance
(Intercept)	7.95	0.84	9.49	< 2e-16	****
Location					
North (°)	-0.33	0.06	-5.16	3.82E-07	****
West (°)	-0.90	0.13	-6.94	1.46E-11	****
Vendor Gender					
Male vendor	1.78	0.59	3.03	2.57E-03	***
Seed coat color					
Brown	-0.23	0.38	-0.60	5.51E-01	-
Purple	-0.87	1.07	-0.82	4.15E-01	-
Purple Brown	0.12	1.72	0.07	9.45E-01	-
Red Brown	0.42	0.45	0.92	3.57E-01	-
Red Purple	0.28	0.52	0.54	5.91E-01	-
Red Purple Brown	0.63	0.59	1.06	2.92E-01	-
Seed coat pattern					
Full Coat	0.47	0.82	0.57	5.67E-01	-
Mottled	2.07	0.91	2.27	2.37E-02	**
Other	-0.92	0.57	-1.62	1.06E-01	-
Speckling	0.68	0.88	0.77	4.42E-01	-
Smooth	-0.59	0.76	-0.78	4.36E-01	-
Other seed characteristics					
100 seed weight (g)	0.09	0.02	4.07	5.62E-05	****
Holes per 100 seeds	-0.02	0.02	-1.30	1.96E-01	-

The intercept indicates a sample with the following characteristics: seeds with black coloring and an eye pattern, purchased from a female vendor. Probability codes: 0 = ****, 0.001 = ***, 0.01 = **, 0.05 = *. System R^2 = 0.26.

Table 3. Analysis of variants table for cowpea seeds.

Coefficient	Df	Sum Sq	Mean Sq	F value	Pr(>F)	Significance
Gender of Vendor	1	104.64	104.64	19.19	1.49E-05	****
100 seed weight (g)	1	211.27	211.27	38.74	1.14E-09	****
Holes per 100 seeds	1	0.00	0.00	0.00	9.79E-01	-
Seed Coat Color	6	32.70	5.45	1.00	4.25E-01	-
Seed Coat Pattern	4	44.43	11.11	2.04	8.83E-02	*
Seed coat texture	1	0.50	0.50	0.09	7.63E-01	-
North	1	166.82	166.82	30.59	5.51E-08	****
West	1	262.45	262.45	48.13	1.46E-11	****
Residuals	434	2366.58	5.45	-	-	-

Significance codes: 0 = ****, 0.001 = ***, 0.01 = **, 0.05 = *.

the capitol of the Ashanti region, and smaller towns like Bawku, in the Upper East region. Market location had a large effect on cowpea price. The price decreased in markets further north and west. The major areas of cowpea production in Ghana are in the north of the country. Indeed, the lowest average price could be found in the Upper West region, which produces the most cowpea in Ghana.

The dominance of women as petty traders in markets observed in this study, where 95.9% of samples were purchased from women vendors, conforms to previous research about vendors in Ghana. Both Langyintuo et al. (2004) and Mishili et al. (2009) reported that women are primarily the market vendors in Ghana. Indeed, in observations of markets in Ghana by the authors, it was noted that the majority of vendors of any type were

women. Men are much more highly involved in the wholesale business of cowpea grains.

The two most common patterns observed in samples were the presence of an eye, where pigmentation is restricted to the area around the hilum and full coat pigmentation. Previous studies on consumer preferences for cowpea seed traits have quantified the value of the eye pattern but make no distinction between types of eye (Faye et al., 2004; Langyintuo et al., 2004; Mishili et al., 2009; Mundua et al., 2010). Of the observed seed coat traits, only the mottled pattern had a significant effect on price. This could be due to the market already accounting for consumer preferences. For example, no samples consisted of seeds with black color and a full coat pattern. Indeed, it is common knowledge that no market exists for such seeds in West Africa.

The size of cowpea, as measured by 100 seed weight, averaged 17.4 g, with a standard deviation of 6.4 g. In contrast, cowpea sold in the United States has a 100 seed weight of 20-25 g (P. A. Roberts 2018, personal communication, 28 August). Since cowpea serves as a cash crop for many farmers, increases in both yield and seed size can have major positive effects on farmer income. It should be noted, however, that the observed seed size is higher than previously reported seed sizes of 12.2 g per 100 seeds in the north of Ghana (Langyintuo et al., 2004) and 14.4 g per 100 seeds in southern Ghana (Mishili et al., 2009). The observed increase in seed size could be due to the release and adoption of improved lines since the previous studies. Almost all the largest seeds, those with 100 seed weight greater than 30 g, for which sources were reported or which had names indicating the source, came from Nigeria. Nigeria is the largest producer of cowpea in the world, outputting 58% of worldwide production (IITA, 2018). In contrast, seeds which were purported to come from neighboring countries, such as Burkina Faso and Togo, had seeds similar in size to those produced in Ghana.

It is common knowledge that consumers are adverse towards bruchid holes in seeds, seeing those with holes as lower quality. The average number of holes observed across all of Ghana was 6.3 per 100 seeds, with a standard deviation of 3.4 holes. This indicates a low tolerance for bruchid holes across Ghana. Indeed, during collection of the samples, vendors were seen sorting through their stock to remove seeds with holes. Previous studies reported much higher levels of infestation than observed here. Langyintuo et al. (2004) reported an average of 13.0 holes per 100 seeds in northern Ghana while Mishili et al. (2009) reported an average of 12 in southern Ghana. No region examined in this study had levels of infestation comparable to these levels. The decrease in infestation levels may be due to the use of improved storage techniques, including the use of triple bag and chemical storage systems (Ibro et al., 2014). It is notable that the number of holes per 100 seeds was not found to have any significant effect on price. This may be due to the relatively low incidence of insect damage. Further, the collection period was in August and September, before the harvest, so the incidence of holes would be expected to be the greatest at this time.

While other analyses of cowpea prices were able to describe over 90% of observed price variation, the present analysis accounts for only 26% of the variability. One possible cause could be differences in sample collection methods. Previous studies collected samples at a small number of locations (3 to 5) over the course of several years, while the present study collected from many locations over the months of July and August. This period is referred to as the “hunger period” as it is between when the seeds have been sown, but the harvest has not yet been brought it. This shortage of supply causes prices to rise, especially in the south of the country where the supply must be imported, so it is the time of year with the highest prices. Additionally, the low number of samples collected for this study (562) compared to previous ones (over 500 per market) likely contributes to the low R^2 value. To better understand the national market, future studies should combine the approaches and collect both widely and over a longer time.

Conclusions

This study uses samples collected from 91 markets spread across the ten regions of Ghana in July and August 2018 to estimate the value of certain characteristics to consumers in Ghana. Consumers prefer large seed size and price is determined mostly by location of purchase. The specific pigments present on the seed coat, seed coat texture and most of the patterns of the pigmentation are of low importance to Ghanaian consumers. The location effect indicates that increased profits for smallholder farmers could be achieved through dissemination of varieties with larger seeds and with more developed infrastructure to allow smooth transport of goods.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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