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# **Hedonic price analysis to guide breeding for upgrading an orphan crop in India and Nepal**

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## 1 Introduction

There are many examples of less well-known plants, such as the ricebean (*Vigna umbellata*), which continue to be grown particularly in rural areas of developing countries, and thus contribute to the livelihood for small farmers, most of whom are poor. These species are known as ‘orphan’ or ‘underutilised’ crops. They are i) locally plentiful but globally rare, ii) there is little scientific information and knowledge about them available and iii) their current use is limited, relative to their economic potential (GRUERE ET AL. 2007). Many of these orphans have a high potential to be improved by breeding as a mean of generating food and sustainable income for the local producers and chain actors.

The ricebean as one orphan crop has received little scientific attention with the consequence that no enhanced varieties exist. Thus, it has fallen far behind the major pulses regarding area and produced quantity in India and Nepal. Disadvantages such as low yield and high labour inputs in comparison to e.g., green gram (*Vigna radiata*) and black gram (*Vigna mungo*) have resulted in a decrease of areas planted with ricebean.

The hypothesis behind this research is that plant breeding will reduce these disadvantages and improve its position against competing crops in two ways. First, by increasing the yield and, second, by introducing new varieties which would satisfy consumer preferences and therefore, fetch a higher price in the market.

Consumer preferences were obtained from ricebean samples with their respective prices from Nepalese and Indian markets. The samples were then analysed in labs to document several parameters. Multivariate regression was used to estimate the influence of characteristics significantly affecting prices. With this information breeders can assess the expected price of an improved ricebean variety at an early stage in plant breeding based on quantities of as little as 100 to 200 grams. The terms ‘characteristics’, ‘traits’, and ‘attributes’ are used interchangeably to designate quality attributes of products.

This paper is divided in three sections. The importance of the ricebean for people in India and Nepal is described in the first section. This includes information regarding ricebean marketing in rural markets, production and consumption, research efforts to improve the ricebean, and how the objectives of plant breeders complement with consumer desires. The second section provides a brief review of literature on hedonic price analysis followed by a description of the selected variables used in the analysis to identify the visible and cryptic

traits that influence the price of ricebean. Further, data collection and the results of the hedonic analysis are presented and discussed. The final section summarises the research results.

## **2 Economic issues in ricebean development in India and Nepal**

### **2.1 Ricebean: An orphan pulse crop in India and Nepal**

The ricebean (*Vigna umbellata*), is a traditional pulse in India and Nepal. Crops, like the ricebean are known as ‘orphan crops’ because they have been largely ignored by the research community despite their importance to rural livelihoods on a local level - particularly in poor areas. These ‘orphan’ crops tend to be well adapted to low-input conditions that are typical of marginal areas and so produce yields even in situations where modern crop varieties struggle to survive. However, no improved ricebean varieties have been developed and it is only grown by poor farmers living in marginal areas.

Ricebean is found in many parts of Nepal and in the Indian states of Uttarakhand, Orissa, Madhya Pradesh and Chhattisgarh, often intercropped with maize. Areas where the ricebean is grown today are characterised as remote in respect of access to markets and prevalence of subsistence households. The ricebean grows well on many soils, and exemplifies pest resistance as well as the potential for good yields of nutritious fodder for animals and high quality grain. There are no established marketing channels, and seed supply is also limited or non-existent. Thus, farmers who grow ricebean have to use their seeds from the previous year.

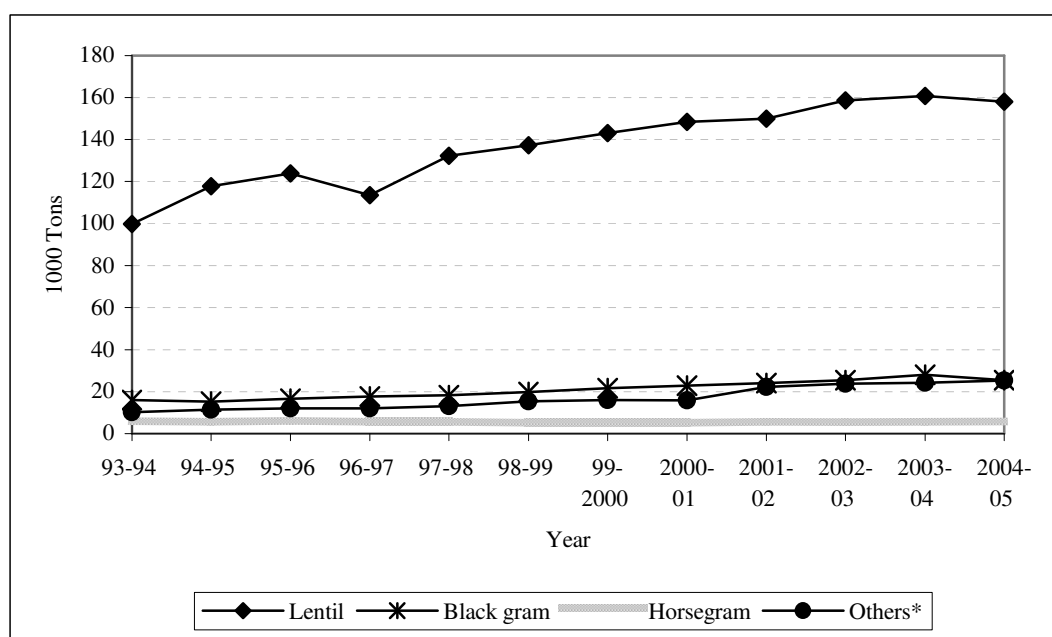
### **2.2 Ricebean marketing at rural markets, production and consumption in India and Nepal**

Since the ricebean is an orphan crop no official governmental data about area, yield or production exists. Only the Nepalese government documents a group of ‘other’ pulses (Figure 1) in their statistics which include the ricebean, referred to as *masyng*. One quarter of the group entitled ‘Others’ is represented by the ricebean. The graph also shows that the production of the most important Nepalese pulse, the lentil, has increased. The lines of pigeon pea, chickpea, grass pea and soybean did not show any positive or negative changes and were deleted from Figure 1 in order to enhance the clarity of the illustration.

There are four different purchase schemes through which the ricebean reaches the consumers in India and Nepal. The first possibility to purchase ricebean is *haats* or *mandis*. A

*mandi* is an official open market place with fixed operating days and hours. There are about 7,200 *mandis* in India which are usually situated near to important hubs of production, towns and district headquarters. Thus, farmers from remote areas have limited access to *mandis* and depend on commission agents and wholesalers to sell their products. The unregulated markets are called *haats* of which there are about 47,000 in India (DEBROY 2005, KUMAR AND PATWARI 2008). Comparable numbers for *mandis* and *haats* were not available for Nepal. Street traders represent the second alternative for consumers to buy ricebean. They sit at the roadside during the operating hours of the *mandis*. Fixed retail outlets are the third scheme through which ricebean is sold. These are the permanent shops in buildings can be specialised in selling certain goods such as pulses, however, the great majority of them trade in almost everything from food to hygiene products to toys. The fourth alternative to purchase ricebean is the emerging supermarkets (MINTEN 2008). These were found to be sources for purchasing ricebean in Nepal but not in India.

**Figure 1: Pulse production in Nepal, 1993-2005**



\* Masyng, Field pea, Cowpea, Broad bean, Phaseolus, Mungi etc.  
Source: Agricultural Census Nepal

The research carried out, in India and Nepal revealed that the ricebean is cultivated in many different ways. Often the ricebean is intercropped or mixed cropped with maize at maize field borders. Further, ricebean is grown on the terraces of rice fields alongside with pigeon pea. Seldom it is grown as sole crop. The area observed which farmers use for growing ricebean varies between 20 and 1500 m<sup>2</sup> in Nepal and 1.5 to 1000 m<sup>2</sup> in India. Nepalese farmers harvest approximately 0.1-0.6 kg per m<sup>2</sup>, whereas Indian farmers harvest

0.1 to 1.0 kg per m<sup>2</sup>. Many farmers use ricebean for home consumption only i.e., they do not sell it at markets because of the small quantity produced thus, preventing them from getting a good price for it.

A difference is seen with the consumption of ricebean in India and Nepal, as it is strongly connected to religion and rituals in Nepal but not in India. The ricebean is consumed during celebration of many festivals in Nepal, it represents a fixed part of their religious life. Mainly it is eaten as dhal, a kind of soup which is consumed together with rice. It can also be roasted and offered as a snack. Another form of preparation is to mix the soaked ricebean with spices and let it dry in the sun. Finally, ricebean is also used as fodder plant for animals.

### **2.3 Ricebean improvement research**

The complex ricebean research is conducted within the context of ‘Food Security through Ricebean Research in India and Nepal’ (FOSRIN), a 6<sup>th</sup> Framework Programme of the European Commission. It involves cooperation with seven different partners (including Universities, NGOs and governments) in Europe and Asia, including Agricultural Universities in Palampur (Himachal Pradesh) as well as Jorhat (Assam) both located in ricebean growing areas of India. The project aims to make ricebean a much more widely grown crop than it is currently the case, by providing varieties that match both farmers’ and consumers’ needs. The interdisciplinary cooperation in the project permits the identification of promising parents for breeding programmes, and varieties which also meet consumers’ preferences.

### **2.4 Plant breeding objectives and the desires of consumers**

In the case of this orphan crop ricebean, there are two main objectives which ought to be achieved. First, poor farmers in remote areas should benefit from an improved ricebean variety with higher yields and good pest resistance in order to feed their families and animals. Thus, a new ricebean variety has to fit within farmers’ agronomic and taste preferences. In the second place, farmers should be able to leave their subsistence level and sell the ricebean at markets thereby producing income. Consumers, who purchase at markets, will only purchase ricebean which meets their preferences, regardless of agronomic constraints. Thus, there has to be a compromise between breeding in order to secure better yields and other agronomic aims and the preferences of consumers which can include farmers and non-farmers. Consumer’s preferences were captured by estimating a hedonic demand function which is explained in the next section.

### **3 Estimating a hedonic demand function for ricebean**

#### **3.1 Brief review of hedonic demand estimation**

The central idea of the hedonic price analysis is that goods are valued by consumers for their utility deriving characteristics (LANCASTER 1966). Hence, consumers are not evaluating the good itself but the characteristics of goods and demand is a function of product characteristics, not of the product. But the demand for a special characteristic is revealed through the demand for a product that contains that characteristic. Therefore, if the quantity of the characteristic demanded changes, the product prices will change too (BROCKMEIER 1993).

Rosen (1974) proposed that characteristics have implicit prices in competitive markets because consumers evaluate the characteristics by purchasing the product with the desired attribute. Further, the market price is a sum of all the implicit prices of all quality characteristics. Thus, the product price is a function of its characteristics  $p(z) = p(z_1, z_2, \dots, z_n)$  (ROSEN 1974).

The hedonic price analysis has been applied many times to identify characteristics of food products which significantly influence the price. This was done by Frederic Waugh (1927) when he found a relationship between changing qualities of asparagus and changing prices (WAUGH 1928). The study conducted by Ladd and Suvannunt aimed to develop a consumer goods characteristics model with retail prices per pound. They found a willingness to pay for energy and protein and a willingness to avoid phosphorus, iron and vitamin C (LADD AND SUVANNUNT 1976). Similar results were stated by Brockmeier (1993), when she analysed German fruit juice. Consumers had a negative willingness to pay for minerals and they preferred energy in form of kcal and vitamins (BROCKMEIER 1993). In her Ph.D. thesis, Jiménez Portugal investigated price differences of bean lots in Mexico and changing quality characteristics. The quality characteristics that were detected to be significant relative to price were moisture content, cooked protein, carbohydrates digestibility, hectolitre, dry weight and non shrunken beans (JIMÉNEZ PORTUGAL 2004). Finally, the presented studies show that there are preferred characteristics of food and therefore influence the price.

### 3.2 Determinants of ricebean value to consumers

As described in the beginning of this section, goods are valued by consumers because of their utility-deriving characteristics. Thus, the quality or value of a whole good depends on its individual characteristics. The quality of a specific item as evidenced through consumers acceptance and purchase is not determined by a few visible characteristics. It is more a complex composition of several traits where many of them are not visible (VON OPPEN 1978). Characteristics of beans which influence the quality and therefore the value for consumers can roughly be separated into two groups, evident and cryptic characteristics. Evident traits like colour or shape are visible to consumers whereas cryptic traits are not visible and can only be judged after consumption. Examples of cryptic traits are composite ingredients such as fat or protein and culinary qualities like swelling capacity. Both types of characteristics, evident and cryptic, are related to each other. Thus, consumers by evaluating evident characteristics, infer certain conclusions regarding the cryptic characteristics. For instance, it is widely known that a really green apple will taste sour whereas, red or yellow apples tend to be sweet (JIMÉNEZ PORTUGAL 2004).

The characteristics in Table 1 which were included into the hedonic price analysis were chosen by reviewing articles concerning the nutritional composition of ricebean as well as characteristics affecting domestic processing and cooking (JIMÉNEZ PORTUGAL 2004, MALHORTA ET AL. 1988, THARANATHAN AND MAHADEVAMMA 2003, PATWARDHAN 1962). After choosing the traits chemical analysis provided by the AOAC (Association of Official Analytical Chemists) catalogue was applied. The analysis in Nepal was conducted in the lab of a project partner, Li-Bird in Pokhara. In India, the samples were analysed at the Agricultural University in Anand, Gujarat.

**Table 1: Selected characteristics for the hedonic price analysis**

<i>Ricebean characteristic</i>	
1. Fat	8. Swelling capacity
2. Protein	9. Water up-take capacity
3. Moisture	10. L/B ratio
4. Ash	11. Colour
5. Carbohydrate	12. Share foreign matter
6. Crude fibre	13. Colour diversity index
7. 100-seed weight	

Table 2 gives an overview of the quality characteristics that were quantified in the labs. All characteristics explained below are in the order used in Table 2. The price as the dependent variable is shown to give an idea of the ricebean price variation. The weight of 100



seeds is used as an indicator for the seed size. The higher the weight of a sample of 100 seeds, the bigger the seeds. The water uptake measures the weight increase by soaking. Ricebean like other pulses is soaked over night before cooking; thus it is an important processing trait. Instead of weight increase the swelling capacity documents the volume increase by soaking. Both traits were quantified with a sample size of around 100 seeds not with single seeds. That gives the advantage that both characteristics can reveal the problem of hard seeds. Hard seeds are definitely not preferable because their seed coat is impermeable for water. Hence, these seeds do not swell and often stay hard even after cooking (REYES-MORENO ET AL. 2000). The ricebean form was measured by the length to breadth ratio. A value of one would reveal a round form because length and breadth are the same, however, the minimum value of the L/B ratio in the sample (Table 2) is 1.36 which depicts an elongated form. The maximum value is at 2.05 and compared to the minimum value it shows the great differences in ricebean forms. The cleanliness or purity was determined by weighing the sample with and without dirt. Dirt and foreign materials include small stones, other pulses and broken/ destroyed beans. The foreign material corresponds to the share which would be removed before soaking or cooking the ricebean.

**Table 2: Outline Indian and Nepalese samples**

Characteristic	Unit	Minimum	Maximum	Mean	Standard deviation
Price Nepal	Nepalese Rupees (NPR)/kg	25.00	65.00	43.38	9.94
Price India	Indian Rupees (INR)/kg	12.20	36.00	23.22	6.81
Seedweight	g/100 seeds	4.07	19.42	9.20	3.33
Water uptake ratio	Ratio of weight increase	1.69	2.20	2.00	0.11
Swelling capacity ratio	Ratio of Volume increase	1.02	1.96	1.33	0.30
LBRatio	Ratio length to breadth	1.36	2.05	1.66	0.16
Foreign matter	%	1.10	19.31	6.81	3.53
Moisture	%	8.10	15.51	10.26	1.16
Ash	%	2.44	5.10	4.03	0.49
Fat	%	0.12	0.75	0.39	0.16
Protein	%	14.53	32.16	22.53	4.14
Carbohydrates	%	58.15	71.99	65.08	3.49
CrudeFibre	%	3.55	6.98	4.71	0.76
Colour diversity	Herfindahl-Index	0.27	1.00	0.59	0.22

N = 162

Source: Own data

The moisture content depicts the remaining water in the seeds. This characteristic is often disliked by consumers because good quality ricebean is carefully dried in the sun and freshly harvested seeds have considerably higher water content. The characteristic ash denotes the quantity of remains after the ricebean sample was burned in a funnel. Therefore, ash does not contain any organic material, rather only minerals such as iron, zinc or copper. When

compared to related pulses like black gram and green gram the ricebean has a higher average ash content. Analyses of the ricebean revealed an ash content of 4.38 per cent (KAUR AND KAPOOR 1991) and the analysis for this article depicts an average ash content of 4.03 per cent. This can be contrasted with the ash content of black gram which is about 3.64 per cent (KAUR AND KAPOOR 1991) and for green gram 3.32 per cent (USDA 2008). The fat content in ricebean is approx. 0.4 per cent. Another important component for the inhabitants of developing countries is protein because many Indians and Nepalese are vegetarians and proteins from animal products are more expensive than proteins from plant products. The protein content of ricebean is on an average 22.5 per cent and was determined by the nitrogen content. The digestible carbohydrates were calculated based on of the Weender analysis. Due to the fact that moisture, fat, protein, ash and crude fibre are determined in per cent they can be subtracted from 100 per cent. The remaining share contains digestible carbohydrates. Crude fibres belong to carbohydrates but they cannot be fully digested in the human intestine. The characteristic colour is mentioned in Table 1 only; it is not shown in the outline of Table 2. The different prevalent colours in each sample were measured to identify preferred colours and to determine whether consumers prefer mixed coloured lots of ricebean. The latter was calculated by a colour diversity index. Usually ricebean is offered in sacks at the markets and consumers will find, e.g. pure black, yellow and gray ricebean or they find all or some of these colours mixed together in one sack.

Several diversity indices from different fields such as ecology exist. The simplest way to measure diversity is to count the different colours, but that does not consider the frequency i.e., the per cent share of each colour is ignored (DRESCHER 2007). The Herfindahl-Index (*HI*) shown in F 1 is often used to determine industrial concentrations (PATIL AND TAILLIE 1982). It is calculated as the sum of the quadratic colour shares of each sample (DRESCHER 2007). The Herfindahl-Index (*HI*) is defined as follows:

$$\text{F 1: } HI = \sum_{i=1}^n s_i^2$$

where  $s_i$  is the relative abundance of the  $i$ th colour e.g., black in the sample containing  $S$  colours (MOUILLOT AND LEPRÊTRE 1999). It ranges from  $1/n$  to 1, whereas the maximum value of 1 indicates total concentration i.e., the sample consists only of one single colour (DRESCHER 2007).

The Simpson or Berry-Index (*BI*) presented in F 2 is closely related to the Herfindahl-Index as their indices are reversions of each other. The Berry-Index ranges from 0 to 1-1/n, whereas 0 indicates no diversity in colour and 1-1/n means equal distributed colours.

$$\text{F 2: } BI = 1 - \sum_{i=1}^n s_i^2$$

Economists take advantage of the Berry-Index to determine industrial concentrations and ecologists apply it as the Simpson-Index to estimate diversities of species (PATIL AND TAILLIE 1982).

The third diversity index presented in F 3 is the Entropy-Index (*EI*), which is defined as follows:

$$\text{F 3: } EI = \sum_{i=1}^n s_i \ln\left(\frac{1}{s_i}\right)$$

Values of *EI* range between zero and  $\ln(n)$ , whereas the value of zero results when the share of a colour equals one which reveals unequal distribution. Thus, the maximum value of  $\ln$  of  $n$  presents total equal distribution (LEE AND BROWN 1989).

Another but very similar diversity index is presented in F 4, the Shannon-Index (*H*) (MOUILLOT AND LEPRÊTRE 1999).

$$\text{F 4: } H = -\sum_{i=1}^n s_i \log(s_i)$$

This review of diversity indices does not claim to be complete. Several indices like Gatlin's-Redundancy-Index, Camargo-Evenness-Index, Pielou-Regularity-Index or the Gini-Coefficient are also used to determine diversity but it is not necessary for our purpose to enter into a detailed explanation of all of these methods. In any event, the Herfindahl-Index was chosen because it cannot take the value zero. This is important since the metric variables are taken into the regression in log form. The next section contains some facts about the sample collection circumstances.

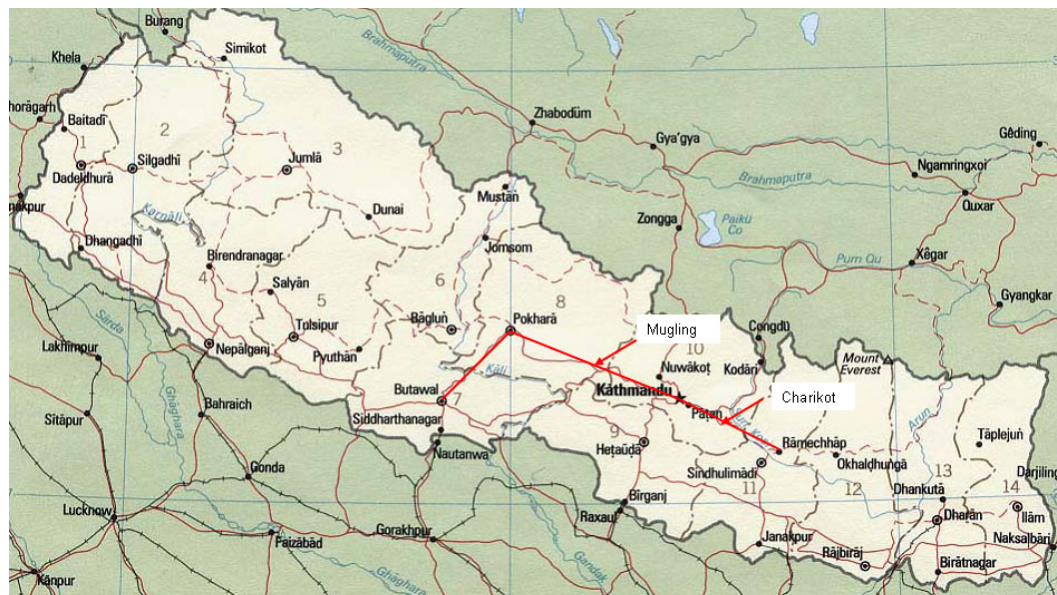
### 3.3 Ricebean sample collection and analysis

Ricebean is planted in June-July and the harvest season is from October to November. The sample collection in India and Nepal had to be organised within a restricted time period to ensure comparable qualities and the availability of ricebean in the markets.

All samples were collected between January 10<sup>th</sup> and March 9<sup>th</sup>. The locations investigated were selected through a distribution report conducted by the Nepalese and Indian partners of the project. Sample collection began in Nepal, Ramechhap, which is located in the

east of Nepal, the right end of the red line illustrated in Figure 2. All together 14 market places were visited to collect 114 ricebean samples in Nepal. The route can be reconstructed by following the red line in Figure 2 from right to left.

**Figure 2: Locations in Nepal**



In India, 56 ricebean samples were collected in the states Chhattisgarh, Orissa and Uttarakhand. The research in the east of Madhya Pradesh was unsuccessful because the ricebean was not available in the markets only ricebean growing farmers were found. Ricebean samples were collected from 16 markets in India.

**Figure 3: Locations in India**



The first samples were collected in Chhattisgarh. The two main areas in Chhattisgarh are marked in the map (Figure 3) with red circles and denoted with a number 1 within the circles. The work in Chhattisgarh was hampered by Naxalite riots, a communist movement in India. Their presence prevented access to remote areas and markets. The order of the remaining areas can be reconstructed according to the numerical sequence illustrated.

### 3.4 Estimates of hedonic demand functions

Multivariate regression was used to estimate the influence of characteristics significantly affecting price. The statistical analyses were conducted with SPSS, statistics software. The characteristic water uptake was eliminated because of correlation with the characteristic swelling capacity.

As functional form a double-log was chosen because it gives direct indication of the elasticity of every characteristic. The equation is shown in F 5 where  $P_i$  is the price of a ricebean sample,  $\alpha$  is the constant,  $\beta_1$  is the coefficient of characteristic 1, e.g. fat and  $q_{1i}$  is the quantity of characteristic 1 in sample  $i$ . The last term represents the random error.

$$\text{F 5: } \ln P_i = \ln \alpha + \beta_1 \ln q_{1i} + \beta_2 \ln q_{2i} + \dots + \beta_j \ln q_{ji} + \mu$$

Due to the large number of independent variables, a stepwise regression with price as dependent variable was conducted. Initially 20 variables were included in the model and all irrelevant independent variables were incrementally eliminated (BÜHL, 2002). All eliminated variables are shown in the right column of Table 3. The dependent variable price and all metric independent variables were put into natural log form. The log form was chosen to facilitate the interpretation of the variables coefficients. The calculated coefficients can be read as elasticities of the characteristics. Further, dummy variables were introduced to differentiate countries and regions within countries. Table 3 depicts the results of the regression. The country variable for India and Nepal was included because the samples of each country were analysed within the country. Thus, the data of two laboratories were used and the dummy was necessary to prevent distortion in the results. The location of markets is reflected by a dummy with three categories, rural, semi-urban and urban. The assumption is that ricebean is not grown in cities and thus ricebean prices/ kg rise with proximity to cities because of transportation and transaction costs. The locations were grouped into the categories due to their population density in persons/km<sup>2</sup>. The base category is semi-urban.

The characteristics fat, seed weight, colour group gray, location rural and the Herfindahl index have a significant influence on price at a level of  $\alpha = 0.01$ . Whereby, fat and

seed weight have a positive influence and colour group gray, location rural and the Herfindahl index have a negative influence. Consumers prefer a high fat content, which is reasonable due to its high caloric energy. With regard to the colour diversity consumers prefer mixed coloured ricebean lots. The Herfindahl-Index ranges from  $1/n$  to 1, whereas the maximum value of 1 indicates total concentration i.e., the sample consists only of one single colour. The Herfindahl index has a negative value and by reducing this characteristic diversity increases. The negative value of rural indicates that prices in rural areas are significantly lower than in semi-urban areas. Further the colour black is significantly preferred at a significance level of  $\alpha = 0.05$ .

**Table 3: Regression results**

Dependent variable: ln price		
Variable		Eliminated variables
Constant	<b>2.113</b> *** (5.84)	Country
ln_protein	<b>0.204</b> * (1.86)	ln_moisture
ln_Fat	<b>0.187</b> *** (3.59)	ln_CrudeFibre
ln_Seedweight	<b>0.305</b> *** (6.14)	ln_Carbohydrates
ln_Foreignmatter	<b>-0.044</b> * (-1.48)	ln_Ash
ln_LBRatio	<b>0.287</b> * (1.85)	ln_Brown_group
ln_SwellingCap	<b>0.027</b> (1.27)	ln_Yellow_group
ln_Black_group	<b>0.014</b> ** (2.35)	Urban
ln_Gray_group	<b>-0.013</b> *** (-2.79)	
ln_Olive_group	<b>-0.007</b> * (-1.85)	
ln_Red_group	<b>-0.009</b> * (-1.92)	
Rural	<b>-0.420</b> *** (-11.34)	
ln_Herfindahl_Index	<b>-0.146</b> *** (-2.67)	
N:162; adj.R <sup>2</sup> :	0.65	

\*\*\*/\*\*/\* significant at 1; 5 or 10% significance level, T-values in bracket

Source:Own data

The characteristics protein, foreign matter, LB ratio and the colours olive and red are significant at a level of  $\alpha = 0.1$ . Protein is preferred by consumers because pulses are a cheap source for proteins in low income countries such as India and Nepal. Other sources of protein like animal products (meat) are costlier than pulses.

A LB ratio of 1 would indicate a round form and higher values indicated a longish form. The value of the LB ratio is positive, thus consumers prefer longish ricebean. Further, the colours olive and red are not favoured by consumers. The following section refers to the interpretation of the coefficients obtained from the regression.

### 3.5 Interpretation of results

The following interpretations of the results are made under *ceteris paribus* assumptions. If one variable is changed all remaining variables remain constant. The coefficients for the colour black, gray, red and olive indicate that consumers in India and Nepal prefer black ricebean and do not like gray, olive and red ricebean. For the interpretation of the remaining characteristics Table 4 is used.

**Table 4: Significant characteristics**

Characteristic	Mean	Minimum	Maximum	Difference	%	Coefficient	Price effect %
Seed weight	9.14	4.07	19.42	5.06	124	0.31	38
Herfindahl Index	0.59	0.27	1.00	-0.32	-119	-0.15	17

Source: Own data

Table 4 includes the quality variables seed weight and colour diversity (Herfindahl Index) with their respective means, maximums and minimums to show how the trait differs in the sample. Since the coefficient is the price elasticity of a characteristic, a percentage change in the quantity of the characteristic changes the price by the coefficient. Seed weight has a positive coefficient of 0.31. That means consumers like bold ricebean seeds and an increase in the seed size would increase consumers willingness to pay. An increase of the sample's minimum value to the mean value would imply an increase from 4.07 g/100 seeds to 9.14 g/100 seeds. This reveals a relative gain of 124 per cent. A 124 per cent increase multiplied with the coefficient/ elasticity of 0.305 results in a price increase of 38 per cent, assuming all other characteristics remain constant. The negative elasticity of the Herfindahl-Index could be interpreted as follows. Decreasing the index implies an increase of colour diversity (see F 1). If the index is reduced from the mean value of 0.59 to the minimum value of 0.27 the value of ricebean reflected by the price would increase by 17 per cent because consumers like high colour diversity. A price increase reflects that consumers are willing to pay a higher price because the ricebean has the preferred characteristics.

## 4 Conclusion and discussion

Breeding without having consumer's needs in mind can lead to crop varieties which help neither farmers nor consumers. Where farmers cultivate an improved crop with high yields and better pest resistant, this is only beneficial if that crop can be sold to generate income. In the worst case scenario, even the farmer himself is not interested in consuming the ergonomically superior crop. There has to be a balance between agronomic improvements and the preferences of consumers.

The results show that there are potential characteristics which should be considered when breeders choose the parents for further breeding. Increasing the seed size which is depicted by seed weight and colour diversity would have a positive price effect reflecting consumer preferences. As also shown in Table 3 consumers do not like foreign material nonetheless, the content of foreign matter is not a breeding problem. Farmers or traders could solve this problem by cleaning the ricebean prior to selling, as this paper shows the prevailing willingness to pay for cleaner ricebean lots. With these elasticities breeders can assess the expected price of an improved ricebean variety at an early stage in plant breeding as quantities of 100 to 200 grams are sufficient to calculate the consumer preferences.

Future prospects must combine farmers and consumers requirements. In conclusion, an improved breed of ricebean could pave the way for an increase in yield and higher prices for better quality.

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