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## ABSTRACT

The potential of brown rice Just-In-time Hulling Technology (JITHT) was analyzed through qualitative and quantitative research. The proposed JITHT aims to produce brown rice at the right place, at the most appropriate time, and at the right price considering that brown rice has a very short storage life and has high price in the market.

A total of 174 respondents were interviewed in the field. They are among the brown rice consumers, retailers and millers.

The research has successfully established the basic technical specifications including the financial and socio-economic factors that may warrant the viable operation and acceptability of the proposed technology. The JITHT could well fit the operational requirements of 'regular rice retailers' at output capacity of 104 kg/hr and at a selling price of P18,500/unit. Likewise, the technology could also be feasible at the consumer's level but at output capacity of only 12 kg/hr and selling price of Php8,500/unit, subject to some environmental and operational restrictions.

The development and eventual commercialization of the technology could contribute in making brown rice readily available and affordable in the market, thus, will lead to the wider consumption of brown rice in the country.


## INTRODUCTION

Under the road map of the Food Staples Sufficiency Program (FSSP) of the government for 2011 to 2016, managing and maintaining the per capita rice consumption of 120 kg/yr (DA-BAS, 2011) through the consumption of unpolished or brown rice is one key strategy in achieving rice self-sufficiency (DA, 2011). Brown rice is a type of whole, natural grain that has a mild nutty flavour. Also called "unpolished rice," it is produced by removing the hull of each grain of rice, retaining its outer, brown-colored bran layer.

The widespread consumption of brown rice could positively affect both the supply and demand of rice in the country. Brown rice has the potential of increasing the availability of rice supply in the market by 10 to 15 percent as a result of its 70 to 78 percent milling recovery compared to white rice' 65 to 67 percent milling recovery. The high milling recovery of brown rice is mainly because of the non-removal of the bran part which is reported to contain essential nutrients (Cade, 2007; Erkkila, 2005).

Likewise, brown rice will not only contribute in addressing food security but also help solve the problem of malnutrition in the country. Brown rice is rich in vitamins and minerals. According to USDA SR-21, each cup of cooked brown rice (195 g) provides 216.45 calories, or 12.03 percent of the daily value (DV). It is also an excellent source of manganese, a trace mineral, providing 88 percent DV, and a good source of selenium and magnesium, providing 27.3 percent and 21 percent DV, respectively. A cup also contains protein (10.06% DV), carbohydrates (14.92% DV) and dietary fiber (14.04% DV).

The process that produces brown rice removes only the outermost layer, the hull of the rice kernel and is the least damaging to its nutritional value. The complete milling and polishing that converts brown rice into white rice removes 15 percent of protein, 85 percent of fat, 90 percent of calcium, 75 percent of phosphorous, 80 percent of thiamine, 70 percent of riboflavin, and 68 percent of niacin (Fortin, 1996). Per USDA report, fully milled and polished white rice in America is required to be "enriched" with vitamins B1, B3 and Iron. But the form of these nutrients when added back into the processed rice is not the same as in the original unprocessed grain, and at least 11 lost nutrients are not replaced in any form even with rice "enrichment" (Rabbani and Ali, 2009).

Brown rice constitutes a small portion of the rice market and is considered a niche market for many. Pabuayon and Quilloy (2011) noted that majority of the consumers do not eat brown rice continuously but rather do so for less than a year to 2 years. The estimated volume of brown rice traded in Luzon in 2009 was about 396 metric tons that were mostly sold in Metro Manila. The estimated monthly consumption was low at 6.75 kg per household. Based on this consumption pattern, it is estimated that about 5,000 households have included brown rice in their dining table.

The study of Pabuayon and Quilloy (2011) revealed that brown rice consumers discontinued their consumption because brown rice was expensive, had poor eating quality and was not readily available. The study also revealed that majority of brown rice consumers are "better off" (middle to high-income groups) and health conscious consumers who can afford to buy the commodity even at a given price of as high as Php 59/kg which was almost double the price of white or polished rice. But most importantly, it was emphasized that one of the major constraints in the market chain of brown rice in Luzon is the lack of milling equipment specifically designed for it.

The most significant drawback on brown rice is its shorter shelf life due to its susceptibility to microbial and insect damage. The hulling process breaks-up the bran cells, releasing their lipase enzyme that breaks down the oil in the bran, and produces free fatty acids that causes rancidity and spoilage (Champagne and Grimm, 1992). Based on the initial result of environmental scanning, brown rice starts to deteriorate one month after milling. Hence, producing big volumes of brown rice without a readily available market could be too risky on the part of producers due to storage problem.

One approach in dealing with the short shelf-life of brown rice is the development of "just- in-time hulling technology" (JITHT). As noted by Liker (2003) and Womack and Jones (2003), it would be desirable to introduce synchronised flow and link "Just-in-time" (JIT) through the entire supply chain. As such, the concept of the JITHT is to have a small capacity hulling machine that is readily accessible in the households so that they can mill their two to four-week supply and properly manage their brown rice inventory thus avoiding quality deterioration.

To ensure that there will be a potential taker of the proposed JITHT, it has been decided that an ex-ante be conducted first. This bold move by PHilMech management is consistent with the advocacy of the International Development Research Center (IDRC) and other leading international and local research institutions for the aggressive

commercialization of mature technologies. The IDRC (1986) discovered that research is often confined to the laboratory or pilot plant, with products or processes being developed in the absence of market evaluation. As noted by Young and Mac Cormac (1986), many projects in the food technology field in developing countries are never commercialized. The research investments are wasted because of the absence of conducting ex-ante market assessment. Mongkolsmai (1986) thus emphasized that the purpose of the "market assessment" is to provide the necessary information about the market to aid decision-making about product development and marketing. The required information include identification of the consumers of the target group, acceptability of the product to the consumers, their willingness and the ability to pay for the product/ machine at various prices, and social factors that may affect utilization or consumption.

As such, the process and findings that emerged in this research will help resolve the management decision and marketing research problems. The management decision problem was to determine if PHilMech should proceed in the development of a household type brown rice huller as initially proposed. The marketing research problems are to determine if there are some potential buyers and what should be the basic features of the proposed JITHT so that this will be adopted by the target end-users.

## OBJECTIVES

**General:**

The project aimed to establish the potential viability and acceptability of brown rice Just-In Time Hulling Technology (JITHT) in the market.

**Specific:**

1. Characterize the consumers and handlers of brown rice;
2. Determine the basic features of the technology in terms of capacity, operating costs/requirements, and price, among others, to satisfy the requirements of the market;
3. Establish the socio-economic factors that influence the adoption of the proposed technology by the target end users; and,
4. Identify the potential changes in the marketing system/practices that will lead in the potential adoption of the technology.

## CONCEPTUAL FRAMEWORK

The conceptual framework of the project is illustrated in Figure 1 following the traditional input-process-output model approach. The figure starts with the major causes of problems concerning the physical characteristics of brown rice --its very short storage life of four weeks under ordinary condition before it starts to deteriorate; and the limited supply of rice variety with good milling recovery and palatability. These problems cause the instability of supply and high price of brown rice in the market.

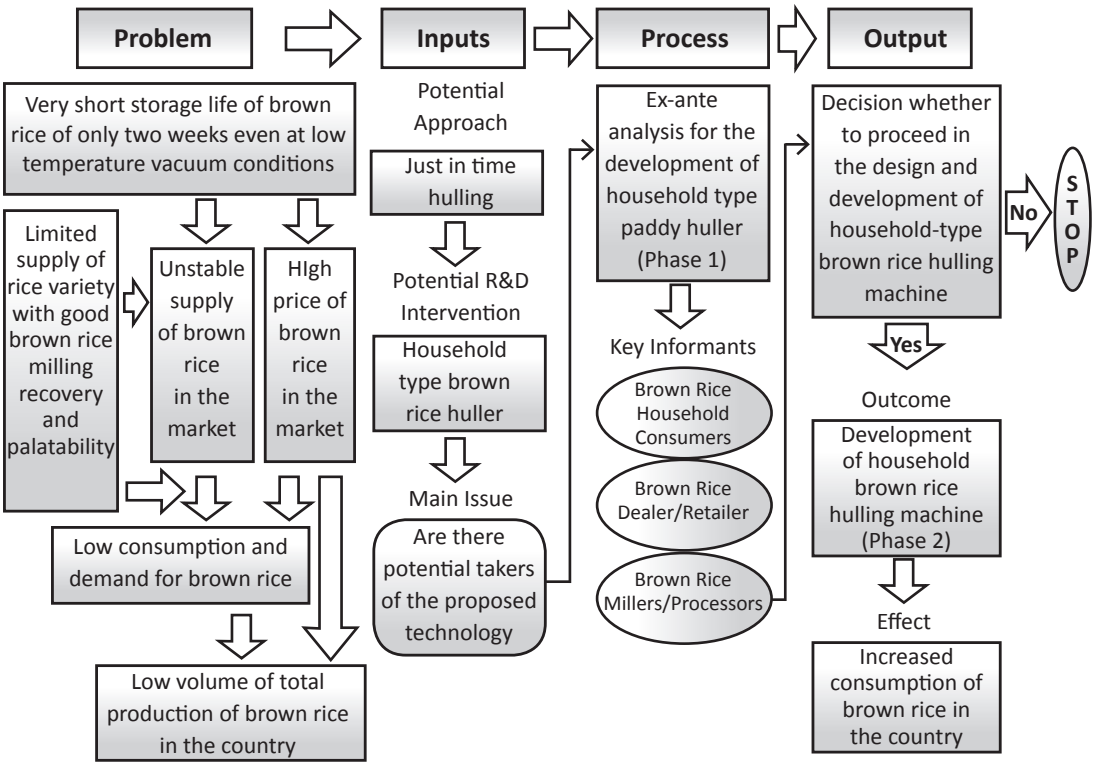



Figure 1. Project conceptual framework

Therefore, the major challenge on the part of the engineers is how to produce brown rice at the right place, at the most appropriate time, and at the right price. As an input in dealing with the stated problems, one potential approach is the JITHT, wherein the household can produce their one-to-four-week brown rice requirements right at their own backyard. Likewise, it was assumed that the potential user of the technology is not limited to household consumers but also the rice retailers.

In the case of rice retailers, it was assumed that they will use the proposed JITHT at the time the demand arises or use it to maintain a manageable inventory given the high risk of maintaining large volume of stocks of brown rice. In dealing with the problem, the process involves an assessment on the potential of the proposed technology in the

market. Survey was conducted with household consumers, rice dealers/retailers and the rice millers. The hypothesis used indicates that there are indeed viable potential takers of the proposed technology, which is the main output of this research.

## METHODOLOGY

### Identification of Respondents and Development of Survey Questionnaires

Three groups were identified as key informants. They include (1) brown rice consumers; (2) brown rice wholesalers/retailers; and, (3) brown rice millers/distributors.

It was assumed that the target buyers of the proposed JITHT are the current brown rice consumers and rice retailers. As such, two different types of structured questionnaires were developed for the conduct of field survey for household consumers and rice retailers.

Table 1. Location of study areas and number of respondents

| Type/Location | Consumers | Retailers | Millers | Total |
|---|---|---|---|---|
| Luzon | 50 | 26 | 4 | 80 |
| Metro Manila | 10 | 9 | 0 | 19 |
| Nueva Vizcaya | 8 | 8 | 2 | 18 |
| Nueva Ecija | 21 | 5 | 2 | 28 |
| Isabela | 5 | 0 | 0 | 5 |
| Baguio, Benguet | 6 | 4 | 0 | 10 |
| Visayas | 44 | 18 | 4 | 66 |
| Metro Cebu | 17 | 3 | 0 | 20 |
| Bohol | 9 | 11 | 1 | 21 |
| Iloilo | 18 | 4 | 3 | 25 |
| Mindanao | 22 | 5 | 1 | 28 |
| Cagayan de Oro | 7 | 5 | 1 | 13 |
| Davao and others | 15 | 0 | 0 | 15 |
| TOTAL | 116 | 49 | 9 | 174 |

The current brown rice consumers are classified as those who eat brown rice on a regular basis but not necessarily every day or thrice a day. Rice retailers, on the other hand, are those market intermediaries that link brown rice producers/millers and consumers regardless of volume of sales, as long as they are engaged in direct selling to the brown rice consumers.

**Sampling Procedure**

Given the very limited number of stakeholders currently involved in the emerging brown rice industry, the respondents were purposively selected in Luzon, Visayas, and Mindanao. The respondents were located based on referrals from current brown rice consumers including those existing brown rice retail outlets in the market. From this, the active brown rice millers, retailers, and consumers in the given locality were identified.

**Data Gathering**

Data were gathered using sets of questionnaires, key informant interviews, use of secondary data, and actual observation. Secondary data, in the form of published research studies were obtained from library research and the World Wide Web.

**Locations of the Study, Samples and Sample Size.**

The collection of data was conducted in highly urbanized cities and nearby municipalities to capture the different types of current brown rice consumers, retailers and rice millers. Table 1 shows the total number of study samples for current brown rice consumers, retailers and millers per selected provinces in Luzon, Visayas and Mindanao. There were 174 respondents during the study period from April 1 to September 30, 2012.

**Method of Analysis**

After the field interview, the data gathered were organized and summarized. Data analysis was done using descriptive statistics presented in tabular and graphical forms.

To characterize the consumers and handlers of brown rice, qualitative analysis was primarily explored to understand 'how' and 'why' the target takers would use the proposed technology instead of focusing only on 'what' motivates the target takers to adopt the proposed technology. Quantitative analysis was also explored to develop and employ mathematical or econometric models or hypotheses that will support the results of qualitative research.

The profit maximization model was used in analyzing the major characteristics of the technology in terms of capacity, operating costs/requirements, price, among others, that could warrant its acceptability and viability.

The profit maximization model, can be expressed as:

$$\pi = \sum_{i=1}^{n} p_i y_i - \sum_{i-1}^{m} w_i x_i \qquad (1)$$

where $\pi$ is the profit; $p$ is the price of output; $y$ is the total output; $w_i$ is prices of input; $x_i$ is the factor of production. As evident, the first term of the equation is the revenue, and the second term is costs.

One way to maximize the profit of the firm is to minimize the costs of producing any given level of output (Varian, 2009). In this research, it was assumed that the brown rice consumers or retailers could minimize their cost by producing their own brown rice using the proposed JITHT. Likewise, it was assumed that the JITHT is a perfect substitute technology in the production of brown rice, wherein consumers and retailers would use whichever cheaper options are available/beneficial to them. Therefore, the benefits to be derived using the proposed JITHT, Bπ, can also be expressed as

$$\mathbf{B\pi} = \sum_{i=1}^{n} p_i y_i - \sum_{i-1}^{m} w_i x_i = R - c \qquad (2)$$

The first term (R) is the cost using the current system of producing brown rice, while the second term (c) is the cost involved using the proposed JITHT. Therefore, the total operating cost of the proposed brown rice JITHT (second term of equation 2) should be less than the current cost of buying brown rice using the traditional way to realize positive benefits.

One powerful tool in evaluating the desirability of investments for a certain period is by computing the internal rate of return (IRR). The IRR of an investment or project is the "annual effective compounded return rate" or "rate of return" that makes the net present value (NPV) of all cash flows (both positive and negative) from a particular investment equal to zero (Hazen, 2003). In more specific terms, the IRR of an investment is the discount rate at which the NPV of costs (negative cash flows) of the investment equals the NVP of the benefits (positive cash flows) of the investment, as depicted in the following equations:

NPV = 0

Present Value of Future Cash Flows – Initial Investment = 0 (3)

$$\left[\frac{CF_1}{(1+r)^1} + \frac{CF_1}{(1+r)^1} + \frac{CF_1}{(1+r)^1} + \ldots + \frac{CF_1}{(1+r)^1}\right] - I_i = 0$$

$$\left[\frac{CF_1}{(1+r)^1} + \frac{CF_1}{(1+r)^1} + \frac{CF_1}{(1+r)^1} + \ldots + \frac{CF_1}{(1+r)^1}\right] - I_i \qquad (4)$$

where r = internal rate of return, CF1= period one net cash inflow, CF2= period two net cash inflow, CF3= period three net cash inflow, and so on, and I_i = initial investment cost.

Suppose that the acquisition cost of the JITHT (K) is only the initial investment cost (I_i), and CF is equal to R – c, then Equation 5 will become:

$$K = \sum_{j=1}^{n} \frac{(R-c)}{(1+r)^j} \qquad (5)$$

Simplifying equation 5, the IRR is defined as r that satisfies the following equation:

$$K = \sum_{j=1}^{n} \frac{(R\text{-}c)}{(1+r)^j} = \frac{(R\text{-}c)\ \{(1+r)^j - 1\}}{\{r(1+r)^n\}} \qquad (6)$$

where K = acquisition cost of the brown rice JITHT, R = cost involved in acquiring brown rice using the traditional way or the first term of equation 2, c = total cost involved in producing brown rice using the proposed brown rice JITHT or the second term of equation 2, and n is the usable life of the brown rice JITHT. If the estimated IRR of the proposed JITHT is greater than the current discount rate, the proposed technology is found to be economically feasible.

Finally, quantitative analysis using Probit regression model was employed to establish the socio-economic factors that may influence the acquisition of the proposed technology. In probability theory and statistics, the Probit function is a quantile function, i.e., the inverse cumulative distribution function (CDF), associated with the standard normal distribution (Cohen, et al., 2003), which can be expressed as:

$$Pr = (Y = 1 \mid x) = \emptyset\ (X'\ \beta) \qquad (7)$$

where Pr denotes probability, and Ø is the cumulative distribution function (CDF) of the standard normal distribution. The parameters β are typically estimated by maximum likelihood. The dependent variable (Y) in the model represents the consumers who are willing or unwilling to acquire the proposed brown rice JITHT. The vector of regressors ($X_i$) represents those dependent variables or the socio-economic factors that may influence the acquisition of the proposed technology. The standard normal distribution is commonly denoted as N(0,1) and its CDF as Ø(x). Function $Ø_i$ is a continuous, monotone increasing sigmoid function whose domain is the real line and range is (0,1). In particular, the Shazam (Version 10), a comprehensive econometrics and statistics package software, was used in the Probit regression analysis.

## RESULTS AND DISCUSSION

### Socio-Demographic Profile of Respondents

The respondents were grouped into the following categories: (1) brown rice household consumers-respondents; (2) brown rice retailers-respondents; and, (3) brown rice millers-respondents.

#### Brown Rice Consumers

To identify who among the current brown rice consumers are the potential takers of the proposed JITHT, the consumer-respondents were classified according to the social class category of the Social Weather Station, as follows: (1) Class A - upper class, with income greater than Php100,000/month, (2) Class B - upper middle class, with income of Php50,001 to 100,000/month, (3) Class C - middle class, with income of Php15,001 to 50,000/month, (4) Class D - lower middle class, with income of Php8,001 to 15,000/ month, and (5) Class E - lower class, with income less than Php8,000 per month. The result of the survey showed that majority of the brown rice consumer-respondents were in the middle class (Class C) representing 72.3 percent of the total number of consumer-respondents. Some consumer- respondents belong to Class A and B of the society , comprising 18. percent, which is consistent with the study of Pabuayon and Quilloy (2011). It is surprising, however, that there are consumers belonging to the lowest income, the Class D and E of the society comprising 22.7 percent of the total consumer-respondents. The reasons cited by these group of consumer-respondents (Class D and E) during the interview include eating brown rice as part of the culture and doctor's prescription to improve their health conditions (e.g. diabetic treatment).

The current brown rice consumers were willing to buy brown rice at any 'particular' price the market will offer, regardless of its selling price. The result of field survey revealed that Class E consumers were buying their supply of brown rice from Php30 to 50/ kg and some Class D consumers were buying their supply at price from Php35 to 60/kg. This was more or less similar to the purchase price of Class A, B and C of Php35 to 60/kg, Php40 to 60/kg and Php50 to 60/kg, respectively.

With these findings, the research determined what motivates the current brown rice consumers. Survey results revealed that the motivation could be traced by grouping them into four major classifications, as follows: (1) "traditional" consumers – people who have been consuming brown rice as part of their custom or tradition; (2) "sick" consumers – those with health problems who consumed brown rice for its medicinal effects; (3) "curious" consumers – those who have heard of the benefits of brown rice and tried consuming it out of curiosity; and, (4) "health conscious" consumers – usually financially capable people consuming brown rice as part of their existing healthy lifestyle.

Most of the consumer-respondents started consuming brown rice for less than a year (35.4%) while 26.7 percent were already consuming it for more than four years. These consumers were brown rice advocates and medical practitioners who were aware of the health benefits of brown rice. It revealed that the craze for eating brown rice is growing or

expanding. The indigenous people are also brown rice consumers since it is part of their culture.

The average household brown rice consumption is estimated at 2.80 kg/week or about 134 kg/year which is comparatively 'low' considering that the average family size in the country is 4.6 members (NSO, 2010) and the rice per capita consumption is estimated at 120 kg/year (DA-BAS, 2011). The major factors that contributed to the low level of brown rice consumption per household can be traced to the following:

1. **Irregularity of consumption.** Survey results revealed that 43.1 percent of the total respondents ate brown rice daily (either once a day, twice a day, or every meal) while only 29.3 percent of the total respondents ate brown rice every meal. Consequently, 37.1 percent of the total respondents were eating brown rice irregularly. Irregular brown rice consumers were those who ate brown rice at no definite cycle.
2. **High cost.** The estimated average buying price of brown rice was about Php 50.66/kg, which is 48 percent more expensive than the premium polished rice of Php35/kg in the market. Majority of the total consumer-respondents were buying brown rice at a price of Php50/kg or more. Likewise, the survey results revealed that 34 percent of the total consumer-respondents were not eating brown rice regularly because they perceived brown rice as expensive.
3. **Unavailability of supply.** Almost one-third of the total consumer-respondents who were not eating brown rice regularly complained of the irregularity of supply in the market. In most cases, brown rice can only be found in big supermarkets in key commercial districts or cities in the country. Even at supermarkets, the availability of supply could not be sustained because of short shelf-life of brown rice. Suppliers sometimes retract the continuous delivery and supply of brown rice to certain supermarkets when there is big volume of "bad order". "Bad order" is the term used when a certain volume delivered has been returned partly because the stock is already in bad condition due to quality deterioration.
4. **Unpopular Eating Quality/Poor Palatability.** While 96 percent of the total consumer-respondents have encouraged their children to eat brown rice, the average number of household members eating brown rice is only three. The result implies that not all members of the family, particularly the children, do not accept or like the taste of brown rice. Such conclusion supports the findings in that one of the major reasons behind the irregularity of brown rice consumption is its unpleasant taste. The result of interview revealed that some brown rice consumers had to prepare two types of rice for the household: (i) polished rice for the children; and, (ii) brown rice for the elderly. The two types of preparing rice were found to be too tedious and expensive on the part of the current consumers. To remedy the problem concerning the unpleasant taste of brown rice, almost half of the total consumer-respondents had to mix brown rice with polished rice at a common ratio of 'one is to one' to improve its palatability.

**Brown Rice Retailers**

A total of 49 brown rice retailer-respondents were included in the study. The result of the survey revealed that the price of brown rice is highly dependent on the source and packaging of the product. For example, if brown rice has been packaged as healthy rice (Figure 2), there is a premium price of Php5/kg even of the same variety which passed the same processes (Figures 2 and 3 with markings 1 and 3). More so, 'Jasmin' brown rice is more expensive than the ordinary brown rice coming from ordinary rice variety (Figure 3 with markings 1 and 2). 'Jasmin' is a type of rice variety with good eating quality or palatability. Likewise, brown rice has been classified depending on the target buyer as shown in Figure 3.


Figure 2. Packaging of brown rice as healthy rice in one rice retailing store in Cebu City


Figure 3. Different prices of brown rice in one retailing store in Nueva Vizcaya

The result of qualitative research revealed that every rice retailer faces two important decisions: choosing how much to produce, and choosing what price it should set. If there are no constraints on a profit maximization for rice retailing store, this would set an arbitrarily high price and produce an arbitrarily large amount of output. But no rice retailing store exists in such an unconstrained environment.

For the brown rice retailers, one limiting factor is technology as summarized by a "production function". Note that there are two ways that the current brown rice retailers out-sourced their supply of brown rice. These were (1) buying brown rice from rice distributors; and, (2) producing their own by buying palay and then processing these

through custom mill providers in the vicinity who were willing to accept the production of brown rice. The former was the most common option selected by the brown rice retailers. The second constraint facing the rice retailers is a market constraint. The rice retailers can produce whatever was physically feasible, and can set whatever price they want, but can only sell as much as the brown rice consumers willing to buy. Note that brown rice is highly perishable, and has a very short shelf life of one month before it starts to deteriorate. As such, the rice retailers have faced an important decision of how much volume of stocks or inventory they would risk to ensure the continuous availability of supply in their stores.

The average volume of sales per week by the brown rice retailer-respondents was 2.16 bags/week or 108 kg/week. Less than half of the brown rice retailers have a volume of sales of less than one bag per week. The result implies that majority of them have volume of sales of more than 50 kg/week.

The result of field survey revealed that several regular rice dealers in the wet market have already incorporated brown rice as one of their product lines. During the field interview in Manila, a total of six public markets out of the seven public key markets visited have one or more rice retailers selling brown rice. To come up with a distinction over the nature of their business, the brown rice retailers/distributors were categorized as follows:

1. **Traditional** – rice retailers in the public wet market that included brown rice in their stores and treated brown rice as an ordinary rice to serve the common customers and traditional brown rice consumers;
2. **Regular** -rice retailers in the public wet market that packaged brown rice as healthy or organic rice; and
3. **Special** - generally institutional distributors or high-end retailers that usually catered the high-end market.

The result of field survey revealed that majority (51%) of the respondents were regular retailers, 31 percent were traditional retailers, and 18 percent were special retailers. The result of analysis revealed that the price of brown rice was highly dependent on the classification of the store. Likewise, traditional rice retailers sell brown rice at Php 35/kg and below, regular brown rice retailer from Php 40 to 50/kg and special rice retailer at Php50.00/kg and above.

Traditional and regular types of retailers have been selling brown rice for more than five years while majority of the special type of retailers have sold brown rice for less than five years. Traditional and regular brown rice retailers sourced their supply from rice millers through agents. Majority of special brown rice retailers produced their own brown rice using owned or rented rice mills.

### Rice Millers

Although rice mills of different types engaged in custom milling service can be found in the country, only nine rice millers engaged in the production of brown rice were found in the study areas during the survey period. These rice millers provided custom milling services to brown rice retailers or brown rice distributors with market outlets in different regions/areas in the country. The results imply that the number of rice mills willing to accept the production of brown rice was limited.

Rice millers who cater to the production of brown rice require at least 20 bags per transaction to defray the start-up cost of the big rice mill machine and to cover the cost of adjusting and returning back to the original setting the polishing mechanism of the rice mill. All of the rice mills engaged in the production of brown rice in Luzon are of the rubber roll type. This type of rice milling system produces a higher milling recovery of 63 to 65 percent. Milling fee in Luzon for the production of brown rice ranged from Php1.70 to Php 2.00/kg, output basis. On the other hand, the conventional cono system, popularly known in the area as "Bernabe" ricemill, is the type of rice mill accepting custom milling of brown rice in Visayas and Mindanao. This type of rice mill uses under-runner stone disc hullers. However, the electricity cost is high since this type of rice milling system has large components that require bigger power capacity. Milling cost in the production of brown rice ranged from Php 2.00 to Php2.25/kg.

## Basic Features of the Proposed Brown Rice Huller

### Preferred Price

Based on the results of the survey, about 84.5 percent of the respondents who showed interest in acquiring the proposed JITHT, whether they belonged to the consumers or retailers group, preferred the price of the brown rice huller to be at the range of Php10,000 to15,000. However, about 59 percent of the retailers group showed interest on the proposed technology even at the price of Php15,000 to 25,000/unit. For the pooled data of consumers and retailers, the average preferred price was Php 12,655/unit.

### Break-even Capacity of the Brown Rice Huller

Critical in estimating the capacity of the brown rice huller is the total volume of consumption and sales by the household consumers and retailers, respectively. As discussed in the earlier section, the average consumption of consumers per household per week was only about 2.8 kg or a total of 134 kg per year, while the average sale of brown rice retailers was 108 kg/week or about 4,752 kg per year.

Given such volume of production of brown rice per year, the break-even analysis was conducted to determine the volume of production in which the total cost is equal to the revenue. The unknown variable here is the capacity and not the volume of production, which was already established during the field survey. As such, the mathematical model

could be used in determining the break-even capacity of the proposed JITHT with the assumption that the total cost of producing brown rice is equal to the revenue. All factors involved in producing brown rice using the proposed machine and the total output and value of production per year have been included, valued at current market price. For example, the labor of the household helper is an input and has been counted as part of the costs. Substituting all related costs in the equation, it turns out that the variable cost is a function of the capacity of the huller given a volume of brown rice to be produced per year. The estimated break-even capacity of the huller to at least recover the cost of operation at the household level is only 2.3 kg/h, while 37.9 kg/h at the retailer's level.

**Operating Cost**

After establishing the break-even capacity, it is now possible to determine the operating cost of the huller per kg output (Table 2). To simplify the computation and to come up with comparative analysis concerning the viability of the proposed JITHT both at the household and retailer levels, the computed break-even capacity of 38 kg/h at the retailer's level has been used in estimating the operating cost even at the household. The estimated total cost involved in operating the JITHT at the consumer's level is about Php12.90/kg as compared to only Php1.86/kg at the retailer's level, or a difference of Php11.04/kg.

The high operating cost per kg output at the consumer's level is primarily due to the high fixed cost involved (Php11.50/kg) compared to only Php0.60/kg at the retailer's level. The high fixed cost indicates that the brown rice requirement at the consumer's level is much less than the capacity of the proposed technology. The average annual brown rice consumption by the household-consumers respondents was estimated at only 134 kg/kg compared to the average requirements of retailers of around 4,752 kg/kg.

| Particular | Consumers | Retailers |
|---|---|---|
| Fixed Cost, Php/kg | 11.50 | 0.60 |
| Depreciation cost: huller[1] | 9.42 | 0.27 |
| Depreciation cost: rubber roll[2] | 0.20 | 0.20 |
| Repairs and maintenance[3] | 1.88 | 0.13 |
| Variable Cost, Php/kg | 1.40 | 1.26 |
| Electricity cost[4] | 0.19 | 0.19 |
| Labor cost[5] | 1.21 | 1.07 |
| Total Cost, Php/kg | 12.90 | 1.86 |

Table 2. Estimated operating cost of the proposed brown rice JITHT at the consumer's and retailer's levels

[1] 10% of investment cost (Ic) or P12,655/134 kg for the consumer or 4,752 kg for the retailer
[2] Php8,000/40,000kg
[3] 2% and 5% of investment cost (Ic) or *P12,655/134 kg for the consumer or 4,752 kg for the retailer
[4] {Php 11/kWh x 0.55kW x 3.54h/0.85}/134kg and {Php 11/kWh x 0.55kW x 125.05h/0.85}/4,752kg
[5] {Php250 x 3.54h/(8 x 0.85 x 0.80)}/134kg and {Php250 x 125.05h/(8 x 0.85 x 0.90)}/4,752kg for consumer's and retailer's level, respectively.

**Cost-Benefit Analysis**

At the household-consumer's level, the estimated cost involved in buying brown rice in the market is about Php 56.15/kg. The total cost covers the average cost of brown rice of Php 50.66/kg including the involved transportation and labor costs of buying brown rice in the market. Therefore, the total production cost (total operating cost plus the cost of raw material/palay) when the household-consumers decided to produce their own brown rice using the proposed JITHT should not be more than Php56.15/kg to realize positive benefits.

At the retailer's level, there were two common practices in acquiring brown rice, as follows: (1) from any rice distributors or (2) by buying palay from farmers and have it processed through custom mill services available in the area. In the estimation of cost of producing brown rice using the proposed JITHT, the latter option has been used due to higher profit involved as against the former.

The total estimated cost on the part of retailers in producing brown rice through custom milling is about Php2.48/kg. This involved the milling fee of Php2/kg, the transportation cost of palay of Php0.35/kg and labor cost of Php0.13/kg. Therefore, the maximum operating cost of using the proposed technology should not be more than Php2.48/kg to ensure that the retailers will realize the financial benefits.

Based on the result of the estimation, the household-consumers are still better off if they will produce their own brown rice using the proposed JITHT, subject to certain environmental restrictions such as the proper disposal of rice hulls in the household. Consumers would realize a modest net benefit of Php 2,120/year for utilizing the proposed JITHT as compared to sourcing their brown rice supply in the market. In the same manner, the retailers will entail higher profit by as much as Php 2,622/year if they will produce their own brown rice using the proposed JITHT rather than producing their own through custom milling even at a very conservative capacity of the huller of only 38 kg/h. Note that the total labor cost is estimated at Php5,108 at the retailer's level, which constitutes 58 percent of the total operating cost. The result of cost-benefit analysis thus suggests that the capacity of 38 kg/h at the retailer's level is indeed the minimum capacity and not the right capacity. As such, higher profit could be expected if the capacity will be increased.

**Rate of Return**

In order to confirm the financial soundness of the proposed JITHT for 10 years, the assumed life span of the proposed JITHT, given an investment cost of Php12,655 per unit and initial assumed capacity of 38 kg/h, the estimation of Internal Rate of Return (IRR) has been pursued (Table 3). Under several set conditions, the following technical and economic parameters shall be taken into full consideration:

Table 3. Estimated rate of return of acquiring the proposed brown rice JITHT under

| Particular | Consumers | Retailers |
|---|---|---|
| Internal Rate of Return | 14.05% | 22.27% |
| Cost-Benefit Ratio | | |
| @ 10% Interest Rate | 0.97 | 0.77 |
| @ 16% Interest Rate | 1.23 | 0.98 |
| Internal Rate of Return Under Different Scenario | | |
| Scenario 1 - Increase capacity of Huller by 20% | 14.53% | 38.54% |
| Scenario 2 - Increase volume of production by 20% | 25.14% | 37.89% |
| Scenario 3 - Increase price of huller by 20% | 4.37% | 9.79% |
| Scenario 4 - Under set conditions | 57.72%* | 40.25%** |

several conditions

* Hulling capacity of 12 kg per hr and investment cost of Php8,500 per unit

** Increased price of huller to P17,500 corresponding with the increased of capacity to 104kg/ h

**Consumer's level**

**Preferred Price.** Increasing the given price of Php12,655 by 20 percent or at a price of Php15,186 per unit would result to an IRR of 4.37 percent which is no longer financially feasible even at 10 percent interest rate. Therefore, the challenge on the part of the researcher or engineer who will be in-charge of the development of the technology is how to satisfy the preferred price as set by the target users.

**Volume to be processed per year.** By increasing the current level of 134 kg per year by 20 percent (160.8 kg), the economic viability of the brown rice huller will significantly improve given an estimated IRR of 25.41 percent, wherein the rate of increase is 81 percent as compared to the 20 percent increase in the volume to be processed. The result suggests that the volume to be processed is a very critical variable in ensuring the economic viability of investing in the technology at the consumer's level.

**Capacity of the huller.** If the research engineer during the developmental stage of the proposed JITHT (Phase 2 of the project) could increase the capacity of the proposed technology by 20 percent (from 38 to 46 kg/h) without sacrificing the current level of investment cost, operating costs, etc. as used in the estimation, the effect is nil since the estimated IRR is only 14.53 percent. The result thus implies that the current capacity of 38 kg/h is so big at the consumers' level of operation based on their current volume of requirements of 134 kg/year. What is the most appropriate capacity then for household level of operation?

To come up with estimation, it is assumed that any decrease in the capacity of the

technology will result to the decrease in the production/investment cost of the machine. In the estimation, the relationship of investment cost with respect to the capacity of the machine is as follows: IC=160Ca+6,560, ^where IC is investment cost, Ca is the capacity of the technology and the constant variable of 6,560 represents the total costs of fabricating the basic component of the machine with no effect for any increase or decrease of the capacity. Such assumption will pave the way for the estimation of total cost function since the fixed costs (depreciation and repairs and maintenance) is highly dependent on the investment cost, while the variable costs (electricity and labor costs) is highly dependent on the capacity of the machine. Using the cost function, therefore, the most cost efficient capacity of the huller given an annual brown rice requirement of 134 kg is only 12 kg/h. From this level of capacity, the estimated investment cost is about Php8,500/unit. Under these conditions, the estimated IRR of the technology will become 57.72 percent.

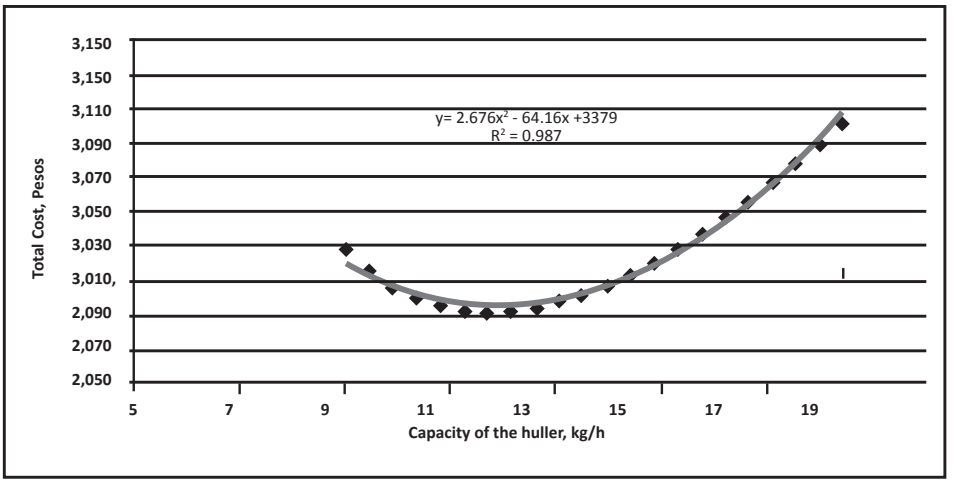
The estimated level of capacity can be easily verified through mathematical estimation by applying differential calculus by getting the first derivative of the total cost function of the brown rice consumers (Equation 7) with respect to the capacity of the machine.

$$TC = 2.676\,Ca^2 - 64.16Ca + 3{,}379 \qquad (7)$$

where TC is the total cost in producing brown rice, Ca is the variable capacity of the machine and the constant variable 3,379 captures the total fixed cost involved in operating the proposed JITHT. Under the first condition of profit maximization, the marginal cost (MC) should be equal to 0. As such, the first derivative of equation 7 with respect to Ca becomes,

$$MC = \frac{dC}{dCa} = 5.352Ca - 64.16 = 0 \qquad (8)$$

The value of $C_a$ is equal to 11.98. This is the point where the marginal cost (or simply




the rate of change of total cost) is equal to 0 as shown in Figure 4.

Figure 4. Behavior of total cost with respect to the capacity of the proposed JITHT at the consumer's level

From this very important information the researcher or engineer that will be assigned to develop the proposed JITHT have now the basis in determining the type of fabrication materials, size of electric motor and other features of technology in order to satisfy the most cost-efficient capacity of the proposed technology.

**Retailer's level**

**Preferred price.** Table 3 shows that, by increasing the price of the machine by 20 percent (from Php212,655 to Php 15,186) would result to an IRR of 9.79 percent. The effect is similar at the consumer's level. The result implies that increasing the price of the machine without correspondingly increasing the capacity of the dryer will make the investment on the technology not financially feasible even at 10 percent interest rate.

**Volume to be processed per year.** The computed IRR under this scenario of increasing the volume to be processed by 20 percent is 37.89 percent. The rate of increase under this scenario is estimated at 70 percent (from 22.27% to 37.89%) compared to a 20 percent increase in volume to be processed. The result implies that the volume to be processed in a given period is very critical on the financial feasibility of the proposed technology.

**Capacity of the huller.** The results of estimation revealed that by increasing the capacity of the huller by 20 percent without increasing the price of JITHT, the IRR will become 38.54 percent, the highest IRR among the three scenarios.

In order to determine the most appropriate capacity of the machine at the retailer's level, the same methodology used at the consumer's level has been utilized. The most cost efficient capacity of the huller given the current level of output of 4,755kg/year is 104 kg/h at an investment cost of Php17,500. Under this condition, the estimated IRR of the technology becomes 40.25 percent. The result further supports the findings in the previous section that the cost of huller could be increased with a corresponding increase in the capacity, but only at a certain point where the marginal cost is equal to 0, the first condition of profit maximization. This finding can be easily verified through mathematical calculation method as used at the consumer's level.

**Socio-Economic Factors that Influenced the Adoption of the Proposed JITHT**

**Brown Rice Consumer**

Table 4 shows the result of the Probit Regression Analysis at the household-consumers level. The dependent variable (Y) in the model represents the consumers who are willing or unwilling to acquire the proposed brown rice JITHT. The vector of regressors (Xi) represents those dependent variables that explain the outcome of the dependent variable in the model, as follows:

**Price of Brown Rice.** This variable explains the buying price of brown rice by the consumers if they bought it in the market or obtained it from their own farm, family members or friends. The result of the analysis showed that the coefficient of the

Price of Brown Rice variable is positive and significant which suggests that the higher the purchasing price of brown rice in the market, the higher the probability that the household consumers will acquire the proposed JITHT. The result of field data revealed that majority of the household consumers who bought their brown rice at Php40/kg or more preferred to acquire the proposed JITHT compared to those who bought brown rice for less than Php40/kg. They considered their purchasing price as expensive and thought it would be less costly if they acquire the proposed JITHT. Conversely, reserved buyers, who usually bought brown rice at less than Php 40/kg, believed that the purchasing price of their brown rice was reasonable enough. They thought that having the proposed JITHT will be an additional labor and expense on their part.

**Nature of Work of Consumers.** In this variable, the medical practitioners working at private offices or connected to the national or local government units were selected as the dummy variable. The results of the Probit regression analysis showed that the coefficient of the variable is positive and significant. This suggests that this group of consumers would most likely acquire the proposed JITHT, given the medical benefits of brown rice. Majority of the medical doctors interviewed, prescribed brown rice for good diet or to control hypertension and diabetes.

The result of field survey revealed that consumers who work in health institutions were most likely to be the potential buyers of the proposed JITHT (65%).

Table 4. Likelihood factors that may influence the household consumer-respondents' willingness to acquire the proposed hulling technology, Household-Consumer's Level[a/]

| Variable Name | Estimated Coefficient | Standard Error | T-Ratio |
|---|---|---|---|
| Price of BR | 0.622 | 0.344 | 1.812* |
| Nature of Work of Consumers | 1.445 | 0.692 | 2.086** |
| Consumer's Outlook | 0.695 | 0.199 | 3.491*** |
| No. of Years Eating BR | 0.268 | 0.121 | 2.226** |
| Volume of BR Consumption | 0.259 | 0.126 | 2.060** |
| Income Group of Consumers | 0.681 | 0.276 | 2.463** |
| Consumer's Educ. Attainment | -0.428 | 0.286 | -1.498 |
| Age of Consumers | -0.018 | 0.017 | -1.103 |
| Luzon: Location of Respondents | -0.119 | 0.352 | -0.337 |
| Visayas: Location of Respondents | 0.069 | 0.373 | 0.184 |
| Constant | -3.450 | 1.100 | -3.135*** |

[a/] Probit analysis with the dependent variable that takes 1 for consumers willing to buy the proposed hulling technologyand 0 for consumers unwilling to buy the proposed technology.

***, ** and * stand for the significance level at 1%, 5%, and 10%, respectively.

Total number of observations: 116, Total number of consumer-respondents willing to acquire the proposed brown rice hulling technology: 60;

Durbin-Watson = 1.8306; Von Neumann Ratio = 1.8499; Rho = 0.06898;

**Length of Brown Rice Consumption.** Results of the Probit regression analysis showed that the number of years the consumers ate brown rice is a variable with positive coefficient. This variable has significance in the consumer's decision in acquiring the proposed JITHT. The result suggests that the longer the consumers religiously eat brown rice, the more likely they are willing to acquire the proposed JITHT. The field survey revealed that consumers who had been consuming brown rice for one to two years or more were more likely to buy the JITHT. Reserved buyers or those who just started consuming brown rice recently considered brown rice consumption not a necessity but as an additional choice to their existing preference.

**Volume of Household Consumption.** The variable Volume of BR Consumption in Table 4 of the result of Probit regression analysis is the kilogram per week consumption of consumers' household. With the variable having positive coefficient and has significance on the purchase decision of the consumers, it suggests that the larger the volume of consumption, the higher the possibility that they are willing to acquire the proposed JITHT.

Potential buyers consumed more than five kg of brown rice per week. These consumers needed more stable and larger supply of brown rice. On the other hand, reserved buyers usually consumed only less than one kg of brown rice per week. They just recently started eating brown rice and needed a smaller volume of brown rice and instead preferred ready to cook brown rice because of time constraints.

Lapsed consumers stopped their brown rice consumption because of similar reasons. Their household members did not like brown rice. One lapsed consumer stopped eating brown rice because of the higher cost and additional labor it required. This consumer had to prepare two kinds of rice, brown rice for the elderly and white rice for the children.

**Income Group of Consumers.** The variable Income group of consumers received positive coefficient from the regression analysis, a significant variable. It therefore suggests that the more affluent the brown rice consumers, the higher the probability that they are to acquire the proposed JITHT. These people practiced healthy living and were more health conscious. They could afford the higher cost of a healthy lifestyle. Reserved buyers, on the other hand, usually were those who belonged to class D and E of the society.

**Consumer's Outlook.** In this variable, the result in the Probit regression analysis in Table 4 revealed that it is a positive coefficient and is significant. Consumers were asked about their views on the possible increased consumption of brown rice in the Philippines. Results suggest that consumers with more positive outlook regarding the wider consumption of brown rice in the future were more likely interested in acquiring the proposed JITHT.

**Educational Attainment and Age of Consumers.** Results showed that educational attainment and age of consumers have negative coefficient in the regression analysis and have no significance in the decision of consumers in the acquisition of the proposed technology.

Brown rice consumers with higher educational attainment (MS) and are employees in the government perceived the machine as an additional load or chore to their busy schedule (hence the coefficient of variable is negative), though this findings is not conclusive at the moment.

**Location of Respondents.** The result of regression analysis revealed that the location of respondents has negative coefficient and is not significant. Geographical location of consumers does not favor any advantage in terms of the adoption of the proposed brown rice consumers to acquire the proposed JITHT.

**Brown Rice Retailers**

Table 5 shows the result of the Probit regression analysis. The demographic characteristics of brown rice retailers that most likely influence potential buyers of the proposed technology are as follows:

Table 5. Likelihood factors that may influence the retailer's respondents willingness to acquire the proposed hulling technology[a/]

| Variable Name | Estimated Coefficient | Standard Error | T-Ratio |
|---|---|---|---|
| Business Classification | 1.495 | 0.888 | 1.6835* |
| Volume of BR sold Per Week | 0.760 | 0.392 | 1.981** |
| Brown Rice Retail Price | -1.061 | 0.461 | -2.3013** |
| Encountered Storage Problem | -3.061 | 1.138 | -2.6897*** |
| Source of Brown Rice | 3.158 | 1.202 | 2.6266*** |
| Retailers Outlook on Brown Rice | 0.929 | 0.703 | 1.3212 |
| Luzon: Location of Respondents | -1.844 | 0.820 | -2.2487** |
| Constant | 2.515 | 1.542 | 1.6307 |

[a/] Probit analysis with the dependent variable that takes 1 for brown rice retailers willing to buy the proposed hulling technolog; and 0 for consumers unwilling to buy the proposed technology.
***, ** and * stand for the significance level at 1%, 5%, and 10%, respectively.
Total number of observations: 50, Total number of reatiler's -respondents willing to acquire the proposed brown rice hulling technology: 24;
Durbin-Watson = 1.8306; Von Neumann Ratio = 1.8499; Rho = 0.06898

**Business Classification.** For this research, the business type has been classified into three categories, namely: (1) wet market 'traditional' brown rice dealers; (2) wet market 'regular' brown rice dealers; and, (3) 'Special' brown rice dealers. In the estimation of Probit regression function, the wet market 'regular rice retailer' was used as the dummy variable given a value of 1. The results of analysis showed that it has a positive coefficient and significance which suggests that this type of retailer was most likely to acquire the JITHT over the other. This group of rice retailers has established regular costumers with certain volume of requirements per week, realized higher profit in selling brown rice than selling only ordinary polished rice, and sourced their supply from rice agents or directly engaged in palay trading and milling for their rice supply. The acquisition of the proposed JITHT would give them better leverage in ensuring the availability of brown rice supply for their rice retailing business. Traditional rice dealer on the other hand are not selling

brown rice year round. They are only selling when there is an available supply and the brown rice supply only lasts for three months after the harvest season. Their selling price is Php32/kg or less.

**Weekly Volume of Brown Rice Sold.** This variable is the total volume of brown rice sold per week by individual retailer. The result of estimation revealed that the coefficient of variable is positive and significant. This implies that the higher the volume of brown rice sold by the retailer, the higher the probability that the retailers will purchase the proposed JITHT.The result of survey revealed that 73 percent of the rice retailers selling less than 1 bag per week are hesitant to acquire the proposed JITHT. As the volume is increased, more than 60 percent of potential retailers are most likely willing to acquire the proposed JITHT. The result of estimation statistically supports the estimated IRR in Table 3. By increasing the volume of brown rice sold per week, the decision to acquire the proposed JITHT will improve the viability of their business.

**Brown Rice Retail Price.** In the regression analysis performed, the variable Brown rice retail price got a negative coefficient and was significant. The result implies that those retailers who sold their brown rice at lower price were more likely to buy the proposed technology. Retailers who priced their brown rice higher were usually under the category of 'special' brown rice retailers and were likely satisfied with the profit they were gaining from the price at which they sold their brown rice. On the contrary, ordinary retailers who experienced higher level of competition wanted to increase their possible profit by improving their efficiency through the acquisition of proposed JITHT.

**Storage Problem.** This variable got a negative coefficient from the regression analysis. Similar to the retail price of brown rice variable, this variable also has significance in the probability of adopting the proposed hulling machine. The results suggest that retailers with no storage problems were more likely to buy the proposed JITHT. It is because storage problem directly relates to the length of time the brown rice had been stored and retailers who had not experienced storage problems, which in this case are the potential buyers of the technology, had fast turnover of brown rice inventory which means higher sales of brown rice. Otherwise, it means retailers have low sales of brown rice, given that their supply was stored for a long period of time, thus storage problems occurred.

**Source of Brown Rice.** In this variable, farmers/farmer's cooperatives were selected as the dummy variable. In the regression analysis, this variable has a positive coefficient and significance that suggests retailers who sourced their brown rice from farmers or farmer's cooperatives were most likely to be the takers of the proposed JITHT. The result of survey revealed that about 88 percent of the retailers willing to acquire the proposed JITHT were sourcing their brown rice supply from farmers/farmers cooperative. This is the group of retailers who are buying palay that produces brown rice through a milling service available in the area.

**Location of Respondents: Luzon.** Similar to brown rice retail price and encountered storage problem variables, geographic location of respondents particularly in Luzon, have negative coefficient and is also significant. This result suggests that retailers in Visayas and Mindanao were most likely the potential takers of the JITHT. Note that the type of

rice mills engaged in the production of brown rice in Visayas and Mindanao is Bernabe rice mills or the under-runner stone disc huller which is considered an out moded type of ricemill. Due to its high power requirement, they are charging milling fee that ranges from Php2.00 to 2.25/kg compared to the rubber type of rice mill in Luzon that charges a milling fee of around Php1.75 to 2.00/kg. In addition, the start-up cost of Bernabe type rice mill is higher compared to rubber roll type rice mills and, as such, will accept only milling service with a minimum volume of 20 bags per transaction.

**Retailer's Outlook on Brown Rice.** Although this variable received a positive coefficient from the regression analysis results, it has no significance in the decision of retailers on whether or not to acquire the JITHT unlike in the consumer's group which has a high significance.

**Changes in the Marketing System/Practices that Warrant the Potential Adoption of the Technology**

Based on the results of desk research and one-on-one interviews conducted with 116 brown rice consumers, 49 rice retailers and 9 rice millers, the following developments in the current marketing system may stimulate the adoption of the proposed brown rice technology:

1. **Regular rice retailers have started including brown rice in their product lines.** Survey results revealed that several regular rice dealers in the wet market have already incorporated brown rice as one of their product lines. During the field interviews in Manila, a total of six markets out of the seven public key markets purposely visited had one or more rice retailers selling brown rice.

   The diffusion of brown rice as one of the product lines of key rice dealers or retailers in the public market will make the commodity readily available and affordable to the public. Note that the price of brown rice in the wet market is cheaper by more than 40 percent than in the supermarket or institutional distributors. To the extent that all parties are seeking to further their own interest and are aware of the alternative prices being charged in a certain locality, a situation with different prices being charged for the same good may not continue to persist. As such, the price of brown rice in the wet market to some extent may influence the pricing of brown rice in the supermarket and institutional distributors in the long run.

2. **Supermarket's adoption of ordinary rice retailer's method of showcasing/ displaying their products.** The supermarket branch managers' confirmed the Filipino consumer's common practice of touching the item or product before buying to inspect the quality of the product being sold. The manner by which fresh agricultural products have been displayed in the supermarket was also adapted to brown rice to introduce and popularize the commodity. Such aggressive marketing strategy will certainly create awareness and thus induce the consumption of brown rice.

The managers of supermarkets interviewed also confirmed that unlike a decade ago, where only the class A and B of society goes to the supermarket to buy fresh products, such scenario is totally different to date, considering the increasing popularity of supermarket to the middle class and even the ordinary people in buying agricultural and fishery fresh products. With the aggressive marketing promotion and innovations being implemented by the supermarkets to compete among each other and with the wet markets by providing affordable and yet good quality products, it is logical to assume that the price of brown rice displayed in the supermarkets will go down just like the way they drastically reduced the price of fresh product such as the vegetables, beef, chicken, fork, etc.


**Figure 5.** New methods of displaying fresh agricultural and fishery products in the supermarket

**3. Consumer's positive outlook concerning the steady increase of brown rice consumption in the future.** The results of the field interview revealed that 85 percent of the consumer respondents have positive outlook on the steady increase of brown rice consumption in the country. The result reflects the wider recognition of Filipinos concerning the health benefits of brown rice in their regular diet. There is also a growing awareness of Filipinos on the different healthy agricultural commodities readily available in the country.

The research report on the "Philippine Food and Drinks Market: Emerging Opportunities" attributed the rise in the demand for health food and drinks to the growing young affluent population, rising disposable income and increasing consumer awareness of health and safety concerns. Affluent consumers in markets like India, China and Southeast Asian countries, including the Philippines, are demanding quality and attributes like 'organic' and 'green' labels.

Likewise, according to a survey by the Philips Index Health and Living, 54 percent of the Filipino population rated themselves as conscious about their health and well-being. Filipinos are paying more attention to their food intake and are steering toward foods that are beneficial to their bodies and that sustain their health.

4. **Private sector active participation in promoting brown rice as healthy food.** Along side the government effort of addressing the problem on brown rice, the private sector (non-government organization and private individuals) has also aggressively promoted the consumption of brown rice as part of the solution in addressing the high incidences of diabetes and hypertension in the country.

   Field interviews revealed that majority of the individual medical practitioners particularly the endocrinologist, were prescribing the consumption of brown rice to their patients and peers as one of their treatments in managing diabetes and/or hypertension problems.

## SUMMARY, CONCLUSION AND RECOMMENDATIONS

The Food Staples Sufficiency Program (FSSP) of the government promotes the consumption of brown as one of the major strategies in achieving rice sufficiency program of the government. However, brown rice has very short storage life and, as such, more expensive than polished rice. The proposed JITHT aims to produce brown rice at the right place, at the most appropriate time, and at the right price given the very short storage life and high price of brown rice in the market. Based on the data gathered from 174 respondents among current brown rice consumers, retailers and rice millers in key selected urban and rural areas in Luzon, Visayas and Mindanao, the results of both the qualitative and quantitative research were as follows:

1. Brown rice retailers will realize more profit if they will use the proposed JITHT than source their brown rice supply using their existing practice. The most potential buyers of the proposed technology are the “regular” rice retailers.

   Using Probit regression analysis, the most likely buyers of the proposed technology among brown rice retailers are as follows: (1) rice retailers that sell brown rice at Php 40/kg or less; (2) brown rice retailers that encountered storage problem; (3) brown rice retailers with sales of at least one bag per week; and, (4) those stores that sourced their supply directly from the farmers or farmer’s group. The results of Probit analysis also suggest a higher probability for rice retailers in Visayas and Mindanao to buy the technology than those in Luzon due to the inefficiency of current ricemills accepting custom milling and the higher milling fee collected than those rice millers in Luzon.

   Brown rice retailer could minimize their operating costs and maximize their profit if the capacity of the machine could be increased to 104 kg even and at investment cost of PhP17,500.00/unit. Under this set conditions, the engineers will be fully guided in the design of the brown rice huller or mill particularly on the selection of size of motor and type of fabrication materials to be used in fabrication.

2. Brown rice consumption at the household level is very low, estimated at 2.8 kg/ week or about 134 kg/year. The major factors that contribute to the low level of consumption are the following: (1) not all members (average of 3 members) in the household eat brown rice; (2) only 51 percent of the current brown rice consumers prepare and cook pure brown rice; (3) current brown rice consumers do not eat brown rice every meal; (4) the unpleasant taste of brown rice; and, (5) price of brown rice is 48 percent more expensive than premium polished rice.

Household brown rice consumers are better off using the proposed technology than directly sourcing their brown rice stock in the market. While one out of two brown rice consumer-respondents have shown interest on the proposed JITHT, not all of them are recommended to be the target market of the proposed technology especially those households that are living in condominium or apartment with no enough space for operating the technology and without dust control system inside the room including the limitation of disposing the by-products of palay such as hull and bran. The result of Probit regression analysis showed that the most likely buyers among household-consumers are as follows: (1) medical practitioners; (2) consumers who bought their brown rice at more than Php 50/kg; (3) those level of consumption is more than 3 kg/week; (4) household consumers who are already consuming brown rice for two or more years; and, (5) consumers who have positive outlook concerning the growing consumption of brown rice in the country. In order to maximize the benefits at the consumer's level, the design capacity of the proposed JITHT shall be 12 kg/hr with a selling price of Php 8,500.00/unit only.

It is expected that the diffusion of the proposed JITHT in the country could reduce and stabilize the price of brown rice in the market, and as such, make brown rice accessible and affordable to the public in the future. Given the commitment of the government of extending higher priority to banner programs that will contribute in achieving food self-sufficiency, the proposed JITHT is a practical and alternative solution of addressing the short shelf life of brown rice, a problem that continually impinge the wider consumption of brown rice in the country.

Simple analysis showed that by converting 30 percent of the total palay production to brown rice would yield an additional rice supply of 500,000 MT for the country. The total volume is equivalent to 58 percent of the total rice importation of the Philippines in 2011.

As such, the development and the eventual commercialization of the proposed JITHT should be pursued by the government to promote the wider adoption of brown rice in the country. This policy program and direction should be embraced by the government as one of the development strategies to achieve and sustain food self-sufficiency in the country.

Finally, the methods used in the quantitative analysis using profit maximization and probit regression models have provided new scientific approach in assessing and quantifying the potential of developed technology in the market, thus, minimizing the risk of not being adopted by the target end users.

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# About PHilMech

The Philippine Center for Postharvest Development and Mechanization, known then as the National Postharvest Institute for Research and Extension (NAPHIRE), was created on May 24,1978 through Presidential Decree 1380 to spearhead the development of the country's postharvest industry.

As a subsidiary of the National Grains Authority in 1980, the agency's powers and functions were expanded in line with the conversion of NGA to the National Food Authority.

In 1986, PHilMech moved to its new home at the Central Luzon State University compound in Muñoz, Nueva Ecija.

The agency was transformed from a government corporation into a regular agency through Executive Order 494 in 1992. It was renamed the Bureau of Postharvest Research and Extension (BPRE).

For years now, PHilMech is engaged in both postharvest research, development and extension activities. It has so far developed, extended and commercialized its research and development outputs to various stakeholders in the industry.

With Republic Act 8435 or Agriculture and Fishery Modernization Act (AFMA) of 1997, PHilMech takes the lead in providing more postharvest interventions to empower the agriculture, fishery and livestock sectors.

Pursuant to Executive Order 366 or the government's rationalization program in November 2009, BPRE became the Philippine Center for Postharvest Development and Mechanization (PHilMech) with twin mandates of postharvest development and mechanization.

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