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Evaluating Milled Rice Quality for Marketing Opportunity: A Case Study of Thai Jasmine Rice

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Abstract: Rice production in Thailand represents a significant portion of the Thai economy and labor force. Thailand has a strong tradition of rice production. Thai fragrant organic rice accredited by bioagricoopitaly and department of agriculture and cooperatives, Thailand. All rice, produced and supplied under the Capital Rice's trademark is genuine quality guaranteed, clean and neatly packed in various sizes to suit the specific needs of customers. Practically, the millers have to perform several reprocessing activities to segregate broken grains and other impurities from whole grains. These extra steps make the rice industry less profitable and competitive. The limitation of the process that has impact on supply chain would be determined. The bottleneck analysis assesses the impact of drying and milling processing capacity limitation on the supply chain and determines the maximum amount of good quality paddy that can flow from farmers to wholesalers after drying and milling processes. The objectives of this study are to: (1) investigate rice quality associated with quality assurance criteria, (2) quantify the mathematical models for predicting potential PMR, PHR, and FY as a function of Rice Quality, and (3) identify marketing opportunity for international consumers.

Key words: milled rice; Jasmine rice; quality management
JEL code: M31

1. Introduction

Rice is the most important staple food for a large part of the world's human population, especially in tropical Latin America, and Asia. Asia has the most suitable climate for rice cultivation. Most of the time, the world's top three rice producers remain all within the Asian region, although the total production may vary from year to year (Wikipedia, 2009). Rice is the main national economy and a main staple crop in Thailand. Thailand devoted approximately 58 million rais (6.25 rais = 1 hectare) of land to rice cultivation and produce approximately 28.0 to 30.0 million tones, and get approximately 180,000-200,000 million baht income.)Ministry of Agriculture And Cooperatives, 2007(Even though, the world rice consumption has increased year-by-year whereas the value rice marketing is fluctuating. However, there are various factors that affect Thailand's rice production include the lack of competitive advantage, labor shortage, declining production, unpredictable weather and soil, domestic and international markets and also logistics.

Rice production in Thailand represents a significant portion of the Thai economy and labor force. Thailand has a strong tradition of rice production. It has the fifth-largest amount of land under rice cultivation in the world

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and is the world's largest exporter of rice. Thailand has plans to further increase its land available for rice production, with a goal of adding 500,000 hectares to its already 9.2 million hectares of rice-growing areas. The Thai Ministry of Agriculture expects rice production to yield around 30 million tons of rice for 2008.

Thai fragrant organic rice accredited by bioagricoopitaly and department of agriculture and cooperatives, Thailand. All rice, produced and supplied under the Capital Rice's trademark is genuine quality guaranteed, clean and neatly packed in various sizes to suit the specific needs of customers. The different stages involved in the rice process from farmers to wholesalers impose complications on the efficiency and coordination of the entire rice supply chain. Each process has its own issues and problems that hinder the efficiency of the entire process. The two most vital processes involved in transforming harvested paddy into rice are drying and milling. Any improvement in these two processes could produce major gains in efficiency for the entire rice value chain. The selling price for inferior quality rice is roughly 50% lower compared to good quality rice. Millers have to bear the penalty cost when inferior quality rice is produced. Furthermore, millers have to perform several reprocessing activities to segregate broken grains and other impurities from whole grains. These extra steps make the rice industry less profitable and competitive. The limitation of the process that has impact on supply chain would be determined. The bottleneck analysis assesses the impact of drying and milling processing capacity limitation on the supply chain and determines the maximum amount of good quality paddy that can flow from farmers to wholesalers after drying and milling processes. The objectives of this study are to: 1) investigate rice quality associated with quality assurance criteria, 2) quantify the mathematical models for predicting potential PMR, PHR, and FY as a function of Rice Quality, and 3) identify marketing opportunity for international consumers.

2. Literature Review

2.1 Theory and Definition

2.1.1 Rice

Rice is the seed of the monocot plants Oryza sativa (Asian rice) or Oryza glaberrima (African rice). As a cereal grain, it is the most widely consumed staple food for a large part of the world's human population, especially in Asia and the West Indies. It is the grain with the second-highest worldwide production, after maize (corn), according to data for 2010. Since a large portion of maize crops are grown for purposes other than human consumption, rice is the most important grain with regard to human nutrition and caloric intake, providing more than one fifth of the calories consumed worldwide by the human species. There are many varieties of rice and culinary preferences tend to vary regionally. In the Far East, there is a preference for softer and stickier varieties. Because of its importance as a staple food, rice has considerable cultural importance. Rice is often directly associated with prosperity and fertility. Therefore, there is the custom of throwing rice at weddings. Rice is normally grown as an annual plant, although in tropical areas it can survive as a perennial and can produce a ratoon crop for up to 30 years. The rice plant can grow to 1-1.8 m (3.3-5.9 ft) tall, occasionally more depending on the variety and soil fertility. It has long, slender leaves 50-100 cm (20-39 in) long and 2-2.5 cm (0.79-0.98 in) broad. The small wind-pollinated flowers are produced in a branched arching to pendulous inflorescence 30-50 cm (12-20 in) long. The edible seed is a grain (caryopsis) 5-12 mm (0.20-0.47 in) long and 2-3 mm (0.079-0.12 in) thick.

Rice cultivation is well-suited to countries and regions with low labor costs and high rainfall, as it is labor-intensive to cultivate and requires ample water. Rice can be grown practically anywhere, even on a steep hill or mountain. Although its parent species are native to Asia and certain parts of Africa, centuries of trade and exportation have made it commonplace in many cultures worldwide. The traditional method for cultivating rice is flooding the fields while, or after, setting the young seedlings. This simple method requires sound planning and servicing of the water damming and channeling, but reduces the growth of less robust weed and pest plants that have no submerged growth state, and deters vermin. While flooding is not mandatory for the cultivation of rice, all other methods of irrigation require higher effort in weed and pest control during growth periods and a different approach for fertilizing the soil.

Rice is a major food staple and a mainstay for the rural population and their food security. It is mainly cultivated by small farmers in holdings of less than 1 hectare. Rice is also a wage commodity for workers in the cash crop or non-agricultural sectors. Rice is vital for the nutrition of much of the population in Asia, as well as in Latin America and the Caribbean and in Africa; it is central to the food security of over half the world population. Developing countries account for 95% of the total production, with China and India alone responsible for nearly half of the world output.

2.1.2 Quality Assurance

Quality assurance (QA) refers to the systematic activities implemented in a quality system so that quality requirements for a product or service will be fulfilled. It is the systematic measurement, comparison with a standard, monitoring of processes and an associated feedback loop that confers error prevention. This can be contrasted with quality control, which is focused on process outputs. Two principles included in QA are: “Fit for purpose”, the product should be suitable for the intended purpose; and “Right first time”, mistakes should be eliminated. QA includes management of the quality of raw materials, assemblies, products and components, services related to production, and management, production and inspection processes. Suitable quality is determined by product users, clients or customers, not by society in general. It is not related to cost and adjectives or descriptors such “high” and “poor” are not applicable. For example, a low priced product may be viewed as having high quality because it is disposable where another may be viewed as having poor quality because it is not disposable. The quality of products is dependent upon that of the participating constituents, some of which are sustainable and effectively controlled while others are not. The processes which are managed with QA pertain to Total Quality Management. If the specification does not reflect the true quality requirements, the product’s quality cannot be guaranteed. For instance, the parameters for a pressure vessel should cover not only the material and dimensions but operating, environmental, safety, reliability and maintainability requirements.

2.1.3 Marketing

- Marketing Definition

Marketing is defined by the American Marketing Association (2015) as “the activity, set of institutions, and processes for creating, communicating, delivering, and exchanging offerings that have value for customers, clients, partners, and society at large”. Further definition is that marketing is a social and managerial process by which individuals and groups obtain what they need and want through creating and exchanging products and value with others. Marketing is a key factor in business success. The marketing function not only deals with the production and distribution of products and services, but it also is concerned with the ethical and social responsibility functions found in the domestic and global environment. The marketing concept holds that achieving organizational goals depends on knowing the needs and wants of target markets and delivering the desired satisfactions better than competitors do. Under the marketing concept, customer focus and value are the paths to sales and profits. Instead of a product-centered “make and sell” philosophy, the marketing concept is a customer-centered “sense and respond” philosophy. The job is not to find the right customers for your product but to find the right products for your customers. Implementing the marketing concept often means more than simply responding to customers' stated desires and obvious needs. Customer-driven companies research current customers deeply to learn about their desires, gather new product and service ideas, and test proposed product improvements. Such customer-driven marketing usually works well when a clear need exists and when customers know what they want. There are four activities, or components, of marketing:

(1) Creating — the process of collaborating with suppliers and customers to create offerings that have value.

(2) Communicating — broadly, describing those offerings, as well as learning from customers.

(3) Delivering — getting those offerings to the consumer in a way that optimizes value.

(4) Exchanging — trading value for those offerings.

- Marketing Strategy

The company's marketing strategy outlines which customers it will serve and how it will create value for these customers. Next, the marketer develops an integrated marketing program that will actually deliver the intended value to target customers. The marketing program builds customer relationships by transforming the marketing strategy into action. It consists of the firm's marketing mix, the set of marketing tools the firm uses to implement its marketing strategy. The major marketing mix tools are classified into four broad groups, called the four Ps of marketing: product, price, place, and promotion. To deliver on its value proposition, the firm must first create a need-satisfying market offering (product). It must decide how much it will charge for the offering (price) and how it will make the offering available to target consumers (place). Finally, it must communicate with target customers about the offering and persuade them of its merits (promotion). The firm must blend each marketing mix tool into a comprehensive integrated marketing program that communicates and delivers the intended value to chosen customers. Normally, the traditional way of viewing the components of marketing is via the four Ps:

(1) Product — goods and services (creating offerings).

(2) Promotion — communication.

(3) Place — getting the product to a point at which the customer can purchase it (delivering).

(4) Price — the monetary amount charged for the product (exchange).

- Marketing Analysis

Market analysis studies the attractiveness and the dynamics of a special market within a special industry. It is part of the industry analysis and thus in turn of the global environmental analysis. Through all of these analyses the strengths, weaknesses, opportunities and threats (SWOT) of a company can be identified. Finally, with the help of a SWOT analysis, adequate business strategies of a company will be defined. The market analysis is also known as a documented investigation of a market that is used to inform a firm's planning activities, particularly around decisions of inventory, purchase, work force expansion/contraction, facility expansion, purchases of capital equipment, promotional activities, and many other aspects of a company (Wikipedia, 2015).

2.2 Literature Survey

Ciptono (2007) explored a research on the relationships between quality factors and customer satisfaction for the Triple-A supply-demand chain management (Agility, Adaptability, and Alignment). The unique contribution of the study is the empirical analysis of a sample Strategic Business Units (SBU) managers from the Indonesia's oil and gas industry and the use of Importance-Performance Ratings and Factor Analysis to determine the link between quality factors (external quality and internal quality) and customer satisfaction for the Triple-A supply-demand chain management. Additionally, Omar et al. (2007) mentioned that the dynamic market environment in the global supply chain has increased the pressure and challenges among the manufacturing companies in Malaysia to be innovative, to improve quality and to reduce cost. In the present competitive environment quality management is critical as products must meet expectation of global customers in terms of quality, design and price expectations.

On the other hand, Dhamodaran (2007) stated that when globalization is discussed, it is the big multinational brands that usually come to mind. The small and medium enterprises can also cash in on the opportunities of globalization, if they take advantage of modern management practices and information technology. The globalised industrial scenario today is such that, it is inevitable for every progressive organization to keep pace with the developments taking place within and outside their national boundaries, in order to overcome the challenges and become successful in their respective industries. In 2010, Benabdelhafid stated that one of the biggest car manufacturers announced last August that he called back 1,13 million models of his star car for a problem of engine, having already called back more than 10 million vehicles in the world since autumn. This phenomenon increases with the financial crisis and concerns several manufacturers. The abseiling of manufactured goods raises the problem of production of spare parts. In this article we present a study in an automotive supplier this study consists in creating a decision-making tool.

Kuhn (201) Supplying goods and services on a worldwide scale is not a new phenomenon: In the early 20th century vehicles (Ford), sewing machines (Singer) or chemicals (Du Pont) are only some examples for goods being exchanged between the continents. Continuing until the 1970s the shipping of all these goods was a very complex process consisting of many interfaces with the related documents as for example customs declarations, bill of lading or hazardous material declarations. Furthermore, Perez-Arostegui et al. (2011) analyzed the impact of Information Technology (IT) competence, composed of IT infrastructure flexibility, IT technical and managerial knowledge and the integration of IT strategy with firm strategy, on competitive advantage, which is measured based on improvement in quality performance. Since, according to the Resource based-view (RBV), IT alone is not able to sustain a competitive advantage; we must analyze the moderating effect of orientation to leadership on this relationship. The data, taken from a sample of 230 Spanish firms, show the importance of some dimensions of IT competence on the improvement of quality performance, as well as the key role that leadership plays in determining this relationship.

Moreover, Ganesan and Dhanapal (2012) conducted a study in technological changes that have contributed to economic growth globally, leading to significant improvement in the quality of life of people in different parts of our world. In recent days, the growing universalisation and internationalization of banking operations, driven by a combination of factors, such as the continuing deregulation, heightened competition and technological advancements have altered the face of the banks from one to mere intermediator to one of provider of quick, efficient and consumer friendly services. While, Teeravaraprug (2012) defined quality loss function (QLF) that is one of the most important issues encountered in quality engineering. QLF is used to quantify the quality loss of a product on a monetary scale. This monetary loss occurs when a product performance deviates from customer expectation.

In 2012, Polyorat and Buaprommee mentioned that consumers are more concerned with meat safety after the outbreak of mad cow disease and bird flu. Meat traceability, therefore, become more widely implemented in order to handle the food safety concern. While traceability is more common among manufacturer-wholesaler-retailers cycle, it is rarely used as a marketing tool to persuade consumers who are meat endusers. According to the quality management in logistics, Manikas et al. (2012) analyzed how well the priorities of third party logistics providers in the UK are aligned to that of their customers and how these priorities change dependent upon industry segment and size. The data gathering was achieved mainly through a quantitative dyadic questionnaire although qualitative semi-structured interviewing will take place following the pilot of the questionnaire.

Longtau (2003) stated that although rice is a traditional crop in Nigeria, local production was limited until recently. Internal demand is growing and, at the same time, rice is a major commodity of world trade. Nigeria is therefore under pressure from international bodies not to restrict imports; production under local conditions to match prices of rice produced on large mechanized farms therefore represents a considerable challenge. The study was conducted in two phases; a literature review and a nationwide survey of rice farmers, intended to both describe the situation of rice producers, and to explore the policy environment. Survey techniques were designed to parallel similar studies conducted in Mali and Ghana. A key finding is that despite considerable national and policy emphasis on irrigated rice and large-scale schemes, these now represent an extremely small proportion of rice production. The decline of subsidized inputs during the 1990s has meant that almost all cereal staples are produced in low-input environments on small farms.

Moreover, Giraud (2013) investigated fragrant rice estimated to account for 15-18% of the rice trade procuring the highest prices on the world market. Worldwide rice production totaled 481 million metric tons in 2011, including 7.1% in trade. Some new players are interested in entering this premium segment, including the US, Vietnam, and other rice growers and traders. The fragrant rice commodity chain is deciphered through a meta-analysis of data on rice cropping and trading. We conclude on a possible split between fragrant and coarse rice markets. The upcoming challenges for fragrant rice industry are discussed with the next release of genetically modified varieties; water scarcity in rice cropping; and land use trade-offs between fragrant and coarse rice. The review of literature above discusses the previous and recent works of rice production, domestic consumption, rice export, and quality assurance. Previous and current research on the quality assurance has become very important in variety of contexts.

John (2014) International rice markets are seen as volatile due to the thin nature of the market which is believed to be exacerbated by a low level of substitution between major rice export markets. In other words, this perceived lack of price transmission amongst international rice markets is believed to further thin out an already thin world rice market. The paper tests for price transmission between five major rice exporting markets representing Asia and the Americas over the past decade. It uses a vector autoregressive framework and performs Granger and Toda-Yamamoto causality tests and generalized impulse response functions to interpret the model’s results. The findings suggest that price transmission exists across these major rice export markets with price relations being the most widespread between Asian markets. Furthermore, the direction of price transmission suggests that Asian prices act as price leaders for North and South American prices.

On the other hand, Santacoloma (2008) compared the organizational structure and marketing strategies in organic supply chains operating under three certification schemes in developing and transition economies. A value chain management approach needs to be considered when analyzing the requirements associated with supplying certified organic products. Regardless of the scheme, complying with organic standards and procedures involves making managerial decisions at the production, processing, certifying and marketing levels. A modern and transparent organizational structure should be developed along the chain in order to ensure lasting organic quality.

3. Research Methodology

The data for this study were collected from both primary and secondary sources. Primary data were collected from samples of the respondents. Sources of primary data were smallholder farmers, traders, brokers, retailers and rice millers. The data collected through a questionnaire survey includes the following:

- Data on quantity of rice marketed, price of rice supplied, total acreage of rice cultivated, expenditure on factors of production, distance from market, size of output, access to market, market information, livestock ownership, land holding, extension service contact, credit access, family size, were collected and these were used to analyze factors determining marketable supply of rice.
- Data on output produced and sold, production costs, input costs, and marketing costs were collected and used to analyze the net returns (profitability) of rice production and the cost and price information used to construct marketing costs and margins.
- Data on market information system, exchange arrangements, system of storage, transport facilities, price setting strategy, purchasing strategy, selling strategy, barriers to entry and capital were collected from sample informants using a questionnaire, and these were used to investigate the structure and conduct of the market.
- Data on input usage, credit facilities, agriculture extension service, marketing information, and institutional support activities were collected and used to analysis production and marketing support services.

The selection of measurements stems from the need to derive quality assurance for rice supply chain. The quality assurance criteria was identified, and further investigated by the questionnaires that include rice-desired (quality, grade, nutrition, color, cleaning), environmental care (chemical, pesticide, fertilizer, contamination), method of cultivation (conventional, organic), brand, and quality award in order to collect all possible factors to adjust the quality assurance criteria. Moreover, GAP is production and farm level approaches to ensure the safety of fresh produce for human consumption. Good Agricultural Practices (Pre-Season Rice Safety Inspection) questionnaire is used to identify several factors such as water, soil amendments, environmental factors, field employee practices & hygiene, field sanitation.

Furthermore, this research also investigated the mathematical models for Predicting Potential PMR, PHR, and FY as a function of Rice Quality that identify as follows:

- Percent Milled Rice Prediction Model

  Percent milled rice is directly related to the process of dry matter accumulation during the ripening stage.
- Percent Head Rice Prediction Model

  During the early ripening stage, PHR increases very rapidly due to the rapid increase in kernel dry matter and mechanical strength. When the rice kernel reaches full dimensions and maximum mechanical strength, PHR would also be expected to reach a maximum.
- Field Yield Prediction Model

  PMR can be interpreted as the ratio of milled rice yield (MRY) to FY.

4. Results Analysis

(1) Questionnaire of pre-season rice safety inspection

- Water
  - The sources of water for this ranch were: well, surface/canal/reservoir (78%), municipal water supply (19%), and others (3%) (see Figure 1).
  - All sources of water and distribution systems clearly identified on the ranch map
  - A sanitary survey sometimes completed for each water source
  - Not all the water sources were tested for generic E.coli prior to plant germination
- Soil Amendments

- Raw or partially composted animal manure was rarely used to supplement soil
- The following compost materials were used: composted animal manure or aged animal manure (46%), physically heat treated compost (22%), and non-synthetic crop treatments (compost teas, fish emulsions, fish meal, blood meal, bio-fertilizer, etc.) (32%) (see Figure 2).
- The composting processes was validated
- No QARSC application time period was followed
- No required QARSC analysis was done on record

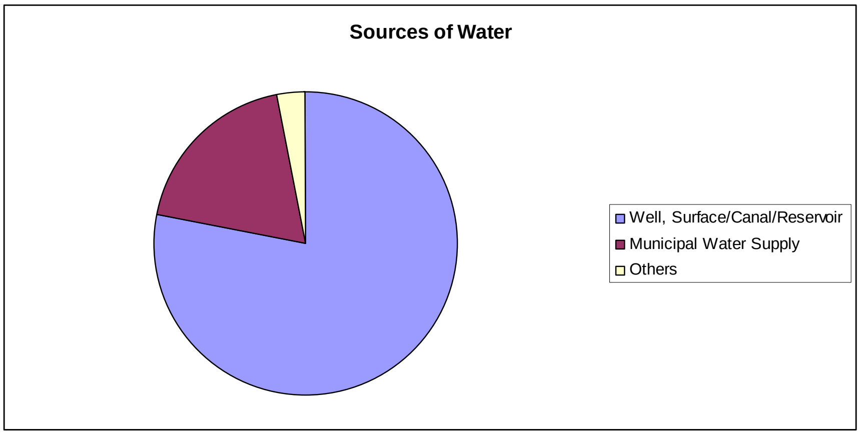

Figure 1 Sources of Water

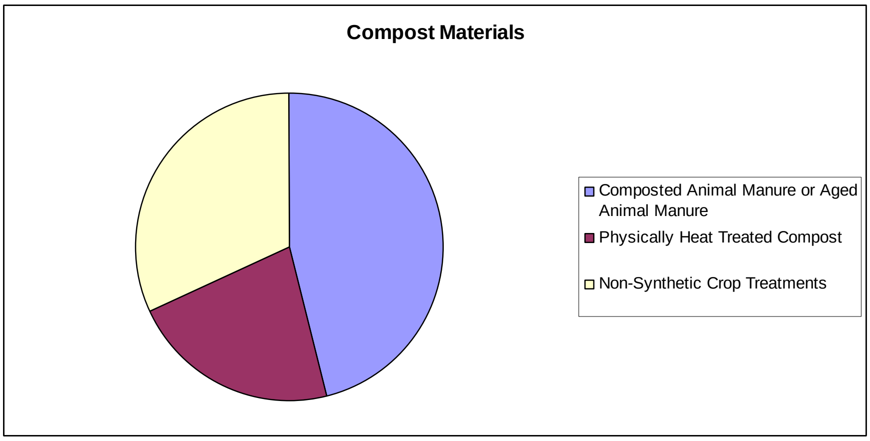

Figure 2 Compost Materials

- Environmental Factors
  - There was evidence of intrusion by animals of significant risk in or around the growing area (animals present, animal tracks, feces/urine, etc.)
  - No procedures identified were followed in the “Production Locations — Encroachment by Animals and Urban Settings” of the GAP metrics
  - There was no history of flooding within the last 60 days
  - The field was used for activities other than growing crops (hazardous activities including but not limited to CAFO, municipal waste, toxic waste, landfill, etc.) or as grazing land within the last 1 year)
  - There was no evidence of downed fencing?

- The following QARSC Adjacent Land Use issues were not presented?
  - Compost operations within 400’ of the crop edge
  - CAFO within 400’ of the crop edge
  - Storage of non-synthetic soil amendments within 400’of the crop edge
  - Grazing lands or domestic animals within 30’ of the crop edge
  - Septic leach fields (home or other building) within 30’ of the crop edge
  - Well head within 200’ from untreated manure
  - Surface water protection buffer zone distances from untreated manure
  - 100’ for sandy with a slope < 6%
  - 200’ for loamy or clay soil with a slope < 6%
  - 300’ for all slopes > 6%
  - Natural vegetation, riparian areas or other adjacent land uses that pose a food safety risk to crops
- Field Employee Practices & Hygiene
  - There was no evidence that worker hygiene rules have been violated
- Field Sanitation
  - There was a specific individual responsible for identifying and documenting potential contamination risks during the growing and harvesting of crops

(2) Test Methods for Paddy Grading

(a) Preparation of working sample

The representative samples were passed to the Department of Internal Trade for testing paddy and milled rice grading. The working samples were tested for tree trials for each test. A size of 100 grams investigating the paddy grading was used for purity determination, immature, chalky, discolored, damaged and red kernels. 150 and 250 grams were used for moisture content determination, and potential milling recovery, respectively. Furthermore, a size of 100 and 150 grams testing the milled rice grading was used for headrice, brokers and brewers, discolored, damaged, red, red streaked, chalky, immature and foreign matter, as well as moisture content determination, respectively.

(b) Moisture Content Determination

The moisture tester was used constantly for three trials and different weights as illustrated in Figure 3. The moisture content in rice is determined using a grain moisture analyzer that derives the percent of water content within the grain. If moisture content is too high, risks include heat, mold development, insect infestation, and discoloration. Practically, a vital component to harvesting an optimal rice product is obtaining an accurate moisture reading in the field that is comparable to the moisture reading at the elevator. Recent advances in moisture tester technology have improved the analysis of moisture content percentage to aid in determining prime harvest conditions.

Figure 3 Moisture Tester

Paddy Grading

(c) Purity Determination

$$\% \text{ Purity} = \frac{\text{weight of pure paddy}}{\text{wt. of working sample}} \times 100$$

$$\% \text{ Foreign matter} = \frac{\text{wt. of foreign matter}}{\text{wt. of working sample}} \times 100$$

$$\%\text{Weed seed and other crop seeds} = \frac{\text{wt. of weed seed and other crop seeds}}{\text{wt. of working sample}} \times 100$$

A calculation of % purity, % foreign matter, and % weed seeds and other crop seeds testing with 100 grams paddy grading was as follows:

$$\% \text{ Purity} = \frac{75}{100} \times 100\%$$

$$= 75\%$$

$$\% \text{ Foreign Matter} = \frac{21.4}{100} \times 100\%$$

$$= 21.4\%$$

$$\% \text{ Weed Seeds and Other Crop Seeds} = \frac{83}{100} \times 100\%$$

$$= 83\%$$

(d) Determination of contrasting type and type classification

$$\% \text{ Contrasting type} = \frac{\text{wt. of contrasting kemels}}{\text{wt. of whole brown rice}} \times 100$$

A calculation of % contrasting type testing with 100 grams paddy grading was as follows:

$$\% \text{ Contrasting Type} = \frac{2.8}{100} \times 100\%$$

$$= 2.8\%$$

(e) Determination of Defective Grains

$$\% \text{ Chalky and immature} = \frac{\text{wt. of chalky kemels and immature kernels}}{\text{wt. of working sample}} \times 100$$

$$\% \text{ Discolored kemels} = \frac{\text{wt. of discolored kemels}}{\text{wt. of working sample}} \times 100$$

$$\% \text{ Damaged kemels} = \frac{\text{wt. of damaged kemels}}{\text{wt. of working sample}} \times 100$$

$$\% \text{ Red kemels} = \frac{\text{wt. of red kemels}}{\text{wt. of working sample}} \times 100$$

A calculation of % chalky and immature, % discolored kernels, % damaged kernels, and % red kernels testing with 100 grams paddy grading was as follows:

$$\% \text{ Chalky and Immature} = \frac{3.6}{100} \times 100\%$$

$$= 3.6\%$$

% Discolored Kernels = $\frac{1.2}{100} \times 100\%$

= 1.2%

% Damaged Kernels = $\frac{9}{100} \times 100\%$

= 9%

% Red Kernels = $\frac{0.7}{100} \times 100\%$

= 0.7%

(f) Determination of Potential Milling Recovery

% Potential milling recovery = $\frac{\text{wt. of milled rice}}{\text{wt. of pure paddy}} \times 100$

A calculation of % potential milling recovery testing with 250 grams paddy grading was as follows:

% Potential Milling Recovery = $\frac{87}{100} \times 100\%$

= 87%

Milled Rice Grading

(g) Determination of head rice, big brokers, other brokers and brewers

% Brewers = $\frac{\text{wt. of brewers}}{\text{wt. of the working sample}} \times 100$

% Big brokens = $\frac{\text{wt. of big brokens}}{\text{wt. of the working sample}} \times 100$

% Other brokens = $\frac{\text{wt. of other brokens}}{\text{wt. of the working sample}} \times 100$

% Headrice = $\frac{\text{wt. of headrice}}{\text{wt. of the working sample}} \times 100$

A calculation of % brewers, % big brokens, % other brokens, and % headrice testing with 100 grams milled rice grading was as follows:

% Brewers = $\frac{1}{100} \times 100\%$

= 1%

% Big Brokens = $\frac{16}{100} \times 100\%$

= 16%

% Other Brokens = $\frac{5.6}{100} \times 100\%$

= 5.6%

% Headrice = $\frac{13.4}{100} \times 100\%$

= 13.4%

(h) Determination of Contrasting Type and Type Classification

$$\% \text{ Contrasting type} = \frac{\text{wt. of contrasting type}}{\text{wt. of working sample}} \times 100$$

A calculation of % contrasting type testing with 100 grams milled rice grading was as follows:

$$\% \text{ Contrasting Type} = \frac{3}{100} \times 100\%$$
$$= 3\%$$

(i) Determination of Foreign matter and Defective Milled Rice

$$\% \text{ Discolored kernels } \frac{\text{wt. of discolored kemels}}{\text{wt. of working sample}} \times 100$$

$$\% \text{ Damaged kernels} = \frac{\text{wt. of damaged kemels}}{\text{wt. of working sample}} \times 100$$

$$\% \text{ Red kernels} = \frac{\text{wt. of red kemels}}{\text{wt. of working sample}} \times 100$$

$$\& \text{ Red streaked kernels} = \frac{\text{wt. of red streaked kemels}}{\text{wt. of working sample}} \times 100$$

$$\% \text{ Chalky and immature kernels} = \frac{\text{wt. of chalky \& immature}}{\text{wt. of working sample}} \times 100$$

$$\% \text{ Foreign matter} = \frac{\text{wt. of foreign matter}}{\text{wt. of working sample}}$$

A calculation of % discolored kernels, % damaged kernels, % red kernels, % red streaked kernels, % chalky and immature kernels, and % foreign matter testing with 100 grams milled rice grading was as follows:

$$\% \text{ Discolored Kernels} = \frac{2}{100} \times 100\%$$
$$= \%$$

$$\% \text{ Damaged Kernels} = \frac{12}{100} \times 100\%$$
$$= 12\%$$

$$\% \text{ Red Kernels} = \frac{1}{100} \times 100\%$$
$$= 1\%$$

$$\% \text{ Red Streaked Kernels} = \frac{0.7}{100} \times 100\%$$
$$= 0.7\%$$

$$\% \text{ Chalky and Immature Kernels} = \frac{1.9}{100} \times 100\%$$
$$= 1.9\%$$

$$\% \text{ Foreign Matter} = \frac{0.4}{100} \times 100\%$$
$$= 0.4\%$$

(j) Determination of Milling Degree

Milling degree is a measure of the amount of bran removed from the brown rice. It is usually defined as the extent to which the bran layers of rice have been removed during milling. Milling normally removes the germ and the bran layers which include the outer pericarp of the rice kernel, the aleurone layer, and some of the starchy endosperm. To measure the milling degree, several parameters should be determined such as visual, color, or surface. Visual observation shall be maintained by the Department of Agriculture, and shall be available for reference in all inspection offices that inspect and grade rice. Color is measured typically with the higher the milling degree, the whiter the kernel. Lastly, surface lipid content is measured with the most of the lipid in the kernel that is in the germ and bran. As milling degree increases, the surface lipid content is reduced. Surface lipids are extracted and quantitatively measured.

The degree of milling for milled rice can be identified as “hard milled”, “well-milled”, and “reasonably well-milled”, that shall be equal to, or better than, that of the interpretive line samples for such rice. Most Thai rice tested in this research study falls into the category of well-milled which means that all of the bran and germ have been removed during milling. Only a minimal amount of the endosperm (starchy area) has been removed. Hard-milled means rice has been milled longer and removed more of the bran and outer endosperm layer. It will typically be stickier than well-milled rice. Its protein level may be lower also. Reasonably, well-milled rice will have the germ and most of the bran removed, but may still have bran streaks (patches of bran that have not been removed) on the kernels. In summary, milling degree affects processing properties of rice as follows:

(1) Under milled rice still has bran attached to the kernel. This can reduce water absorption, adds fiber, protein, and lipids (thus reducing % starch). This would affect applications such as cooking time, kernel to kernel interactions (stickiness versus separateness), color of the rice and interactions with other ingredients.

(2) Higher lipid content would affect how a rice kernel would pick up spices or seasoning coating.

(3) Highly milled rice will have a higher starch content and lower lipids and protein than rice milled to a lower milling degree. This affects starch pasting properties and the effect can be seen in a higher curve run on an RVA (Rapid Visco Analyzer).

(k) Grading

Standards are a quantitative way of measuring and comparing certain quality characteristics. This measured comparison of recognizable quality characteristics can be described as “grading”.

Table 1 Comparison of Recognizable Quality Characteristics

Grade Specification		Grade			
		Premium	Grade 1	Grade 2	Grade 3
Head Rice (Min %)					
Brokens (Max %)					
Brewers (Max %)					
Defectives	Damaged Grains (Max %)	0	0.25	0.50	2.00
	Discolored Grains (Max %)	0.50	2.00	4.00	8.00
	Chalky and Immature Grains (Max %)	2.00	5.00	10.00	15.00
	Red Grains (Max %)	0	0.25	0.50	2.00
	Red Streaked Grains (Max %)	1.00	3.00	5.00	10.00
	Foreign Matter (Max %)	0	0.10	0.20	0.50
	Paddy (Max No./Kg)	1	8	10	15
	Moisture Content (Max %)	14.00	14.00	14.00	14.00

In general, grading factors for paddy are (1) purity, (2) foreign matter, (3) defectives and (4) moisture content. For milled rice, the characteristics considered for grading are (1) head rice, brokens and brewers percentages (2) defectives, (3) foreign matter, (4) presence of paddy and (5) moisture content. The objectives of establishing standards and grades are as follows:

(1) To ensure only edible rice reaches the consumer

(2) To improve postharvest practices so as to eliminate or reduce waste

(3) To improve agronomic practices to increase farm yields

(4) To improve processing practices for better milling recoveries and for market expansion

(5) To protect consumers from price/quality manipulation

In relation to the first objective, the characteristics such as moisture content, foreign material, seeds and discolored (damaged) grains are important considerations in assuring that only edible rice reaches the consumers. By setting standards for the degree of milling, broken rice content, moisture and damaged grains, the second objective is addressed. Better threshing and drying, and improved storage facilities are expected to emerge to meet the required standard. The third objective provides incentives to the farmer/agricultural scientist to optimize production by considering standards for chalkiness, varietal purity, foreign seeds, immature grains and red rice. The fourth objective provides a measure of the miller's success in delivering high milling recovery and allowing the market expansion. Characteristics considered are standards for degree of milling, broken rice, paddy kernels and foreign matters. Finally, standards which clearly identify to consumers the true value of their purchases will provide the protection required against the possibility of unfair trading practices.

(3) Develop Mathematical Models for Predicting Potential PMR, PHR, and FY as a function of Rice Quality

Percent Milled Rice Prediction Model

Percent milled rice is directly related to the process of dry matter accumulation during the ripening stage. The proposed model by Lu et al. (1992) of PMR is as follows:

$$PHR_p = A_T\left(1 - B_T \exp\left(-\frac{C_T}{(M\text{-}M_O)}\right)\right)$$

$$PMRp = 100\ (1 - 150 \times \exp\ (-\frac{50}{(85-62)}))$$

Percent Head Rice Prediction Model

During the early ripening stage, PHR increases very rapidly due to the rapid increase in kernel dry matter and mechanical strength. When the rice kernel reaches full dimensions and maximum mechanical strength, PHR would also be expected to reach a maximum. After this stage, PHR would remain constant unless some adverse weather condition such as rain is encountered. The same exponential function form as that of PMR was used to describe the potential PHR.

$$PHR_p = A_H\left(1 - B_H \exp\left(-\frac{C_H}{(M\text{-}M_O)}\right)\right)$$

$$PHR_p = 120\ (1 - 100 \times \exp\ (-\frac{35}{(85-62)}))$$

Field Yield Prediction Model

Since PMR can interpreted as the ratio of milled rice yield (MRY) to FY, the following expression for the potential FY can be stated:

$$FY_p = \frac{FY_P - (BY_P + HY_P)}{(PMR/100)}$$

$$FYp = \frac{60-(85+67)}{\frac{PMR}{100}}$$

List of Symbols		Subscripts	
a, b	parameters in the percent head rice reduction model	H	head rice
c	constant in the potential field yield model (kg/ha)	O	the lowest possible harvest moisture content
A, B, C	parameters in the potential percent milled rice or percent head rice model	P	potential yield
BY	bran yield (kg/ha)	T	milled rice
FY	rice field yield (kg/ha)		
FYR	field yield reduction (decimal)		
HRR	head rice reduction ratio (decimal)		
HY	hull yield (kg/ha)		
M	moisture content, wet basis (%)		
MRY	milled rice yield (kg/ha)		
N	number of days after rice reaches the maximum field yield		
PHR	percent head rice (%)		
PMR	percent milled rice (%)		
γ	field yield reduction rate (day^{-1})		

5. Marketing Opportunity for Quality Milled Rice

Considering the above factors, this study applies the metaphor of how quality milled rice can be analyzed using market opportunity.

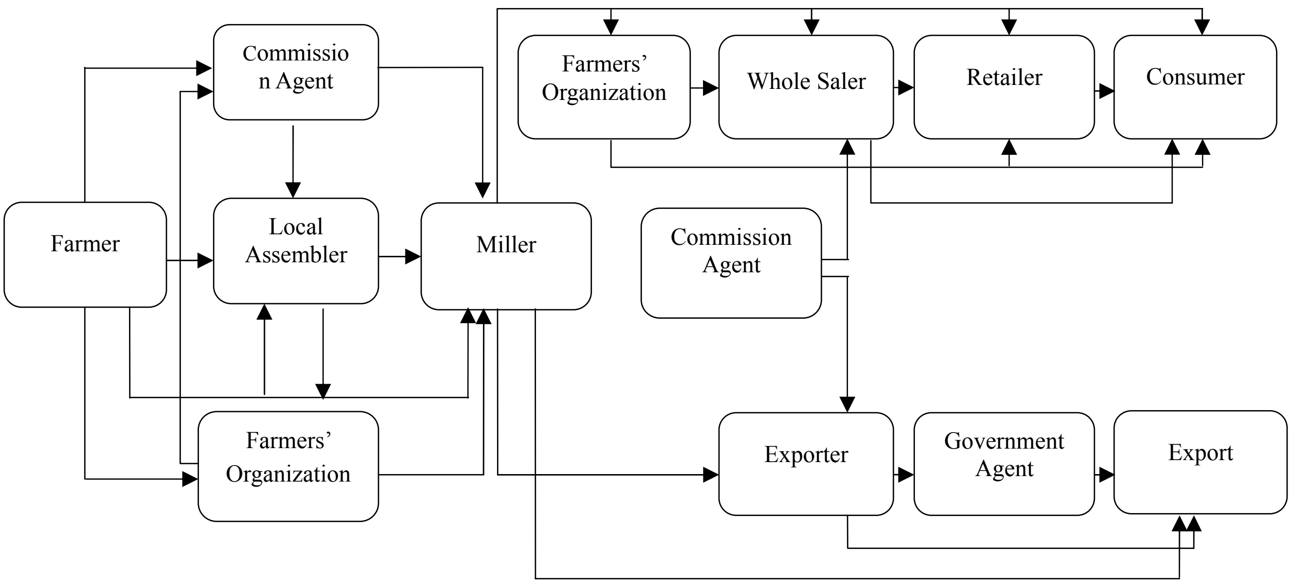

Figure 4 Metaphor of Quality Milled Rice System

Normally, the framework is comprised of five forces that drive market opportunity: customer, product, timing, competition, and finance (Mind the Product Ltd, 2014). Each factor can be subdivided as follows:

1. Customer • Clearly identifiable customer • Meaningful problem to solve • Segmentable market • Customer accessibility • Customer loyalty
2. Product/service • Tight niche focus • No network effect • Lean method viable • Team-to-market fit • Inherent story (virality)
3. Economic • Healthy margins • Demand constraints • Supply constraints • Sunk costs • Cash flow requirements
4. Timing • Secular trend alignment • Recent innovation enabler • Market inefficiency • Recent competition surge • Signs of commoditization
5. Competition • Limited competition • Competitor fitness • Team fitness • Defensible position • Barriers to entry

Firstly, customer of milled rice (Jasmin) can be categorized into two categories: domestic and international. To explain the market opportunity, most of rice is produced on small farms where about one-half of the production was for family consumption. The surplus is sold in the market through traveling buyers who collect traveling paddy and moved down the canals to Bangkok, the central and terminal market for all crops. For the international market, Thailand is the largest rice exporter to the world market, the largest rice producing country is China. For the Jasmine rice, some millers are specialized in the high quality variety, and tend to make direct business with the end buyers

Secondly, Thailand should plan to focus on high quality milled rice for export, and prove if the price paid to farmer reflects real value. It is suggested that a number of interrelated features determine the quality of paddy such as moisture content of paddy, purity degree, varietal purity, cracked grains, immature grains, and discolored/fermented grains and damaged grains. These characteristics are determined by the environmental weather conditions during production, crop production practices, soil conditions, harvesting, and post-harvest practices (Betuco, 2015).

Thirdly, Thailand nowadays becomes a major competitor for long grain rice in the world market due to the stable political conditions relative to the neighboring countries. Accordingly Global Economic Symposium (2015), it illustrates that three key factors have contributed to steady growth in demand for rice, which is increasing globally by around 5 million tons each year. Population growth is outstripping production growth, and rapid economic growth in large countries such as India and China has increased demand for consumption and for livestock production. Rice is an increasingly popular food in Africa, with imports into Africa accounting for almost one-third of the total world trade.

Fourthly, Wiboonpongse and Chaovanapoonphol (2001) explained that timing can be defined as the season to grow rice. They suggested that more rapid increase in the production is remitted from application of high-yielding varieties grown especially in the hot dry season (February to June). During 1990-1996, dry season rice production area accounted for 5.5% to 10% of the wet (main) season (August-December) cultivated land (Table 1). Production of dry season, however was 12% to 24% of the main crop production (since the average yield of dry season was more than double).

Finally, Pilavong et al. (2012) commented that Thai rice export volume had been ranked as the number one in the Global Rice Market for 10 years (refer with: National Statistical Office Thailand), until 2010, then Thailand lost this position to India and Vietnam. Thailand also has neighbors that are both competitors and partners in rice trading. They are Myanmar, Vietnam, Laos, Indonesia, Malaysia, Philippines, and Cambodia.

6. Conclusion and Discussion

The quality assurance criteria was identified, and investigated by the questionnaires that include rice-desired, environmental care, method of cultivation, brand, and quality award in order to collect all possible factors to adjust the quality assurance criteria. The questionnaire was given for collecting the data on the pre-season rice safety inspection. Data measurement and analysis was done towards the midstream level (rice industry, processed rice). Each questionnaire, calculation, and index was used for investigating rice quality chain, whereas three models were developed to predict PMR, PHR, and FY as a function of rice moisture content at harvest. Further research is needed to quantify the effects of several parameters towards rice quality along supply chain.

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