Development of a Digital Image Processing Tool for Rice Grain Quality Analysis through Machine Vision

A Research Proposal Presented to the

Community of Calatagan, Batangas

In Partial Fulfillment of the Requirements

for the Capstone Project

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TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION

As with the rest of the developing world, the locality of Calatagan, Batangas is reliant on rice (*Oryza sativa)*, a staple food crop of which 475.64 metric tons are consumed internationally with approximately 42% of the caloric intake of the international human population being accounted for with the rice crop (Ricepedia, n.d.). This dependence on the rice crop is further exemplified in third-world countries, wherein Ricepedia.org (n.d.) reports that "for the extreme poor in Asia who live on less than $1.25 a day, rice accounts for nearly half of their foo expenditures and a fifth of total household expenditures, on average." With its necessity and essentiality, moreso in rural and rural and impoverished communities that rely on this staple grain for daily consumption, it is crucial to ensure that the quality of rice remain positive and high quality in the forms of nutritional benefit and safety for consumption (Othman, 2017). In accordance to the International Rice Research Institute (2017), the security of rice in our communities and agricultural sphere also equates to a significant boost in general food security across several communities. Moreover, the general ensurance of food security is essential in order to assure that rice maintains its high nutritional content and value while remaining cheap and accessible to the general public; rendering even those under the poverty line of benefit and ensuring them a continuous access to a staple crop that provides for a large amount of caloric needs and other daily nutritional requirements, among others.

With the gap in a directly standardized form of rice grain measurement and assessment due to the absence of a “proper definition or description of rice grain quality,” several evaluative standards and grading systems have risen. Another consideration is that the perspective on rice quality varies from different areas, rendering a significant need for contextual understanding on the valued factors—which are also dependent on the presence of particular rice grains in an area. For instance, in terms of cooking: aroma, grain size, and appearance are observed to discern cookability whereas a rice miller describes rice quality in terms of total recovery of broken rice kernels (Jafar, 2010). The breadth of different views towards rice quality has led to different evaluative and classification systems. In the United States, these properties revolve around the (1) hull and pericarp of the rice, (2) its color, grain size, shape, weight, uniformity, and general appearance, and (3) kernel chalkiness, translucency, and color (Khush & Singh, 2000). As such, observing these grain properties are key to determining other characteristics of rice, such as its performance and resulting consistency and reactions when cooked -- as well as the quality of the milled grain sample when counting the broken granules in a sample. Despite the difference and variety in factors taken of value when evaluating samples of rice grains and the multitude of standards and systems, grain assessment in the appropriate contexts and under the consideration of the relevant variables and factors is crucial to maximizing and helping in the efficiency of rice. In consideration of these differences, variety and flexibility of a tool that can adequately process grains and take into

consideration a multitude of factors with the ability to post-process data is highly recommended.

In contextual understanding of the community: composed of approximately 10,527 hectares of land, of which 6,698 or nearly 63.62% of the total land masses are used for agricultural and farming purposes--Calatagan is a common example of a standardized rural setting in the Philippine environment, wherein a portion of the population depend on agriculture for their livelihood. As depicted in Table 1.1 found below, the land use for agriculture comprises majority of the agricultural municipality. Further assessment is also indicative of the total open grassland covered by an area amounting to about 8,823 hectares (Assessor's Office, 2016). As such, the various barangays are divided into sectors: three in particular are focused on in the project proper, namely Barangay Real, Barangay Poblacion 2, and Barangay Balibago that are known for agricultural work, general living and agricultural vocations, and fishing and some farming respectively--with the latter being located directly next to major waters. With the prevalence of the agricultural lifestyle and livelihood, along with data regarding the counts of rice fields and farmers within the locality, analytics and information regarding quality factors present an additional benefit to the farmers and agricultural parties within the community to gain familiarity with their crops and understand which strains tend to be most effective based on the milled outputs and assessments after the investigative research procedure ("Assessor's Office, Office of the Municipal Planning and Development Coordinator, Calatagan, Batangas", n.d.).

Land Use Classification	Area (in hectares)	Percentage of Total (%)
Built-up Areas	391.6375	3.72%
Tourism	197.9243	1.88%
Agricultural	6,698.0766	63.62%
Industrial	40.0000	0.38%
Roads	143.3610	1.36%
Planned Unit Development	871.0806	8.27%
Swamps, Fishponds, and Bodies of Water	417.2529	3.96%
Open Grasslands	1,768.5561	16.81%
TOTAL	10,527.8890	100%

Table 1.1. *Existing Land Uses of Calatagan, Batangas (2001).* Taken from Assessor's Office/Office of the Municipal Planning and Development Coordinator

With agriculture as the traditional economic base within Calatagan, citizens largely take to these vocations and areas (Municipality of Calatagan, n.d.). One of the major agricultural activities of Calatagan include crop production in which the major crops raised in the municipality include rice (or *palay* in Tagalog), sugarcane, fruit trees, vegetables, corn, and root crops.

Amongst the agricultural land use, the agricultural profile and production output of the municipalities is depicted in Table 1.2 found below--though this may not necessarily include citizens and farmers that farm for their own personal use. As further reported in their socio-economic profile, rice is the staple food crop of the municipality. The data below indicates that rice is the third most prevalent agricultural crop, next to sugarcane and fruit tree production, occupying a total land area of 642.919 hectares--roughly 9.6% of the total agricultural area. Although the land profile is majorly dominated by sugarcane, rice farming and plantations play a major part in the livelihood of the citizens within Calatagan—consisting of a large amount of their actual consumption and relying on rice as a community staple.

Agricultural Crops	**Area Planted in Hectares**	**Percentage to Total**	**Volume of Production in Metric Ton**
Rice • Irrigated • Upland	642.9190 • 92.5000 • 550.4190	9.60% • 1.38% • 8.22%	2,803.236 • 1,108.000 • 1,695.236
Sugarcane	3,913.6076	58.43%	249,260.884
Fruit Trees	1,582.5100	23.63%	20,002.880
Vegetables	100.2600	1.50%	59.850
Corn	264.3600	3.94%	437.520
Root Crops	264.3600 194.3200	2.90%	116.520
TOTAL	6,698.0766	100%	

Table 1.2 *Summary of Area Planted and Production of Major Agricultural Crops within Calatagan, Batangas.* Taken from the Department of Agriculture (1996).

Aside from agriculture, commerce and industry play a significant role in the economic structure of the municipality. Based on the records of the Treasurer's Office, there are a total of 310 commercial establishments as of 2000, broadly categorized into 9 different sectors (Municipality of Calatagan, n.d.). Figure 1.1 details the breakdown of inventory of commercial establishments of the municipality of Calatagan.

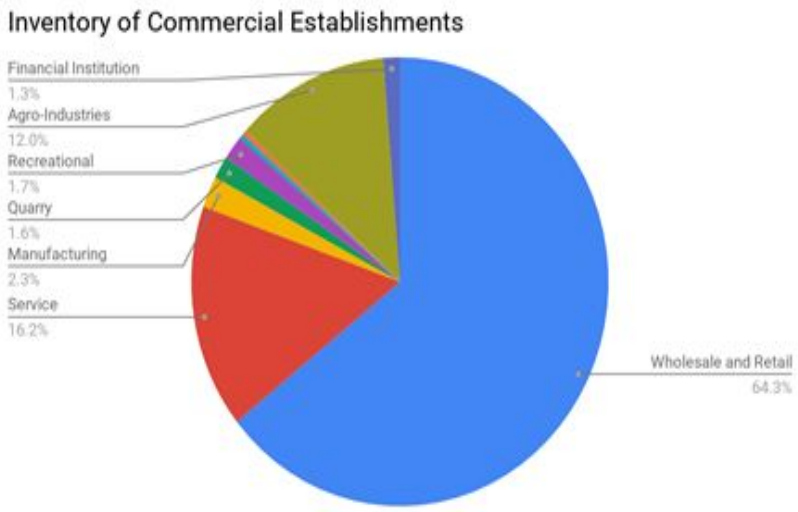


Figure 1.1 *Inventory of Commercial Establishments*

Taken from Treasurer's Office - Municipality of Calatagan (2000)

The figure implies that majority of commercial establishments found in the municipality are wholesale and retail establishments. As indicated in Figure 1.2 below, within this sector, roughly 73.9% of these establishments are 'sari-sari stores' which sell

a variety of general goods -- including that of rice. In a national perspective, it is also found that 93% of all sari-sari stores nationwide are located in residential areas (Bonnin, 2004).

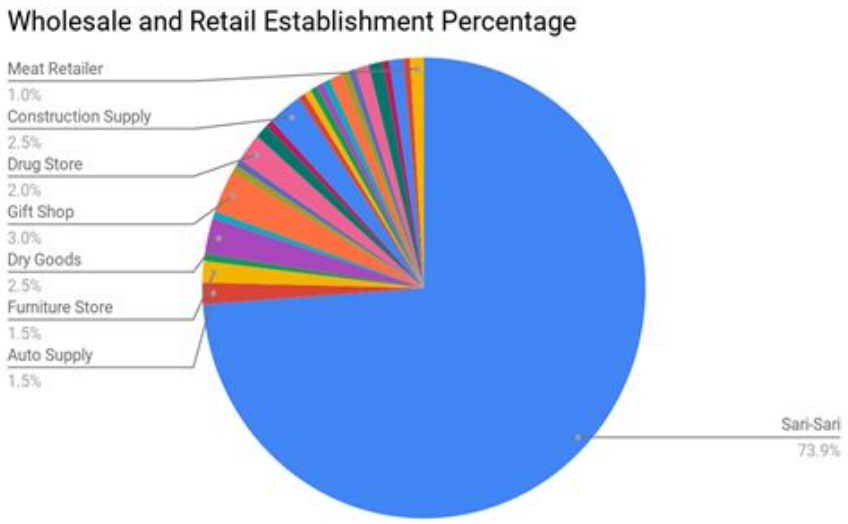


Figure 1.2 *Breakdown of Wholesale and Retail Commercial Establishments (2000)*.

Taken from Treasurer's Office - Municipality of Calatagan.

Although the agricultural sector and vocational nature of citizens within the community of Calatagan would imply that some households produce their own rice and consume it, the researchers have found that the majority of visited households upon the visitation purchase rice through small sari-sari stories that act as the main distributors within these locales. Figure 1.2 further illustrates the prevalence of these small-time distributors within the locality. Table 1.3 details the main sari-sari stores and distributors present within the area of each of the barangay's respective localities. As the prevalent distributors situated internally within each community, the researchers focused on

suppliers within the constraints of the area. However, it is worth noting that a significant portion of interviewed and assessed respondents mentioned that alongside purchase from sari-sari stores, areas outside of the municipalities that lay “on the roadside” around the outskirts of Calatagan and entering their general location present themselves as a much larger, commercial supplier of grains at a similar pricing to what is offered directly in the agricultural community’s internal economic system. It is shown that the majority of rice distributors offered within the municipalities are small-time stores.

Barangay	Store Name	Store Type	GPS Coordinates
Real	Personal Collection	Sari-sari	13°52’38” N 120°40’4” E
Real	Manang Eli’s Sari-sari Store	Sari-sari	13°52’25’’ N 120°39’54” E
Poblacion 2	Lhynne’s Sari-sari store	Sari-sari	13º49'58" N 120º37'25" E
Balibago	Household distributor	Sari-sari (rice and assorted food items)	13º52'38" N 120º40'4" E

Table 1.3. *Details of visited rice distributors within the community of Calatagan, Batangas.*

The figures present an implication towards the prevalence of not only rice consumption with its status as a staple food, but also the concentration of select distributors and suppliers in hyper localized areas, presenting dominance within the research locale. With the concentration of select distributors and the nature of their commercial establishments as locally-managed and organized, there suggests several motives to assess the quality of rice grains as the production, distribution, and consumption of rice within the community is not driven by several external factors or properties—but rather is chained to the citizens along every means of production, distribution, logistics, and several other factors that allow for direct communication and understanding among all ends of the rice supply chain as agricultural providers and distributors are closely linked as common citizens of their respective localities. Overall, the consideration of all these factors in the perspectives of the consumer, distributor, and producer suggests an importance to assess quality of these grains alongside their other relevant factors (such as production costs or logistical choices in deciding which brands or varieties of rice to sell or distribute). With several distributing establishments across the locality, consumers may use the developed analytical tool or make use of and understand the report and analytics to their advantage as it allows them to identify several physical characteristics and purchasing factors of the rice in their locality. With the interweaved chain amongst different citizens and individuals playing different roles

with the end-all consumption and purchase of rice, it is then desirable to highlight and explore the options and present grains.

Aroma, scent, and size of milled grains (amount of chipped grains)	Not concerned with price, purchasing behavior entirely dependent on quality	Dependent on supplier and their trustworthiness
Purchase mixed grains, dependent solely on brand	Aroma and color of grains	Not concerned with price, dependent on grain size and broken amount per kilo

Table 1.3. *Selected comments from interview proper regarding rice purchasing behavior (citizens of Barangay Balibago)*

In understanding the consumer factors that influence citizens pertaining to their purchasing behavior for rice grains, showcased in Table 1.3, several citizens within the locale of Barangay Balibago, as interviewed and questioned during the researchers' visit to the locale, expressed interest in rice grain quality to a minimal extent, indicating more concern in intrinsic properties (aroma, color, and size) over extrinsic factors such as age, moisture content, and count of immature grains. Aroma, in particular, as stated by Vaingankar and Kulkarni (1986) extends as a good indicator for rice brand and grain type as this is a factor internally dependent on the strain of the rice crop. However,

majority of the physical factors of grains are exhibited to not be heavily considered by consumers, despite being major factors of grain quality and serve as indicators of nutritional content and dietary value.

In pursuit of empowering communities with an understanding of the food options and quality available in their locality, moreso for a staple food such as rice, the group intends to provide information and analytics regarding the status of rice grains in the area as well as other similarly relevant information. A more thorough and deeper understanding on the distribution of these rice grains, general grading of certain rice brands, comparative means of assessment on the options of grains available to them, and at its core are to be provided—these desired outputs are done through the provision of providing an accessible assessment tool that acts as an alternative to the existing set-up and procedure of manual grain grading—a process that is not often accessible, especially in remote areas and is not easily performed by consumers or ordinary citizens as it may only be performed by an authority experienced and assigned to perform rice grain gradings—with even then tends to be overtly time consuming.

The intention of the development of the digital image processing tool is to provide an efficient and accessible means of extracting the properties of rice grains; extending towards the analysis and processing of the obtained information to provide a quantitative and analytical means of understanding the status of grains in the area, and the application of such analysis and provision of the tool for long-term and future data generation to continuously aid the locality with informative datasets.

In response to the presented problem, the researchers believe in the association of empowered purchasing power and better-informed buyer choices to food security and integrity in not only the citizen behavior, but also the inclination of distributors and sellers to better understand the different strains and varieties of rice present within the hyperlocal community situation—allowing for adjustments and further planning on the ends of the rice producers as well. Informatics and analytics regarding rice grains, and in the future, other strands and varieties of common crops—intends to produce tools for assessment and response, developing knowledge and strategies for wiser and more cost-efficient purchasing methods, as well as desired milled grain characteristics and comparative analyses of traits and factors present in different brands.

CHAPTER 2: PROPOSAL TO THE PROBLEM

2.1 Background of the Proposal

In response to the issues and present gaps in processing tools and analytics regarding common crops and staple food present, the researchers sought to develop a tool that would allow for the accessible provision of materials and resources for deepened understanding of rice quality in relation and contrast to various other factors.

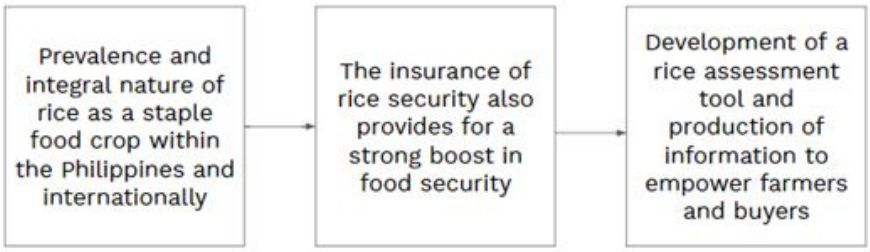
With the intentions stated, two parts for the processing and analysis of the gathered data are proposed. Within the proposal, several advancements and adjustments are made in regards to the processing tool discussed in the original paper, “Development of a Digital Image Processing Tool for Rice Grain Quality Analysis

through Machine Vision.” Modifications to the previous research paper involve the contextual understanding of the materials, technology, and resources available within the community of Calatagan.

In understanding the community of Calatagan, Batangas—the nature of the community is heavily rural, as evidenced by its socioeconomic profile. Furthermore, the chain of production, distribution, and thus consumption of rice in the agricultural area is heavily citizen-powered; as influenced by the agricultural nature and the presence of several rice fields with rice or *palay* as the third most common crop within the area, it is a means of livelihood for various farmers alongside a staple consumption for most households within the location. Distributors mostly consist of small-time and locally-owned stores within the communities, of which Barangay Poblacion 2 and Barangay Balibago only had one major rice grain distributor found within the municipality (in consideration of only internally-located shops)—both carrying only one brand of rice, Dinorado and Sinandomeng (or Sunshine) respectively.

Distributors and consumers are closely linked and may be sourcing a large portion of their rice purchases from these internally-located sari-sari stores and establishments, although several interviewed households have mentioned that another major grain supplier is located outside the municipality of Calatagan and is located alongside the highway leading up to the area. Nevertheless, the rural setting and climate conducive to rice farming has led to a strong reliance to rice in this developing area of Batangas reliant to agricultural development for its primary form of livelihood. The understanding of how such a dominant crop grows and thrives in terms of quality

and its observable factors is crucially needed in the communal sphere and ideals of the residents within the community. This is evidenced by the lack of consideration from the interviewees regarding purchasing methods or beliefs, despite rice being a huge staple: citizens are not aware of even regular and common indicators for grain quality (few mentioned aroma while fewer mentioned aspects such as broken grain count and such), calling for better and more comprehensive understanding regarding the quality of grains in a means that would be accessible and inclusive for people of any position within the rice supply chain, of any background. With the prevalence of rice in production and consumption in the community of Calatagan, the researchers seek to provide more information in order to pursue efficiency, transparency, and a deepened understanding of not only grain quality, but the factors that influence consumer behavior. This can then be analyzed and understood by distributors and producers to change their production methods or adjust certain aspects of production to ensure more quality grains get redirected to suppliers—leading to an overall, ultimately beneficial understanding and healthier outlook of rice from different fields and positions in the supply and consumption chain.



Proposal Roadmap

Fig 2.1. General proposal roadmap and objectives for Calatagan, Batangas

Ultimately, the project's intended value is in the information and analytics that it provides—especially through the assessment tool. The raw information processed with the analytical tool itself goes through several processing and assessment factors (computations and algorithms accounting for the used grading scheme), using the post-processed data rather than the raw datasets.

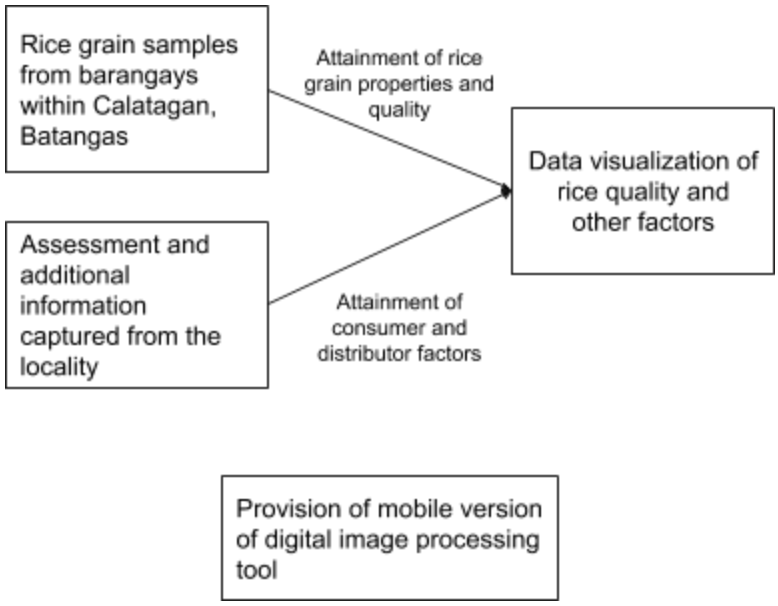


Fig 2.2. Proposal overview diagram, featuring relevant components

In that nature, the proposal intends to make further use of information and data to provide a deeper understanding of the status and quality of rice grains within the locale. This seeks to ensure rice security in the community of Calatagan, Batangas, and to ultimately improve not only customer consumption or selective provision of high quality grains, but to allow for adaptation in other markets, and to ensure crop security in other

fields as citizens and consumers consider several factors in purchasing—while also empowering farmers and producers to better understand and account for specific deficiencies in grains (such as milling degree, which can be attributed to the milling process in the post-processing of collected grains) to resolve them in later harvests (Belsnio, n.d.). Figure 2.2 summarizes the nature of the proposal as heavily reliant and rooted towards the processing of information; it is noted that the provision of a mobile digital image processing tool acts more of a supplement to the proposal and is intended for increased accessibility to the project in contrary of providing more information on itself. As the digital image processing tool is needed to generate the datasets regarding rice properties and thereby quality, either software method can be utilized. Fundamentally, all components of the proposal lead to the generation of post-post-processed datasets relating rice grain quality to other factors that are influential and considered within the community of Calatagan by its citizens. The relation of qualitative factors with quantitative and the abundance in means of comparison and analysis that would be presented by a data visualization allows an easily accessible way of communicating an abundance of information to the citizens of the locale regarding any aspect of the project that concerns them most (especially considering the variance in position of the citizens among the rice production and consumption chain). The model presented is also designed to continuously be adaptable with a ready-to-develop method as built with agile development principles. In the case of adding new information and new statistics or queries, the data visualization is easily receptive to such additions.

After discussing the necessity and the implications of the finished project, the specificities of the two proposed components are then discussed.

2.2 Proposal to the Problem

As previously mentioned, the researchers seek to create a report that would inform the citizens of Calatagan about their current rice status and the options present and what efficiencies/improvements can be made alongside such, while also creating a direct assessment tool that can be provided to any officials or technological boards to continue developing the tool even outside of the initial, first-time assessment conducted by the researchers. Within the two-step proposal, Table 2.1 details the two processing materials to be assessed for the proposal project in response to the needs of a community to shed further understanding regarding rice choices and quality: a digital report and analysis featuring a map of the locality, with a study and markings on different fields and variables concerning grain quality and purchasing factors such as brand type, cost, location, and a deployable mobile application version of the originally-developed MATLAB tool designed for mass processing, further adding ease to the accessibility and inclusivity of the processing tool towards citizens and users, enabling them to run the tool and gain raw datasets from themselves. In essence, the report is a visualized and deeper understanding built with the raw datasets obtained from the first proposal.

Although pricing may seem to be directly connected to crop quality, this is often not the case. On the agricultural end, farmers and producers cannot avoid crop

production problems from natural issues such as flooding, droughts, or other related anomalies in the farming procedure as these are unavoidable aspects of the process; however, understanding the present qualities such as grain whiteness, shape, and broken grain count help provide an understanding of how rice production is meeting common quality standards—with the knowledge that whiteness and color is a common quality indicator in rice (Azom, n.d.). On the distribution end, merchants and suppliers in different localities have the potential of using these assessment tools, as recommended by the International Rice Research Institute (n.d.), to boost profitability by accurately measuring quality by assessing and knowing of grain standards under different classification systems present. For consumers and buyers, it is important to purchase rice that are of generally good standard to allow for the nutritional content to be maximized within a crop that accounts for 30-50% of daily caloric intake.

For specificities regarding the scope of the proposal and the itinerary covered within it, two components ultimately are designed to provide an effective means of generating relevant information specific to the context of Calatagan, adaptable in the sense that it is available to further additions.

Component	**Description**
Report and visualization (data visualization)	Interactive digital and visual map characterizing the qualities of rice grains in the Catalagan, compared with other consumer and producer considerations; report generated from datasets sourced from the mobile application/digital image processing tool

Mobile application (mobile application)	Mobile-intuitive and friendly version of the digital image processing tool; coded with C, designed for usage on any smartphones

Table 2.1. *Research proposal components and description*

Table 2.1 presents an overview of the components of the research proposal, wherein their “common name” is referred to within the parentheses. Both components and subprojects are interweaved, and can be continuously developed alongside one another or independently for more features and availabilities. Furthermore, both tools can be utilized externally (not constrained within the direct citizens of the community) on desired intervals to check on rice quality from various suppliers and relevant buyer factors, thereby allowing for designated officials or groups to survey Calatagan or any other desired communities with the processing tools—especially under the consideration that these officials and groups would have constant access to devices needed and listed as prerequisites for the listed tools. In the provision of information and analytics, the assessment itself (to be detailed and expounded upon in the methodology) data visualization tool, after filterable processing, can output tables that compare various cost factors or quality factors for printable and digestible mass usage and dissemination—to better relay desired information to the relevant citizens and crowds that would be concerned and influenced by the findings.

Visualization Tool

After processing raw data from rice samples within the community, a data visualization is created to better convey the findings regarding rice quality as mapped unto a movable, geographical capture of the area of Calatagan. The results of the assessment analyses of rice grain quality are distinguished per area, drawing boundaries between the three visited localities within Calatagan, thereby pinning and noting down the distributors of rice grains per barangay. The results are distinguished and laid out per area for more efficient comprehending of the bulk of results, moreso the citizens of the area of Calatagan. The data visualization also seeks to map out other factors that were discovered through the visitation and were rendered significant by several other research articles, and as consulted by agricultural experts who understand the economic and market distribution of food, particularly indigenously-rooted crops, in rural communities and localities. As Calatagan presents itself as a case wherein the distribution chain can closely be linked back to one another in terms of area, proximity, and citizen relations with the producers, consumers, and distributors in a relatively small and enclosed community—a visualization tool seeks to graphically benefit and create informants out of all sections of the Calatagan community: drawing out information both on pure quality factors, but also understanding the economics and potential gain between certain brands of rice that are more nutritionally beneficial at certain cost margins.

Feature	Description
Geographical map	Centered around the target locality, that is, Calatagan, Batangas. Mapped with satellite imagery, built with OpenStreetMap and Google Maps.

Distributor markers and push pins	Map markers illustrated and tacked onto the map to depict the approximated locations of rice distributors. Attained during visitation procedure with coordinate-grabbing applications.
Grain quality and samples	Lists information on each of the grain's properties and its ratings under designated grading systems and classification schemes; paired with sample images and photography of the distributor
Pricing and cost efficiency	Pricing per kilogram of the rice sample as obtained during the visitation procedure; cost efficiency as calculated with rice grain quality to cost per kilo--in reference to nutritional and overall consumer benefit
Sorting and filtering	Adjustment of the visible markers and showcase of information that compares and contrasts relevant information from costing, brands, pricing, and other factors

Table 2.2. Features of the data visualization

Friedman (2008) writes that the main goal of data visualization is to communicate information clearly and effectively through graphical means, communicating information effectively, providing insights, and communicating several complex data sets with the presentation of its key-aspects in an intuitive way, balancing form and function for user understanding—with the main purpose of simply communicating information. Table 2.2, summarizing the features of the data visualization, relates grain quality as the primary variable being assessed with several other factors and traits mentioned in the process of understanding the consumer and producer perspective amongst the citizens of the various barangays. With the generation of datasets from the rice samples collected from

the communities within Calatagan and interviews with household workers and citizens to understand how they act as consumers and store workers distributors, a connection can be formed and visualized with various factors by relating grain quality and distributor variables to one another. Thereafter, consumers and other citizens can sort and filter the visualization to their needs.

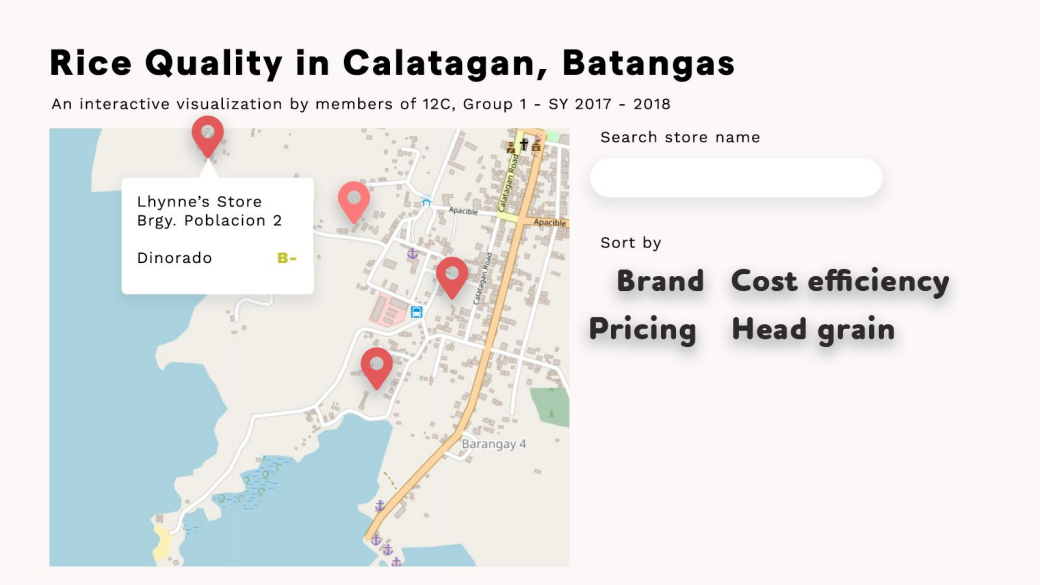


Fig 2.3. Mockup of digital image processing tool, optimized for the Web and designed with d3.js

The digital image processing tool, in its full suite of usage, is aimed to be served online where filters, sorting, and other relevant features can be drawn with an interactive map. In recognition that the majority of citizens of Calatagan may not be concerned with accessing the data visualization on a more advanced device, printed tables and information regarding working couples as well as a detailed report (the data visualization itself intended to be an easily comprehensible report) of the ongoings,

observations, and trends present. The report given to different agencies and individuals across may also be customized and printed in accordance to the needs, not restrained to the full load but rather perfectly focused on certain aspects.

As different brands differ from each other based on physical characteristics, quality, and the price offered, the developed analytical tool aids consumers in purchasing rice grains suited to their preference and consumption patterns. Furthermore, it is inherently designed to be able to fetch key characteristics and assessment tools According to Daiko, Sakyi-Dawson, Bediako-Amoa, Saalia, & Manful (2010), consumer preference for rice varies per country though most are concerned about the quality and price of the commodity when they made a purchase. This purchasing behavior is seen in a study conducted by Suwannaporn and Linneman (2008) which reported that consumers in Japan, Korea, China, and Taiwan preferred to purchase rice at a low price and indicated that high price is a factor that prevents consumers from purchasing a certain brand of rice they preferred.

Several studies have also suggested that demographic factors have portrayed dominance in influencing purchasing behaviours. As seen in a study conducted by Tomlins, Manful, Larwer & Hammond (2005), consumers who lived in urban area and has high standard of living, high income and education, tend to purchase rice of high quality based on their nutritional content; whereas Kassali, Kareem, Oluwasola, & Ohaegbulam (2010) found that income, age of the consumers and frequency of purchase were the important factors that influence household food consumption. Moreover, the proximity of consumers to different rice distributors and channels have

also been influential towards consumption patterns and purchasing behavior as reported by Azabagaoglu & Gaytancioglu (2009). The study concluded that consumers tend to make a purchase at the retails closer to their homes because it makes them easier to get the rice and will purchase whichever rice brand that is available in the market.

Demographic factors, quality and rice attributes, location and accessibility to the marketing outlets, price, packaging as well as branding are determinants that need to be focused in the production and marketing of rice (Musa, Othman, & Fatah, 2011). Through the developed analytical tool, the datasets and information obtained to create the visualization report gives consumers the benefit of easily identifying which rice distributor best complies with their consumption preferences.

Digital Image Processing Tool (Deployment to mobile)

With the requirement of the digital image processing tool to determine rice grain quality efficiently and effectively, and serving as a prerequisite to the attainment of any forms of post-processed information, the adaptation of the original digital image processing tool (available on desktop devices) serves to increase the accessibility and allow for the provision of the tool to more citizens and people.

As adapted from the digital image processing tool, the mobile edition of the tool is to be ported from MATLAB to C, a compatible programming language. Afterwards, the tool may be used to take photos of rice grain samples, and process them in bulk.

Improvements and benefits to mobile application version of digital image processing tool	
Seamless transition from image capture of rice grain samples to processing of samples and attainment of rice grain grade	Several grading schemes present, more oriented towards giving immediate results than flexibility and agility with raw data
More accessible and reachable by the public	Can queue several images for processing

Table 2.3. Details regarding the benefits and advantages in the mobile application of the developed tool

Overall, the intended usage of the digital image processing tool is not necessarily for every citizen to be able to analysis their rice grains, but rather to serve as a means of assessing the general state of the community--in addition to agricultural broadcasts regarding the prices of rice or the condition of farmers and workers, the researchers seek to provide for trainings and briefings regarding the usage of the digital image processing tool to concerned researchers, professors, and developers--particularly those in the International Rice Research Institute or are concerned with agricultural or economical relations to help perform an assessment of rice grain quality in different sectors and stages of processing.

CHAPTER 3: METHODOLOGY

METHODOLOGY

For purposes of preparation of the project proposal and after assessment of the target area, the group sought to undergo various methodologies and steps in order to create a tool that would satisfy the objectives of the project: both the machine needed to extract raw data and generate relevant data sets in regards to the quality of rice surrounding the community of Calatagan, Batangas and other relevant information and properties for attainment; and the processed and digestible information that comes as the output of the digital image processing tool, as well as a report that solidifies and gathers the collection of the raw data. This constitutes an umbrella of the grading system of the rice grains itself based on the extracted properties from the digital image processing tool that can then be analyzed under different systems as long as inputted into the program, as well as relating these datasets to additional variables and factors attuned to the needs and quality of living observed and exemplified in the visited locale. The following chapter details the visitation of the different communities focused to, more specifically the three barangays within the area of Calatagan, Batangas--the procedures and variables considered for the second partition of the proposal as well as the extraction process of the raw rice grains itself to gather datasets and information about the rice quality within the community.

As the proposal is divided into two parts that consist of quite different outputs and intended materials (a graphical visualization with printed aspects and a mobile or web

application) the sections presented in the methodology are split and the project in question is distinguished. Additionally, the materials and procedures needed for the researchers in creating the proposal is different from the use case materials and prerequisites once launching for the intended user—as such, both cases will also be detailed for purposes of understanding the scope of the developed analytics tools.

3.1 Research Design

The proposal itself is oriented towards the provision of tools in the understanding of the status of rice grains in the perspective of citizens of the targeted locality of Calatagan, Batangas in all aspects of the "rice chain" from production to consumption. As such, the proposed design is more of an evaluative and explanatory design tool that offers deeper analysis on the qualitative and quantitative information aggregated from different processing tools. As stated by Creswell (2003), an explanatory or more specifically, "sequential explanatory" design is determined by the collection and analysis of several data points surrounding a topic.

Further, an explanatory research is used to broaden and provide further insights about a problem or topic--although this does not give conclusive evidence, it does give fragments of a potential new discovery; the information gathered and processed in the conduction of the research also allows for the discovery of possibly beneficial insights to the field in question (Yousaf, 2018). These results and collected information are then presented for a deepened understanding on the topic, potentially producing more quantitative and numerically-consumable datasets. In particular, this pertains to the

desire of researchers to produce tools and analytics about a field that has not been previously concentrated on in the past.

Data Visualization

The research design for the data visualization aggregates qualitative information observed from the visitation and quantitative information gained from the qualities of the rice grains assessed from each locality.

Grain quality (*properties and measurements sourced by the digital image processing too*l)	Store location (*attained with the usage of GPS coordinates*)	Rice cost per kilo
Rice brand	Cost efficiency	

Table 3.1. Parameters and properties accounted for within the data visualization tool

In particular, the creation of a visualization takes complex datasets obtained throughout the course of the experiment and makes it readable and accessible for humans. As showcased in Table 3.1, the assessed parameters are only partially related to the actual indicators for grain quality--extending heavily to towards consumer-oriented factors such as the location of the store, cost, and other variables.

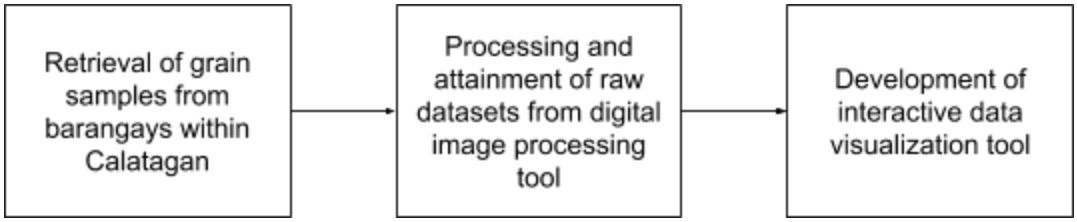


Fig 3.1. Methodological flowchart of data visualization tool

As part of the explanatory research, Figure 3.1 details the prerequisites before the development of the interactive visualization tool. The researchers are to collect rice grain samples to run through the processing tool (whether the upcoming mobile version of the formal desktop-compatible version), of which the raw datasets regarding the rice grain properties as processed through that will be made available on the web visualization.

Application (Processing Tool)

As in the development of an image processing tool, the accuracy of the tool is assessed with a comparative research model—comparing the results from the software trials and applications In the search of the accuracy and feasibility of a developed software to act as an alternative to manual rice inspection and grading, the undergone research falls under the matched pairs experimental design, a randomized block design. The randomized block design essentially is a standard statistical design for agriculture experiments that divides and arranges experimental units in groups. The design on its own is a strategy commonly used for two groups, given that they have two treatment

conditions under one factor. In the classification of grains, each trial takes a sample which undergoes a manual, human-performed inspection and grading procedure as well as photographic analysis as performed through the developed software. In this case, the two different methods of extracting and interpolating the qualities and characteristics of the grains are the experimental procedures done to a common sample in each trial of the experimentation procedure. Experimental units (image processing and manual testing) undergo both means of property extraction and grading. With the application in the current proposal, the researchers intend to simply modify and adapt the existing developed tool for compatibility with its new intended platform, mobile devices. As with running analyses on the sample image sets, these datasets extracted from the rice grain samples obtained from the selected subdivisions of Calatagan are then post-processed into the data visualization tool.

The research design of the proposal thereby centers around the provision of an analytics tool, and the provision of an exploratory tool that aggregates information about direct factors of rice quality such as its properties to external conditions concerning the economic and consumer considerations of purchase--presenting new parameters and analytics to deepen one's understanding about the present grains and other options, as evaluated by several factors from raw quality to consumer considerations.

3.2 Research Locale and Set up

The researchers received samples and survey responses from three barangays in Calatagan, Batangas, particularly that of Barangay Balibago, Barangay Poblacion 2, and Barangay Real. Respondents from the communities that were visited came from a variety of backgrounds, ranging from regular citizens that mainly purchased rice grains from around the vicinity and select localities, households that farmed their own rice for the sole purpose of consumption whom did not partake in selling, and farmers and agricultural workers that relied on selling rice or *palay* as a means of livelihood. With the breadth in the respondents, the researchers were able to understand the interconnected nature in the community of Calatagan--observing the ruralities as a homogenously connected community. In the contextual analysis, the researchers observed that the community and its citizens were closely connected that in contrast to other urban areas or larger regions, the production, distribution, and consumption of rice grains was not acquitted to large third-party buyers. Farmers within the area produced grains, post-processing and milling occurred before direct transfer into sacks for the distrbutors in the local sari-sari stores to sell to citizens; as such, there was a keen understanding of the procedure of rice grain production and the responsibilities shared and promulgated within the locality. This also promotes for a deeper sense of awareness and accountability to the citizens, to which they may be more receptive and reactive upon receiving the data visualization tool and other informatics and analytics gathered from the visitation procedure.

3.3 Research Instruments/Materials

The researchers underwent several processes in the construction and presentation of a digital image processing tool. The following table lists all the materials that were made use of in the initial and post-processing assessment that were involved in the construction and digital engineering of the processing tool; another list serves as the list of materials intended for usage of the proposal tool by the users, serving as the material prerequisites for the proposal, particularly the digital image processing tool.

Researchers: Processing

The following materials are utilized in the set-up of the experiment, in the sampling procedure, data collection, and in the development of the analytical and visualization report tool proposed to the research locale.

1. Rice Grain Samples

Around 1kg of Dinorado and Sinandomeng rice was obtained from the rice suppliers and distributors present within the research localities. The rice samples are labeled with the store they were purchased from. Furthermore, the samples will undergo the image processing software for digital analysis of the grain quality. The values of the physical characteristics as well as the coordinates and prices will be collated into datasets to be further utilized into a comprehensive visualization report.

2. Camera (iPhone 6/6+)

It will be utilized to capture photos of the respective rice grain samples that will undergo the image processing software for rice grain quality assessment. The iPhone 6

has a resolution of 1334 x 750 working out at 326 ppi (pixels per inch) with an 8-megapixel iSight camera with 1.5 micron pixels. Contrarily, the iPhone 6 Plus has a resolution of 1920 x 1080 display, working out at 401 ppi, as well as the additional feature of optical image stabilization. These camera properties allows the conversion of images to as low as 144dpi, one of the lowest quality displays and image resolutions still commonly available as of today. Although the researchers made use of advanced mobile phones and imaging tools for the collection process, the imaging procedure can be done with any suitable camera phone.

3. Black Polymer Sheet (background image)

A black mat or consistent black background is to be used under the rice grain samples so as to obtain an accurate collection of images during data collection to eliminate intrusive shadows. This in particular is used as background due to its filtration properties (Ullman's Encyclopedia of Industrial Chemistry, 2012). However, any solid sheet may be used for the processing of the rice grains so as long as it presents a sufficient amount of contrast against the color of the rice grains. As such, cloth, colored paper, and other solid, hard surfaces of a dark contrasting color are recommended for usage.

4. Vernier Caliper

This instrument that is used to measure external or internal dimensions of minuscule objects (IGNOU, 2017). For this experiment in particular, it will be used to

manually measure the grain dimensions (major and minor axes) of the sample. The caliper is an essential part of the comparative analysis scheme.

5. Data Collection Sheet

In the visitation of Calatagan, a sheet was provided that listed down the needed variables and other relevant notes and factors surrounding the atmosphere and nature of rice consumption and production in the locality. Columns for store name, brand, cost, location, and other materials were used. In addition, the smartphone for images was used to obtain the GPS coordinates of the visited distributors and areas, among other related factors.

Others: Processing (Digital Image Processing Tool on Mobile)

The aforementioned materials are for the researchers' usage in the refinement and adjustment of the developed tools using a comparative analysis model. Usage of the developed image processing tool and its components are applied differently when given to the intended users of the proposal and its beneficiaries. Specifically, the following prerequisites are intended for usage by the organizations and individuals looking to perform assessments of food quality and food security in the rice grain sector of targeted communities, applicable even outside of the locality of Calatagan. It is not necessarily recommended for usage by individuals within the community, rather select officials and assessment planners overseeing and concerned with the agricultural and economic industry, most especially the vocational aspect of such. Ergo, the list of upcoming materials is presented as somewhat modernized and advanced, especially

for an area located in a rural, agricultural-focused provincial location, but is still designed for accessibility and heightened efficiency.

The following materials are needed to run the provided tool; the prerequisites for both mobile and desktop versions of the software are similar and thus, the materials listed below are applicable to both:

1. Imaging tool of at least 144dpi

In order to take images of grain samples to run through the processing tool, any tool that can capture photographs or images of at least 144dpi (one of the lowest quality resolutions available on modern cameras) is recommended. Other materials that can be used as a substitute are smartphones, cameras, and image scanners. The captured images are to be saved in an image file format (.jpeg, .png, or similar) for the ability to be processed through the imaging tool.

2. Digital Image Processing Tool Application (mobile) or Software (desktop)

The original digital image processing tool is designed for compatibility on personal computers, and is programmed with the MATLAB programming language; the tool is cross-compatible with several operating system. The proposal involves the "porting" or adaptation of the desktop-compatible version of the digital image processing tool to mobile platforms, particularly Android with the usage of the C programming language. The adaptation of the tool on mobile allows for extended accessibility, as it would work on a greater amount of devices and in several scenarios and instances. For

the mobile version, a smartphone with capabilities of loading on the images of the grains (the image can be captured by the same device to run the application) is recommended.

It is also assumed that the software itself, present on the prerequisite mobile or desktop devices, is able to be attained by the user. As such, any modern device alongside the detailed imaging tool (of which both can be fulfilled at once) is satisfactory for the running and processing of the project.

3.4 Data Collection Procedure

On the scheduled visitation to the target area of Calatagan, Batangas, the researchers sought to attain two major fields of information: 1.) collection of rice grains and the resulting datasets descriptive of their properties and quality; 2.) miscellaneous information regarding consumer and distributor behavior surrounding rice grains, such as the locations and coordinates of rice distributors, variety and availabilities, as well as consumer perceptions and ideals regarding rice purchasing and favored variables. Three barangays within Calatagan were targeted, and as such, the researchers divided themselves as detailed in the following table:

Barangay	**Researchers**
Real	Diaz, King
Poblacion 2	Trinidad, Manalo
Balibago	Amisola, Baterna

Table x. Visitation of Calatagan, Batangas and researcher assignments

Upon visitation of the designated area, the researchers sought to collect data by following different tasks and plans of action. Table x summarizes the processes and taskings undergone by the researchers within the designated one-day timeframe.

Task	**Description**
Collection of rice grain samples	Locating major distributors in each barangay and visiting the establishments; purchasing one kilogram of rice from each, noting down the coordinates, location, store name, brand, and other related variables
Survey (informal)	Understand and assessment of the available technologies, present distributors, and consumer/distributor/producer behavior
Interview	Household visitation to broaden understanding and gain insights on consumer behavior and additional factors that influence consumers and farmers in the locality

Table x. Plan of action and overview upon visitation of Calatagan, Batangas

After collecting rice grain samples, the researchers are to run the rice grain samples through the digital image processing tool. The raw datasets measuring the eccentricity of the rice grains, their length and width as well as the resulting grain ratio, and other relevant factors. Thereafter, the group intends to use the information collected from the digital image processing tool and other relevant samples to communicate and provide an understanding and link between several factors and attributes that are

relevant in the supply and distribution chain of rice grains. The data visualization is to be programmed with the datasets collected from the digital image processing tool, and those collected in the field fromm the field interview and surveying sessions.

After the aggregation of data from the digital image processing tool with the information from the field procedures, the researchers intend to broaden the understanding of rice quality to ensure food security. In the pursuit of analyzing several factors, recognizing the interweaved nature and connections made between seemingly irrelevant attributes, the researchers seek to transform several pools of data into an accessible and empathetic tool that makes it easier to grasp the situation of rice crops in the scenario present in the community of Calatagan, from users of different backgrounds due to the scope of the assessed factors. In compilation of the procedure, Figure 3.x presents information with the total proposal.

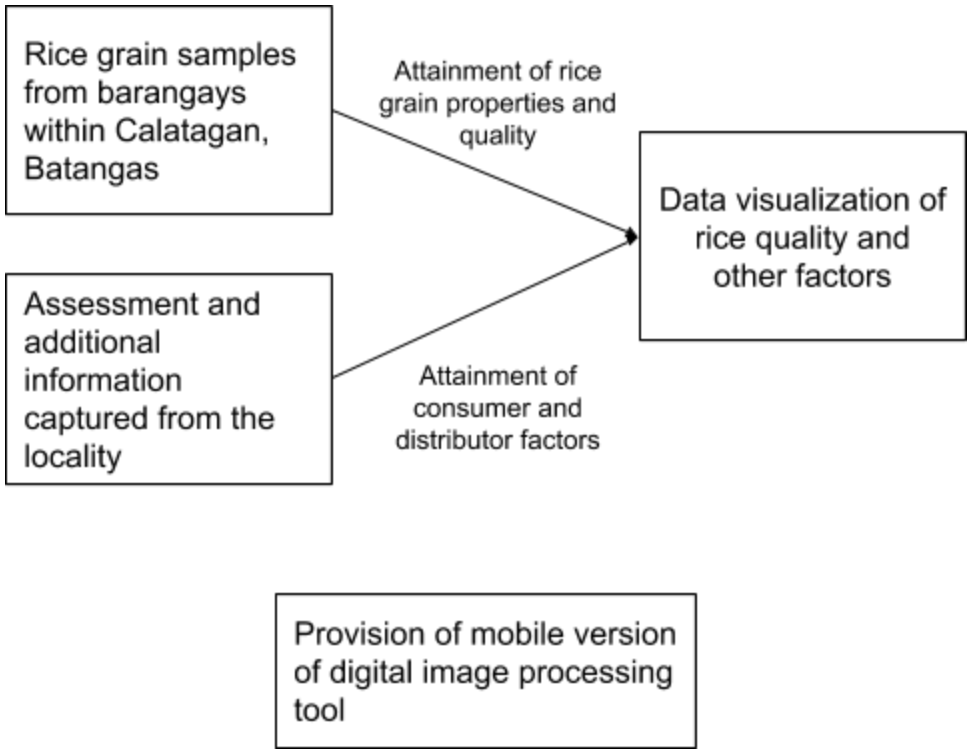


Fig x. General proposal roadmap and overview

The summary of the proposal feature highlights the different aspects of the procedure leading up to the desired output; it is immediately seen that the majority of the procedure is reliant around the collection of information and data, while the product is the presentation of such data in another perspective that can be observed by others, but is mostly intended for response and reaction by citizens of the community.

3.5 Data Analysis Procedure

Upon the researchers' visitation to the municipalities and hyperlocal abodes within Calatagan, the first objective was to understand the agricultural, economic, and familial scene within the area to have a better grasp of the present facilities that were accessible, as well as to grasp an understanding of the quality of rice by attaining samples from the main distributors. After locating the major distributor (smalltime sari-sari stores present in each barangay) within the mentioned areas, the researchers noted down various other related factors such as the area of the store, rice brand, store name, and costing of the sample. The samples are to be processed with the developed image processing tool (whether the desktop or mobile iterations), and raw datasets regarding the rice grain properties ready for assessment and classification under several grain grading schemes are produced. Under the scope of the proposal, this information is paired with the initially retrieved additional considerations, with the quality factors and properties of the rice grain themselves placed into a data visualization that

allows for comparison not solely of the quality indicators, but also other relevant factors such as cost, location, and other attributes.

In terms of processing the captured images of rice grains, the raw datasets are generated by the digital image processing tool under several methodologies and algorithms. As such, the analysis procedure involves understanding the formulas and tehcnicalities used to work out, deconstruct, and create the processes needed to understand the rice quality as determined by several physical property factors.

As such, the data analysis procedure sets itself similar to the initially proposed construction of the digital image processing tool, involving the photographic capture of randomized grain samples from the sacks of rice grains collected from the community, then followed by processing through the tool. The raw datasets are then post-processed in the form of a data visualization tool and may be assessed under different grading schemes and factors.

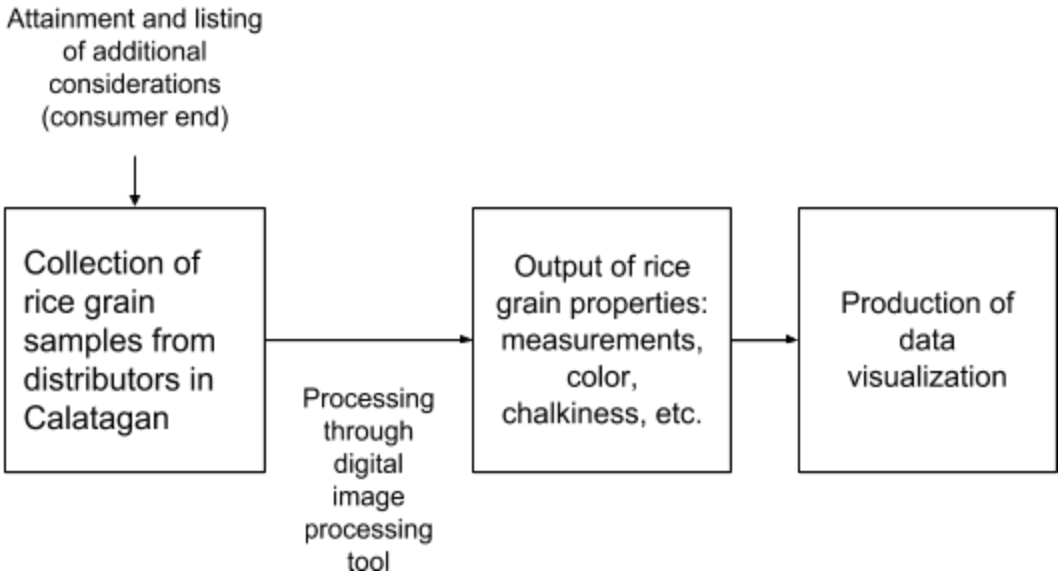


Fig x. Roadmap of assessment procedure and proposal

The experiment involves the classification of grains based on the extracted values of their morphological features. Various algorithms are used to segment the images and extract the features from the grains -- while others are processed after such features are segmented in order to classify the quality counts of the grain, as available and conducted by the developed image processing tool. The tool accounts for the following properties, which is then noted down for consideration in the data visualization tool; the variables present are also aligned with the stipulations of International Rice Research Institute, particularly Rickman and Gummert (2006) as crucial milled rice characteristics used for grain quality assessment.

External Properties of Rice Grains (Quality Indicators)		
Color	Chalkiness	Translucency

Broken Grain Count (or Head Rice Count)	Grain length and ratio	Grain shape (as measured by eccentricity)

Table x. *Milled rice characteristics and grain quality indicators*. Taken from IRRI, Rickman and Gummert (2006).

The analysis procedure concerning the quality of rice grains present and available in the locality of Calatagan is restricted to physically observable properties, thereby the characteristics of the grains that may be captured by the photographic imagery. Other characteristics that may also serve as quality indicators such as aroma and scent (a factor that was mentioned particularly often throughout the interview procedure) are not considered, serving as a limitation of the developed tool. However, the present externally observable characteristics serve as indicators of different parts of the rice grains, involving extensive (grain shape, length), and intensive (color, chalkiness, etc.) properties and indicators that serve as information for different portions of the rice procedure, ranging from factors that may originate right from the main producer within the core of the agricultural and farming sector, but also post-processing sectors that affect the production and quality of the rice grains before they enter the hands of the distributors.

With the assumption of the software's feasibility and the proposal reliant on the success of the existing digital image processing tool, a statistical treatment regarding the verification of the accuracy of the grain samples is tested for some portions of the material, such as the performance of a comparative analysis regarding the broken grain

count for certain samples. Ultimately, the explanatory research seeks to output a mobile application or an extension of the digital image processing tool that is not confined to the application alone. Furthermore, it seeks to analyze and create a deeper understanding of data crucial to different users and citizens of different backgrounds and areas, applicable and adaptable to several scenarios.

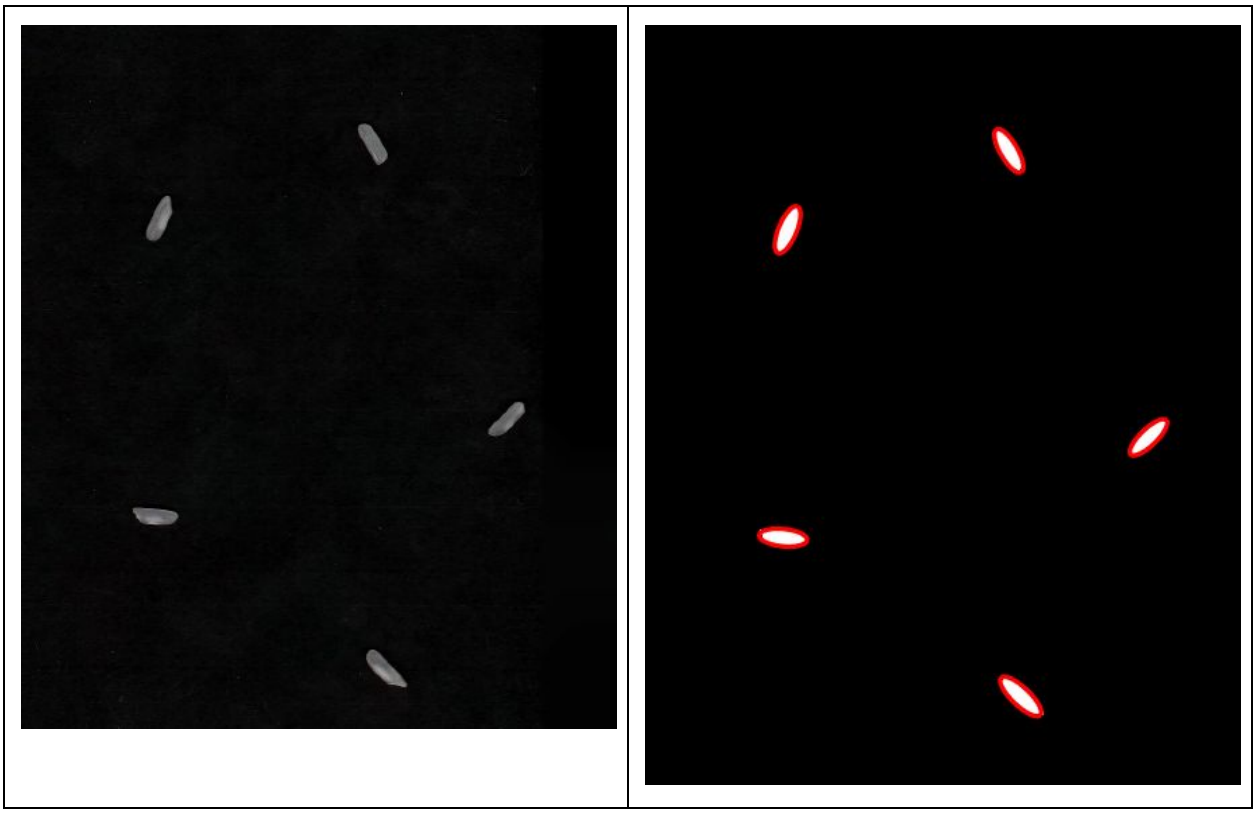
CHAPTER 4

RESULTS AND DISCUSSION

In the construction of the data visualization, the researchers sought to specifically assess and understand the current situation of rice grains and quality within the locality of Calatagan, Batangas—as well as to transform these datasets into a graphical visualization, taking into account and processing the provided raw information into tools for understanding the relation of rice grain quality to different properties and factors that exist outside of the internal and external rice grain characteristics, such as in the economics and distribution of such materials: location of the rice grain distributor, costing of the grain sample, and beyond. After the collection procedure, the researchers processed the information of various rice grains by taking over 30 samples of grains from each distributor as detailed in the methodology, sampled by a variety of rice grains.

The following data details the individually-assessed parameters as obtained by the tool for the rice grain samples themselves, as well as the profile data and information from different suppliers and vendors that the researchers had visited in the allotted timeframe. Furthermore, the parameters to be assessed for the visualization tool (as borrowed from the processing tool and application) are noted.

Digital Image Processing Tool: Barangay Balibago Samples



It is observed that in this particular sample, the shapes of the rice grains are a lot more distinct and are near-perfect when traced with the ellipsoid method of drawing the boundaries of the isolated grains, aside from chips in the grains that cannot be fully processed.

Centroid_1	Centroid_2	MajorAxisLength	MinorAxisLength	Eccentricity	Orientation
201.247	507.4665	34.43844	12.45514	0.932309	-5.67698
204.489	287.1099	36.22257	13.02833	0.933078	67.28294
362.5357	230.6101	35.44262	12.4245	0.936543	-59.7851
371.0661	621.1614	38.7284	12.89539	0.942937	-43.6627
462.4563	435.6406	35.38793	11.84963	0.942272	44.02884

Table 4.1.2. Unprocessed rice grain properties

CHAPTER 5: CONCLUSION

Upon the contextual understanding of the prevalence and dominant nature of rice in the community of Calatagan, moreso in its relevance in the fields of production, it is observed that within the rurality wherein agricultural is a dominant and prevalent vocation, the community presents itself as something where rice does not only manifest as a crop that is consumed, but also remains relevant as a means of livelihood on the ends of production, and is commonly distributed in hyperlocal areas accessible to specific citizens even inside the concentrated areas of Calatagan. With the prevalence of rice in all aspects of living and the locality's unique agricultural focus, there is a need to empower its citizens with a better understanding of the implications of rice grains observed externally through different means and phases--thus calling for the necessity of information and analytics to make better sense of and better analyze the climate and nature of how life around the municipality of Calatagan thrives on rice, produces it, and consumes it--with the provision of such in the pursuit of better improving this information analytics in the future, and exhibiting key relationships with not only grain quality itself but other relevant attributes and factors that may not be commonly concerned or seen.

With the group's presentation of accessible tools to create analytics and process a large majority of data at the same time, the generated processing tool runs in 10 seconds and is approximately 30 times faster than the manual means of assessing grain quality, is applicable in several grading schemes due to its focus on the raw measurements and properties, and is then focused on its deployability and adaptation to a mobile field for usage; this presents itself as a tool that can be extended to any

targeted hyperlocal community, wherein selected officials, citizens, or groups can generate information and reports about the tool. The data visualization seeks to be seamlessly compatible with new information and data about the locality, allowing for a continuous stream of interactive and filterable information but also a means of reporting crucial information and comparing integral variables with one another in a concentrated matter. With the information and analytics, the processing of such is designed to be able to be done efficiently and accessibly for a targeted concentrated area--with the resulting outputs able to conform to the needs of several citizens. In particular, for the community of Calatagan--despite its rurality and existing scenario with technological tools and modernization, the group intends to perform an assessment and create a report that is modifiable to the needs of different citizens: whether farmers and producers, distributors of the grains in their post-milling and post-processed states, or ordinary families who are heavy consumers of this core crop to then be empowered to understand and make better purchasing decisions or adjust their means of rice production and farming. The full breadth of tools is designed to be easily picked up by any citizen, but in considerations of Calatagan's technological level, is recommended for an adviser or organization in charge of overseeing the progress and advancement of Calatagan's agricultural movement and climate to perform regular assessment about the rice grain throughout; helping not solely consumers throughout the process but every livelihood, vocation, and interest in the rice chain--a process that is hugely essential to our life.

With information and analytics, the group seeks to not only create one-time solutions and reports, but to empower and help groups understand the potential scope

that can be reached by tools that provide data and information about seemingly ordinary things, goods, and areas--providing a new layer of understanding and depth to the way we interact, engineer, and live alongside rice; information and analytics mold us, and are a crucial tool for adaptation in the future, where we run by data science and visualizations of people from all backgrounds and levels to better diversify our understandings and create deeper analyses on our communities in the agricultural, economic, logistical, and technological levels, among others.

RECOMMENDATIONS

After the generation of various datasets and analytics, the researchers have proposed several improvements to both the general scope and nature of the proposal's design as well as specific improvements to the subprojects that were involved in the conducted experimentation process.

In terms of the general scope of the project, informatics and analytics—along with any proposed data visualization fields, would be more effective with the conduction and appropriation of seminars and other resources that would empower and help citizens understand the true significance of these sheets of data and available information and recommendations for their consumer and productional behavior. Aside from merely providing sheets and flyers regarding the effectivity of rice quality alongside certain time periods, the composition of the proposal may be done more fluid with the citizens, their current knowledge, and in understanding of the current and future capacities of the areas in question. This would involve further development and

engineering of the proposed data visualization tool, requiring responsive transformation and adaptation into several platforms.

The researchers may have also looked into the surrounding grain distributors around the area. In the informal survey and interview sessions, several citizens, particularly ones from Barangay Balibago and Barangay Real, shared that their purchasing of rice grains was commonly from major suppliers located at the outskirts of Calatagan, outside the scope of the visitation throughout their daily needs--only purchasing from local suppliers when given no option or for majority of the week. Finding that this choice is done because rice is directly brought there and more brands and varieties congregate there, more research and samples could have been conducted.

In addition, in grading the quality of rice grains, specifically in the assessment of properties, the researchers could have bought more than one kilo of rice to have a more thorough and larger breadth of grains to test from as opposed to rice grains that could fit into one plastic container from each locality. This may have limited the results in the case of purchasing and receiving a weak sample of grains, or a weaker portion of it within the distributor's sack or storage.

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Appendix

APPENDIX A
DOCUMENTATION FROM BARANGAY BALIBAGO, CALATAGAN, BATANGAS

	
Residents of Brgy. Balibago	Interviewing residents from Brgy. Balibago
	
Residents of Brgy. Balibago answering a survey	Picture with local from Brgy. Balibago who serves as a guide

Table A.1. Documentation of Data Collection in Brgy. Balibago

APPENDIX B
DOCUMENTATION FROM BARANGAY REAL, CALATAGAN, BATANGAS

	
Interviewing residents from Brgy. Real	"Manang Eli's" Sari Sari Store where rice was purchased
	
Residents of Brgy. Real answering a survey	"Personal Collection" Store where rice was purchased

Table B.1. Documentation of Data Collection in Brgy. Real

APPENDIX C
DOCUMENTATION FROM POBLACION II, CALATAGAN, BATANGAS

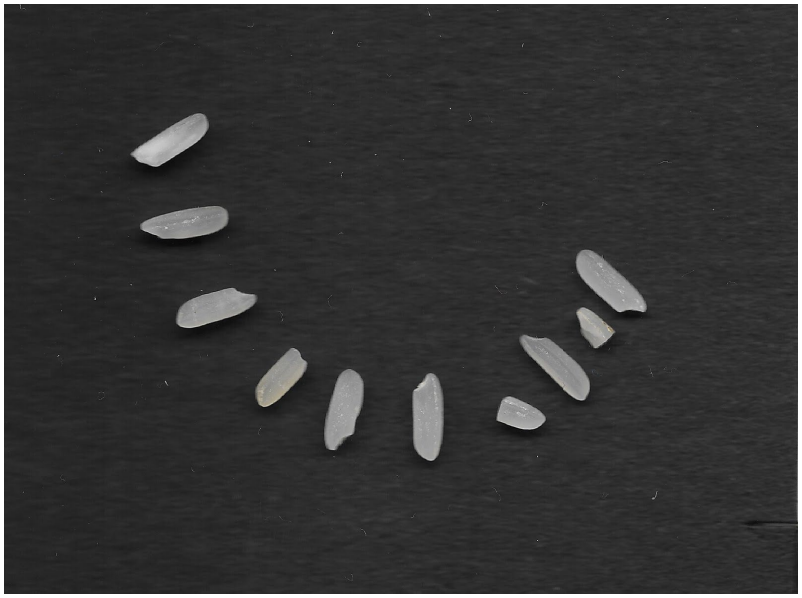
Obtaining Dinorado rice grain sample from Lhynn's Sari Sari Store

APPENDIX C
RICE GRAIN SAMPLE TRACKER SHEET

Barangay	Store Name	Brand Name	GPS Coordinates	Rice Cost and Amount/
Real	Personal Collection	Dinorado yellow	13°52’38” N 120°40’4” E	50/kg (125 php per salop (2.5 kg)
Real	Manang Eli’s Sari Sari Store	MRWN Dinorado Puro	13°52’25’’ N 120°39’54” E	48/kg (120 php per salop (2.5 kg)
Poblacion 2	Lhynne’s Sari Sari Store	Dinorado	13º49'58" N 120º37'25" E	57/kg
Balibago	Anna's store	Sinandomeng	13º52'38" N 120º40'4" E	53/kg

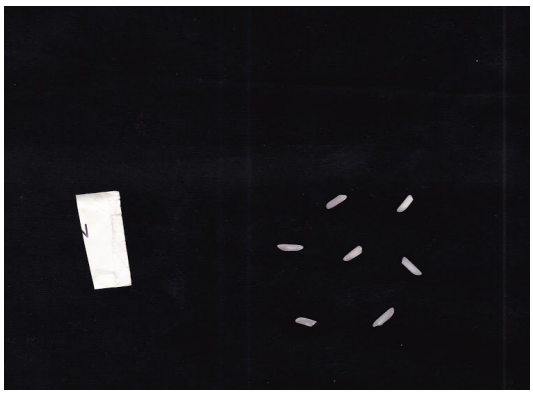
Table D.1. Rice Grain Sample Tracker Sheet

APPENDIX D
DINORADO RICE GRAIN SAMPLES FROM POBLACION II

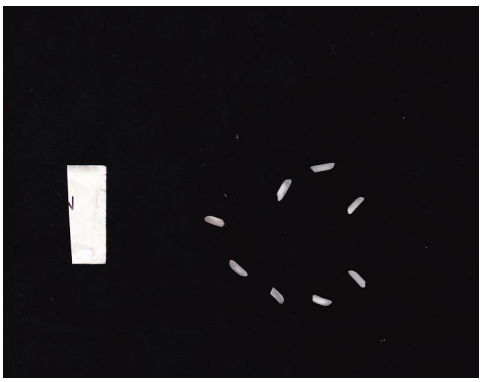


Grain No.	Major Axis (length in mm)	Minor Axis (length in mm)
1	5	3
2	4	3
3	5	3
4	6	4
5	5	3
6	5	3
7	5	2
8	7	2
9	6	3
10	6	3
11	5	3
12	4.7	2
13	5	3
14	4	3
15	5	2

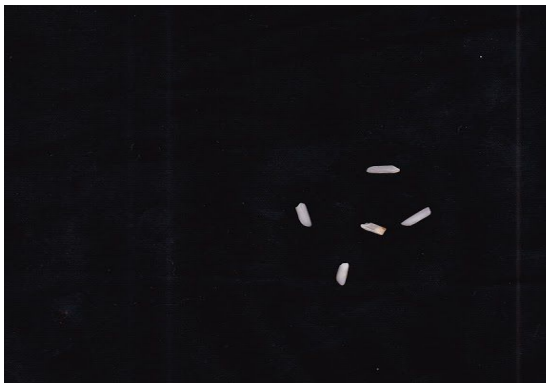
Table D.1. Data Tables of Poblacion II Rice Grain Sample Manual Tests



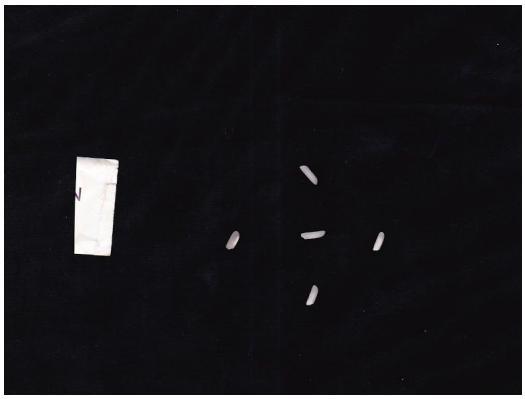
Poblacion II Dinorado Grains
Sample Set 1



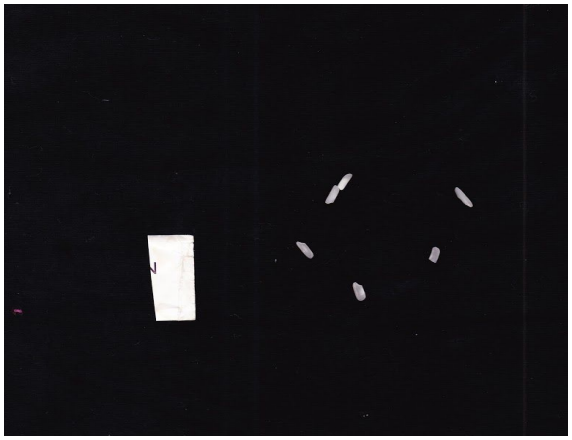
Poblacion II Dinorado Grains
Sample Set 2



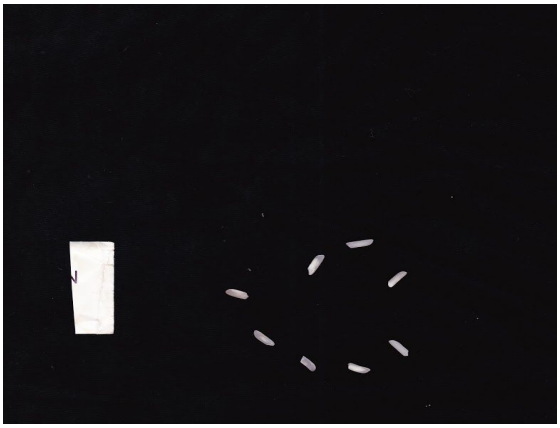
Poblacion II Dinorado Grains
Sample Set 3



Poblacion II Dinorado Grains
Sample Set 4



Poblacion II Dinorado Grains
Sample Set 5



Poblacion II Dinorado Grains
Sample Set 6

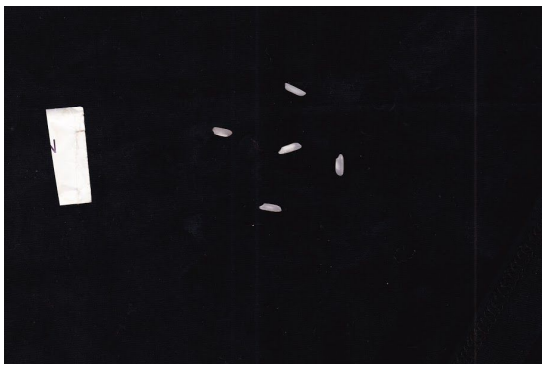
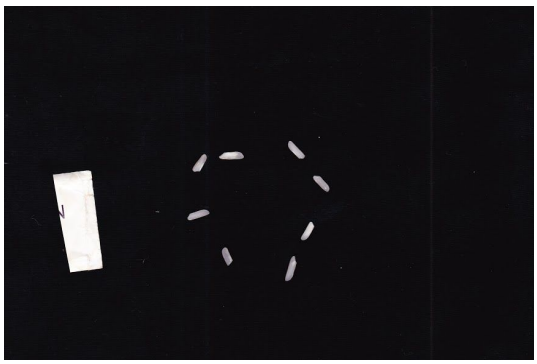
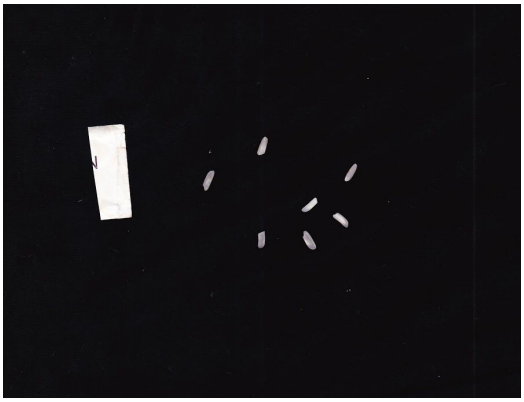
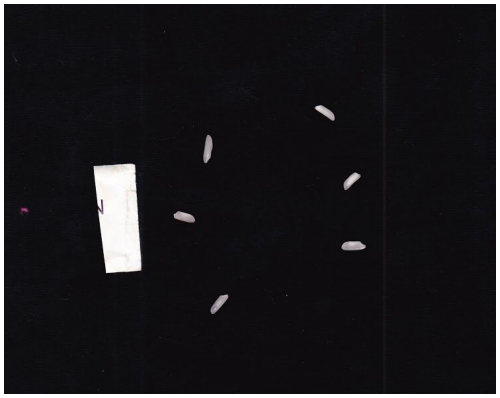
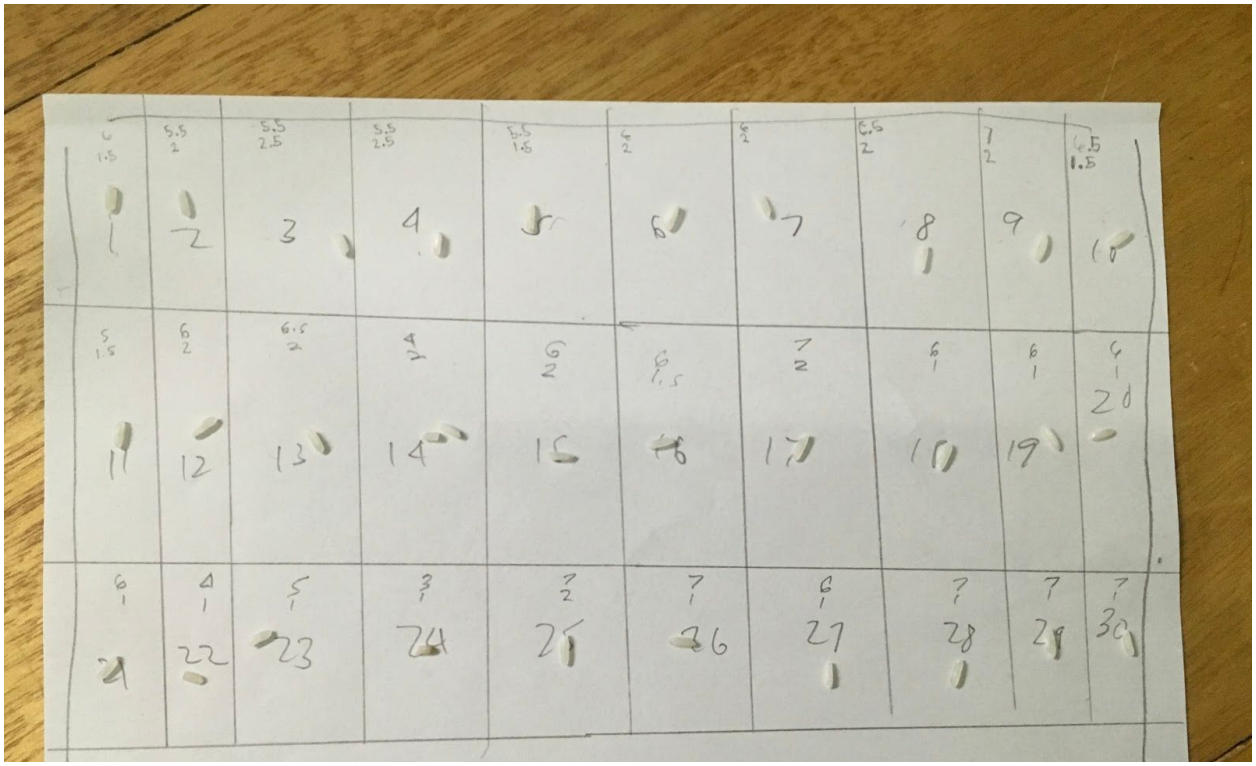
 Poblacion II Dinorado Grains Sample Set 7	 Poblacion II Dinorado Grains Sample Set 8
 Poblacion II Dinorado Grains Sample Set 9	 Poblacion II Dinorado Grains Sample Set 10

Table D.2. Poblacion II Dinorado Grain Sample Sets

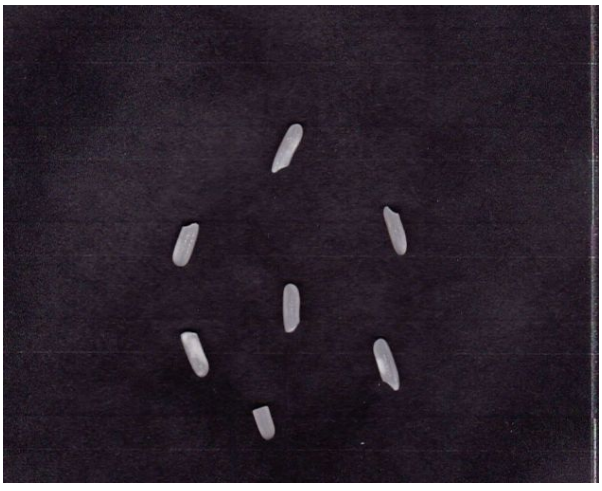
APPENDIX E
DINORADO RICE GRAIN SAMPLES FROM BRGY. REAL



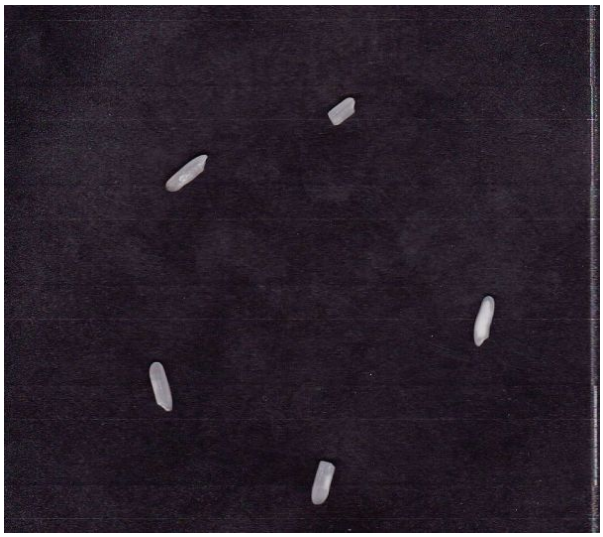
Grain No.	Major Axis (length in mm)	Minor Axis (length in mm)
1	6	1.5
2	5.5	2
3	5.5	2.5
4	5.5	2.5
5	5.5	1.5
6	6	2
7	6	2
8	6.5	2
9	7	2
10	6.5	1.5
11	5	1.5
12	6	2
13	6.5	2
14	4	2

15	6	2
16	6	1.5
17	7	2
18	6	1
19	6	1
20	6	1
21	6	1
22	4	1
23	5	1
24	3	1
25	7	2
26	7	1
27	6	1
28	7	1
29	7	1
30	7	1

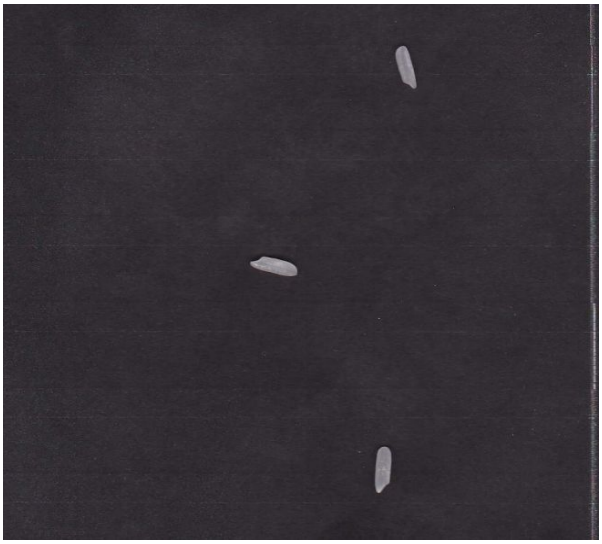
Table E.1. Data Tables of Brgy. Real Rice Grain Sample Manual Tests



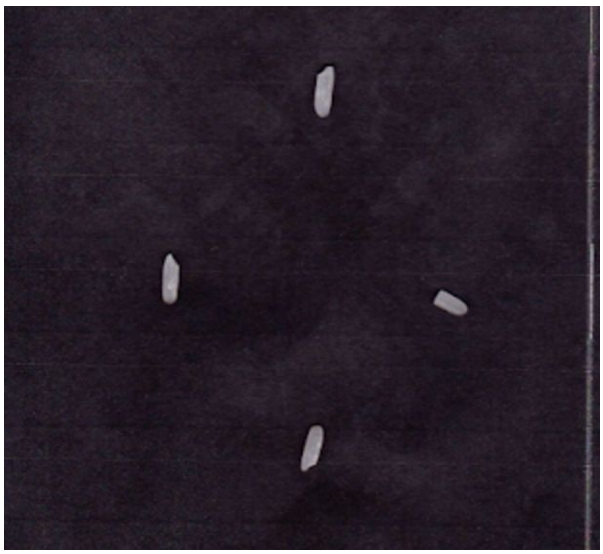
Brgy. Real Dinorado Grains
Sample Set 1



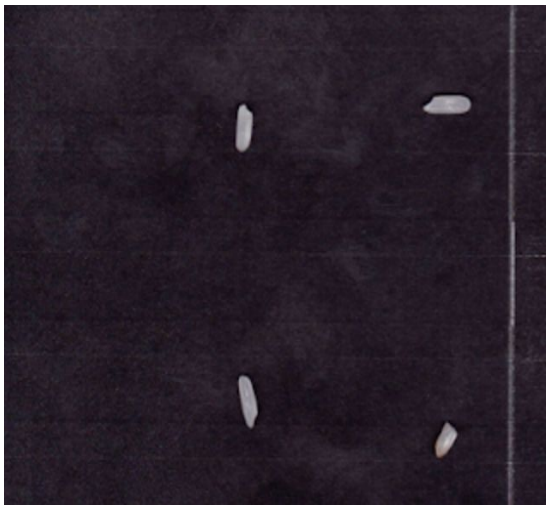
Brgy. Real Dinorado Grains
Sample Set 2



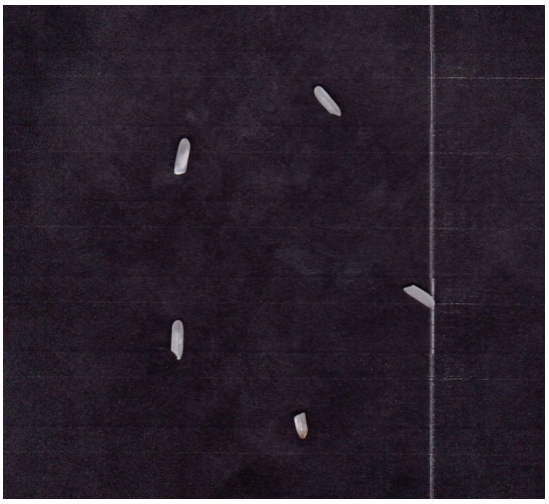
Brgy. Real Dinorado Grains
Sample Set 3



Brgy. Real Dinorado Grains
Sample Set 4



Brgy. Real Dinorado Grains
Sample Set 5



Brgy. Real Dinorado Grains
Sample Set 6

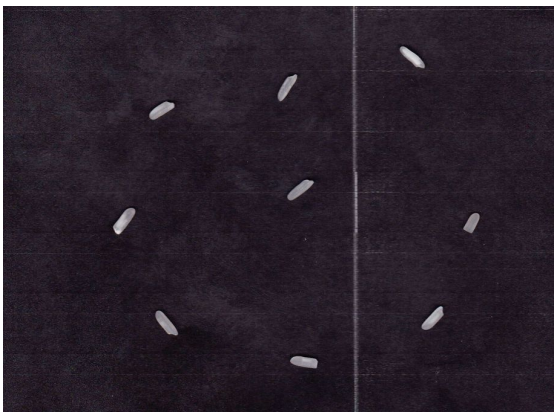
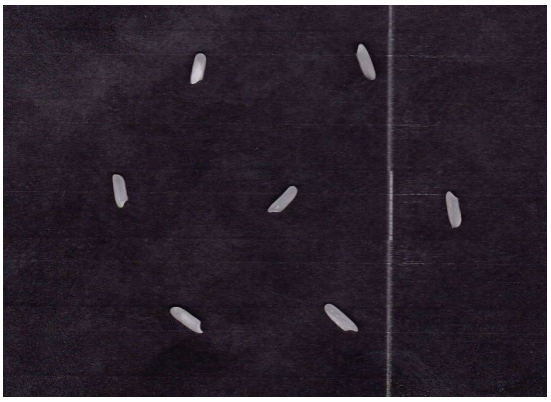
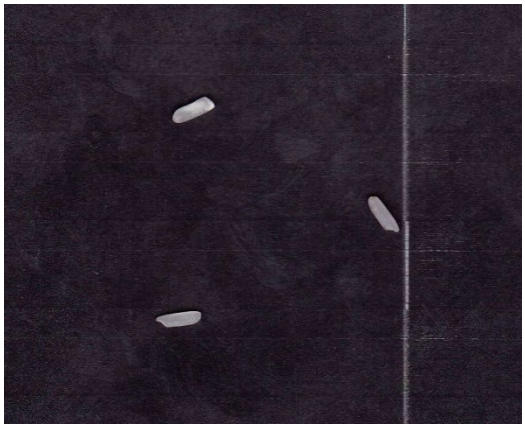
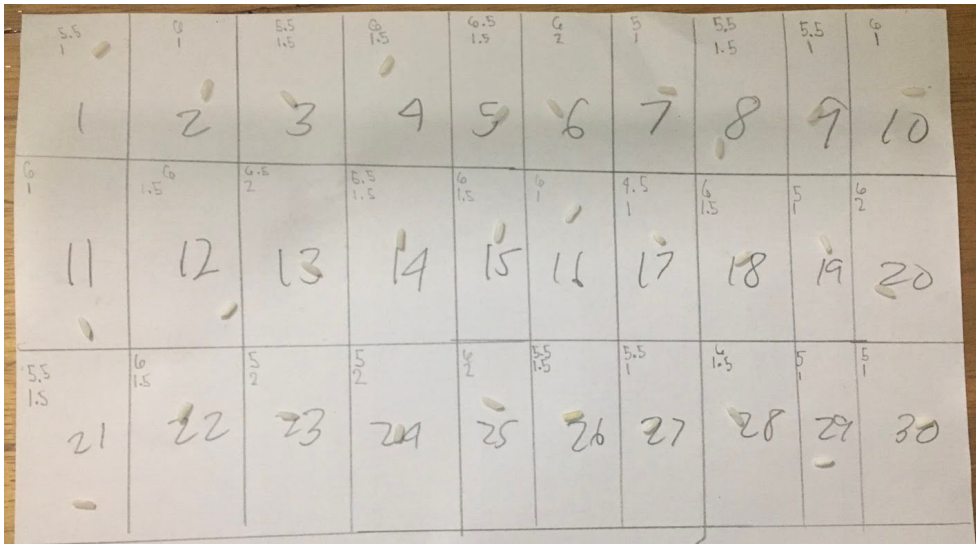
 Brgy. Real Dinorado Grains Sample Set 7	 Brgy. Real Dinorado Grains Sample Set 8
 Brgy. Real Dinorado Grains Sample Set 9	 Brgy. Real Dinorado Grains Sample Set 10

Table E.2. Brgy. Real Dinorado Grain Sample Sets

APPENDIX F

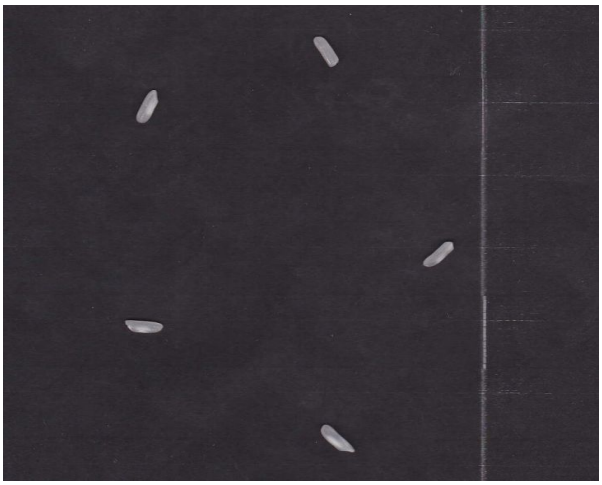
SINANDOMENG RICE GRAIN SAMPLES FROM BRGY. BALIBAGO



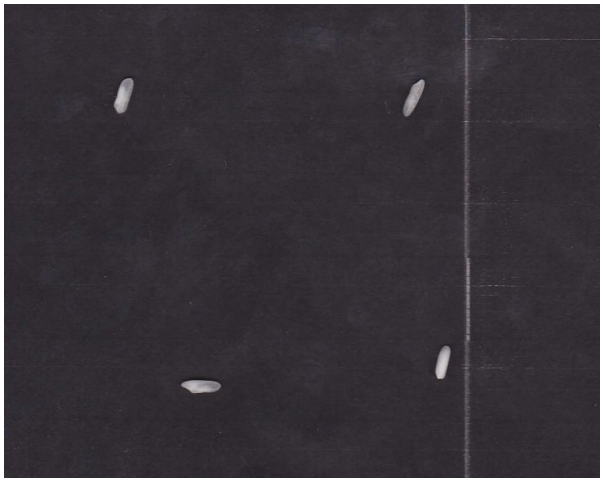
Grain No.	Major Axis (length in mm)	Minor Axis (length in mm)
1	5.5	1
2	6	1
3	5.5	1.5
4	4	1.5
5	6.5	1.5
6	6	2
7	5	1
8	5.5	1.5
9	5.5	1
10	6	1
11	6	1
12	6	1.5
13	6.5	2
14	5.5	1.5
15	6	1.5
16	6	1
17	4.5	1
18	6	1.5

19	5	1
20	6	2
21	5.5	1.5
22	6	1.5
23	5	2
24	5	2
25	6	2
26	5.5	1.5
27	5.5	1
28	6	1.5
29	5	1
30	5	1

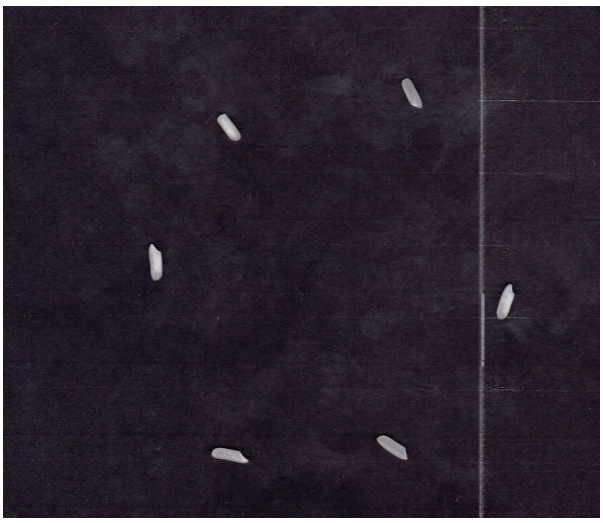
Table F.1. Data Tables of Brgy. Real Rice Grain Sample Manual Tests



Brgy. Balibago Sinandomeng Grains Sample Set 1



Brgy. Balibago Sinandomeng Grains Sample Set 2



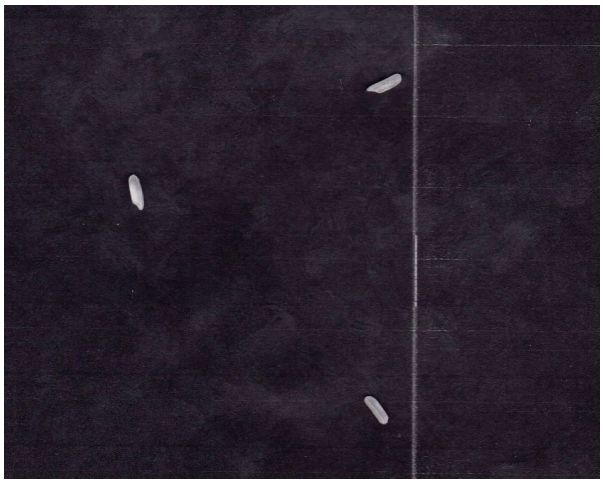
Brgy. Balibago Sinandomeng Grains
Sample Set 3

Brgy. Balibago Sinandomeng Grains
Sample Set 4

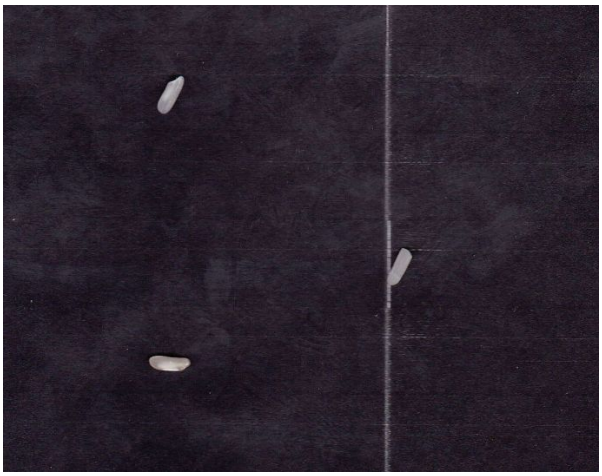
Brgy. Balibago Sinandomeng Grains
Sample Set 5

Brgy. Balibago Sinandomeng Grains
Sample Set 6

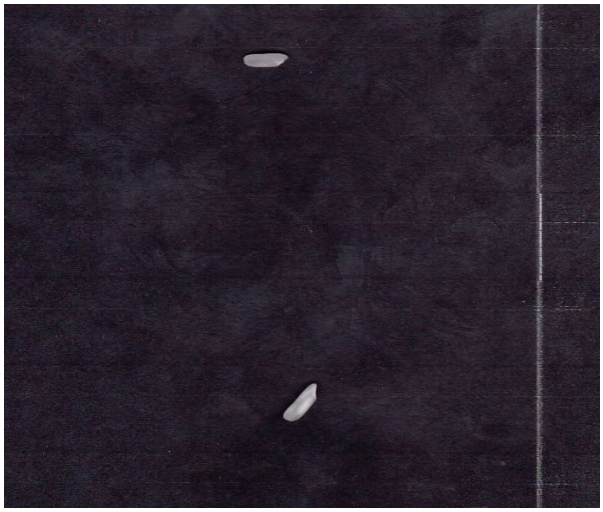
Brgy. Balibago Sinandomeng Grains
Sample Set 7



Brgy. Balibago Sinandomeng Grains
Sample Set 8



Brgy. Balibago Sinandomeng Grains
Sample Set 9



Brgy. Balibago Sinandomeng Grains
Sample Set 10