AN EQUIPAMENT TO MEASURE WHITENESS AND TRANSPARENCY OF RICE

Tâmara C. do Nascimento (student)
Rafael Galli (adviser)
tamnasc@hotmail.com
r.galli@ibest.com.br
Electronic Technical Course, Pelotas Federal Center for Technological Education (CEFET-RS)

Abstract. This paper describes a low cost electronic equipment to measure the whiteness and transparency of rice grains. The rice whiteness and transparency determine the rice milling degree at plant and laboratory levels and product quality for consumers. The equipment improves the grain milling process and quality assessment and, therefore, decreases the typical losses of milling process. The electronics circuits can be divided in two separated parts: one for whiteness and other for transparency measurements of the milled rice; the resulting signals from these two circuits are processed and calculated into values representing the whiteness and transparency degrees percentage. Experimental results have demonstrated the good performance of the proposed equipment. Although it was developed for rice, this system can also be used to measure the whiteness and transparency of paper, sugar, salt and wheat flour.

Keywords: Whiteness, Transparency, Milling, Whiteness degree, Transparency, Rice and grain milling degree, Process and quality assessment.

1. INTRODUCTION

Rice is the world's most consumed staple food grain. Brazil produces an important quantity of rice and a good part of its production takes place in the south of the country. One of the most important aspects of rice grain quality and production cost is its milling process. The main method of milling process assessment is the measuring of the processed rice whiteness and transparency (USDA, 2005). The project development took place in Pelotas city, Rio Grande do Sul state, south of Brazil, as a technical school task of the Electronics course at Centro Federal de Educação Tecnológica de Pelotas. In Pelotas region there is a big production of rice. In this region, in addition to two big milling industries, there are many small milling industries (Elias, 2005). Today's Brazilian market availability of Whiteness/Transparency electronic meters relies in importation of such equipments from other countries resulting in high cost acquisition equipments. The acquisition cost is the main factor that makes small producers have no access to such equipments on their production lines and therefore making them less competitive in the market. Small producers are forced to control the process and quality by visual inspection, bringing either low product marketable price or low profit margin due high production costs resulting of over milling (Meneguett, 2005).

Due to the exposed above, this paper authors identified an opportunity to develop a low cost and reliable electronic device that could be accessible to the local market. The developed whiteness and transparency meter is an electronic device capable of measuring light reflection (whiteness) and transparency (opacity) of rice grains. The developed equipment can also be used to measure the same characteristics on sugar, salt, wheat flour and printing paper.

This paper describes the project and development of the proposed equipment and is organized into four sections. Section two describes the research made to acquire knowledge of rice milling process and the concepts to develop the equipment. Section three, describes the electronic concepts and block diagrams. In section four, the conclusion and perspective are outlined.

2. RESEARCH

The project followed the pace of the author's apprenticeship formation in Electronics at CentroFederal de Educação Tecnológica de Pelotas. As a start and for simplicity sake, the project targeted the whiteness measuring only. Transparency measuring was added on a later phase. The project took about two years to reach its actual stage (from initial study to final prototype). Firstly it was necessary to acquire the rice milling process knowledge. The research resources were technical publications, internet published articles, rice milling industry site surveys and related professional personnel interviews. It was studied the rice production stream since the harvest to the end consumer final product obtained at the industry phase. The industry phase consists in to remove the rice hull, the endosperm and then the bran layer around the rice kernel, via milling process, rice grain selection, blending, product packing and market delivery (Tribble, 2004). It was found that milling process is the industry final process stage where production costs and losses are vital factors that are watched very closely. It is important for rice process industry, to produce a rice grain of high market acceptance (white and translucent) with an optimum milling energy consumption and the least grain losses possible (broken grains and kernel losses). The milling process consists of remove the bran layer, which typical colour is yellow, until the grain reaches a semi transparent white colour typical of rice grain kernels. A low level of milling, gives a "yellow" rice which has no good end consumer acceptance. An over milled rice, gives a high cost process product due unnecessary time and energy consuming and grain losses. An optimum milling level degree must be found to satisfy the above constraints. The milling degree is correlated to the level of whiteness and transparency of rice that justifies the usefulness of measuring such characteristics during the rice milling processing. It was also found that the rice whiteness is influenced by other causes than milling process such as humidity, plagues, storage time and handling. Grain loss due transport and handling is another cost factor, which has to be compensated at the industrial phase. Rice market price is closely related to the grain appearance and its quality after cooking process (Rickman, 2002). As whiteness and transparency are measured using light absorption and reflectance properties (Ryer, 1998), optoelectronic solutions are applied to such equipments.

The goal of the project was to provide a low cost and easy of use equipment with reasonable accuracy and repeatability of measurements using new technology optoelectronics components that makes not necessary expensive optical components like mirrors, colour filters, lenses special lamps, typical of expensive imported equipments available in the brazilian market (Saxena et al., 1994). Such technology simplification also reduces the maintenance and complicated optical components set up.

3. THE EQUIPMENT

As the white colour is the merge of the entire visible spectrum of colours, it was found that the less white light reflection a surface produces, the less blue colour wavelength is present on the measured spectrum of the reflected light of such surface (Trevisan, 2005). Then it was necessary to find light sources and sensors that have its working range on blue colour wavelength. As light sources, blue light emitting diodes were used. As sensors, filtered photodiodes were used. Both LED's and Photodiodes work on wavelength of 440nm (Lange, 1990). The simplified block diagram of the equipment is shown on Fig 1. The sample of rice to be analysed is conditioned in special cartridge. The cartridge has transparent windows located on both front and back sides. The sampled rice can be seen via these windows. Whiteness level is taken by measuring the reflected light, (HunterLab, 1996), on a rice sample from light sources. (L1 and L2). The reflected light is captured on sensor S1. Transparency level is taken by measuring the light passing through the sample, from the same light source of whiteness measurement (Legget, 2005). The sensor S2 captures the passing through light.
Sensors S1 and S2 have embedded filters with bandwidth for wavelength of 440nm. Sensors signals are amplified and normalized on analogue amplifiers circuits A1 and A2 (Malvino, 1987) Amplifiers outputs are processed by an analogue to digital converter (ADC) that sends measured value to a four digits digital display (Boylestad et al, 1984). The values are displayed in percentage ranges. Calibration of the equipment is done using calibration samples that are conditioned on the sample cartridge. For the zero % point either for whiteness and transparency calibration, total absence of light is used as reference. A calibration sample made of white semitransparent acrylic material gives the reference calibration for whiteness and transparency levels. A calibration sample made of opaque brown coloured acrylic material is used to calibrate low whiteness reflection.
Calibration samples were tested and measured on different available whiteness/transparency meters available on local industry and government regulation agencies (Elias, 2005). The values found for the calibration samples are shown on table 1. The standard 100% level of whiteness is given by reflected light over a sample of magnesium oxide, as per Japan international standard JISZ8722 (HunterLab, 1996).

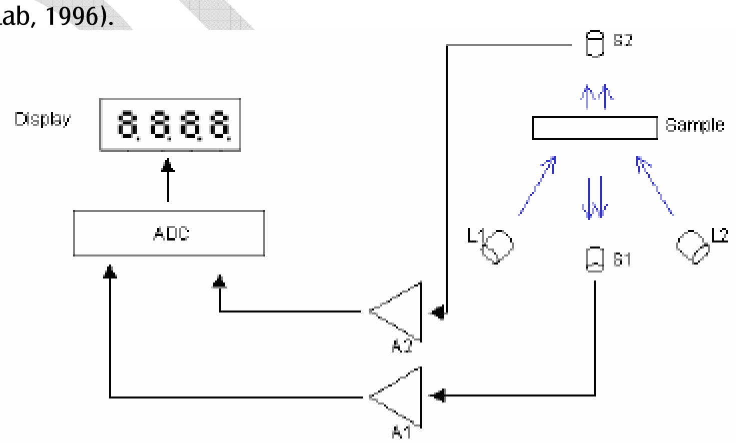

Figure 1– Simplified block diagram

4. RESULTS AND CONCLUSION

The resulting equipment prototype is shown on Fig 2. Comparison performance tests were made using the prototype and a commercial whiteness meter equipment in one of the local rice mill industry.
Some sample results can be seen on tables 1 to 5. All values are an average of threemeasurements per sample.

Figure 2- Developed equipment prototype photograph

Table 1. Calibration samples values measured at the prototype

Calibration Samples	Whiteness	Transparency
White	87,6%	3,9%
Brown	12,9%	0,0%
Light absence	0,0%	0,0%

Table 2. Calibration samples results on commercial whiteness meter.

Calibration Samples	Whiteness	Transparency	Milling degree
White[1]	83,9%	4,1%	0
Brown[2]	12,9%	0,0%	0
White[3]	87,6%	3,9%	199

[1]calibration sample of similar equipment
[2]calibration sample of similar equipment
[3]calibration sample of the prototype

On tables 3, 4 and 5, rice samples used by one local rice mill industry to verify its whiteness/transparency meter, were measured by the prototype. The results given by the prototype shows no sensible deviation from the measurements given on commercial equipment.

Table 3. Laboratory samples

Rice type	Grain visual conditions	Milling process time
Long thin (sample 1)	Yellow	Low
Long thin (sample 2)	Good and few broken grains	Appropriate
Long thin (sample 3)	Too many broken grains	Excessive

Table 4. Laboratory samples tested on prototype

Rice type	Whiteness	Transparency
Long thin (sample 1)	40,5%	3,3%
Long thin (sample 2)	42,1%	3,3%
Long thin (sample 3)	44,6%	3,1%

Table 5. Laboratory samples tested on commercial whiteness meter

Rice type	Whiteness	Transparency	Milling Degree
Long thin (sample 1)	40,7%	3,4%	100 %
Long thin (sample 2)	42,0%	3,3%	111%
Long thin (sample 3)	44,7%	3,2%	116%

The samples of rice type long thin, were separated in three different portions, in order to get different milling degree for different milling time. Over milled rice, results in high loss of grains, which is clear seen on sample three. On Fig 3, the three samples can be seen.

The commercial whiteness meter, gives a third measurement result which is the rice milling degree. According to the manufacturer, the milling degree results from an empirical calculation, and ranges from 0 to 200% (Satake, 2005; Kett, 1990). No further explanations were found about this calculation. It was also noticed that users also don't know which fundamentals generated such milling degree calculation. But in the absence of other automatic method, the measurement is being used as an informal industry guidance. It was also found a physical method of milling degree determination. Its is based on the amount of bran removed from the yellow rice grain (Pan, 2004). It is necessary to weight the yellow rice before milling and after milling when a desired whiteness level is achieved. Then the following formula should be applied at the Eq. (1):

%milling degree = (weight milled rice / weight yellow rice) * 100 (1)

Such method sounds more sensible to the majority of the rice industry producers. Such mass loss on milling process and its correlation with rice whiteness and transparency, will be object of future improvement of the prototype, where artificial intelligence techniques such as neural networks and a standard computer interfaces will be applied. The prototype was built using ordinary materials like MDF, acrylic, universal printed circuit boards for electronic circuits prototyping and electronic components. The total cost of the prototype was R$ 300,00 (Three hundred brazilian reais) approximately US$ 150.00 (hundred fifty American dollars). The cost and price of a commercial version of the prototype, was not object of study on this paper. But it is easily seen that a commercial version would be very competitive in the local market, as the minimum price found on the local market for an imported commercial whiteness meter was US$ 5995.00 (five thousand nine hundred ninety five American dollars). The price is origin export price. The project has achieved all expectations in terms of project execution, reliability of the measurements and low cost prototype. The study and prototype, with a little investment, are ready for industrial scale production.

REFERENCES

Boylestad, R., Nashelsky, L., 1984. Dispostivos Eletrônicos e Teoria de Circuitos. Prentice-Hall do Brasil, Rio de Janeiro.

Elias, M. C., 2005. Rice Milling Process Clarifications. Faculdade de Agronomia, UFPEL, Pelotas.
Galli, R., Santos, M., 2005. Project Orientation. CEFET-RS, Pelotas.

HunterLab. 1996. Applications Note: Whiteness Index. HunterLab, Reston.

Kett. 1990. Operating Instructions of Digital Whiteness Meter for Rice. Kett, Villa Park.

Lange, B., 1990. Operating instructions of Micro Color. Dr. Lange, Düsseldorf.

Leggett, G., 2005. How to Measure Translucent Materials. HunterLab, Reston.

Malvino, A. P., 1987. Eletrônica. McGraw-Hill, São Paulo.

Meneguett, V. L., 2005. Pratical orientation on Whiteness Meter operation. Faculdade de Engenharia Agrícola, UFPEL, Pelotas.

Morales, M., 2005. Project General Notes. ABB Switzerland Ltd, Baden.

Pan, Z., 2004. Annual Report, Comprehensive research on rice. Improvement of Consistency and Accuracy of Rice Simple Milling. USDA ARS WRRC, Albany.

Rickman, J. 2002. Grain Quality from Harvest to Market. Agricultural Engineering Unit, Philippines.
Ryer, A., 1998. Light Measurement Handbook. International Light, Newburyport.

Satake. 2005. Whiteness Meter, www.satake.com, viewed on February 27, 2005.

Saxena, S.C.; Sahu, C., 1994. Differential Inductive Ratio Transducer with Short-Circuiting Ring for Displacement Measurement, IEEE Trans. Instrum. Meas., v. 43, pp. 777-780.

Trevisan, R., 2005. Colorimetry notes. EMBRAPA Clima Temperado, Pelotas.

Tribble, C., 2004. Study Guide for Texas Rice Education. Texas A&M University, Beaumont.
USDA. 2005. Grain Quality Assessment, http://usda-ars-beaumont.tamu.edu/, viewed on February 27, 2005.