



UNICER - Bebidas de Portugal



Biological Engineering Department

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# Development of Image Analysis Methods to Evaluate Barley / Malt Grain Size

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# Motivation

- Grain size evaluation is a sufficiently important method either for the malt producers or for the brewers.
- Its dimension is a parameter of valuation / approval of the raw material, since the grain size has influence in the speed of absorption of the water that is intended uniform to guarantee uniformity of the preparation of malt process.
- For the brewers, the malt size is equally important in the sense where it also guarantees the standardization of the milling process and because it is straight related with the its amount of extract.

# Image Analysis

- Image analysis is, nowadays, a well-established complement of optical microscopy. It allows a routine classification and quantification of particles in an automated and non-subjective manner.
- With the exponential increase of the processing capabilities of computers, as well as their price reduction, image analysis has become a routine in several granulometry applications.
- Image Analysis allows for:
  - Enhancement of pictures
  - Automatic identification and isolation of particles
  - Fast means of getting morphologic information, thus saving tremendous effort and time.

# Design of a Low Cost Solution

In the development of the procedures of image acquisition and analysis of barley/malt grains we had the concern of design a low cost solution:

Hewlett-Packard  
digital camera  
(Photosmart 912,  
2.24-megapixel  
CCD)

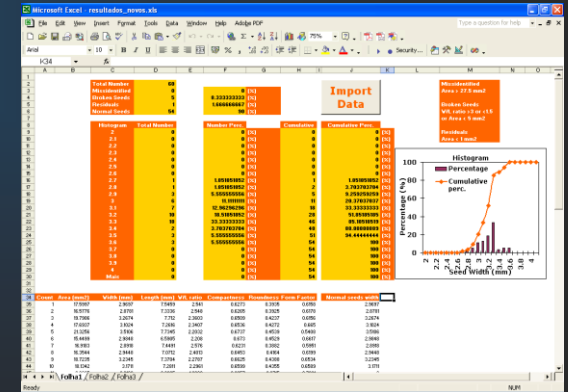


Public domain  
software for image  
processing:  
**ImageJ**

(National Institute of Health, U.S.A.)



The ubiquitous  
Microsoft EXCEL  
for the calculations



<http://rsb.info.nih.gov/ij/>

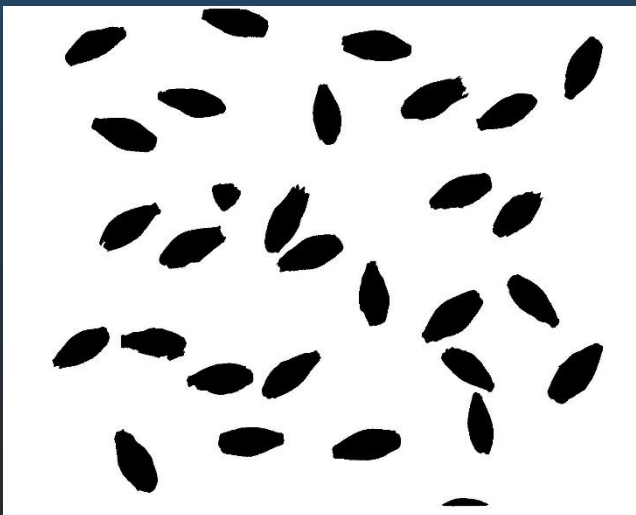
# Image Acquisition

- About thirty seeds are placed in a rectangle of black bristol board, where it exists drawn a 5 cm bar of reference for size quantification of the seeds
- Assays with 5 lots of grains with acquisition of 25 images for lot had been carried out.



# Image Analysis

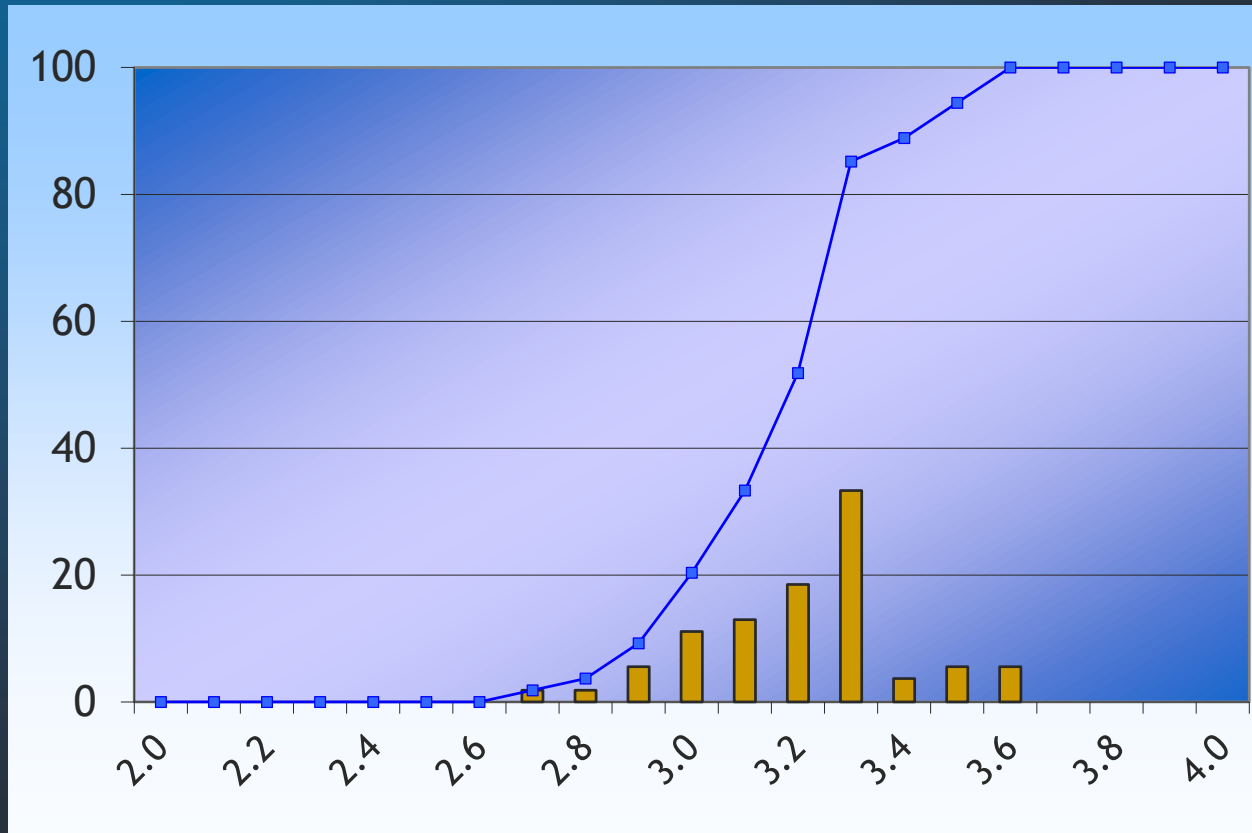
- A macro of commands in JAVA language for execution in the ImageJ was developed. The macro makes the sequential reading of each image and the following operations are processed:
  - treatment for obtaining a binary image
  - identification of the scale bar in 15% of the left side of the image
  - separation of the seeds



# Excel Macros

- For each seed the following morphologic parameters are calculated and recorded in a file:
  - area, length, width, ratio length/width, compactness, roundness, and form factor.
- This file is later read by a macro developed in Excel originating the following information:
  - normal seeds width
  - total number of seeds
  - misidentified seeds
  - broken seeds
  - normal seeds
  - residues and respective percentages.
- Additionally, the macro originates the histogram of percentage and cumulative percentage of the width of the seeds.

# Histogram

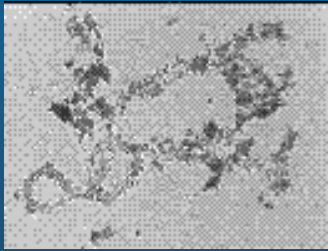




# In-house Image Analysis software currently in use and development include (1/3):

## ■ Activated Sludge in Wastewater Treatment Processes:

- Morphological sludge characterization a WWTP using Partial Least Squares (correlation with settleability, SVI)
- Validation on full-scale plants



## ■ Protozoa in Wastewater Treatment Processes:

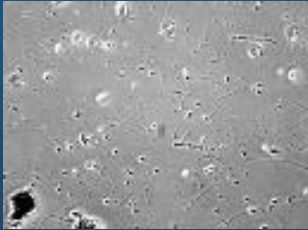
- Automatic recognition of protozoa by image analysis
- Study of Protozoan Population in WWTP by Image Analysis (PCA)



# In-house Image Analysis software currently in use and development include (2/3):

## ■ Anaerobic Digestion:

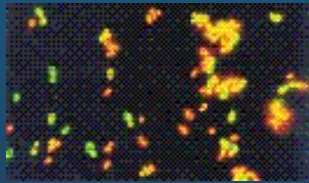
- Characterisation by Image Analysis of Anaerobic Sludge from Two EGSB Reactors Treating Oleic Acid: Automatic Detection of Granules Disintegration Image analysis as a tool to recognize anaerobic granulation time
- Image analysis and molecular biological techniques to monitor granular sludge from an EGSB reactor fed with oleic acid
- Characterization by Image Analysis of Anaerobic Microbial Sludge under Shock Conditions
- Monitoring methanogenic auto-fluorescence and granulation



# In-house Image Analysis software currently in use and development include (3/3):

## ■ Other Applications in Biotechnology and Food Technology:

- Classification of *Saccharomyces cerevisiae* morphology using image analysis
- Morphological Analysis of *Yarrowia lipolytica* under Stress Conditions through Image Processing
- Automatic counting of viable/non-viable yeasts by epifluorescence microscopy with acridine orange as dying agent
- Characterization of bubbles in a bubble column by image analysis
- Simultaneous monitoring of lactic acid bacteria and yeast during Vinho Verde fermentation using phase contrast microscopy coupled to image analysis



# Other expertise in BioPSE group

- Model-based & Expert Systems in Supervision & Control
- Adaptive Control & Software Sensors for State & Parameter Estimation
- Process Integration and Design for Pollution Prevention: Synthesis, Analysis and Optimization
- Chemometrics in Environmental Processes - Environmetrics

These main research topics have been applied to  
**Biotechnological, Chemical, Biopharmaceutical & Environmental** processes

More Information about Projects and Resources  
may be browsed throughout the web page :

[www.deb.uminho.pt/BioPSEg](http://www.deb.uminho.pt/BioPSEg)

