ABSTRACT

In order to obtain valuable food supplies the research plays an important role concerning the implementation of new technologies which have to be simpler, with a shorter time for the working cycle, low energy costs and specific consumption of fewer matters etc.

In the food industry, the malt is an important semi product as far as it concerns the economical aspect, being used as raw material in the liquor industry, bakery products industry, beverage industry, pharmaceutical industry, etc.

In the PhD thesis "**Research on optimization the work process to obtain malt**", the author aims to explore the domain of manufacturing technologies of malt in order to obtain new versions of work on operations of soaking-germination of barley and drying green malt, the optimization of the work process, without modifying the physicochemical characteristics of the malt obtained by current technologies.

In **chapter I** it is shown the importance of malt as an economic factor, as food product concerning the physicochemical composition and as a useful product in many areas of the food industry.

In our country, for malting manufacture it is necessary a quantity of barley seeds over 200,000 tons annually. Romania ranks 4th place in Europe after the Czech Republic, Austria and Germany, in terms of per capita consumption of malt and 5th place in Europe in terms of consumption of malt to the number of inhabitants (www.ziare.com / consumer + beer + Romania). Since the 1980s malt had an increasing request from large baking industry (needed as sugar content improver for dough fermentation, as natural colorant, for improving the content of enzymes and vitamin B complex), in laboratories of pastry and since 2004 - 2005 it is used in the beverage industry with natural nectar, given the intake of dry matter. Also, the malt also has a great practicability in pharmaceuticals.

The malt is used in the industries listed above under various types, such as blond malt, brown malt, caramel malt, acid malt, melanoidin malt, "sharp" malt, Vienna malt, Munich malt, Amber malt, chocolate malt, black malt, Roast Barley malt etc.

Chapter II presents current research on manufacturing technology of malt. Evaluation of raw and auxiliary materials used to manufacture malt is treated in the first subchapter. The

main raw material is barley seeds. For the manufacture of malt water has great importance because it determines processes for malting barley seeds. As auxiliary matters there are used disinfection materials of barley soaking, germination stimulus materials during germination, sanitation materials of production spaces, materials and substances for laboratory analysis, air conditioning, heated fluids, refrigerants, packaging materials.

Barley seeds recommended for use to obtain malt are those of the species *Hordeum vulgare L.* (common barley) with six rows of grains per spike with protein content by 11.4%, and of the species *Hordeum distichum L.* (barley) with two rows of kernels per spike, also containing proteins under 11.4%. In the case of both species of barley, starch granules are the main amount of barley grain, as required in the saccharification process.

The living barley is represented by the embryo through which the water is absorbed in the grain, with a major role in the formation of enzymes, consisting of plumule (acrospires) which will form the new strain of the plants and rootlet (radicle) from which it will be formed the future root plant.

Main auxiliary matters required in the process of malt manufacture is technological water, with a share in terms of quantity of 12 hl ... 18 hl / ton of malt. Parameters that emphasize water quality are: hardness, uncompensated alkalinity and biological purity of water.

The water hardness taken into account in the manufacture of malt is continuous hardness measured in degrees German, which must be comprised within a range of 4 to 12 German degrees depending on the obtained type of malt. Biological purity of the water should be of drinking water corresponding to a total number of germs which does not exceed 20 units / ml of water and the total number of bacilli coli need not be greater than 3 units / liter of water.

The materials for the washing and disinfection of seeds of barley are alkali substances, usually sodium carbonate (Na2CO3) or sodium hydroxide (NaOH) in 2% solution. There are also used for washing, cleaning and disinfecting of production areas substances based on chlorine or iodine, halogenated acetic acids, peracetic acid or quaternary ammonium salts.

Later in this chapter it is treated the current manufacturing malt technology in which are described technological phases of the work process and in which there are presented the tools used for achieving technological operations. The first technological operations are those of the preparation of barley seeds (reception, pre cleaning, cleaning, sorting and storage / ripening of barley seeds) for malting. The main equipment for these operations are: Tipper scales and CFR; pneumatic conveying system; elevators; cyclones for separating dust and light impurities; automatic scales dumpers; Tarara vacuum; spines cutter; Triora cylindrical; barley seed sorter horizontal web; storage buffer barley seeds I and II for maturation; horizontal screw conveyor or

scraper. Barley seed cleaned, sorted and matured are passed to the proper work process of malting which consists of the following: washing-disinfection of grains, soaking and germination of barley seeds and green malt.

During the work process for softening the raw material three important processes took place: washing and disinfection of barley seeds; water absorption in grain; supply of oxygen to the grain. By dipping seeds of barley it is aimed to increase their moisture content from 12 % … 14 % at 40 % … 46 %, in order to begin the process of germination. Following the absorption of water, barley seeds life go from latent to active life. Thus, a moisture content of about 30 % of vital phenomena of the grain has a visible increase. At 38 % moisture the rootlet corner appears, and the value of the humidity of 40 % appears the corner of plumules, which means that the germination process has been initiated.

During the germination of barley seeds it takes place a complex physiological process that uses embryo endosperm nutrients for the synthesis of substances that ensure the development of the little plant.

The purpose of the process of germination is to design the enzymatic equipment necessary for the saccharification processes, both for the saccharification of starch in the malt for obtaining beer, as well as for the saccharification of starch in the malt flour which is added to various types of bread dough in order to improve the fermentation process of dough; saccharification of grain' starch is necessary to change the structure of barley seeds in order to be grind and crushed easier.

Enzymatic equipment which is formed and developed during the germination is composed of starch saccharification enzymes (α-amylase which acts on amylose chains and β-amylase acting on the chains of the amylpectin component of the starch), the proteolytic enzyme (endopeptidases, which attack proteins within the polypeptide chain to form macromolecular protein fractions and exopeptidases, which attack the polypeptide chain from the outside, separating amino acid one by one), hemicellulases, glucanases, phosphatases and lipases.

Barley seed germination is achieved by two basic processes: germination on area and pneumatic germination. Pneumatic germination uses the following germination processes: in boxes; with drums; in mobile heaps. Barley seed germination in boxes (Saladin type) is the process that is practiced using 8 boxes (one for each day of germination), each equipped with a fan and individual air conditioning facility. Each cartridge is provided with a mechanical rake for barley seeds. The process of germination in drums is done similarly to that in the box, except that the return of barley seeds heaps is realized by rotating drums. Germination process with mobile piles alleys sprouting occurs on germination paths, provided with bolter and aeration channel

(the space below the grate is divided by the length of the driveway in a number of 8 compartments, one for each day of germination, by introducing air conditioning with different parameters for each working day). The paths of sprouting are provided with one turn around, in order to achieve mixing and transport of the longitudinal return of the piles, and two air-conditioning plants, each of which carrying out air humidity of 100%, but at different temperatures (a difference of 3... 5^0C). Alley germination is basically a box with a length of 50 ... 60 m.

Malt drying technology is the operation through which drying of malt is done using a drying agent called thermodynamic agent which is hot air. Hot air drying is to make a contribution of heat to facilitate the evaporation of the material subjected to drying. During the work process for drying malt heat and mass transfer occurs in each grain of malt.

The mechanism of drying is determined by thermo processes (diffusion, thermo diffusion) taking place inside the grain malt, at the same time the mass transfer by diffusion and convection heat transfer in the boundary layer, which separates the surface of the malt drying agent (air warm). During the drying process, the initial water evaporation occurs on the surface of the grains of green malt and vapors diffuse into the grain through the malt layer. Gradually, the temperature increases inside the grains of malt and forming vapor diffuses from grain in the dry material layer to the surface.

Drying comprises, in terms of the dynamics of the water removal, the step of pre-drying (fading), which consists of removing water from a constant speed malt at a temperature of 45 ... 55^0C, to a seed moisture content of 10% at blond malt type 20% to the brown type, and the actual drying step (or final), which consists of the removal of water with a decreasing velocity, increasing temperature to 80^0 the blond malt to 85^0C and the moisture content of the seeds 4.5 ... 7.5 % and brown malt 100 ... 105^0C temperature and humidity of 1.5 ... 3.5 %.

Equipments used for drying the malt are made using different designs, such as malt dryer with horizontal chambers, malt dryer grill rocker, vertical and dryer room, and newer devices such as pneumatic cylinder double bottom flat cap dryers and the spherical cap dryers.

After drying, fresh malt is subjected to the following operations: cool malt, malt degermination (breaking of the rootlets, of plumules and a small part of the malt husks), grinding or polishing malt. These operations are designed to eliminate the following risks: water resorption if missing water cooling; occurrence of bitter taste or rancid if the plumules and rootlets are not removed; decreasing the yield of the wort dry extract, malt husks in the case of not removing the exfoliated hulls from the surface of the malt grains. Particular emphasis is given to storage malt for at least four weeks to maturation, when the equipment is intended to

reactivate the enzyme, which during the drying process suffered a heat stroke.

Current trends on cleaning barley seeds with the use of modern equipment, focus on advanced cleaning such as separators, aspirator air recirculation TRC / R made by company OCRIM - Italy; rotating drum type separators Damas in Denmark; vibratory-separators, which perform mass separation of impurities from cereal grains using the moving surfaces inclined plane of vibration (such machinery present in comparison with the oscillating equipments a processing capacity of a specific load and a high technological effectiveness); classifiers (separators) for color, size and transparency manufactured by Buhler, called SORTEX, the barley seeds after the end inside the machine, pass as a thin layer in front of photoelectric cells which separate the barley seeds from those of different sizes (larger and smaller) or impurities.

The purpose and objectives of the PhD thesis are presented in **Chapter III**. Optimization of the workflow to obtain malt is the purpose of this paper. Making germination charts within a shorter time and drying diagrams given as little time as possible, through which is intended to be obtained new technologies for manufacturing of malt, is the main focus of theoretical and experimental research.

Making new families of diagrams for seed germination and drying barley malt was made possible through implementation and experimentation of two lines of micro malting in the food industry laboratory from agriculture mechanization disciplines of USAMV, Iaşi.

To achieve the thesis objectives the following steps were followed:

- analysis of the current state of research on technology and work process technology used in the malting operations. In this phase, the following were made: there were identified the most advanced technologies for the production of malt and so on seed germination process of barley; there have been determined the physical, physiological and biochemical processes which take place during the germination of barley seed; there has been made a theoretical study on convective drying of malt in fixed bed and fluidized bed; it has been established the work process for drying green malt, and for machinery used for germination and drying malt;
- originating, designing and development of an experimental stand (micromalting line for the study of barley seed soaking, germinating and drying green malt) formed of a multifunctional tape attached inside the multi-purpose laboratory vertical dryer, in which the operations of washing, soaking, germination and drying are being done;
- research on mathematical modeling of air flow and temperature field distribution in the multipurpose box for the work process concerning drying;
- statistical processing of experimental results concerning the work process of seed germination, respectively the evolution of rootlets and plumules;

- research for optimizing the experimental process variants regarding to work process to obtain malt.

In **Chapter IV** there are presented the research material and method for research in the laboratory. Experimental investigations have been carried out over a period of two years. These took place in in the food industry laboratory from agriculture mechanization disciplines of USAMV, Iaşi equipped with facilities for providing utilities, water and single phase and three phase electricity.

To perform the sensory and physicochemical properties of barley seed and malt it has been used the lab equipment from chemistry laboratory of oenology discipline of the Teaching Station "V. Adamachi "of USAMV Iaşi and the Malt Factory laboratory " Soufflet Romania "in Buzau. Methods of analysis have followed the working protocol rules of Analytica EBC (European Brewery Convention).

Experiments were conducted according to a research plan which followed:

- performing germination experiments using Jacobsen mass germination, by means of which can be achieved diagrams of soaking- germination barley seed. During the process, one is able to monitor the parameters of temperature and humidity;
- carrying out experiments drying green malt by use of the laboratory vertical drying apparatus, equipped with a microprocessor and which allows monitoring of technological parameters, velocity, temperature and humidity of the drying agent before and after covering the product layer. Drying facility allows continuous weighing of the sample of the product under drying, causing moisture loss during the work process. Parameters monitored during the drying of malt are analyzed graphically, resulting in different diagrams of drying green malt;
- building physical models for barley seed germination and drying green malt;
- development of software simulation workflow for barley seed germination and drying of green malt;
- statistical processing of the experimental data on the evolution of rootlets and plumules in the soaking and germination phases and interpretation of experimental results;
- statistical data processing and their interpretation to optimize the workflow for obtaining malt;
- confirm or refute the hypothesis set;
- using experimental results if the hypothesis confirms or it is gainsaid, work experiences will resume with other parameters;
- research will be carried on and their results will be used in production, scientific papers, etc…

To obtain malt in laboratory conditions there were used barley seed varieties such as Nectaria, Mădalina, Andreea, who were purchased from "Astra" Agricultural Society Trifeşti, Iaşi County, specialized in producing seeds and from Malt Factory " Soufflet Romania "Buzău County. Barley seeds should contain: water = 13 ... 14 %; dry matter = 86 ... 87 %, consisting of: non-nitrogenous extractive substances (starch = 55 ... 60 % sugars (mono and disaccharides) = 1 ... 2 % cellulose = 5 %, ash = 2.5 % vitamins); proteins (albumin, globulins, prolamins, glutelin protein enzyme) = 10 ... 12 %; fats (glycerides, phosphatides, sterols) = 2.5 %; enzymes.

The material used in the experiments was made consisting of: micro malting equipment used in method A and apparatus for micro malting used in method B.

Micro malting installation used in method A consists of: smooth 6-liter flush volume required to wash the seeds of barley, bottomed cylindrical boxes of galvanized mesh, mass germination and vertical Jacobsen dryer laboratory with original plain box.

Jacobsen mass germination, due to its special design, electronic equipment that is equipped with and its components (tank, water pipe, drain pipe (outlet) water tank, water cooling machine, pipe supply bowl with cold water from water cooling unit, connection-return water to the tank water cooling unit, water heating appliance, pipe feeding the tank with hot water from the water heating unit, connection-return water from the tank to the heating appliance water) achieved soaking and germination of barley seeds under the control of temperatures and soaking times.

Vertical Jacobsen dryer laboratory with original plain box is equipped with a operator interface "touch screen" which allows control and monitoring of the drying process. Heat and mass transfer inside the dryer is done by convection heating agent being represented by the heated air helper electrical resistance (3 resistors each 1.5 kW each). The drying agent is sucked from the outside by means of a fan and discharged in a bottom-up inside the dryer.

Micro malting plant used in method B is composed of multifunctional box upright grill and dryer used in the method A. Multifunctional box replaces: stainless steel vessel that took part in the process of washing and soaking barley seeds; PVC bottom boxes of galvanized mesh; Jacobsen mass germination and initial plain stainless steel dryer box. This box, in particular its design, could be used to carry out the above-mentioned four operations only if the cassette has been inserted in place of the original stainless steel laboratory dryer described above.

In order to perform laboratory analysis for seed barley, green malt and finite malt, we used the following equipment: 440-49N KERN electronic scales accurate to 0.1 g, anemometer to determine the speed of hot air under the grate and out of Dryer, model MAC moisture analyzer (thermo balance analytical electronics) for determining the moisture content of cereal

seed before the start of drying, during drying and the drying end of the thermometer probe K, needed for the determination of humidity oven seeds of barley and malt finite Dry , flawed metre to determine friability malt laboratory mill to obtain fine and coarse grist and determination, device preparation by the method Congress Mash-Hartong, apparatus for determining annual and index Kolbach Hartong, microviscosimeter DM 5000 to determine viscosity, DR 5000 spectrophotometer Lange , filtered wort beaker to determine the method of comparing the rate of filtration, saccharification time and color Scrubber B-324 Buchi apparatus for distillation proteins, digital burette for distillate protein titration.

In order to elect malt barley seeds to obtain malt, after sensory and physico-chemical analyzes in the laboratory, it has been experimentally determined the percentage of seeds germinated at temperatures of 15^0C, 18^0C, 21^0C and 24^0C, for varieties of barley seed type such as Mãdãlin, Nectaria and Andrea, with the help of Jacobsen germination mass.

At **15^0C temperature** (control), it is noted that the percentage of germinated barley seeds of the variety Mãdãlin in 5 days was very low, only 69 % in 7 days and the percentage of germinated grains was 91%. In the case of barley seed of the variety Andrea, germination percentage reached 74 % on the 5^{th} day and on the 7^{th} day reached at a rate of germination of 92 %. Nectaria variety reached on the 5^{th} day of germination percentages of 79 %, and on the 7^{th} at the rate of 93%, which is closer to that of the variety Barbara.

At a **temperature of 18^0C**, the percentage of germinated barley seeds variety Mãdãlin on the 5^{th} day was 86 %, and on the 7^{th} day, 94 %. The second variety of barley, Michael, on the 5^{th} day of the germination the germinated beans reached a percentage of 93 % and on the 7^{th} day, 97 %. The third variety, Nectaria had the percentage of germinated barley seeds of 93 % by the 5^{th} day and 97 % on the 7^{th} day.

In the case of germination at **21^0C temperature**, percentage of barley seeds germinated for the Mãdãlin barley variety on day 5 was 93 %, and on day 7, 94 %; barley variety Andrea, has reached on the 5^{th} day a rate of 95 % and on day 7, 97 %. Barley variety Nectaria had had the percentage of germinated barley seeds of 96 % on day 5, and 97% on day 7, very close to the values of the variety Andreea.

After determining seed quality of three varieties of barley it has been passed to malting in the laboratory by two methods: method A with the micromalting installation vessel formed of steel container, bottomed cylindrical PVC boxes of galvanized mesh, mass germination and vertically Jacobsen laboratory dryer; through method B, with the help of the micro malting installation incorporated inside the multi-purpose vertical laboratory dryer.

Both methods have met the same technological phases that are used in industrial units'

namely **quantitative and qualitative reception feedstock seed conditioning, washing, soaking and germinating barley seeds, drying green malt**.

Soaking and germination of the barley seeds were made with the line of the micro malting germination Jacobsen mass (method A), in each 12 experiments for the three varieties of barley (Andrea, Mădălin, Nectaria), resulting in 36 variations.

The following notations were used in the following: v represents the variant; a - A method by which the work was carried out; **b** - method B; **n** - Nectaria variety; **m** - Mădălin variety; **a** - Andreea variety; **1 ... 12** - version number; **I** - the wetting of the immersion of the barley seeds in water; **NI** - no immersion (non-wetting) of barley seeds; **u** - the drying operation.

In the experiments conducted by the method B it was observed the same technological steps as in method A, except that operations have been performed with micro malting technological installation consisting of multifunctional box attached inside the vertical laboratory dryer.

Mathematical modeling of drying malt in laboratory conditions is treated in **chapter V**. Multifunction box made for the laboratory can perform washing operations of seeds, soaking, germination and drying. Box with compartments for running some drying agent was mathematically modeled to optimize the constructive and functional aspects.

Optimizing flow drying agent inside the multifunction box dealt with the leveling of temperature gradient and speed drying agent under the grill on which layer has malt. Complex process optimization of flow simulation applied drying agent CFD (Computational Fluid Dynamics), changing design parameters of drying agent dispenser cassette and functional parameters of speed and temperature at the entrance of this agent in the box.

CFD simulation uses the mathematical model proposed by: completing the steps numerical digitization of finite volume method computing domain in the preprocessing stage; imposing the boundary conditions for obtaining one system of equations which is performed at the stage of preprocessing for geometry and at the step of processing speed for the parameters of the drying agent, temperature, humidity; solving the system of equations in each node of the domain through the iterative method to obtain convergence in the entry; graphical representation of the solutions obtained in each node of the studied parameters speed, temperature, humidity and power lines, in the post-processing stage. CFD simulation was constructed using an optimal model of distributor drying agent under the grill box (initial agent dispenser was empty, and finally the dealer has six baffles), which gives the possibility to obtain a uniform dry malt, and before drying to obtain a uniform barley seeds germination.

Chapter VI of the thesis presents the results of experimental research work on the

optimization to obtain malt. The experiments were carried out for three varieties of barley (Nectaria, Mădălin, Andreea), following the model of three charts on the germination concerning the soaking and germination time at a temperature of 150C, 180C from three, three, and three to 24^0C to 21^0C, resulting in 36 variants for method A and 36 variants for method B.

During the experiments carried out by method A or B germination is interrupted when the rootlet reaches 17 ... 22 mm in length and plumule reaches 7 ... 12 mm in length.

In the experiments carried out by the method A of soaking and germination of a seed, the processes of sorption and desorption of water by barley seeds took place in a period of time between 96 hours and 140 hours, during which time rootlets have reached 17 ... 22 mm, and plumules 7 ... 12 mm.

Softening times and seed germination are:

- in the case of witness experiments carried out at 15^0C attaining the average mentioned took place after a time of 140 hours;
- experiences made at 18^0C attaining the average mentioned took place after a time greater than 122 hours;
- in terms of the experiences made at 21^0C attaining the average mentioned occurred after a medium time of 118 hours;
- for experiments carried out at 24^0C attaining the average mentioned occurred after a medium time of 96 hours.

If there is carried out an analysis of the parameters mentioned above, it is stated that as the temperature is increased at which the soaking and seed germination takes place, it decreases the time in which the processes occur.

Upon completion of germination, experiments were continued by performing the drying operation in step A.

Drying was carried out using the parameters of time and temperature of the air heated up from 35^0C to 80^0C, for all experiments, the only difference was made by the velocity of the heated air which had values of 1.5 m/s, 2 m/s and 2.5 m/s.

Drying variants have been noted to v_{aun}, v_{aum}, v_{aua} or v_{bun}, v_{bum}, v_{bua}, w_{here}: **v** – the embodiment, **a** - method A, **u** - the drying operation, **n** - Nectaria malt, **m** – Mădălin malt, **a** – Andreea malt, **b** - method B.

In the case of A method for drying green malt samples were: Nectaria green malt, $\mathbf{v_{an8}}$ version, which was dried in nine versions ($\mathbf{v_{aun1}}$; $\mathbf{v_{aun2}}$; $\mathbf{v_{aun3}}$; $\mathbf{v_{aun4}}$; $\mathbf{v_{aun5}}$; $\mathbf{v_{aun6}}$; $\mathbf{v_{aun7}}$; $\mathbf{v_{aun8}}$; $\mathbf{v_{aun9}}$); Mădălin green malt, vam6 version, which was dried in nine versions ($\mathbf{v_{aum1}}$; $\mathbf{v_{aum2}}$; $\mathbf{v_{aum3}}$; $\mathbf{v_{aum4}}$; $\mathbf{v_{aum5}}$; $\mathbf{v_{aum6}}$; $\mathbf{v_{aum7}}$; $\mathbf{v_{aum8}}$; $\mathbf{v_{aum9}}$); Andreea green malt, vaa8 version, which was dried in

nine versions (v_{aua1}; v_{aua2}; v_{aua3}; v_{aua4}; v_{aua5}; v_{aua6}; v_{aua7}; v_{aua8}; v_{aua9}).

Finally it was obtained an average malt humidity of 5.6 % when warm air velocity was 2.5 m/s, lower than the 6.6 % average moisture when used in hot air drying speed circulation of 2.0 m/s. At the hot air velocity of 1.5 m/s, final moisture content of the malt had the highest average of 7.7%. The best versions were v_{aun8} drying malt (made from green malt barley seed Nectaria = v_{an8}) with final moisture U = 5.6 %, v_{aum8} (made from green malt barley seed Mădălin = v_{am6}) with U = 5.1% v_{aua7} (green malt produced from barley seeds Andreea = v_{aa8}) U = 5.3%.

For method B research were continued by conducting laboratory experiments to obtain malt in laboratory with multifunction box built inside the drying room of the vertical dryer.

The wetting, drying and germination operations multifunction made with multifunction box followed the respective parameters that have been shown within the work method.

Through method B, the results obtained during the operations of soaking and germination, concerning the water uptake by the barley seed (included within a distance of barley seeds' humidity from U = 37 % to U = 48 %) and the appearance of rootlets (size of 0.1 mm to 2 mm), even during soaking, time based, are the following:

- the experiments carried out at 15^0C (control) water absorption and the appearance of rootlets held for 54 hours, germination of the barley seeds ending in a period of time ranging from 121 hours to 140 hours;
- experiements performed at 180C water absorption and the appearance of rootlets occurred after a medium time of 45 hours, maximum germination realizing after 121 hours;
- experiments performed at 21^0C water absorption and the appearance of rootlets occurred after a medium time of 36 hours, except that after this time has passed the rootlets had a length of 3 mm and germination was stopped after a period of between 86 to 96 hours;
- the experiments carried out at 24^0C water absorption and the appearance of rootlets occurred after a medium time of 30 hours, but, as with the experience made at 21^0C, after this time the length of rootlets averaged 3 mm, and germination was interrupted after 86 maximum hours.

From the point of view of the germination of seeds by method B it is found that as the temperature is increased when the soaking and germination takes place, decreases the time in which the processes occur.

In the case of method B, as in the case of method A, after the operation of germination were followed the procedures for all the sensory analysis after each experiment carried out it was observed that the green malt samples obtained by carrying out experiments at 15^0C (control) at 18^0C and 21^0C have pleasant appearance with full grain without mildew stains, no foreign odors

and specific pleasant odor of green cucumber. Green malt obtained by performing experiments at 24^0C has full grains without mold spots, but with slightly sour smell and taste. In this temperature case, the malt had a pH below 4.4. As with method A and method B, the drying operation has been carried out only for all three samples of each type of green malt from barley's variations.

It is noted that each of the three sample was dried in turn on 9 alternatives, resulting in twenty-seven variants drying using method B: green malt made from barley seeds of the variety Nectaria version v_{bn9} dried in nine variants ($\mathbf{v_{bun1}; v_{bun2}; v_{bun3}; v_{bun4}; v_{bun5}; v_{bun6}; v_{bun7}; v_{bun8}; v_{bun9}}$); green malt made from barley seeds of the variety Mădălin version $\mathbf{v_{bm8}}$ dried in nine versions ($\mathbf{v_{bum1}; v_{bum2}; v_{bum3}; v_{bum4}; v_{bum5}; v_{bum6}; v_{bum7}; v_{bum8}; v_{bum9}}$); green malt made from barley seeds of the variety Andreea version vba8 dry all the nine variants ($\mathbf{v_{bua1}; v_{bua2}; v_{bua3}; v_{bua4}; v_{bua5}; v_{bua6}; v_{bua7}; v_{bua8}; v_{bua9}}$).

Dried malt at the same parameters of temperature and time had finally averaged 6.3 % moisture when warm air velocity was 2.5 m/s, lower than the 7.1 % average moisture when used dry hot air velocity of 2.0 m/s. At the speed of 1.5 m/hot air used to dry, had a final moisture content of the malt had the highest average of 8.2 %.

The final humidity obtained was lower in the drying vbun8 variants (green malt produced from barley seeds Nectaria = v_{bn9}) the moisture content U = 6.2 %, $v_{bum}7$ (green malt produced from barley seeds Mădălin = v_{bm6}) when U = 5.7 % and v_{bua8} (green malt produced from barley seeds Andreea = v_{ba8}) when U = 5.9 %.

Based on the technology provided by the interruption of the germination of the barley seeds rootlets reached the 17 ... 22 mm length, and plumules reached 7 ... 12 mm length, after the end of the experimental steps and centralizing the obtained results it has been passed to the stage of statistical analysis of the evolution of rootlets and plumules during germination for each variety of barley. This analysis used the parametric test: **the test $\mathcal{F}$ (Fisher) for analysis of dispersions**. The $\mathcal{F}$ test is based on testing the parameters of some known distributions (*Stoleriu Iulian, 2010*).

In order to implement the test for analysis of dispersions, concerning the evolution of rootlets and plumules of barley seeds during germination, it has been used the Matlab program by specific order: [h, p, but stats] = vartest2 (X, Y , alpha, tail), (http:/www.mathworks.com).

This application was made for barley seed of three varieties (Nectaria, Mădălin, Andreea) for germination which used both method A and method B, in the following versions:

- the rootlets evolution version at 15^0C compared to evolution of the rootlets evolution version at 18^0C in parallel with the evolution of plumules at 15^0C compared to the

development of plumules at 18^0C;

- the plumules evolution version at 15^0C compared to 21^0C of the plumules evolution in parallel with the evolution of plumules at 15^0C compared to the development of plumules at 21^0C;
- the plumules development version at 18^0C compared to the evolution of rootlets at a temperature of 21^0C, while the progress of plumules at 18^0C compared to the development of plumules at 21^0C;

The test was performed for a significance level $\alpha = 0.05$ and a probability of dispersion around the medium value of 95%.

The results obtained after statistical analysis were established on the evolution of plumules and rootlets during germination, recommend alternatives v_{am6} and v_{am9}, v_{an5} and v_{an8}, v_{aa5} and v_{aa8} from method A, and variants of it v_{bn3} and v_{bn9}, v_{bm3} and v_{bm6}, v_{ba5} and v_{ba8}, in the case of the method B, as the optimum. Note that these options have significant dispersion equal (H_0) and coefficients of determination R^2 greater than 0.9500.

The results of physicochemical malt samples obtained by the two laboratory methods (A and B) emphasize the fact that by **method A** it **was obtained optimal variant v_{an8}** and **v_{aun8}**, and in the case of **method B the best option** is **v_{ba8}** and **v_{bua8}**.

Chapter VII of the thesis deals with the conclusions that have been established in the investigations. The most important conclusions reached by the author of the PhD thesis will be presented:

- Seeds of barley (feedstock for malt) must contain protein in 11.4 %.
- Facilities that are used in industrial technological production lines for malt are complex and performing (special construction machinery for barley seed soaking, sprouting alleys, machinery to turn back green malt, green malt dryers) and can produce different types of malt: blonde, brown, glassy or caramel.
- Malt can be achieved by several methods of germination (sprouting in area, sprouting air drums, air alleys sprouting, sprouting pneumatic bulging bottom cylindrical tanks), but the main technological operations, washing barley seeds by soaking and their germination and drying green malt, takes place in the same timeline work for all methods of germination.
- The tendency to return to vertical dryers, 2 or 3 levels, which aims to reduce energy consumption for transportation of malt, with its free fall from a rack on the other, eliminating equipment, eliminate system green malt return to uniform moisture during drying and using air to preheat the lower floor malted layer on the upper floor.
- The main objective of theoretical and experimental research is the optimization of

working on obtaining new malt families by making charts for soaking and germination of barley seeds and some new families of diagrams for drying green malt, with two lines of micro malting.

- Experiments were conducted in laboratory with equipment for the food industry in the group of subjects with the agricultural mechanization profile of USAMV.
- Method of work experience required making use of the malting technology lab (the phases were scouring seed germination soaking and drying green malt) through A method (which was used in the micro malting line formed of cylindrical PVC tapes, galvanized perforated metal bottom, plus the germination Jacobsen laboratory vertical dryer) and method B (the used micro malting line was composed of multifunctional box built in laboratory dryer).
- In order to improve the drying process it was carried out mathematical modeling of the process of working on the movement of hot air flow through the multifunction box, which resulted in improved physical model for obtaining initial malt multifunction box by box multipurpose CFD simulation requiring variance amendment initially air distributor baffles version three new air distributor with six baffles.
- Experiments to optimize the work process to obtain malt, through method A and method B, emphasize achieving close results of physical indices (length of the rootlets and the length of plumules, humidity germination of seeds at the end) during the steeping and germination compared to conventional methods, but these processes consuming times are less than (86 hours to 96 hours) than traditional procedures (126 hours to 140 hours).
- Through method A one can note down that the best drying variants are: $\mathbf{v_{aun8}}$ final moisture of 5.6 % (by drying the green malt v_{an8} version); $\mathbf{v_{aum8}}$ final moisture of 5.1 % (by drying the green malt v_{am6} version); $\mathbf{v_{aua7}}$ final moisture of 5.3 % (by drying the green malt v_{aa8} version);
- The results obtained during the operation of soaking-sprouting the experiments conducted by the **method B** showed that as the temperature is increased at which the soaking and seed germination takes place, decreases the time in which the processes occur.
- Green malt obtained by performing experiments at 24^0C had full grains without mold spots, but slightly sour smell and taste and a pH below 4.4; because of these drawbacks the malt was not put to dry.
- Using method B there was obtained the following optimal drying diagrams: v_{bun8} (green malt produced from barley seeds Nectaria = v_{bn9}) where U = 6.2 % final moisture, v_{bum7} (green malt produced from barley seeds Mãdãlin = v_{bm6}) when U = 5.7 % and v_{bua8} (green malt produced from barley seeds Andreea = v_{ba8}) when U = 5.9 %.
- Results of statistical analysis on the evolution of rootlets and plumules during

germination, recommend as the optimum working versions $\mathbf{v_{am6}}$ and $\mathbf{v_{am9}}$, $\mathbf{v_{an5}}$ and $\mathbf{v_{an8}}$, $\mathbf{v_{aa5}}$ and $\mathbf{v_{aa8}}$ obtained by method A, and variants of it $\mathbf{v_{bn3}}$ and $\mathbf{v_{bn9}}$, $\mathbf{v_{bm3}}$ and $\mathbf{v_{bm6}}$, $\mathbf{v_{ba5}}$ and $\mathbf{v_{ba8}}$ obtained by **method B**.

- The experimental results obtained in the laboratory, compared with the results of statistical analysis selected the following optimal softening diagrams - diagrams germination and drying malt production: at **method A the best option is** $\mathbf{v_{an8}}$ (sprouts length is 22 mm, the length of plumule is 9 mm, the end humidity germination U = 46.7 %) and $\mathbf{v_{aun8}}$ (malt from the end of the drying humidity U = 5.6 %), and at **method B the best solution is** $\mathbf{v_{ba8}}$ (the length of the sprouts is 19 mm, the length of the plumule 7 mm, the end humidity germination U = 46.7 %) and v_{bua8} (malt from the end of the drying humidity U = 5.9 %).

- Comparing the two versions, $\mathbf{v_{bua8}}$ and $\mathbf{v_{aun8}}$ onthe physico-chemical basis it was found that malt obtained by method A has a total of five parameters with values very close to the limits of admissibility conditions (1 - total protein, 3 - extract the dry, 5 - time filter 6 - friability 7 - vitreous grains), the remaining parameters fit well within the distance and the malt obtained by method B, satisfies all the conditions of eligibility, which demonstrates that the variant $\mathbf{v_{ba8}}$ and $\mathbf{v_{bua8}}$, are the best choice.

- Experiments carried out with the two installations of micro malting through A and B methods have led to shortening time of the soaking and germination drying, from 7 days to 4.5 days, obtaining the malt and the organoleptic and physico-chemical values meet the same eligibility conditions as the malt obtained at least 7 days in industrial installations.

- **The production of new families of soaking-sprouting diagrams and drying with up to three days shorter in the laboratory for the manufacture of malt, the experiments conducted by the method B (with the multifunction box incorporated into laboratory vertical dryer) and by means of a (Jacobsen and mass germination laboratory vertical dryer) compared with malt made with industrial installations, it is concluded that the objectives and purpose of the PhD thesis to optimize the work process to obtain malt were achieved.**

Getting soaking-sprouting family charts and of shorter drying family diagrams, made with micro malting laboratory facilities, in comparison to soaking, germination and drying diagrams existing lines recommend the micro malting lines shown (in the A method and the B method) of major manufacturers of malt in order to determine the best germination's family diagrams of the barley seeds to dry the green malt in a short time and to obtain a wide range of types of malt.

Micro malting line used in the B method is easy to operate (eliminating the additional

operations of transfer from one vessel to another, compared with the number of manual operations to be performed by the A method), and is useful in various industries such as liquor industry (beer, whiskey, etc); bakery and confectionery industry laboratories which uses malt flour for flavor and color; beverage industry where extracted malt is used as dry matter intake, natural dye and for improving the content of vitamins.

Making the micro malting line used in method B, consisting of multifunctional box incorporated into laboratory vertical dryer, opens new avenues for research on the production of new varieties of malt, setting the mode of development of the enzymatic equipment during germination and in the first part of the drying considering the temperature, the humidity and the presence of oxygen, the presence of vitamin, research on the chemical composition of the malt, as well as reducing the content of vitamins in the presence or absence of water in the malt in certain percentages at certain temperatures for certain periods of time.