Using Renewal Energy from Radio Frequency Heat Treatment Combined with Conventional Drying in Green Malt Production.

Karl Eichhorn[1], Suchada Vearasilp[2], Dieter von Hörsten[3], Elke Pawelzik[4] and Wolfgang Lücke [3]

[1] PhD. Student Georg-August University Göttingen, Department of Crop Science, Section Agricultural Engineering, Germany

[2] Postharvest Technology Research Institute/Postharvest Technology Innovation Center, Chiang Mai University, Thailand

[3] Georg-August University Göttingen, Department of Crop Science, Section Agricultural Engineering, Germany

[4] Georg-August University Göttingen, Department of Crop Science, Section Quality of Plant Products, Germany

Back ground

- Malt production is based on:

Steeping, Germination, Kilning

- Steeping increases the water level of barley from 12 to 45%
- In the germination process enzymes are activated.
- The final kilning reduces the water in the green-malt to a level where chemical and biological reaction come to an end.

Kilning is divided in 2 steps:

- Reduction of the moisture during the germinated barley from 45 % to 10-12% with temperature 50-65°C, 12-14 hours
- Reduction of the moisture to 4-5 %, temperature 70°C-90°C, 14-26 hour.

Narziss (1976) concluded:

Enzymes responsibility for starch degradation

- α-amylase (optimum 72ºC-75°C) can resist temperatures upto 80ºC.
- β-amylase (optimum 60ºC-65ºC) Above 70ºC is inactive.
- β–glucanase

  Endo-β–glucanase not affected during the kilning.

  Exo-β-glucanase temperatures over 50ºC the activity decrease to 1/3

- During the slow reduction of moisture in malt the α-amylase is more temperature resistant than the β –glucanase.

- The higher the curing temperature (80-90ºC) the lower is the enzyme activity (Haemaelaeinen and Reinikainen, 2007).

Concerning the basics

It is interesting how to combine the RF-technology and the conventional drying method for drying the malt.

Therefore this experiment will be focus on:

- Enzymatic activities
- Qualities of malt (taste and stability of the beer product).
- Search for appropiate technique

Proteolysis

Malting starts with the enzyme protease that dissolves the protein barrier around the starch corn.

- Over 85°C the enzyme Endo-protease is denaturized. (Osman *et al*. 2002)
- The endo-protease activity level depends on pH, temperature and stability with additives (Osman *et al*., 2002).

Anyhow, there are some contrast reports the hydrolysis of enzyme proteinase will be inactivated when treated 2 minutes at 70°C (Jones and Laurie, 2002; Jones *et al*., 2000).

Cytolysis

Cytolysis is transmitter process to the starch.

Sources: hemicellulose — 80-90% β-glucan

10-20% pentosan

β-glucanase responsible for hydrolyze β-glucan

β-endo-1,4-glucanase → already exists in the grain

β-endo-1,3-glucanase → establishin the malting progress

- In the brewing process, it is important to reduce β- glucan, due to the difficulties in the beer filtration (Senge and Annemueller, 1995).

Amylolysis

- After the surface of the corn is hydrolyze the endo-amylase and the exo-amylase are able to react with the starch (amyloplast).

- β-amylase is already existin barley grain. There is no α-amylase in barley. It is activated and established trough the germination (Kessler, 2006).

After :

Hydrolysis Cytolysis Proteolysis Amylolysis

Germination

Green malt

Kilning

Without kilning the malt can not be kelp for the next procedure, but it affects the enzyme activity, flavor and aroma stability.

the dehydration processes.

The Conventional are Practiced :

1. Moisture reduction from 45 % to 10-12 %
2. Dehydration from 10-12 % to 4-5 %

Because of the very fast dehydration the surface of the corn will be sealed and the hydration will stop even the temperatures increase. Kernels will heat up. High moisture, temperature and the enzymes there is a gelatinization. The result will be crystallized kernels (Sacher *et al*., 2003).

Hypothesis

RF-technology is an alternative technique for dehydration of green malt and a possible combination with the conventional curing when there is a focus in quality and costs.

Advantages

- Combination of RF-technology and conventional-technology can reduce time and cost.
- A better malt quality might be possible to achieve.

Target

- Examinations of enzyme activity of β–amylase, α-amylase, β-glucanase and proteinase when using RF-technology for the green malt dehydration.
- Differences during the dehydration while kilning according to conventional methods should be expelled.
- There is a special focus on inactivation of enzymes and it effects on malt parameter.
- One more aspect is how RF-technology will change color and aroma of the product. In the future small tests (brewing) for sensory evalution are planed.

Analysis

- Moisture
- Malt extract (anhydrous)
- Extract difference
- pH
- Color of the congress wort
- Boiled wort color
- Saccharification time or inert to iodine
- Viscosity
- Amount of protein
- Soluble nitrogen
- Soluble nitrogen rate (Kolbachindex)
- Free Amino Nitrogen (FAN)
- Diastatic Power
- Hartong index
- Friabilimeter
- Grain size over 2.5 mm

Malt parameter (not in use in all malt laboratories)

- The dimethylsulfid-precurser (DMS-P)
- Nitroso-Diethylamin (NDMA)
- Thiobarbitur acid-index (TBA)
- *α - amylase - activity*
- *β - amylase – activity*
- *β - glucanase – activity*

Micro malting Chiangmai Beverage, Chiangmai

- The malt is produced in the micro malting of Chiangmai Beverage Co. Ltd.. The production capacity is limited to 7 Kg.
- This unit contains cooling, aeration and blower or processes are the green manual.

Steeping and germination unit

Humidification of the green malt is manual. There are sensor measures the temperature below the floor in the steeping and germination tank.

Control cabinet

The dehydration of the green malt is done in a separate container that has the same size and is equally constructed as the steeping and germination tank.

Temperature controlling panel

Air is heated up with the heating unit, which is below the floor, and than blown with an adjustable fan through the green malt.

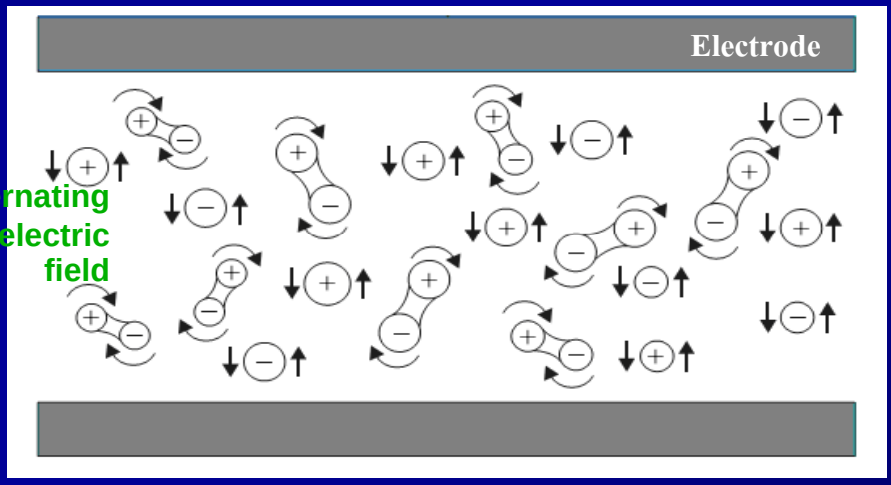
- There are 5 heating steps. Each step is connected to a timer.
- So the temperature is increased automatically after a defined time and temperature level has finished.

Kilning unit

- After that the cooling process had manually done.
- Similar to the steeping and germination unit this unit has some flaps that allow varieties of circulating air during the kilning process. The elimination of the rootlets is done manual after the kilning.

Principle of Radio Frequency Drying Process:

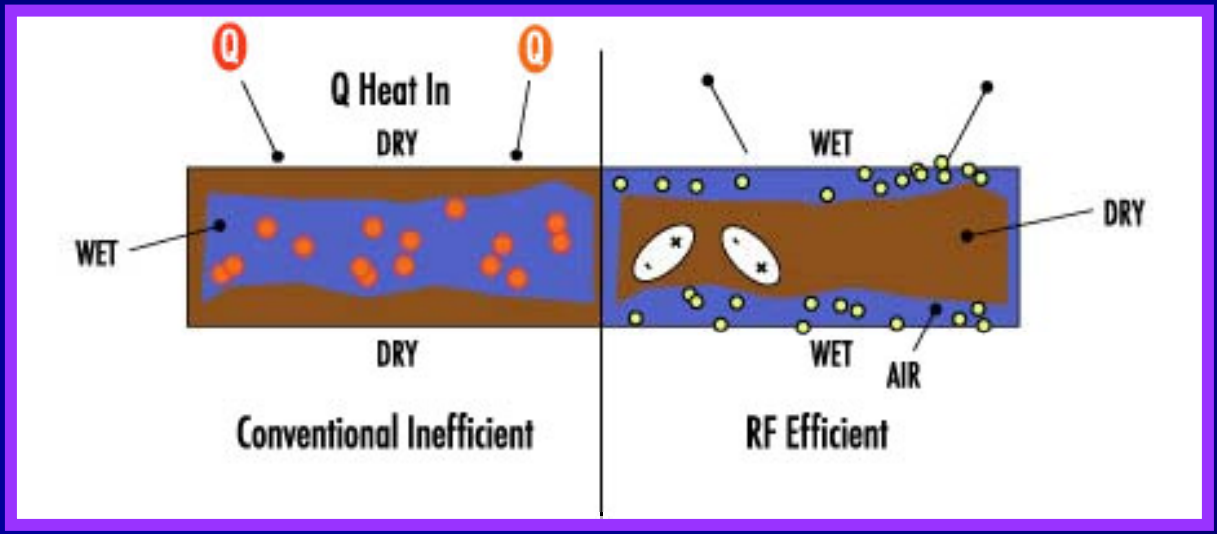
- In radio frequency drying system alternating electric field between two electrodes is created by RF generator.



(Piyasena *et al.*, 2003)

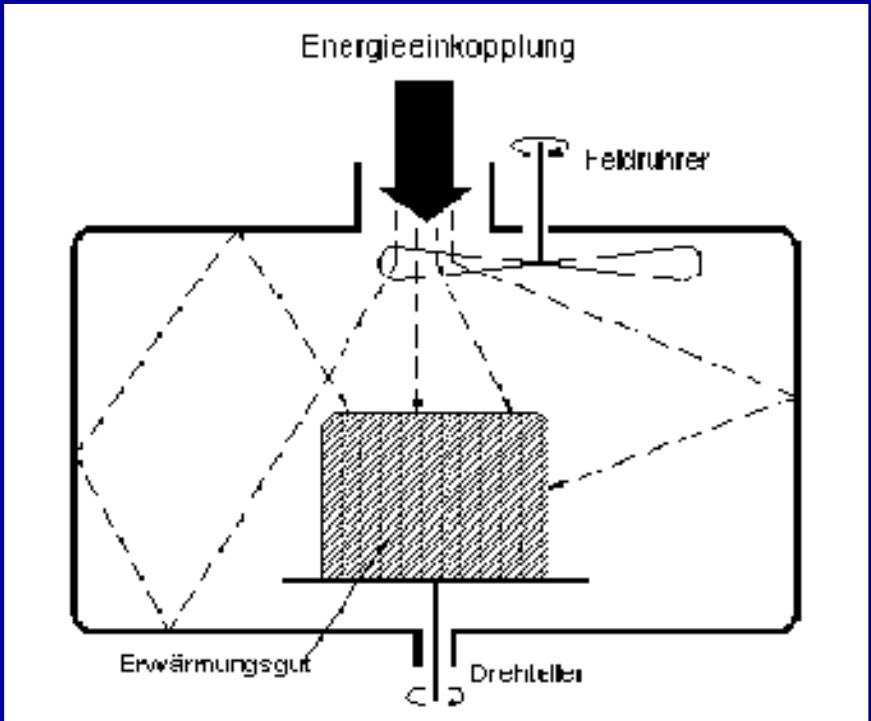
- The material to be dried is put acrossed between the electrodes, where the alternating energy causes polar molecules in the water to continuously re-orient them to face opposite poles - much the same way magnets move in an alternating magnetic field.

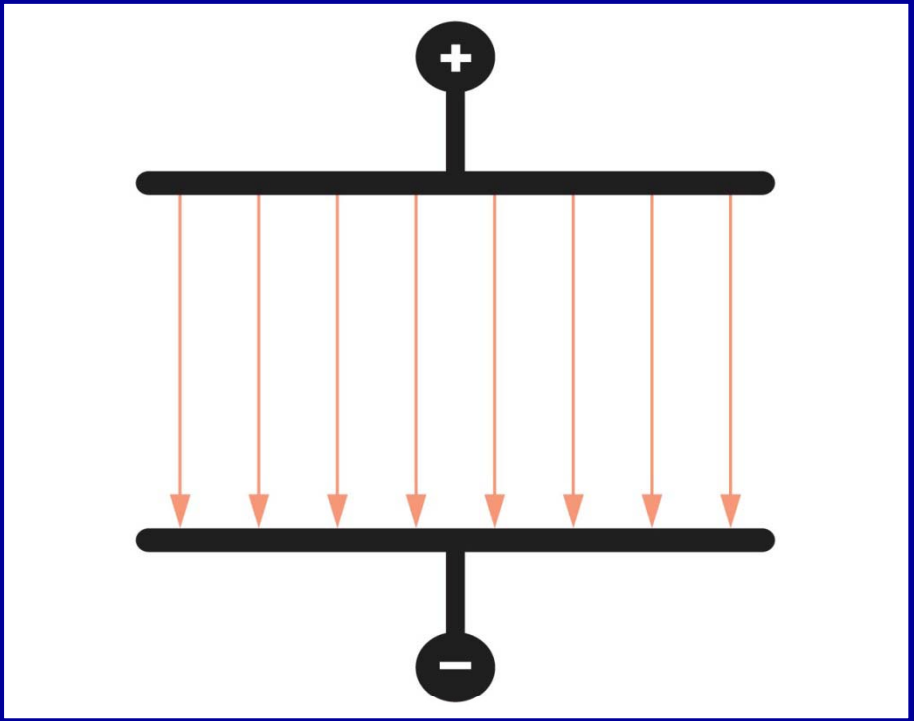
This movement causes the friction and due to this water in the material to rapidly evaporate throughout the material.



www.pscrfheat.com

Electric Field Distribution





➔ MW-Application

➔ RF-Application

(Lücke, 2007)

Why Radio Frequency Drying?

- Water is more receptive than any other dielectric material.
- So in process of RF drying RF power will be absorbed in higher amount from wetter areas which resulting uniform moisture distribution.
- In conventional drying process, it was shown uneven shrinking corn guite often many times, uneven shrinking consequences into surface cracking.
- In RF drying due to uniform moisture distribution Surface Cracking is reduced.

Why Radio Frequency Drying?

- In RF drying Radio Frequency is direct form of applying heat so in this process No Wastage of Heat.
- Radio Frequency Dryer required one fifth or one eighth space required over conventional dryer.
- RF drying is 2 to 20 times faster than conventional drying methods.
- Here heating begins directly to the product so the Dwell Time is far less than in a conventional dryer.
- This process is Eco Friendly process.
- Maintenance cost is low as compare to other drying process.

The Benefits of RF Drying

- Precise Control of Moisture Content and Uniformity.
- Reduction of Surface Cracking
- Energy Savings
- Savings in Plant Space

Experiment

Malting barley (*Hordeum Vulgare* L), type "BAUDIN" from west Australia (Perth region) harvest 2008/2009, is malted in the micro malting of Chiangmai Beverage Co. Ld. th.

- One part of the green malt is dehydrated 100 % conventional (45 % MC ⟶ 4 % MC)
- the other part is conventional dehydrated to a moisture content about 25 %, 15 %, 12 %, 10 %, 8 % and reduced to 4-5 % with RF-technology.
- The frequency of the RF-system is 27.12 MHz.

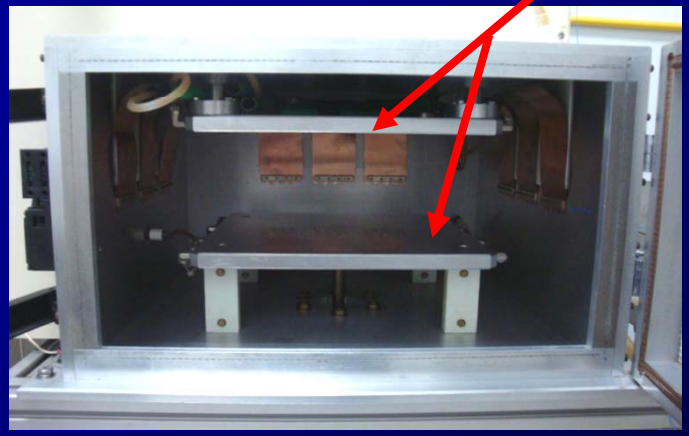
Radio frequency (RF)

Applicator

Fiber optic sensor

RF-Generator

Electrode Plate



Computer controlling

1. **Focus** : Optimum of combination of RF-technology and conventional method in the kilning process

2. **Focus** : Comparison of time and costs of each combination

Time and costs are calculated for each combination. Formula to calculate the energy charge (Thai ABC, 2008):

Energy charge = energy charge rate (bath/KWh) x energy (KWh)

3. **Focus** : Direct comparison of conventional dehydration method to the optimized combination of RF and conventional method

Place of experiment

- Chiangmai Beverage Co., Ltd. 33/1 Moo 5, Chiangmai-Lampang Highway, T. Yangneung, A. Sarapee, Chiang Mai
- Postharveat Laboratory, Postharveat Technology Institute, Chiangmai University
- Seed laboratory, Department of Agronomy, Faculty of Agriculture, Chiangmai University

Malt Analysis Production Nr. : **Micromalt**

Kind of barley : GAIRDNER 2007/2008 Australia

		Micromalt 1 Conventionel	Micromalt 2 RF
Moisture	**%**	4.3	6.6
Extract water free in fine grind	**%**	82.0	82.0
Extract water free in coarse grind	**%**	81.8	81.2
Fine / Coarse grind Difference	**%**	0.2	0.8
Smell		normal	normal
Taste		normal	normal
Drain from fine grind		slow	slow
Drain from coarse grind		slow	slow
Look wort		clear	clear
Saccharify	**min.**	10-15	10-15
Colour EBC		3.2	2.9

		Micromalt 1 Conventionel	Micromalt 2 RF
Protein content	**%**	9.94	9.9
Soluble nitrogen	**mg/100g dry substant**	767	795
Kolbach index	**%**	48.3	50.2
pH		6.08	6.13
hl-Weight	**kg**	54.7	57.60
1,000-grain-weight	**g**	35.0	35.5
Friabilimeter value	**tenderness %**	91.1	88.1
	½ glassy %	8.6	11.5
	1/1 glassy %	0.3	0.4
Kernel over 2.5 mm screening	**%**	95.6	96.4

Malt Analysis Production Nr. : **Micromalting Test,** Chiangmai University

Kind of barley : BAUDIN harvest 2007/2008

		Conventionell Drying	Combine Drying with RF
Moisture	**%**	4.5	5.8
Extract water free in fine grind	**%**	82.2	81.8
Extract water free in coarse grind	**%**	81.8	81.3
Fine / Coarse grind Difference	**%**	0.4	0.5
Smell		Nornal	Normal
Taste		Normal	Normal
Drain from fine grind		Slow	Slow
Drain from coarse grind		Slow	Slow
Look wort		Clear	Clear
Saccharify	**min.**	10-15	10-15
Colour EBC		4.0	4.0

		Conventionell Drying	Combine Drying with RF
Protein cintent	**%**	10.2	10.2
Soluble nitrogen	**mg/100g dry substant**	735	809
Kolbach index	**%**	45.1	49.8
pH		6.0	6.0
hl-Weight	**kg**	54.45	57.60
1,000-grain-weight	**g**	34.9	35.5
Friabilimeter value	**tenderness %**	87.6	88.1
	½ glassy %	11.3	11.5
	1/1 glassy %	1.1	0.4
Kernel over 2.5 mm screening	**%**	97.3	96.4

Malt Analysis Production Nr. : **Micromalting Test, Chiangmai University**

Kind of barley : GAIRDNER 2007/2008

		Conventionell Drying	Combine Drying with RF
Moisture	**%**	4.3	(5.4) 6.4 (6.2)
Extract water free in fine grind	**%**	79.0	78.7
Extract water free in coarse grind	**%**	77.5	77.5
Fine / Coarse grind Difference	**%**	1.5	1.2
Smell		Normal	Normal
Taste		Normal	Normal
Drain from fine grind		Slow	Slow
Drain from coarse grind		Slow	Slow
Look wort		Turbid	Turbid
Saccharify	**min.**	10-15	10-15
Colour EBC		2.7	2.6

		Conventionell Drying	Combine Drying with RF
Protein cintent	**%**	11.63	11.69
Soluble nitrogen	**mg/100g dry substant**	623.4	663.9
Kolbach index	**%**	33.5	35.5
pH		5.94	5.94
hl-Weight	**kg**	56.15	51.50
1,000-grain-weight	**g**	35.7	36.9
Friabilimeter value	**tenderness %**	79.3	77.4 (78.3)
	½ glassy %	18.0	18.9 (18.3
	1/1 glassy %	2.7	3.7 (3.4)
Kernel over 2.5 mm screening	**%**	94.6	94.2

Malt Analysis Production Nr. : **Micromalting Test, Chiangmai University**

Kind of barley : BAUDIN harvest 2008/2009

		Conventionell Drying	Combine Drying with RF
Moisture	**%**	4.1	5.6 (5.2)
Extract water free in fine grind	**%**	81.0	80.6
Extract water free in coarse grind	**%**	80.7	80.3
Fine / Coarse grind Difference	**%**	0.3	0.3
Smell		Normal	Normal
Taste		Normal	Normal
Drain from fine grind		Slow	Slow
Drain from coarse grind		Slow	Slow
Look wort		Clear	Clear
Saccharify	**min.**	10-15	10-15
Colour EBC		3.6	3.9

		Conventionell Drying	Combine Drying with RF
Protein cintent	**%**	10.0	10.1
Soluble nitrogen	**mg/100g dry substant**	847.4	861.2
Kolbach index	**%**	53.0	53.5
pH		5.78	5.74
hl-Weight	**kg**	46.90	46.05
1,000-grain-weight	**g**	33.6	34.2
Friabilimeter value	**tenderness %**	92.5	91.3
	½ glassy %	6.8	7.9
	1/1 glassy %	0.7	0.8
Kernel over 2.5 mm screening	**%**	97.8	98.4

THANK YOU

FOR

YOUR ATTENTION