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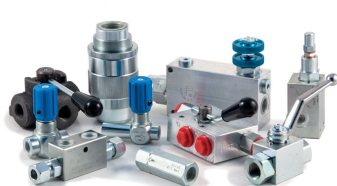
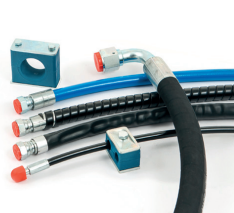
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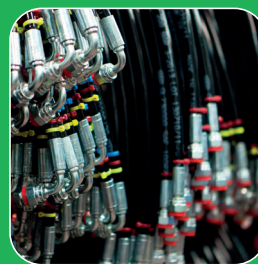
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# EVALUATION OF THE MAINTENANCE PRACTICES IN MECHANIZED AGRICULTURE – SADC REGION

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**Abstract:** The Southern Africa Development Community countries have embarked on mechanizing their agriculture. It is envisaged on the factual basis that it leads to increased labour productivity, reduction in drudgery, creation of employment in Agriculture and other support sectors and increase in farm income. Given that the SADC Governments' rural development focus is based on Agriculture at both small and medium scale level, this research was undertaken to uncover research based information that will inform policy during the resurrection of the agricultural mechanization endeavours. This study assessed the maintenance practices in Namibian, South African and Zambian mechanized agriculture and used the Czech mechanized agriculture maintenance practices as a benchmark. Tribotechnical Analysis was used to monitor component structural changes based on the fact that wear deteriorates mating functional surfaces of machine elements leading to poor component functional that negatively impact on the environment and the non-cost effectiveness of mechanization in SADC primary agriculture. A fleet of Massey Fergusson and Zetor tractors were sampled at 100-ltr-diesel consumption interval. Oil total contaminants and Cleveland open cup flash point method was used to evaluate the condition of the lubricant while Direct Reading Ferrograph assessed the ratio share of Small wear particles (Ds), Large wear particles (DL) and the Total Wear Particle Concentration (WPC). Extreme value showing samples from the Direct Reading Ferrograph were further investigated using the Ferrograph Analyzer. Data were analyzed to generate a baseline based nomogram that is being used as a maintenance support tool. Upon recommendation of this study, Ferrography has been introduced as a cost effective proactive maintenance tool at the Tractor maintenance center in Zambia.

**Keywords:** AGRICULTURAL PRODUCTIVITY, MAINTENANCE SUPPORT TOOL, MECHANIZATION, TRIBOTECHNICAL ANALYSIS

## 1. Introduction

Machinery maintenance, as a support function, has played an important role in mechanized agriculture. The importance of the diesel engine in Mechanized agriculture is indisputable. Condition based maintenance (CBM) technology has gained preference over time based maintenance technology, today. The Success of CBM hinges on the ability to develop accurate diagnosis/prognosis models for diesel engines [10].

Mechanized agriculture has helped, in the last 50 years, few economies to overcome the challenges of development and become truly competitive. In those few cases, there are concrete indications that industrial development, including agro-industrial development, has played a key role. Agricultural mechanization is part of agro-industrial development, and it has either stagnated or retrogressed in many countries of sub-Saharan Africa (SSA). This has occurred despite strong support for mechanization from African political leaders and heavy investments in both animal traction projects and mechanically powered mechanization, such as in tractors, pumps and post-harvest processing equipment [1]. Mechanization does not mean simply the introduction of tractors (tractorization), it includes the improvement of all tools and equipment used in agriculture from clearing and cultivating the land to planting, harvesting and also transport, storage and processing [9].

In the 1970s and 1980s, believing that they could make a positive contribution to agricultural development in Africa, international aid agencies provided literally thousands of tractors and implements to a number of countries under tied-aid government 'ploughing fleet' programmes [2]. These programmes failed to provide sustainable mechanization services; all that was left was broken-down, neglected machinery. There seem to have been no maintenance technology in place to sustain these programmes. [6].

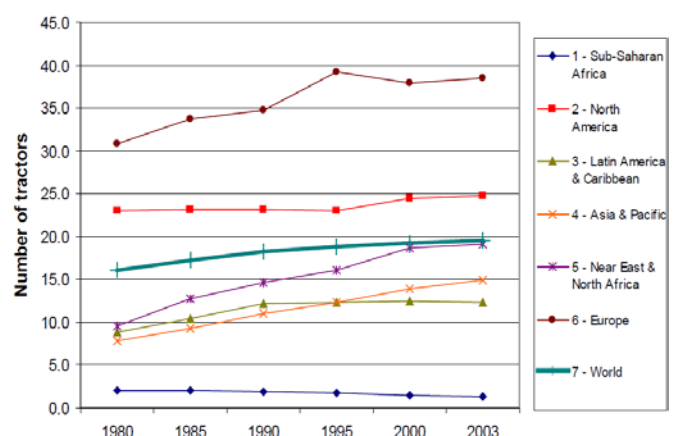
It is evident that tractor use in Africa is on the decline (Fig.1); giving rise to the general picture which shows that yields of maize and other staple cereals typically remain at about 1 tonne per hectare (1 000 kg/ ha), which is about one-third of the average achieved in Asia and Latin America (Table 1).

**Table 1.** Comparison of Africa with other developing world

| Region                          | Cereal yield kg/ha | Fertilizer use kg/ha | Irrigation% irrigation of arable land | Tractors per 1 000 ha |
|---------------------------------|--------------------|----------------------|---------------------------------------|-----------------------|
| Africa                          | 1 040              | 13                   | 5                                     | 28                    |
| Average of 9 selected countries | 3 348              | 208                  | 38                                    | 241                   |

Adapted from: FAO and UNIDO 2008. Time for action. [1]

**Fig. 1** Tractor use per 1000 ha arable land. [12]



The motivation for this study was to contribute towards improving machinery availability for mechanized agriculture. The resulting objective was to arrest the ever increasing mechanization cost for agricultural mechanization. As shown in Figure1, despite past and current investment into mechanizing agriculture in the SADC region, this sub-Saharan region has not performed very well in terms of installed tractor-kW per hectare arable land.

## 2. Materials and methods

The approach method was to measure wear of wetted friction components of the engine and analyze wear impact on the overall condition of the engine. Using tribotechnical methods, lubricant's physical properties were investigated in order to establish the lubricant capability. Ferrographic examination was used to determine the condition of the lubricated components of the engine [5,13]. Two types of ferrographs were used namely the Direct Reading (DR) Ferrograph and the Analytical Ferrograph. [3],[4],[8],[11].

Oil was sampled from engines 20 minutes after engine shut down. Water by Crackle % method (at 165°C) was used to investigate presence of water in the engine oil. Percent contaminants (%CN) were determined using a TCM-U apparatus. It works on the principle of light permeability that determines the amount of insoluble in technical benzene. Fuel dilution in the engine was investigated using the Cleveland Open Cup method [10].

Wear debris investigation was carried out using a PMA-90 DR Ferrograph. The  $D_L$  and  $D_S$  readings from the DR were used to derive the values of Wear Particle Concentration (WPC) and the ratio  $D_L/D_S$ , a function of the wear predominance, was translated into Percent of Large Particles (PLP). The analytical ferrograph tests were conducted on the MA-1 Ferrograph Analyzer. The processed ferrogram were examined under a special bichromatic microscope and photographed using a 35 mm camera mounted on the microscope [4],[7].

The collected data were subjected to discriminant score analysis and the resulting alarm limits were used to design baselines for condition monitoring based maintenance.

## 3. Results and Discussion

Two representative engines, one from Lany tractor population and one from Mkushi tractor population were trended - results for %CN, WPC and PLP against accumulated fuel use in litres. The discriminant analysis produced the alarm values for %CN and WPC (Table 3). The limits were used to construct the baseline for CBM based maintenance. Samples from Lany were in the Green "GO ZONE" of the baseline (Fig. 2); but the Mkushi samples were found to be in the Red "STOP ZONE" of the baseline (Fig. 3) and (Table 2).

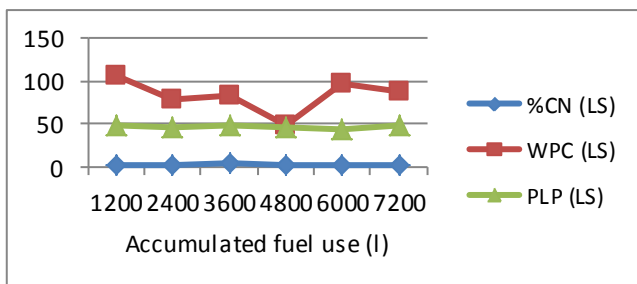


Fig. 2 Trending a Lany Sampled Tractor - Z7711

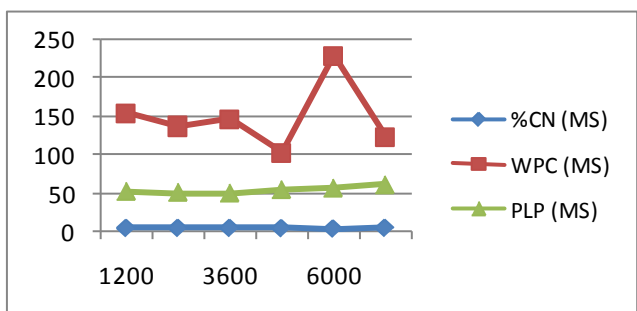


Fig.3 Trending a Mkushi Sampled Tractor - Z7711

The practice of calendar based maintenance that was being practiced by farmers in Mkushi for oil change intervals, proved to be costly for farmers; higher values for %CN (Fig. 4) and alarming values for WPC (Fig.5) and analytical ferrograph examinations uncovered severe wear regimes of wetted parts (Fig. 12).

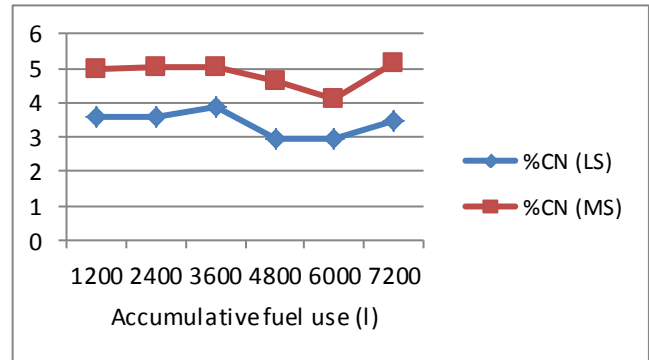


Fig 4. Comparison of Oil Condition (%CN Mkushi against %CN Lany)

Mkushi farmers argued that they had been advised to drain oil based on engine hours but were unable to account for engine hours.

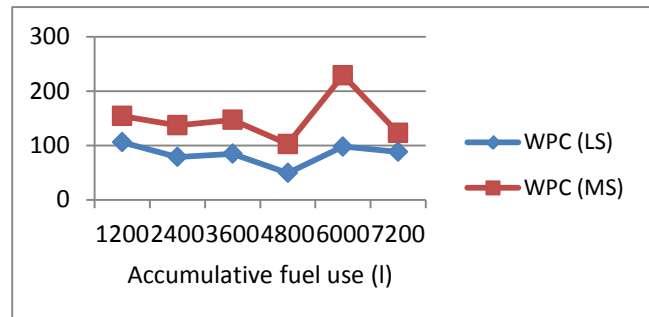


Fig 5. Comparison of the WPC trending (WPC Mkushi against WPC Lany)

It is evident that the samples from the Lany population fare well within the baseline whereas the Mkushi sample fares poorly; and this mirrors the poor maintenance practices obtaining on the ground.

Table 2. Oil analysis results on Samples from Mkushi-Zambia

| Mach       | Z 7711 | Z 7711 | Z 7711 | Z 7711 | Z 7711 |
|------------|--------|--------|--------|--------|--------|
|            | MK001  | MK002  | MK003  | MK004  | MK005  |
| $n_s$      | 1200   | 1200   | 1200   | 1200   | 1200   |
| $n_{act}$  | 1400   | 1360   | 1700   | 1348   | 1900   |
| $k_{nm}$   | 0.85   | 0.95   | 0.75   | 0.9    | 0.63   |
| $H_2O$ (%) | 2      | 0.5    | 1.5    | 1.5    | 2      |
| FP         | 196    | 210    | 200    | 206    | 192    |
| %CN        | 4.95   | 4.88   | 4.96   | 4.95   | 4.82   |
| WPC        | 191    | 172    | 167    | 154    | 196    |
| PLP        | 49     | 50     | 51.3   | 52.3   | 49.4   |

Table 3. Base line limits analyses –against samples from Lany-Czech Republic.

| Mach                 | Z 7711   | Z 7711 | Z 7711 | Z 7711 | Z 7711 |
|----------------------|----------|--------|--------|--------|--------|
|                      | L001     | L002   | L003   | L004   | L005   |
| $n_s$                | 1200     | 1200   | 1200   | 1200   | 1200   |
| $n_{act}$            | 1205     | 1130   | 1200   | 1325   | 1200   |
| $k_{nm}$             | 0.99     | 1.06   | 1      | 0.9    | 1      |
| H <sub>2</sub> O (%) | 0        | 0      | 0      | 0      | 0      |
| FP                   | 218      | 218    | 224    | 220    | 218    |
| %CN                  | 3.41     | 4.82   | 1.73   | 3.09   | 3.58   |
| WPC                  | 95.9     | 127.1  | 84.1   | 98     | 106    |
| PLP                  | 49.2     | 51.6   | 44.3   | 46.2   | 51.23  |
|                      |          |        |        |        |        |
| Rated Power          |          | 50kW   |        |        |        |
| ALARM LIMITS         |          |        |        |        |        |
| %CN                  | critical |        |        | 2.75   |        |
|                      | Normal   |        |        | 1.93   |        |
| WPC                  | critical |        |        | 174.99 |        |
|                      | Average  |        |        | 112.4  |        |
|                      | Good     |        |        | 56.0   |        |

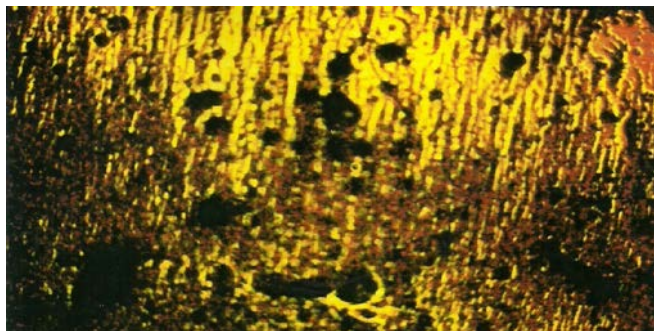


**Fig 6. Ferrogram CL001.**

This is indicative of mixed wear regime (Fig. 6) – small metallic particles and fatigue chunk in the top right corner of the slide. The bottom part of this slide is occupied by particles that originate from bearing material. This is an indication of a severe wear mode.

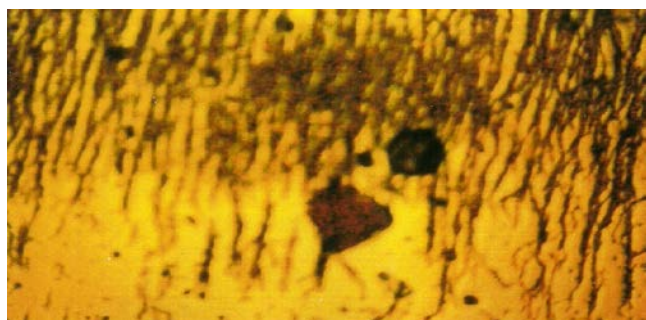


**Fig 7. Ferrogram CL002**

The ferrogram (Fig. 7) indicates the normal condition of the engine oil-wetted parts.

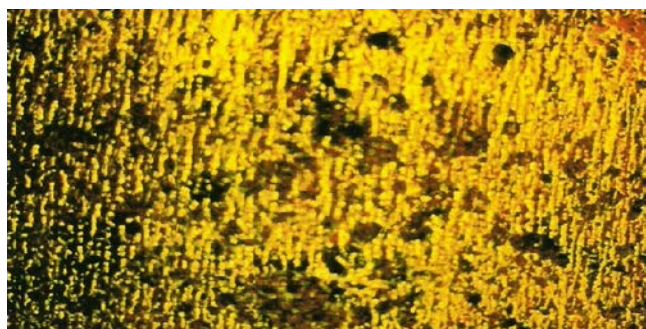


**Fig 8. Ferrogram CL003**

This is a high magnification of the S position (Fig. 8). The L particles are absent. The center shows lubricant degradation (transparent tribopolymers). The wear level is normal.

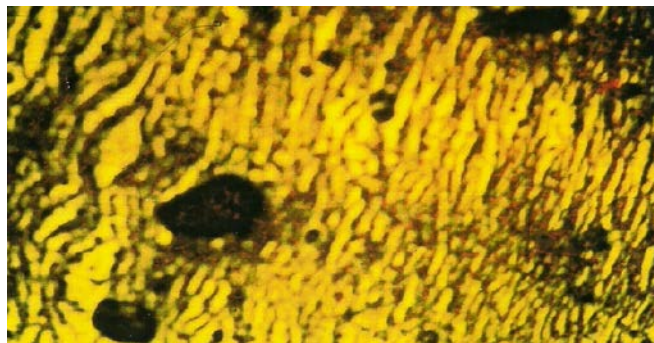


**Fig 9. Ferrogram ZMk 101**

Two big pebble like large particles present (Fig. 9). Top right shows red (pure) metallic particles. Dark metallic oxides (DMO) that are present indicate severe operating conditions (high temperature, pressure, inadequate cooling).

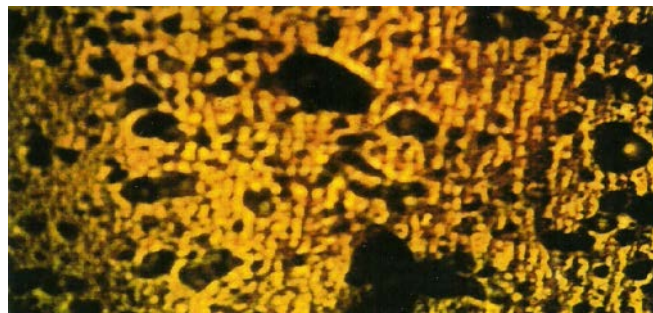


**Fig 10. Ferrogram ZMk 102**

The ferrogram shows a high density of wear particles ranging from 5µm to several tens of microns in size (Fig. 10); including spherical particles. This manifests severe component wear.

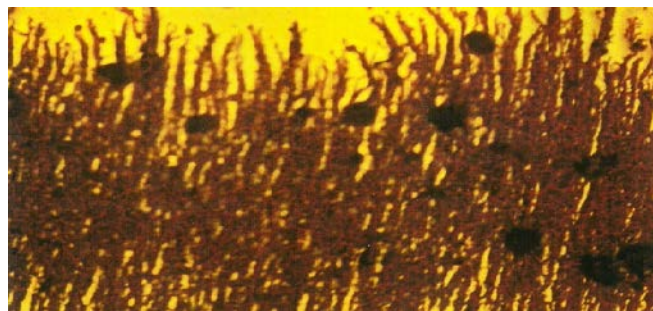


**Fig 11. Ferrogram ZMk 103**

Inadequate lubrication gives its signature through DMO- high concentration of the  $Fe_3O_4$  particles (Fig. 11). The hematite particles that are indicative of corrosion wear are also present. Engine overhaul was recommended.

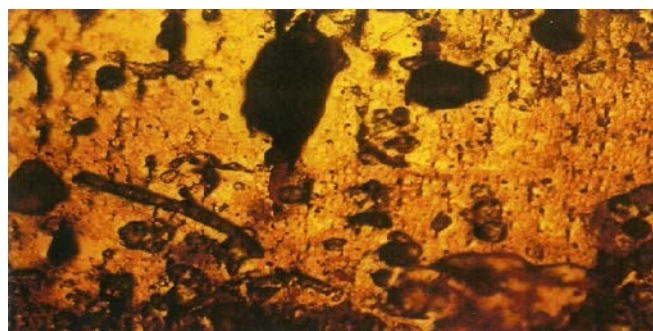


**Fig 12. Ferrogram ZMk 104**

A STOP and repair instruction was issued to this engine, but was not acted upon. This engine ceased. Pebble like chunks (Fig. 12), deposit of oil additives and fiber material most likely from the oil filter. The DMO particles show lines of material flow enclosed in them- finger print for operating the engine under high pressure, high temperature and lubricant starvation.

#### 4. Conclusion

The findings have underlined the important role of Ferrograph methods in CBM. DR Ferrograph and Analytical ferrography and the subsequent ferrogram evaluations provide a method for early diagnosis, progressive assessment of maintenance requirements and prognosis concerning the future trend of engine condition.

The baselines produced from this study have been made available to the custodian centers where samples were collected and study observations were done; namely Czech University of Agriculture Farm at Lany, Technical Services Branch at the Ministry of Agriculture (Zambia), Etunda Irrigation Scheme (Ogongo- Namibia) and the Limpopo Department of Agriculture (South Africa). These baselines should inform the design of the maintenance programme that should include skills impartment,

diagnostic tools and logistics formulation that should enable access to remote areas where the machinery that are given to farmers in governmental and donor developmental projects.

The researchers believe that this should help uplift the standards of diesel engine maintenance in the SADC region that as seen from this study are below required standards.

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# Bewertung der Struktur und der Mischgenauigkeit in Totalen Mischrationen unter Beachtung weiterer Kennzahlen des Fütterungscontrollings

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## Struktur und Mischgenauigkeit

### Einleitung

Das Fütterungscontrolling kann zur Sicherung einer ausreichenden Versorgung mit strukturwirksamer Rohfaser eine Reihe von Maßnahmen aufzeigen (Abbildung 1). Die Abschätzung der Rohfaseraufnahme der Kühe sollte dabei nicht nur auf den Werten der Futtermittelanalyse erfolgen, sondern auch an der TMR und den Tieren überprüft werden. Dazu sind zum Beispiel Kenntnisse des Gehaltes an Rohfaser, der NDF sowie der Partikellänge erforderlich.

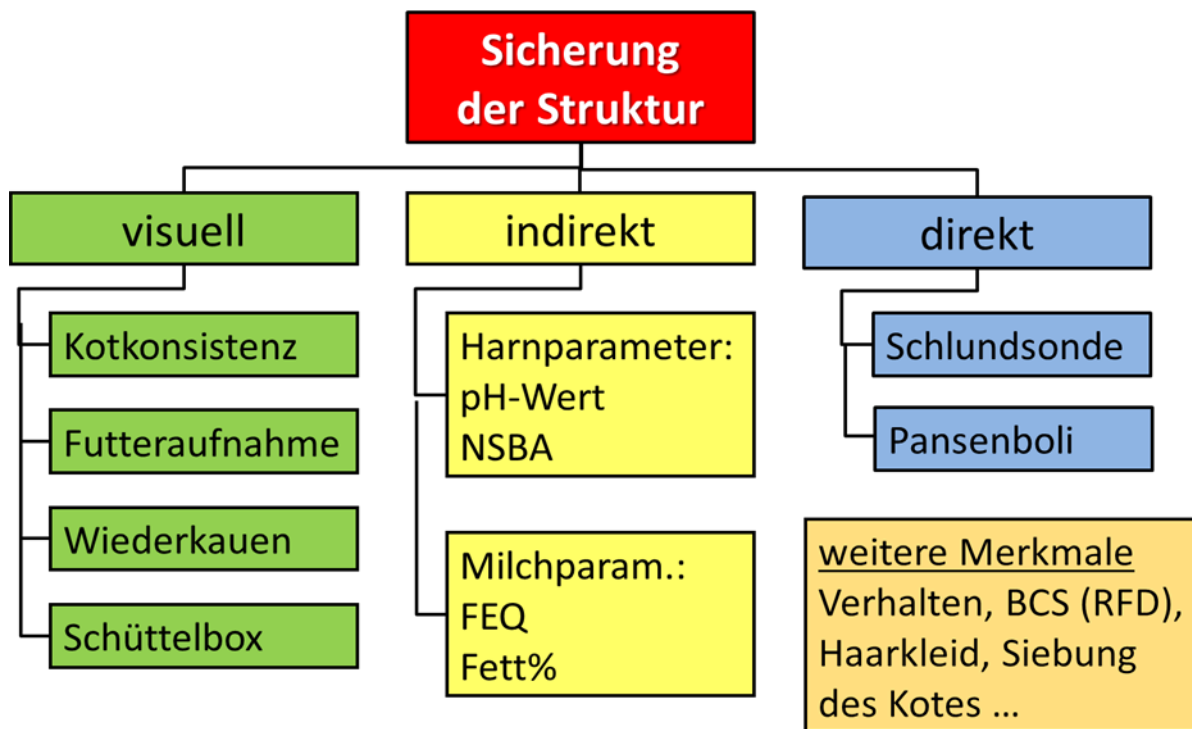


Abbildung 1: Ausgewählte Kennzahlen zur Sicherung der Struktur bei Kühen

Veränderungen in der Struktur der Futterrationen gegenüber den Einzelfuttermitteln können sehr häufig durch den Einsatz verschiedener Mischtechniken hervorgerufen werden. Dies trifft vor allem auf die Grobfuttermittel in der Totalen Mischration zu. Untersuchungen von STEINHÖFEL (2010) belegen den Effekt der Zerkleinerung der Futterpartikel durch den Einsatz verschiedener Fräsen an selbstfahrenden Futtermischwagen oder durch die Mischeinrichtungen selbst.

## Material und Methode

Um den Effekt der Futterentnahmen mittels Fräse oder per Hand auf die Strukturveränderungen der Grobfuttermittel zu analysieren, wurde im ZZT Iden der LLFG Sachsen-Anhalt ein Vergleich beider Varianten an den Rationen der Trockensteher und der Hochleistungsgruppe durchgeführt. Zeitgleich wurde die Mischgenauigkeit der Rationen (Futtermischwagen und Hand) miteinander verglichen. Dazu wurden die exakten Futtermengen des Futtermischwagens über einen Zeitraum von 2 Tagen erfasst und die entsprechenden Rationen per Hand auf 100 kg nachgebildet (Abbildung 2).



Abbildung 2: Futterentnahme und Mischung der Handration

Alle Futtermittel wurden auf ihren Energie- und Nährstoffgehalt überprüft. Beim Ausdosieren des Futters wurden 7 Einzelproben gezogen und anschließend eine Sammelprobe gebildet, sodass insgesamt 8 Futterproben analysiert wurden. Bei der Hand-Ration erfolgt die Entnahme von 3 Einzelproben und daraus resultierend 1 Mischprobe. Die Bestimmung der Partikellänge erfolgte durch den Einsatz einer 3- und 4-siebigen Futterschüttelbox sowie das Ausmessen der Partikel aus dem Obersieb (> 19 mm).

## Ergebnisse

Bei der Ration der Hochleistungsgruppe konnte ein signifikanter Unterschied in den prozentualen Anteilen zwischen der Futtermischwagen- und der Hand-Ration in der Auffangschale von 6 % beobachtet werden. Auf dem ersten Sieb waren die Unterschiede mit 12 % bei der gefrästen TMR und 14 % bei der Handmischung marginal (Tabelle 1).

Tabelle 1: Prozentuale Verteilung der Hochleistungs-TMR auf den einzelnen Sieben

|               | Gefräste TMR      | Handmischung      |
|---------------|-------------------|-------------------|
| 1. Sieb       | 12 %              | 14 %              |
| 2. Sieb       | 33 %              | 37 %              |
| Auffangschale | 54 <sup>a</sup> % | 48 <sup>b</sup> % |

Die Auszählung der Bestandteile auf dem Obersieb (1. Sieb) zeigte eine um 33 mm signifikant längere Partikellänge in der Hand-Ration gegenüber der gefrästen TMR (Tabelle 2). So konnte auf dem 1. Sieb (Obersieb) bei der TMR des Futtermischwagens eine mittlere Länge von 27 mm ermittelt werden. Die Hand-Ration wies dagegen eine mittlere Länge von 60 mm auf.

Tabelle 2: Gemessene Partikellänge auf dem Obersieb (> 19 mm)

|                  | Mittelwert         | Min - Max | Anteil > 19 mm |
|------------------|--------------------|-----------|----------------|
| Futtermischwagen | 27 <sup>a</sup> mm | 10-175 mm | 71 %           |
| Hand-Ration      | 60 <sup>b</sup> mm | 15-340 mm | 100 %          |

Es konnte beobachtet werden, dass 100 % der Partikel der Hand-Ration über 19 mm lang waren (Tabelle 2), während die bei der Ration des Futtermischwagens nur bei 71 % der Partikel zutreffend war. Damit erreicht die Ration des Futtermischwagens das untere Niveau der Länge der Partikel über 19 mm zur Sicherung einer wiederkäuergerechten Fütterung (Tabelle 3).

Tabelle 3: Gemessene und tatsächliche Verteilung auf dem 1. Sieb der Hochleistungs-TMR der Kühe

|                      | Gefräste TMR | Handmischung |
|----------------------|--------------|--------------|
| gemessene Anteile    | 12 %         | 14 %         |
| tatsächliche Anteile | 8 %          | 14 %         |

Die Verminderung der Futterstruktur kann beispielhaft am Futterroggen dargestellt werden (Tabelle 4). Durch die Entnahmen mittels Fräse am Futtermischwagen konnte eine signifikante Verminderung auf dem ersten Sieb um 15 % gegenüber der Hand-Mischung ermittelt werden. Dadurch steigt der Anteil auf dem 2. Sieb und der Auffangschale signifikant an (Tabelle 4). Dieser Zusammenhang kann bei den meisten anderen Grobfuttermitteln ebenfalls beobachtet werden.

Tabelle 4: Veränderung der Anteile auf den Sieben entsprechend der Methode

|               | Gefräste TMR      | Handmischung      |
|---------------|-------------------|-------------------|
| 1. Sieb       | 63 <sup>a</sup> % | 78 <sup>b</sup> % |
| 2. Sieb       | 27 <sup>a</sup> % | 18 <sup>b</sup> % |
| Auffangschale | 10 <sup>a</sup> % | 4 <sup>b</sup> %  |

Die Genauigkeit der Futtermischung wurde über den Gehalt an Mengenelementen überprüft. Hier zeigte sich, dass sowohl die Einzelproben des Futtermischwagens als auch der Handmischung nur sehr gering von den Mischproben sowie der Mischprobe abweichen. Es konnte aber beobachtet werden, dass die analysierten Energiegehalte der Hochleistungs-TMR zwischen den einzelnen Proben und der Berechnung der Ration abweichen (Tabelle 5). Die TMR ohne Fett weist im Mittel eine um 0,6 MJ NEL je kg TM höheren Energiegehalt auf als die Einzel- und Mischproben, wobei der Zusatz von Fett die Differenz zwischen den Proben und der Berechnung auf 0,4 MJ NEL je kg TM vermindern kann. Ursache könnte die Formel zur Schätzung der Energiegehalte der TMR sein.

Tabelle 5: Energiegehalte der Handmischung der Hochleistungs-TMR mit und ohne Zusatz von Futterfett

|           | Einzelproben | Mischprobe  | Berechnung  |
|-----------|--------------|-------------|-------------|
| ohne Fett | 6,42 MJ NEL  | 6,40 MJ NEL | 6,98 MJ NEL |
| mit Fett  | 6,76 MJ NEL  | 6,80 MJ NEL | 7,16 MJ NEL |

Bei den Rationen der Trockensteher konnte eine mittlere Abweichung zwischen den Einzelproben und der berechneten Ration von bis zu 0,9 MJ NEL je kg TM ermittelt werden. Hier sind weitere Untersuchungen angedacht.

### Schlussfolgerung

Aus den vorliegenden Untersuchungen lassen sich für das praktische Fütterungscontrolling folgende Schlussfolgerungen ableiten:

1. Beurteilung von Futtermitteln und Futterrationen mit Hilfe der Futterschüttelbox sind für die praktische Bewertung der physikalischen Struktur gut geeignet.
2. Futterrationen mit Partikellängen (> 19 mm) in einem Grenzbereich sind einer genaueren Betrachtung zu unterziehen. Das Anhaften von Partikeln in der Original-TMR kann durch die Trocknung der TMR (lufttrocken) vermindert werden.
3. Zwischen den berechneten Rationen und den mittels Voll-Analyse ermittelten Energiegehalten konnten Unterschiede bis zu 0,9 MJ NJEL je kg TM ermittelt werden. Für die Abschätzung der Energiegehalte in einer TMR mittels einer chemischen Analyse muss der Rationstyp beachtet werden.

### Anhang

In den Tabellen 6 bis 9 sind die Effekte der Fräse am selbstfahrenden Futtermischwagen gegenüber der Entnahmen der Futtermittel per Hand aus den Silos auf die Struktur der Grobfuttermittel dargestellt.

Tabelle 6: Verteilung in den Siebfraktionen bei Futterroggen für beide Varianten mittels der 3siebigen Schüttelbox (n=38 Schüttelungen)

|            | gefräste TMR         | Handmischung         |
|------------|----------------------|----------------------|
| Sieb 1 (%) | 24 <sup>a</sup> ± 15 | 47 <sup>b</sup> ± 14 |
| Sieb 2 (%) | 54 <sup>a</sup> ± 8  | 41 <sup>b</sup> ± 12 |
| Sieb 3 (%) | 22 <sup>a</sup> ± 10 | 12 <sup>b</sup> ± 3  |

Tabelle 7: Verteilung in den Siebfraktionen bei Grassilage für beide Varianten mittels der 3siebigen Schüttelbox (n=16 Schüttelungen)

|            | gefräste TMR        | Handmischung        |
|------------|---------------------|---------------------|
| Sieb 1 (%) | 49 <sup>a</sup> ± 6 | 67 <sup>b</sup> ± 9 |
| Sieb 2 (%) | 29 <sup>a</sup> ± 5 | 20 <sup>b</sup> ± 7 |
| Sieb 3 (%) | 22 <sup>a</sup> ± 3 | 13 <sup>b</sup> ± 3 |

Tabelle 8: Verteilung in den Siebfraktionen bei Stroh für beide Rationen der 3siebigen Schüttelbox (n=5 Schüttelungen)

|            | gefräste TMR | Handmischung |
|------------|--------------|--------------|
| Sieb 1 (%) | 55 ± 1       | 65 ± 6       |
| Sieb 2 (%) | 34 ± 2       | 21 ± 5       |
| Sieb 3 (%) | 11 ± 2       | 12 ± 2       |

Tabelle 9: Verteilung in den Siebfraktionen bei Heu für beide Varianten mittels der 3siebigen Schüttelbox (n=4 Schüttelungen)

|            | gefräste TMR | Handmischung |
|------------|--------------|--------------|
| Sieb 1 (%) | 87 ± 1       | 94 ± 0       |
| Sieb 2 (%) | 8 ± 0        | 2 ± 0        |
| Sieb 3 (%) | 4 ± 2        | 3 ± 0        |

# HIGH VOLTAGE ELECTROSTATIC FIELD (HVEF) ON THE EFFECTS OF SEED GERMINATION

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**Abstract:** Seed is an important organ in order to maintain the sustainability of the plant species and varieties. Ability of seed germination is important and preferred to be tough. And increasing the percentage of germination as well as the effect of environmental conditions in different applications extend the endurance time the effect is concerned. One is a high voltage electrostatic field application. Successful results in terms of the extension of the duration and strength as well as the germination percentage were obtained with this application. It is also an alternative protection against malicious applications using substances of this embodiment may be also considered. Studies in this context have been found to be mostly positive results. What this study, the next step is to compile the work done on the effects of high voltage electrostatic field germination applications developed recommendations are made.

**Keywords:** STATIC ELECTRIC, FIELD, SEED, GERMINATION

## 1. Introduction

Seed directly limit the reach of efficiency in crop production, the productivity levels of all other inputs used in the production process is an extremely important agricultural inputs affecting indirectly. In agriculture, all the conditions for plant growth at the appropriate level, although sufficient to achieve product depends on the quality of seeds used. All other inputs used in aquaculture production plants helps to perform only the seed production capacity. Seed production capacity and other features are in effect limiting crop production. Fertilizers, drugs, and chemicals and other production factors such as hormones only helps to realize the capabilities of the seed.

To become an economic activity and the industry with being the first agricultural inputs used in the agricultural seed is fairly new. Seed quality testing in the world and work in seed technology field began in the middle of the last century. Of the crops produced in the world is produced by means of seed portion close to about 90% (Tulukcu, 2012).

## 2. Materials and Methods

The first stage in plant breeding and seed planting is grassed. To begin germination of the seed and the continuation of different plant species and varieties of the major environmental factor varies according to the specific requirements (water temperature, oxygen and light) to have the desired level is also important. Due to various factors arising from the seed of the internal and external structure after the October to avoid negative effects such as delay or germination germination and seedling emergence can be bold faced.

When the value of said physical quantity of pure seed Seed 1000 the amount of live and inert matter contained in the seed weight and they understood each other ratios. A good seed is the seed that is 97% pure. Another 1000-grain weight ratio physical purity of the seed value is also important. That the seeds of the coarse-grained and homogenous size helps in driving growth and equal time for all of them. At the same time the seedling root and

isozymes and root tip focuses on criteria such as cell division.

A study to investigate the effect of electric fields on the germination of barley seeds, protecting the viability of the seeds of its methods have been shown to have a positive impact.

The experimental data were found to be significantly increased with the electric field direction between the influence of the electric field is processed statistically. At the same time, there are significant differences in terms of viability and germination were determined. The energy content of the transmitted seed and seed of the electric field strength is indicated to be dependent on the electrical properties (Lynikiene, 2003).

fell to the same depth if necessary moisture and nutrients can take in equal proportions.

When called to understand the biological value of seeds seed germination rate and power. 100 seeds for the calculation of the seed germination rate and power on the 3-5 cm soil covering grass beds; Who counted 3-4 days after germination. This is performed as a number of sampling. Things that the average of the sample taken. This average germination rate in%, while the average of the counts made 7-8 days after germination gives the power.

Genetic characteristics as the following economical seed in the foreground.

- High efficiency
- Earliness
- Winter and drought resistance
- Disease and pest resistance

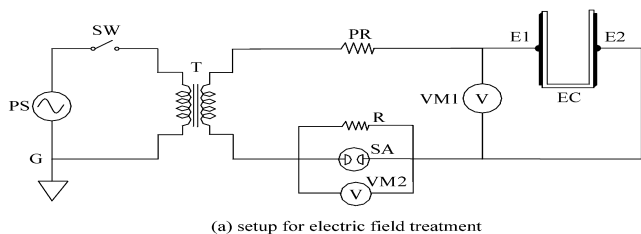
### 2.1.HVEF Applications

Recent research suggests that the effects on the biological phenomena of the natural electric field. High intensity of the electric field accelerating the development of various plants seems to be possible.

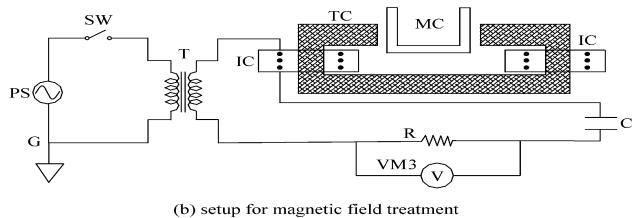
Many researchers in recent years to create high-quality production and improve unsatisfactory aspects of the kind of material they use HVEF both alone along with other physical and chemical factors. Live on the environment in which they live as natural as well as their magnetic fields are also under the influence of a magnetic field. The HVEF in studies conducted to date have been shown to have positive or negative effects on various plant characters.

High voltage electrostatic field (HVEF) is a type of man-made magnetic fields. This energy is absorbed by the plants, the seeds and plant growth has been demonstrated by several studies that make a positive contribution. For this purpose the protection of seed viability studies with HVEF old seed is made. This type of seed viability studies, physiological indexes, soluble proteins,

Alternating current (AC) electric and magnetic fields in a study on tomato seed germination of tomato seeds by applying were exposed AC AC electric field and magnetic field at different concentrations. Compared with the direction of the electric field seed germination rate of seeds subjected to the application so that the tomatoes grown in normal conditions of seed germination rate was found to be about 1.1-2.8 times more. The experimental apparatus is given in Figure 1 (Moon, 2000).



(a) setup for electric field treatment



(b) setup for magnetic field treatment

|         |                       |       |                       |
|---------|-----------------------|-------|-----------------------|
| SW      | : switch              | PS    | : AC 220V, 60 Hz      |
| T       | : HV transformer      | PR    | : protection resistor |
| VM1,2,3 | : voltmeter 1, 2, 3   | R     | : resistor            |
| EC      | : electric field cell | E1,E2 | : copper electrode    |
| SA      | : surge arrester      | G     | : ground              |
| C       | : capacitor           | TC    | : transformer core    |
| IC      | : induction coil      | MC    | : magnetic cell       |

**Fig.1** Experimental setup

Stable different magnetic field strengths in studies on the effects on seeds germination and precocity of the corn seeds were exposed to a magnetic field and the different time intervals at 125-250 m. The plants in the magnetic field was found to be superior to the control product (Florez, 2007).

An alternative could be the use of chemical pesticides in the direction of the effect electrical field of view are available. Plant seeds are indicated the efficacy of the various prevention of diseases transmitted from your application or in terms of electric field treatment.

2 to 16 kV / cm between voltage under varying between 1-30 seconds has been found to be more severe than those untreated by weight of bean seeds subjected to 50 Hz electric field. Seed processing unit 75 kV and 50 Hz test rig consists of a plate-type capacitors have the characteristic generator is used. The experimental setup used is given schematically in figure 2 (Moran, 1999).

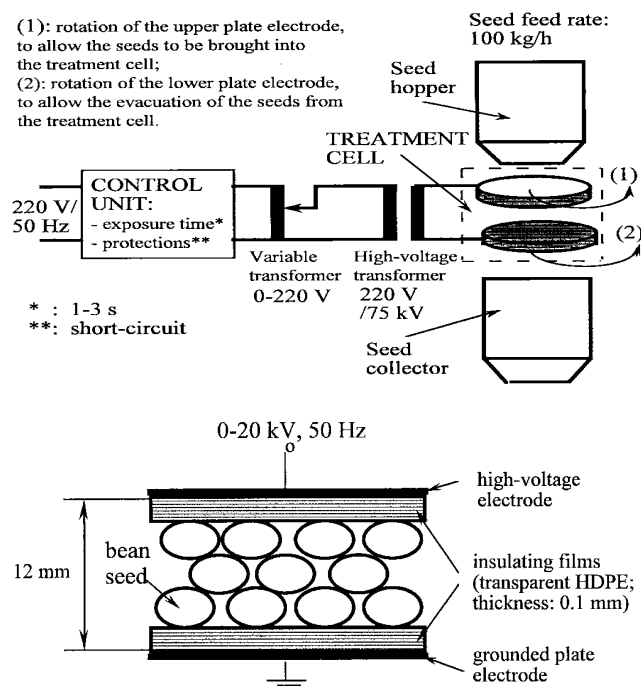


**Fig.2** AC electric field production facilities have been tried Beans

Negative electrostatic field studies on the effects of the application of the trees on the germination of seeds of forest trees extinct with the germination of seeds and emphasized the wooded area can be utilized for redevelopment. Such studies performed on seed germination and seedling growth of static electric field (electrostatic field) is proposed which makes different effects. A study of the germination of pine seeds in a similar positive effect was observed in the study of the electrostatic field treatment on pine seeds -500 kV / m showed no improvement in germination percentage of 10 minutes when voltage is applied. Gibberellic acid on the results obtained in the same study (GA3) in moistened seedlings with 100 ppm was shown to reduce the negative electrostatic charge and seedling growth are shown schematically in Figure 3 (Piras, 2013).

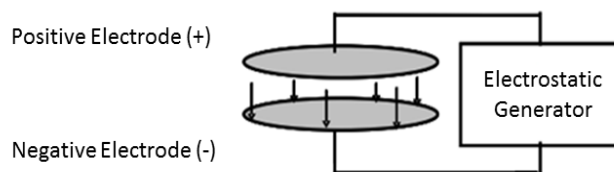


**Fig.3** Seed treatment principle

### 3.Results

High-voltage electrostatic field (HVEF) made application on seed germination studies with stands was more a result of the positive effects of the application. On the practical side to increase the germination rate of the seeds of plants that effect is revealed by researchers.

In studies to be done in this area, especially to increase the value of seed germination is the main factor in the growth of plants, seeds are expected to be taken step in the protection against pests and diseases. The use of chemicals can be said instead HVEF space provided in important contributions to environmental protection.

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# THE EFFECT OF EXCESSIVE MAGNESIUM NUTRITION ON GROWING OF HYDROPONIC LETTUCE (*LACTUCA SATIVA* CONVAR. *CAPITATA* L.)

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**Abstract:** The use of modern technology on hydroponic lettuce (*Lactuca sativa* convar. *capitata* L.) enables the cultivation throughout the year. The plant is a significant vegetable, rich in vitamins. The lettuce grown without soil may have several favourable properties such as faster growth, higher yields, balanced growth, well-automated, environmentally friendly technology and does not require significant manual labour. The experiments of hydroponic cultivation were carried out in the greenhouse of Kecskeket College, Faculty of Horticulture (Hungary). The plants were placed into stone wool, where the submersible pump provided proper moisture and nutrients to the roots. In the course of our experiments  $Mg(NO_3)_2$  treatments were used (50-, 100-, 150-, 200-, and 250 mg/L). The highest biomass weight was measured in the control group, while the lowest biomass was measured after the 250 mg/L  $Mg(NO_3)_2$  treatment. Increasing magnesium content depressed the growing of lettuce and antagonism with potassium and calcium was supposed as well. The average height of lettuce head reached 20 cm.

**Keywords:** HYDROPONIC GROWING, LETTUCE (*LACTUCA SATIVA* CONVAR. *CAPITATA* L.),  $Mg(NO_3)_2$  TREATMENTS, GREENHOUSE

## 1. Introduction

The species of lettuces are grown in extraordinary wide variety nowadays. Lettuce turned from a seasonal vegetable into an all-year grown food. Modern technologies, by using hydroponic lettuce growing, permit continuous cultivation of lettuce for 12 months every year. The average consumption of the plant increased during the previous decade, so it can be inserted into modern healthy nourishment. Lettuce (*Lactuca sativa* convar. *capitata* L.) is a significant vegetable, rich in vitamins and minerals as well. Growing in hydroculture has several beneficial advantages compared to the soil growing as regard of: faster development, higher average of yield, balanced and schemed development. Furthermore, growing can be automated by electric technologies, in an environmentally friendly way, and the production does not require significant manual labour [1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20].

By the use of an automated (electronic technology) system, the nutrient solution can circulate several times a day in the hydroculture channel system.

Magnesium is a central component of chlorophyll, which has a unique role in photosynthesis; magnesium is an essential metal in the plant metabolism, protein biosynthesis, and collaborates as a metallic catalyst in take and release of energy [21,22,23,24,25,26].

The aim of this research was to determine the optimal nutrient concentration of magnesium and to quantify the proper fertilizer concentration for hydroponic lettuce (*Lactuca sativa* var. *capitata* L.) cultivation in the aspect of biomass production.

## 2. Material and methods

Our hydroponic experiment was conducted in the greenhouse of the Faculty of Horticulture at the Kecskeket College, at the end of September 2014. The plants were placed into stone wool (grodan), where the submersible pump provided proper moisture and nutrients to the roots. During the course of the experiment, the magnesium supplements were added in the form of  $Mg(NO_3)_2$ . The following doses of magnesium were added to the standard nutriment solution in our experiment: 50-, 100-, 150-, 200-, 250 mg Mg/l solution. In the control treatment plants were grown with the use of standard nutriment solution without magnesium supplement.

The necessary nutrient solution was made from the following water-soluble fertilizers: 666.7 g Ferticare komplex (N 14%,  $P_2O_5$  11%,  $K_2O$  25%); 733.3 g  $Ca(NO_3)_2$  (N 15%,  $CaO$  26%); 66.7 g  $KH_2PO_4$  ( $P_2O_5$  54%,  $K_2O$  32%); 100ml 60 m/V%  $H_3PO_4$  added to 1000 liters of water.

We filled the hydroponic tanks of 28 liters (Fig. 1) with a new nutrient solution every week. Only highly soluble fertilizers were used. In the hydroponic production watering with the nutrient solution was done using an automated pump system, two times a day for 15 minutes. On the main switch (Fig. 2) we configured when the submersible pump (Fig. 3) should be active. The circulation of the nutrient solution started at 10 and 14 o'clock.



Fig. 1: The 28 l tanks.



Fig. 2: The main switch of the automated system.



Fig. 3: The submersible pump.

The nutrient solution was pumped into the gravity cup (Fig. 4), then with the help of gravity it got into the channel through the pipe network.



Fig. 4: The gravity cup.

Experimental plants were propagated by seeding and subsequent transplant raising in greenhouse. Seedlings were transplanted to multi-cellular transplant raising trays on 3<sup>th</sup> of September 2014. The lettuce seedlings were placed into rock cotton cubes, and put into hydroponic growing channels on 17<sup>th</sup> of September. Each channel of the closed nutrient system had a separate container with a separate submersible pump to ensure adequate circulation of the nutrient solution for plants. The number of plants per plot was 28. The experimental design was a randomized blocks with 4 repetitions. The temperatures in glasshouse were between 15-20 °C. No chemicals or herbicides were applied. The first harvest took place on 14<sup>th</sup> of November 2014, when the biomass was recorded. In each treatment 7 plants were measured.

Electrical conductivity in nutrient solutions was measured by laboratory EC-meter (type ORION 3Star) on 13<sup>th</sup> October in two repetitions, in two growing channels, respectively.

The statistical analysis was accomplished with SPSS v19 software [27]. The mean difference is significant at the 0.05 level. Following harvest, the leaves of lettuce were dried in a LTE-OP-250 drying oven in the laboratory. In the course of the experiment, the nutrient element concentrations nitrogen, magnesium and calcium were determined in the leaves of lettuce.

### 3. Results and discussion

The lettuce grew at a proper rate in the stone wool (Fig. 5). The leaves turned yellow and brown when using solutions of higher concentrations (Fig. 6). For our statistics calculations we compared the growth of the Mg-treated lettuce to that of the control plants. The development of the lettuce head weight is shown in Table 1, Table 2 and Table 3.

**Table 1:** Tukey HSD test of lettuce (*Lactuca sativa* convar. *capitata* L.). Values of the five treatments were measured in 2014 (Parameter: lettuce head weight).

| Treatments | Mean (g) | N  | Standard Deviation | Minimum | Maximum |
|------------|----------|----|--------------------|---------|---------|
| Control    | 285.93   | 28 | 21.106             | 246     | 312     |
| 50 mg/L    | 231.79   | 28 | 31.123             | 162     | 268     |
| 100 mg/L   | 257.61   | 28 | 20.058             | 201     | 296     |
| 150 mg/L   | 205.18   | 28 | 30.804             | 161     | 256     |
| 200 mg/L   | 217.57   | 28 | 24.309             | 176     | 253     |
| 250 mg/L   | 203.86   | 28 | 23.418             | 167     | 251     |

We measured 28 plants from each treatment area. The minimum and maximum mass can be found in Table 1. The maximum weight was found in the control group, while the minimum was among the 150mg/l and 250mg/l treatments.

**Table 2:** Tukey HSD test of lettuce (*Lactuca sativa* convar. *capitata* L.). Values of the five treatments were measured in 2014 (Parameter: lettuce head weight). \*The mean difference is significant at the 0.05 level.

| Treatments (A) | Treatments (B) | Mean difference (A-B) | Standard Error | Significance level |
|----------------|----------------|-----------------------|----------------|--------------------|
| Control        | 50 mg/L        | 54.1428*              | 6.8179         | 0.000              |
|                | 100 mg/L       | 28.3214*              | 6.8179         | 0.001              |
|                | 150 mg/L       | 80.7500*              | 6.8179         | 0.000              |
|                | 200 mg/L       | 68.3571*              | 6.8179         | 0.000              |
|                | 250 mg/L       | 82.0714*              | 6.8179         | 0.000              |

The magnesium treatment led to significant decrease in each case (Table 2). The average mass homogeneity is shown in Table 3.

**Table 3:** Tukey HSD test of lettuce (*Lactuca sativa* convar. *capitata* L.). Means for groups in homogeneous subsets are displayed.  
a. Uses Harmonic Mean Sample Size = 28.000.

| Treatments                |             | N  | Subset for alpha = 0.05 |        |        |        |
|---------------------------|-------------|----|-------------------------|--------|--------|--------|
|                           |             |    | 1                       | 2      | 3      | 4      |
| Tukey<br>HSD <sup>a</sup> | 250 mg/L    | 28 | 203.86                  |        |        |        |
|                           | 150 mg/L    | 28 | 205.19                  |        |        |        |
|                           | 200 mg/L    | 28 | 217.57                  | 217.57 |        |        |
|                           | 50 mg/L     | 28 |                         | 231.79 |        |        |
|                           | 100 mg/L    | 28 |                         |        | 257.61 |        |
|                           | Control     | 28 |                         |        |        | 285.93 |
|                           | Significant |    | 0.340                   | 0.300  | 1.000  | 1.000  |



**Fig. 5:** Hydroponic lettuce in stone wool.

We took samples from the hydroponic tanks to test their EC. Changes in the electrical conductivity are shown in Fig. 7. The control had the lowest EC values (1.95 and 2.05 mS/cm) and the 250 mg/l the highest (3.68 and 4.00 mS/cm). The EC values increased along with the magnesium concentration.



**Fig. 6:** The leaves turned yellow and brown after high Mg-treatments.

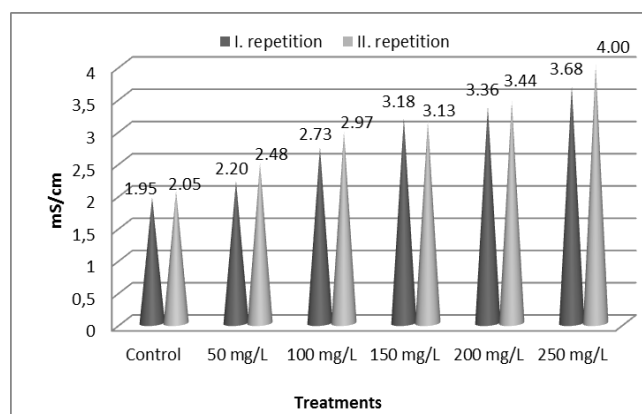


**Fig. 7:** EC of the nutrient solutions in the treatment groups.

#### 4. Conclusion

Despite the widely and commonly used traditional agricultural production technologies, hydroponic growing also has a great role nowadays and in the future as well. In the course of our experiment we found that the easily purchased materials (stone wool, medium raw material) can be used cost-effectively in the hydroponic cultivation.

Human labor is only needed for planting into stone wool, filling in the nutrient solution and harvesting. More work is needed for production on a field. In the case of hydroponic growing there is no need for weeding, fertilizing or groundwork. The leaves turning brown and rotting can be avoided with using adequate nutrient solutions. Higher salt concentration or excessive nutrient ratios may easily cause inadequate growing or disorders.

The lettuce was grown using hydroponic cultivation in our study. Their growth was steady, but there was a great deviation in head weight. While measuring the hydroponic lettuce we found that the magnesium treatment led to a significant decrease in head weight, compared to the control group.

We measured the heaviest mass among the control plants (285.93 g). The 250 mg/l and 150 mg/l plantations had similar results to each other. The 200 mg/l treatment led to a 24% decrease compared to the control. The second heaviest heads of lettuce were found in the 100 mg/l treatment (257.64 g). The mass of the 50 mg/l treatment was 19% less than that of the control group.

As a supposed result of some antagonism, the magnesium concentration blocked the potassium uptake and thus led to the large differences in mass. Potassium is a mobile, translocating element and so the deficiency symptoms were first observed on the older

leaves. The potassium deficient plants have a reduced disease resistance, chlorosis and necrosis often occurs later in lettuce. Calcium deficiency symptoms were also noticeable. The roots had insufficient growth, the apices were mucoid, they turned brown and subsequent necrosis was observed. In some cases the growth of the plants did not begin, as the lettuce did not take up the nutrients at a proper rate.

The temperature and humidity of the greenhouse can be easily controlled with the automated system. The nutrient solution can also be circulated multiple times a day. The advantage of the technology is that the plants grow at the same rate and the heads are harvested at the same time. Harvesting is a short and smooth process, so it makes an efficient use of human resources. This method can be used repeatedly, allowing continuous production throughout the year. Lettuce can be grown as much as six times on stone wool in a year.

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# FERTILIZER PLANTERS FOR RESOURCE-SAVING CULTIVATION TECHNOLOGIES IN THE CONDITIONS OF NORTHERN KAZAKHSTAN

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For the purpose of cultivation of grain crops in northern Kazakhstan the production of grain drills, cultivators such as SES-6 (SES-12) for sowing after cereal backgrounds for sowing on fallow background - disc seeder FFP-3,6, and wetlands soils – paring plough seeder LDS-6 were developed and mastered. At present, grain crops in Kazakhstan is mainly carried out by these morally and physically obsolete drills, and the development and production of new drills in Kazakhstan practically nobody does.

Leaders in the development and production of such seeding equipment in the world are the company «Accord», «Amazonen», «Horsch» (Germany), «John Deere» (USA), «Flexi-Coil» (Canada), and others.

Some models of above mentioned drills with CMC of these firms have been tested in the 80s in the virgin machinery testing stations. None of these models of planters with CMC did not meet the full agro-technical requirements do not provide the necessary uniformity between seed coulters [1].

Also, the machines of foreign companies are expensive and if possible, the need to produce their own cheap planters and

their availability for low income strata of farmers is essential for the widespread introduction of new soil conservation technologies in the region.

At present, the development of sowing machines is carried out in several areas, including the following: improvement of quality indicators of crop, increase productivity of multi-purpose machines. As noted above, a number of these machines are combined with the processing operations, and the fertilizer sowing [3].

In S.Seifullin Kazakh Agro Technical University at the Department "Agricultural and Grain Processing Machinery" under the direction of Professor Aduov M.A. in addition to drills for direct seeding and minimum seeding, fertilizer drills are also being developed. Stubble and fertilizers seeder, Figure 1 [3] consists of a frame, and fertilizers hopper, support wheel, press wheels, tines with distribution of seeds and fertilizers. Cultivator paws in each row are set at different depths interleaved within 2-3 cm. which increases the efficiency of fertilizer use in the initial period of plant growth and increase crop yields.

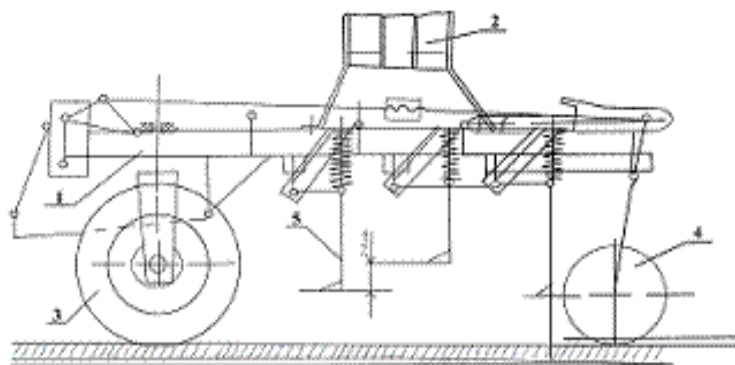


**Figure 1** - Stubble and fertilizers drill

1 – frame, 2 - fertilizers hopper, 3 – jockey (full speed) wheel, 4 – press wheels, 5- cultivator sweep.

Seeder works as follows. When driving drills on the field, seeds and fertilizers from mineral fertilizers box come into the furrows formed by cultivator sweeps.

Following press wheels make soil compaction over sown seeds and fertilizers. Mounted at different levels with distributors seed coulters place seeds and fertilizer in different soil horizons. Located in different soil horizons seeds and fertilizers allow the use of fertilizer in the initial period of development that will improve the crop yield

This group also developed ploughshare, Figure 2 [4] which consists of a hollow bar, at the bottom with cultivator point. Front opener is equipped with a rigidly fixed on it above the lower cutoff of cultivator point by side plates made by an exponential curve bevel upward direction in the opposite direction movement of the

ploughshare. Sinkers mounted between lateral guide seed moving relative to the coulter strut in vertical and longitudinal directions.

When driving the opener, fertilizer come to the bottom of the furrow through the hollow rack formed by cultivator point. Covering the fertilizer by the soil is due to soil layer flowing over the counter and repose from the walls of its furrows, seed grain feed crops come in seed guide located in the area between the side plates.

The side plates retract part of moving soil preventing it from closing immediately after the opener, and another part of the soil from existing in the bottom of the bevel is passed into the space between the cheeks for sheltering the bottom of the furrow. Moreover the amount of skipped into the soil goes with the increase from the beginning of the opener to the periphery of the direction of travel opener.

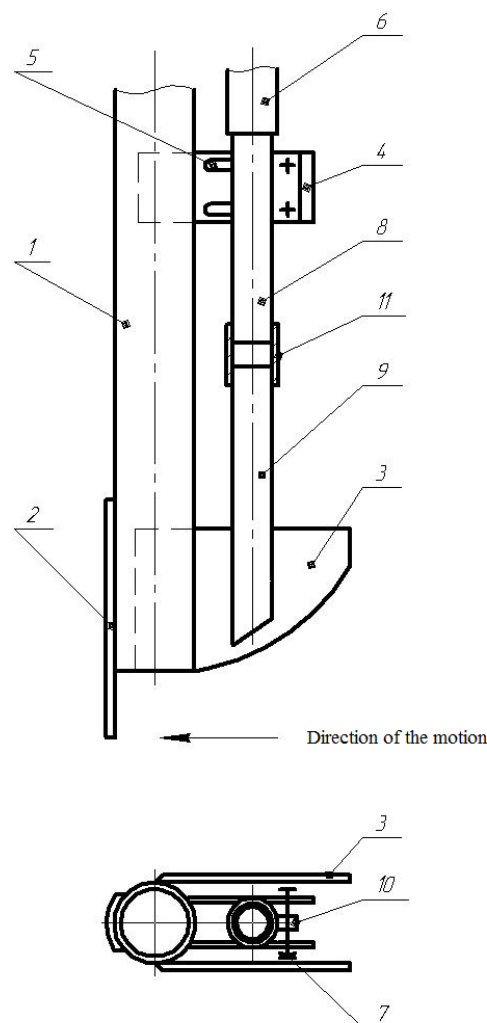


**Figure 2** - The opener for the separation mineral fertilizers introduction  
1 – hollow shank, 2 – cultivator point, 3 - side plates, 6 – seed guide, 9 - coupling.

Seeds from the seed guide are sown on the soil layer hide the furrow, thereby made smaller depth of their termination in comparison with fertilizers, which lie on the bottom of the furrow.

Seed placement of grain crops is due to cover their part of the moving soil layer and due to repose of the soil from the sides of the furrow. Seeding depth of grain and grain feed crops is controlled by moving the slots of the seed guide in the bracket horizontally and by shifting it to the bottom of the coupling in the vertical direction.

In this case, the moving seed guide is relative to the coulter strut in the vertical and longitudinal directions, and enables to plug the seeds and fertilizer into the different soil horizons.

Based on the above mentioned it should be noted that the developed and fertilizers drills for resource-saving technologies aimed at modernization (simplification) in general device, increasing the safety factor implementation process and to improve the performance of seeders, minimal disruption of the soil structure to ensure the quality of sowing on moist soils, providing high cross at sowing after cereal backgrounds, with a spacing of 15 cm. In general, the development and introduction of high-performance

drills allow a 20-25% increase in yield from agricultural crops and the introduction of zero and minimum technologies.

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# Thermal treatment of pea, lupine and flax seeds using microwaves technology on the nutritional value of products

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## Introduction

Seeds of oilseeds and legumes by local production, such as canola, Flax seed (linseed), peas, field beans, lupines and soy beans are rich in nutritionally valuable substances. They are suitable because of their economical efficiency in arable crop rotation and high energy and protein content of the seeds to make a greater contribution to protein supply of livestock and to replace imported soya products partially. The demand for protein feeds for GMO-free feeding and organic livestock could be better served. The new technical method of thermal treatment is done for using of microwaves. The energy turnover in the microwave heat takes place directly in the product through primary coupling to water. The resulting vapor pressure ensures a rapid direct withdrawal of a portion of the water from the product. The product is heated in this process from the inside outwardly. The heating of seeds of oilseeds by means of microwaves and the steam outlet can lead to microstructural changes of membranes and partly to break the seed coat.

## Microwaves machines

In the course of the investigations 2 different systems of microwaves machines were tested. The main results from the analysis of the feed are from the analysis of the PROTOTYPE-microwave, which were used in the experiments with the growing pigs and finishing pigs. At a later date the PROTOTYPE-microwave had to move back to the developers, what was also based on the experiences of from the studies. Later on 2 industrial microwaves were purchased with which the canola was treated for the feeding trial with the dairy cows. An overview of both machines is shown in Figure 1.



Figure 1: both microwaves machine the visual comparison (on the left side the prototype-machine; on the right side the industrial-microwaves)

## Technology parameters of the prototyp-microwaves machine

For the development project was used the prototype of a continuous working microwave system with a planned capacity of 20 kW and up to 500 kg continuously treated product per hour. This system was developed in a german engineering company and during the duration of the project very well developed with colleagues

from the company. At the beginning of the investigations very often had to be observed that the small canola seeds escape from the band of the microwave, which partly resulted in fires in the facility. Also, the band has been changed because of the non-anticipated high load. As a problem appeared the measurement of the temperature at the end of the run of each product, which made a standardized reproducibility of results very difficult.

The feed flow rate of the products to be treated in the different temperature levels was randomly measured during treatment using the prototype-microwave. Thus, in the rapeseed could have an average flow rate of 46 kg per hour determines, with increasing temperature of the seed after the treatment, the amount per unit time has been reduced. However, the planned quantities of up to 500 kg per hour could not be reached, making it difficult to produce larger quantities of products for the planned experiments. Here should other technical possibilities to be found in order to provide a suitable machine for industrial production can.

The achieved temperature at the surface of the products after the exit from the microwave oven is affected by the speed of the conveyor belt and the layer thickness. Thus, a layer thickness of 7 mm was achieved on the tapes, for example, in the treatment always rapeseed, wherein the belt speeds had to be decreased with increasing temperatures (Table 1). The planned variations in the layer thickness and the temperature could therefore not be carried out and should be considered in the evaluations as well as derivatives.

Table 1: layer thickness (mm) / speed of the conveyor belt (m/min)

| Temperature | 90 °C   | 95 °C    | 100 °C  | 105 °C   | 110 °C   | 115 °C  | 120 °C |
|-------------|---------|----------|---------|----------|----------|---------|--------|
| rapeseed    | 7 / 2,9 |          | 7 / 2,3 |          | 7 / 2,2  | 7 / 2,0 |        |
| Flax seed   |         | 10 / 1,5 |         | 10 / 1,3 |          |         |        |
| Peas        |         |          |         | 10 / 2,0 | 10 / 1,8 |         |        |
| Field beans |         |          |         | 14 / 1,2 | 14 / 0,9 |         |        |
| Lupines     |         |          |         | 10 / 1,3 |          |         |        |
| Soybeans    |         |          |         | 10 / 1,8 |          |         |        |

For selected feed, the temperature of the materials in the interval of 5 minutes was measured after leaving the products from the prototype-microwave and the subsequent storage in paper bags to 1 hour after treatment. The peas showed that when treated at 105 °C after 1 hour mean temperatures were still to be found from 90 °C (Figure 2). Within the first hour after treatment decreases in both variants shown the temperature by an average of 15 °C. For the variant in the peas at 105 °C was 4 hours after the treatment, nor an average temperature of 66 °C and 8 hours after treatment of on average 47 °C are detected. Even 18 hours after discharge from the microwave and storage in paper bags mean temperatures were recorded from 26 °C to 33 °C.

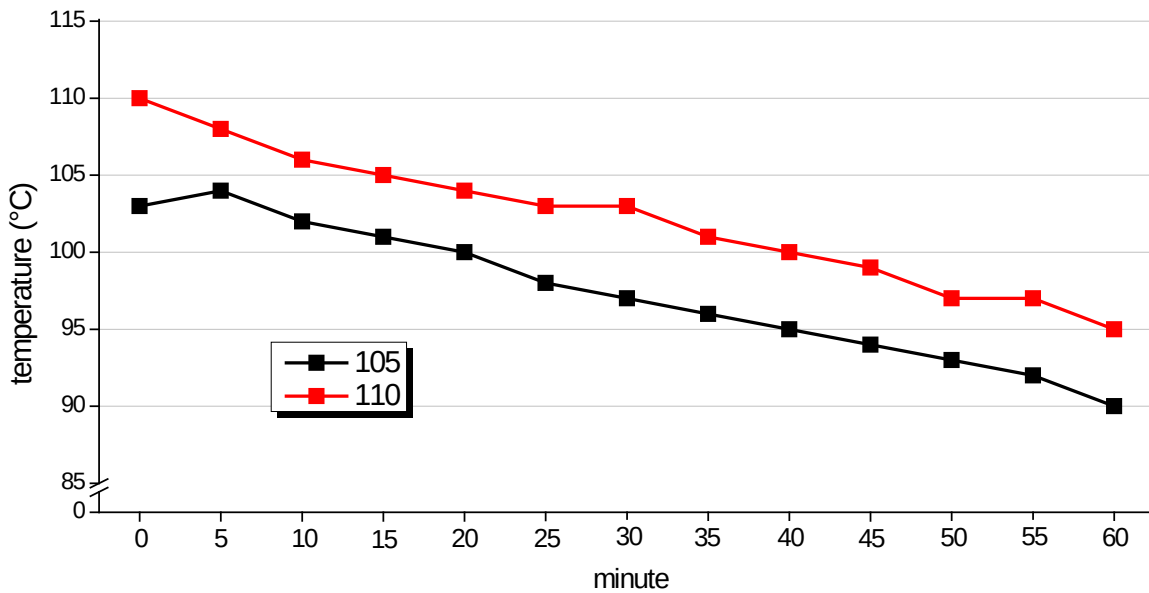


Figure 2: Temperaturverlauf bei den Erbsen nach der Mikrowellen-Behandlung

For rapeseed, the two temperature settings have been selected 100 °C and 115 °C. In contrast to the peas, the curve of the temperatures in rapeseed extends substantially flatter. At a measured temperature of 116 °C immediately after the treatment using microwave could be determined 60 minutes later still mean temperatures of 112 °C. A similar course is also reflected in the variant by 100 °C for rapeseed (Figure 3).

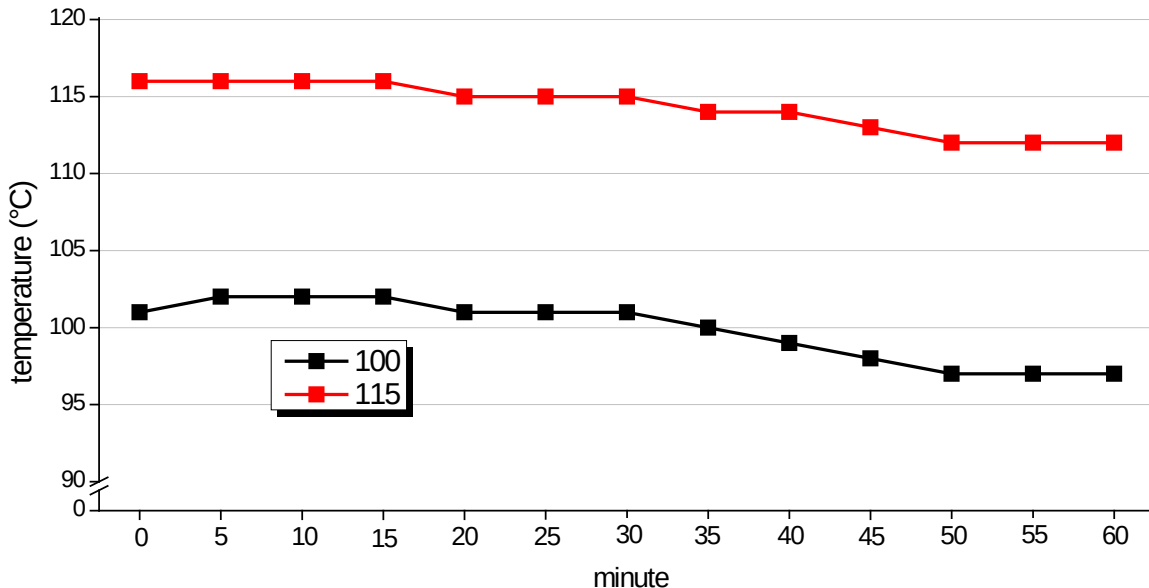


Figure 3: Temperaturverlauf beim Rapssamen nach der Mikrowellen-Behandlung

### Technology parameters of the industry-microwaves machine

The verify industrial microwaves have a power output of 3,200 W, which are achieved by 4 Megatrone with 800 watts (2 pieces on the top and 2 pieces under the feed). A control of the temperature in the products can only be achieved over the duration of the treatment in the plant. Inside the microwave is a volume of about 44 liters available. In the industrial-microwave about 72 kg produced per hour with a

residence time of rapeseed in the investment of an average of 20 minutes. For the other feed the acquisitions have not been conducted. In industry-microwaves, the duration of the microwave treatment can only be controlled by the residence time of the materials in the plant, wherein, for example, for the achievement of 105 °C during 20 minutes rapeseed are needed. Random data for peas and lupines were recorded with. The other feed have not been checked by the contracting capacity.

## Pea

In the case of peas, a significant increase of dry matter could be observed by means of microwave treatment (Table 2). Furthermore, a significant, albeit feeding value-technically only slight increase in the crude protein content of the materials with slow cooling (storage) could be detected, the other ingredients remained at a comparable level. A total of 27 samples were analyzed with the Peas, with 9 samples and the temperature levels 105 °C for 12 samples (6x cooling and 6x storage) and at 110 °C a total of 6 samples (3x cooling and 3x storage) could be examined at the natural seed.

Table 2: Results of nutritional values of peas with 105 °C and 110 °C (n=27)

|           | DM<br>(g/kg FM)        | CA<br>(g/kg DM) | CP<br>(g/kg DM)      | CF<br>(g/kg DM) | CL<br>(g/kg DM) | CS<br>(g/kg DM) |
|-----------|------------------------|-----------------|----------------------|-----------------|-----------------|-----------------|
| Peas      | 878 <sup>a</sup> ± 1   | 34 ± 1          | 210 <sup>a</sup> ± 5 | 75 ± 15         | 20 ± 4          | 511 ± 20        |
| 105 °C C. | 897 <sup>bc</sup> ± 4  | 34 ± 1          | 215 ± 7              | 67 ± 12         | 20 ± 4          | 517 ± 9         |
| 105 °C S. | 912 <sup>bd</sup> ± 3  | 34 ± 1          | 220 <sup>b</sup> ± 3 | 79 ± 10         | 21 ± 7          | 497 ± 11        |
| 110 °C C. | 904 <sup>bde</sup> ± 2 | 34 ± 1          | 217 ± 2              | 73 ± 1          | 17 ± 1          | 507 ± 7         |
| 110 °C S. | 924 <sup>bdf</sup> ± 5 | 34 ± 1          | 220 <sup>b</sup> ± 7 | 79 ± 2          | 16 ± 1          | 504 ± 3         |

C.: cooling; S.: storage

## Lupines

All samples of lupines within the verifying treatment levels had a mean concentration of energy of 8.9 MJ NEL per kg DM. The crude nutrients were fixed by means of microwave treatment were not significantly affected (Table 3), even if the dry matter of lupines has been significantly increased. The lupines, a significant increase in the content of NDF by 4% compared to 24% was found after treatment by prototype-microwave in the natural seed (lupines).

Table 3: Results of nutritional values of lupines with 105 °C (n=9)

|         | DM<br>(g/kg FM)       | CA<br>(g/kg DM) | CP<br>(g/kg DM) | CF<br>(g/kg DM) | CL<br>(g/kg DM) | CS<br>(g/kg DM) |
|---------|-----------------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| lupines | 878 <sup>a</sup> ± 3  | 37 ± 1          | 345 ± 6         | 126 ± 12        | 55 ± 2          | 100 ± 7         |
| cooling | 900 <sup>bc</sup> ± 1 | 38 ± 1          | 349 ± 7         | 118 ± 7         | 56 ± 1          | 113 ± 13        |
| storage | 919 <sup>bd</sup> ± 3 | 37 ± 1          | 335 ± 26        | 118 ± 9         | 54 ± 3          | 101 ± 4         |

## Flax seed

In flax seed a significant increase in the content of crude lipid (CL) with an increase in the content of crude starch (CS) is observed. These higher levels might by the significant reduction in crude fiber (CF) in flax seed caused by microwave treatment. The extent, to which changes in the composition of the oil, as at CHOO et al. (2007) described, occurred, was not analyzed in the present study. The percentage of crude

protein (CP) remains unaffected by the treatment using microwave (Table 4), the average content of 220 g per kg DM compared with the information of DLG feeding value table appears low with an average of 248 g per kg DM. In contrast, the oil levels in the starting material with an average of 425 g per kg DM at a higher level than at the DLG feed value tables with 365 g per kg DM (DLG, 2015).

Table 4: Results of nutritional values of flax seed with 105 °C (n=9)

|           | DM<br>(g/kg FM)      | CA<br>(g/kg DM) | CP<br>(g/kg DM) | CF<br>(g/kg DM)       | CL<br>(g/kg DM)       | CS<br>(g/kg DM) |
|-----------|----------------------|-----------------|-----------------|-----------------------|-----------------------|-----------------|
| Flax seed | 931 <sup>a</sup> ± 1 | 36 ± 1          | 220 ± 1         | 185 <sup>a</sup> ± 20 | 425 <sup>a</sup> ± 18 | 134 ± 3         |
| cooling   | 961 ± 5              | 36 ± 1          | 220 ± 1         | 150 ± 37              | 459 <sup>b</sup> ± 15 | 135 ± 23        |
| storage   | 964 <sup>b</sup> ± 5 | 36 ± 1          | 219 ± 1         | 128 <sup>b</sup> ± 23 | 465 <sup>b</sup> ± 9  | 152 ± 20        |

In the natural seed (flax seed) average levels of NDF of 359 g per kg DM and ADF were determined from 215 g per kg DM. After treatment by the microwave, there was a reduction in levels (Figure 4), which, however, could not be statistically significant. Only after the storage of the treated products a significant reduction in NDF and ADF values could be observed. Even the ADL content decreased from 149 g per kg DM in the natural seed to 101 g per kg DM for the microwave to be significant at 79 g per kg DM after storage (more due to the heat). This reduction in structural carbohydrates could speak in pigs and rearing calves for the use of microwave-treated flax seed and should be checked for special products in these categories of animals.

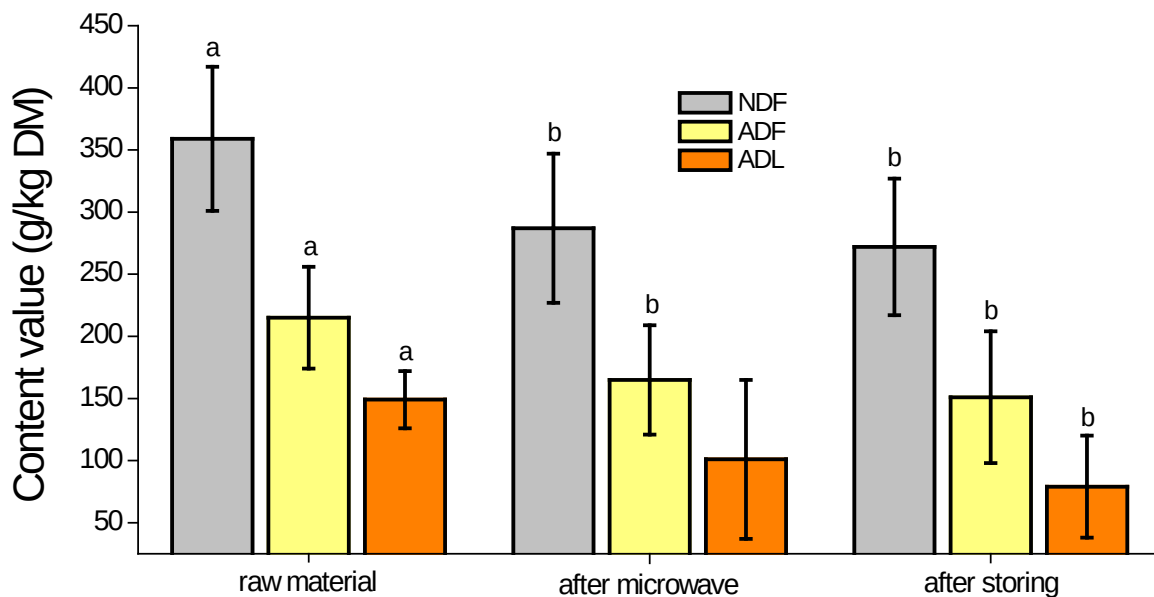


Figure 4: Content value of NDF, ADF and ADL during the treatment (n=9) when treated by microwaves at 105 °C

## Conclusion

All feed was observed by means of microwave treatment, an increase in the content of dry matter. To what extent this may have an impact on the feeding value, would have to be clarified. Flaxseed showed after the microwave treatment on a higher content of oil in a reduction of crude fiber content, which also was reflected in the detergent fiber (NDF, ADF, ADL). This could have a positive effect on the utilization of the flaxseed in the feeding of monogastric animals.