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

Heiko Scholz[1], Wolfram Richardt[2], Petra Kühne[1], Lutz Walzel[3]
[1] Anhalt university of Applied Sciences, faculty LOEL, Strenzfelder Allee 28, 06406 Bernburg
[2] LKS Lichtenwalde, August-Bebel-Straße 6, 09577 Niederwiesa, OT Lichtenwalde
[3] BASU mineral feed, Bergstraße 2, 99518 Bad Sulza

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 economically 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.

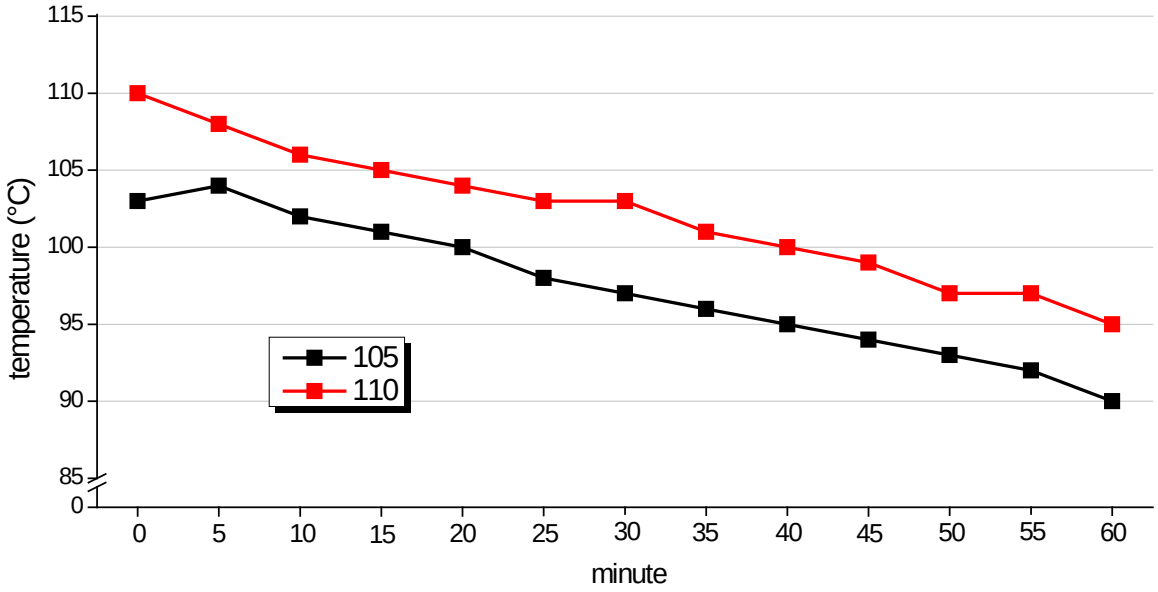

Figure 2: Temperaturverlauf bei den Erbsen nach der Mikrowellen-Behandlung

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).

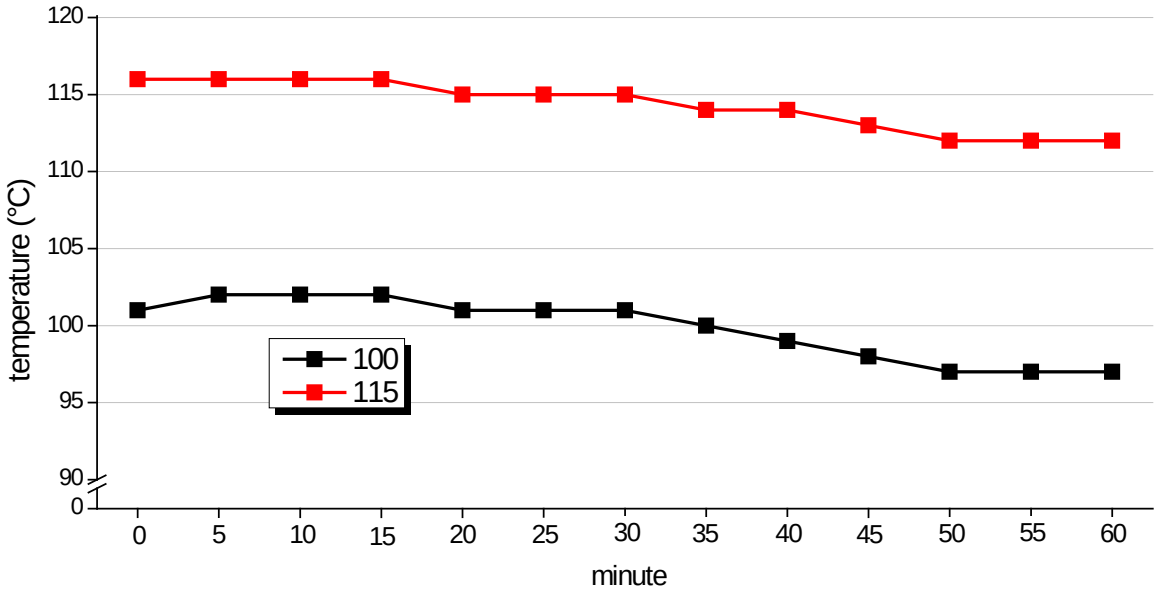

Figure 3: Temperaturverlauf beim Rapssamen nach der Mikrowellen-Behandlung

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 (g/kg FM)	CA (g/kg DM)	CP (g/kg DM)	CF (g/kg DM)	CL (g/kg DM)	CS (g/kg DM)
Peas	$878^{a} \pm 1$	34 ± 1	$210^{a} \pm 5$	75 ± 15	20 ± 4	511 ± 20
105 °C C.	$897^{bc} \pm 4$	34 ± 1	215 ± 7	67 ± 12	20 ± 4	517 ± 9
105 °C S.	$912^{bd} \pm 3$	34 ± 1	$220^{b} \pm 3$	79 ± 10	21 ± 7	497 ± 11
110 °C C.	$904^{bde} \pm 2$	34 ± 1	217 ± 2	73 ± 1	17 ± 1	507 ± 7
110 °C S.	$924^{bdf} \pm 5$	34 ± 1	$220^{b} \pm 7$	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 (g/kg FM)	CA (g/kg DM)	CP (g/kg DM)	CF (g/kg DM)	CL (g/kg DM)	CS (g/kg DM)
lupines	$878^{a} \pm 3$	37 ± 1	345 ± 6	126 ± 12	55 ± 2	100 ± 7
cooling	$900^{bc} \pm 1$	38 ± 1	349 ± 7	118 ± 7	56 ± 1	113 ± 13
storage	$919^{bd} \pm 3$	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 (g/kg FM)	CA (g/kg DM)	CP (g/kg DM)	CF (g/kg DM)	CL (g/kg DM)	CS (g/kg DM)
Flax seed	931^{a} ± 1	36 ± 1	220 ± 1	185^{a} ± 20	425^{a} ± 18	134 ± 3
cooling	961 ± 5	36 ± 1	220 ± 1	150 ± 37	459^{b} ± 15	135 ± 23
storage	964^{b} ± 5	36 ± 1	219 ± 1	128^{b} ± 23	465^{b} ± 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.

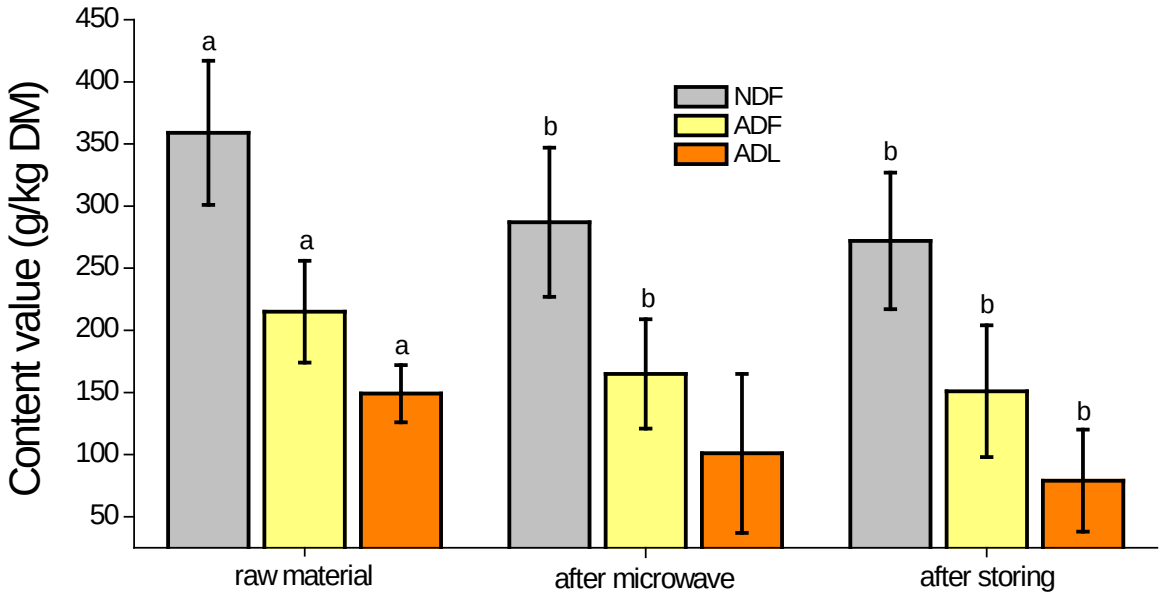

Figure 4: Content value of NDF, ADF and ADL during the treatment (n=9) when treated by microwaves at 105 °C

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.