Monitoring the germination of brown rice, red lentils and flaxseed with NIR using the Polar Qualification System

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Abstract

Germination is a process which significantly alters the composition of seeds. During germination hydrolytic enzymes activate, breaking down starch, fibers and proteins. Moreover it generates various bioactive compounds of health-promoting activities through the enzymatic actions. The aim of this study was to follow up the changes in the NIR patterns during 4 days of germinations in brown rice, lentils and flaxseeds to see, if the NIR is able to assess the exact day of a started germination process. These grains are important raw materials in a gluten free diet.

The research was conducted with METRINIR 10-17 ST-type device in transmission mode (wavelength 700-1700 nm, 2 nm gate distance). In each group 20 kernels were tested, using a single kernel measuring device. Using polar qualification system, the NIR spectra were converted into quality points. These were statistically tested with discriminant analyses.

Our findings showed that this setting was suitable to follow the changes during the germination period, especially in the case of red lentils (67.3% of the original grouped cases correctly classified). Classification of the flaxseed samples at different germination days was the least successful (50.4% of the original grouped cases correctly classified).

Keywords: *germination, NIR, polar qualification system (PQS)*

1. INTRODUCTION

Rice (Oryza sativa L) is one of the major cereal crops and a staple food for the world's population. Brown rice is a rice kernel dehulled from rough rice and consists of an embryo (2-3%), endosperm (92%) and bran (5-6%).

Red lentil (*Lens esculenta)* is a native to South West Asia and cultivated as a pulse crop mainly in North India. Seeds are mostly used as a pulse containing as much as 30% proteins. Most of the proteins in lentil are storage proteins, which are usually consumed by the germ during seed germination. Soup made of red lentil is used in gastric troubles and constipation and its paste or poultice is applied to foul and indolent ulcers.

Red lentil is a leguminous seed that have high levels of natural antioxidant components including condensed tannins. (Amarowicz et al., 2009, Sravanthi et al, 2013)

Flax (Linum usitatissimum L) is an annual plant belonging to the genus Linum and the family Linaceae. Flaxseed is abundant in many nutrients, such as polyunsaturated fatty acid, protein, and lignans. Flax seeds, containing about 36-40 % oil are the richest (among crop plants) source of polyunsaturated fatty acids (PUFA) essential in the human diet. PUFA are highly susceptible to oxidation. (Popa et al, 2012)

Flaxseed flour was used commercially in breads by several bakeries in the USA and Canada in the late 1980s.

The germination of seeds causes dramatic changes inside of the endosperm. During germination the developed sprout activates dormant enzymes and they serve different nutrients. The broken components inside seeds gradually liberate to become available. In

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addition new components are expected to be produced at the germination stage. For example *Ohisha* and others found, that the gamma-aminobytiric acid content of brown rice increased significantly after 8-24 hours soaking in warm water (40°C). In addition in germinated brown rice more digestible compounds will be formed, there is an increase in the amounts of phytic acid, ferulic acid, inositols, dietary fiber, tocotrienols, magnesium, potassium, zinc, gamma-oryzanol and of prolylendopeptidase inhibitor. The changes in nutritional components were depending on the variety of the rice. (Kayahara and Tsukahara 2000; Ohisa at al, 2003; Otshubo et al 2005, Dong-Hwa Cho, Seung-Taik Lim, 2016)

Near infrared analyses are non-destructive, non-invasive and real-time, and therefore suitable to follow up the compositional changes during the germination of different seeds (Osborne, 1996; Pawlinsky and Williams, 1998; Salgó et al, 2005).

The aim of this study was to observe the changes in intact grains of brown rice, red lentil and flaxseed and follow their germination process by NIR. Investigations were focused on using PQS system as a kind of fingerprinting the seeds, to define which day of the sprouting process they are.

2. MATERIALS AND METHODS

2.1. Samples

Brown rice, red lentil and flaxseed were bought in the retail shop. Germination process was done using a micromalting plant (type: KMA-A1-2008, manufactured by Schmid-Seeger). The malting process was conducted for 4 days with the following parameters: in every 8 minutes air was let in into the malting chamber for 400 seconds. Soaking steps at 20 °C water for 3 hours were followed cyclic by dry steps (2 hours at 22°C without water). In the first 2 days grains were mixed 30 times, on day 3 and 4 mixing was done in 3 hours period, to distribute the generated heat and carbon-dioxide evenly.
Samples were taken before the malting process started, and then every 24 hours.

2.2. Methods of measurement and data analysis

The spectra of each sample were recorded on a MetriNIR 10-17 scanning-type spectrometer in the wavelength region of 700 to 1700 nm, with a spectral step of 2 nm (500 points per spectrum). The measurement was performed in transmission mode. 20 kernels were selected and measured from each sample group on each day during the germination process.

For the evaluation of the recorded spectra there are many statistical multivariate methods to choose from. In this study the Polar Qualification System was used. Polar Qualification System (PQS) as an alternative qualification method was introduced by Kaffka and Gyarmati (1991) and was applied in several research approaches to distinguish sample groups (Gergely and Salgó, 2003, Seregély et al., 2004). According to PQS, a sample can be characterized by a center of its polar spectrum. The center, referred to as “quality point” can be defined by two data; in polar co-ordinate system it means an angle and a radius, or in the more usual rectangular Descartes co-ordinate system an abscissa and an ordinate (Kaffka & Gyarmati, 1998). It means a drastic data reduction. In case of a scanning spectrometer giving 700 spectral data, this reduction is 700–2. As the NIR spectrum is a fingerprint of the investigated material, PQS compresses the spectral data in a “quality point” on a two dimensional polar “quality plane” for qualification. The location of the quality point is

influenced by all spectral data, thus, small differences in spectra may result separate clusters of quality points, resulting an effective method for discrimination.

3. RESULTS

The NIR spectra were recorded and using the 3 methods in the PQS system they were converted into quality points.

Discriminant analysis was used to classify the samples according to their quality points.

As an example the recorded spectra (average and deviations) of the sample brown rice is shown in Figure 1. As it can be observed, there is a shift in the absorbance level after the first day of germination, which is connected primarily to the changes in water the content of the samples (result of the soaking). The biggest change is around the first overtone of water, 1500 nm. For all spectra there is also a peak around 1200 nm, which shows the second overtone of C-H bounds.

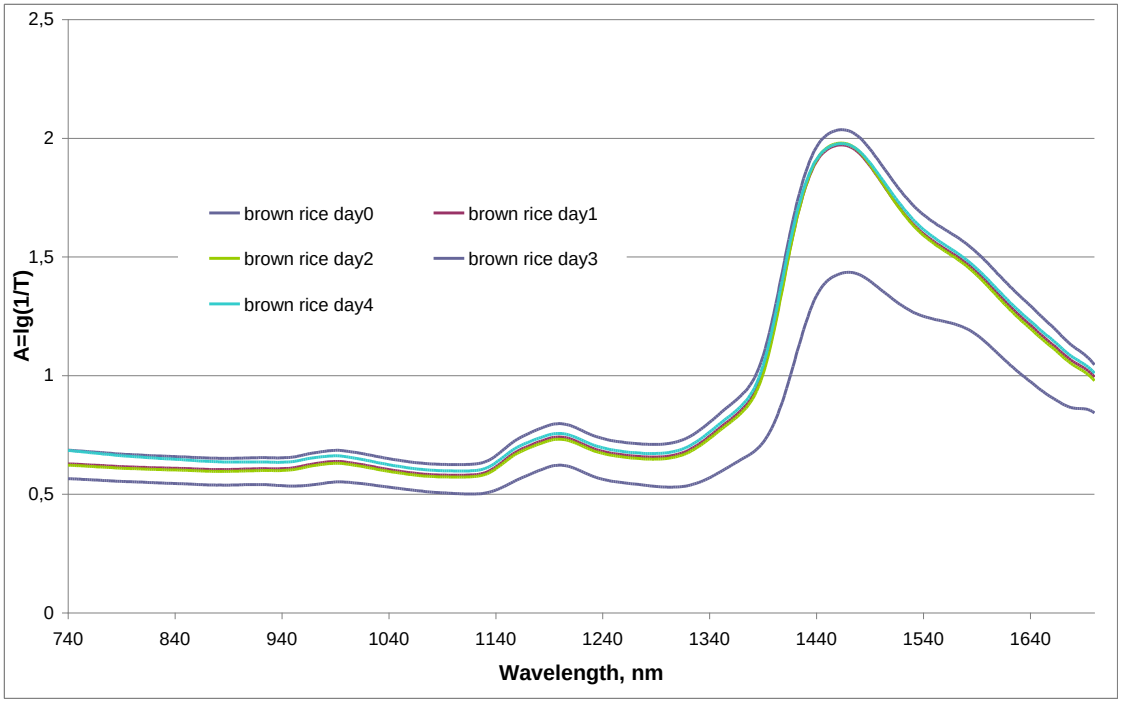

Figure 1. Average spectra (log (1/T)) of the brown rice samples during the germination process

The quality points of the samples were calculated with the 3 different methods of the PQS (point, line and surface methods). An example of the results is shown in Figure 2.

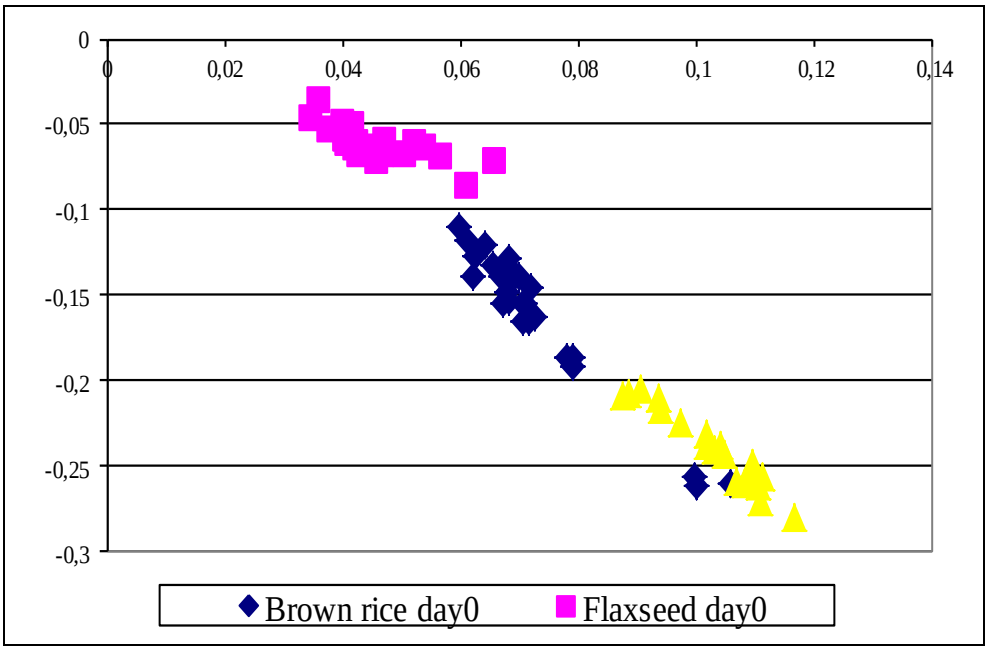

Figure 2 Quality points of all samples at the beginning of the germination process (Day 0) calculated by using PQS point method.

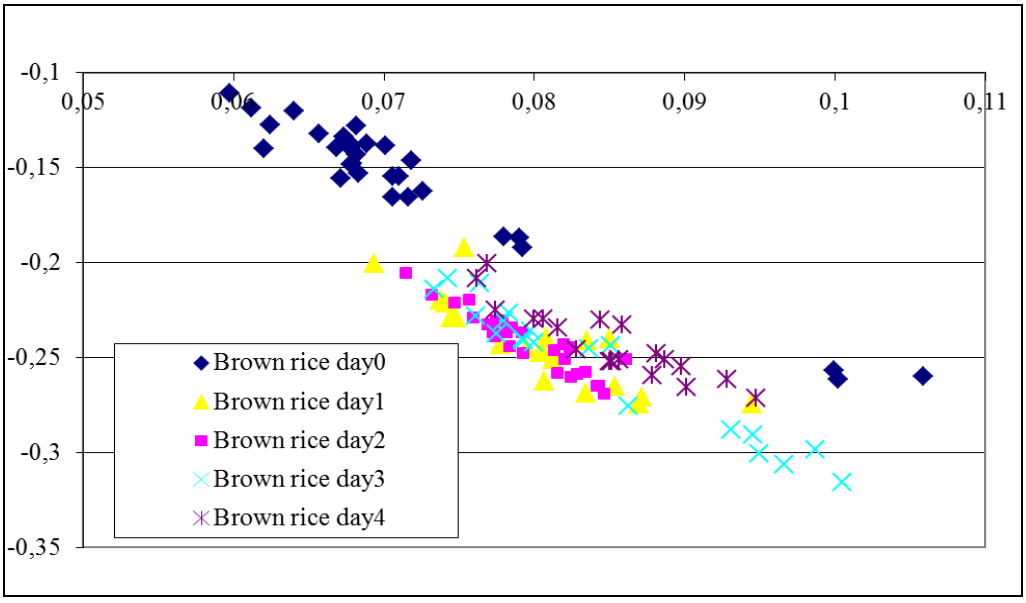

Figure 3. Quality points of brown rice samples during the 4 days germination process calculated by using PQS point method.

Discriminant analyses using SPSS software were performed on the PQS quality points of the 3 seed samples.

As Figure 4 shows during the germination the differences in the quality points (thus in the spectra) are not to be ordered to the days. It also means, that just looking at the raw data we are not able to tell with high confidence, if the given sample has been germinated for 2, 3 or 4 days. Of course day 0 is outstanding, but as explained earlier it might be connected to the different water contents of the samples.

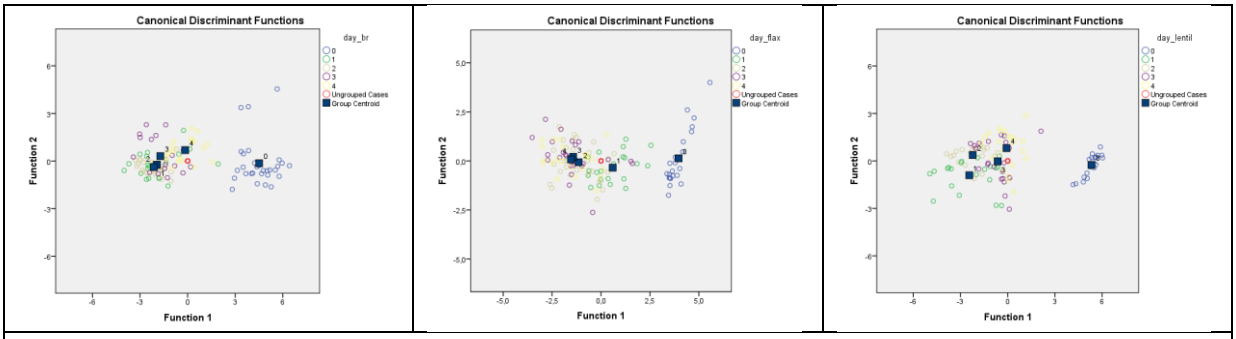

Figure 4. Discrimination result of quality points (PQS point method) calculated from spectral data of brown rice, flaxseed and red lentils during the days of germination

Discriminant analyses were done on the sample sets. In Table 1 the results of the statistical analyses of the sample groups is shown using the PQS quality points, calculated by the point method. Similar results were achieved by the application of the other two calculation methods (line and surface), therefore they are not shown separately.

In all seeds the spectra taken at day 0 was 100% correctly classified. The biggest miss-classifications were between day 3 and 4, especially in case of flax. It can be connected to the fact, that flax is mucilaginous, and this influences its spectral data.

Classification Results[a]

	day_br	Predicted Group Membership					
		0	1	2	3	4	Total
Original Count	0	30	0	0	0	0	30
	1	0	0	17	0	4	21
	2	0	0	25	1	1	27
	3	0	0	10	7	3	20
	4	0	0	1	3	15	19
	Ungrouped cases	0	0	0	0	225	225
%	0	100,0	,0	,0	,0	,0	100,0
	1	,0	,0	81,0	,0	19,0	100,0
	2	,0	,0	92,6	3,7	3,7	100,0
	3	,0	,0	50,0	35,0	15,0	100,0
	4	,0	,0	5,3	15,8	78,9	100,0
	Ungrouped cases	,0	,0	,0	,0	100,0	100,0

a. 65,8% of original grouped cases correctly classified.

Classification Results[b]

	day_flax	Predicted Group Membership					
		0	1	2	3	4	Total
Original Count	0	22	0	0	0	0	22
	1	2	13	6	0	0	21
	2	0	7	13	6	3	29
	3	0	4	10	5	4	23
	4	0	4	9	3	6	22
	Ungrouped cases	0	225	0	0	0	225
%	0	100,0	,0	,0	,0	,0	100,0
	1	9,5	61,9	28,6	,0	,0	100,0
	2	,0	24,1	44,8	20,7	10,3	100,0
	3	,0	17,4	43,5	21,7	17,4	100,0
	4	,0	18,2	40,9	13,6	27,3	100,0
	Ungrouped cases	,0	100,0	,0	,0	,0	100,0

a. 50,4% of original grouped cases correctly classified.

Classification Results[b]

	day_lentil	Predicted Group Membership					
		0	1	2	3	4	Total
Original Count	0	21	0	0	0	0	21
	1	0	11	3	7	0	21
	2	0	3	14	3	0	20
	3	0	1	4	12	6	23
	4	0	0	2	6	14	22
	Ungrouped cases	0	0	0	235	0	235
%	0	100,0	,0	,0	,0	,0	100,0
	1	,0	52,4	14,3	33,3	,0	100,0
	2	,0	15,0	70,0	15,0	,0	100,0
	3	,0	4,3	17,4	52,2	26,1	100,0
	4	,0	,0	9,1	27,3	63,6	100,0
	Ungrouped cases	,0	,0	,0	100,0	,0	100,0

a. 67,3% of original grouped cases correctly classified.

Table 1. Classification results of the germinated brown rice, flaxseed and red lentils (PQS quality points, point method)

4. CONCLUSIONS

The NIR is a useful tool for following the changes which occur during the germination of different seed samples. Using the polar qualification system for the evaluation of the spectral data of germinated brown rice, flaxseed and red lentil samples some differentiation could be done. Our findings showed that this method was suitable to follow the changes during the germination period, especially in the case of red lentils (67.3% of the original grouped cases correctly classified). Classification of the flaxseed samples at different germination days was the least successful (50.4% of the original grouped cases correctly classified).

Our further aim is to narrow the spectra to the wavelength of the protein responses, and to repeat the calculations with these data.

5. ACKNOWLEDGEMENTS

The authors gratefully acknowledge Bence Tóth Kovács and Gábor Sütő and Attila Fogarassy for their contribution in the samples preparations.

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