Near infrared spectrometric analysis of egg products

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Introduction

So far, egg product manufacturers are missing possibilities for fast raw material control because the usual refraction measurements do not allow for conclusion on the actual composition of egg products. As a result, deficits exist for an up-to-date necessary quality assurance and for the option of market-focused product diversifications. Therefore, fast near infrared (NIR) analysis methods should be developed and tested with the intention of considering the different spectral influences which may be caused, for example, by eggs from different origins, qualities and thermal treatments.

Material and methods

Liquid shell egg samples from nine genetic origins (hens): Lohmanns Selected Leghorn, Bovans White, Hisex White, Super Nick White, Lohmanns Brown, Tetra SL, Brown Nick, Hisex Brown and ISA Brown and sample mixtures from yolk, egg white and water. These samples were taken from representative collectives of four commercial size assortments and collectives of five storage conditions (fresh to 28 d / 6 and 20°C). Missing and different carotinoid additives (6) in the chicken feed were taken into account too as well as different (3) laying cycle (hen ages) and even thermal treatments (up to the p-values of the usual pasteurisation).

The reference analysis was done according to the (German) ASU methods; the NIR spectra (reflexion) are determined by spectrometer Bruker 22N/I; 3500–12000 cm^{-1}; software: OPUS NT and FT-NIR spectrometer Büchi; 4000–12000 cm^{-1}; software NIRCAL 4.01; PLS algorithms; temperature controlled sample measurement (24°C).

Results

Spectacularly, it was found that no spectral distinction was possible between the homogenised widely varying samples of liquid whole egg determined by cluster analysis (Ward's and Single Linkage). It was shown that these samples cannot be differentiated spectrally; that means results of the spectral data after mathematical treatment.

These crucial initial findings were exemplarily validated for the thermally-treated whole egg samples with the inspection devices used thereby. The graphs (Figure 1) show the development of P-effect over process time with different target temperatures varied effecting the "slope" of graph (selected examples shown).

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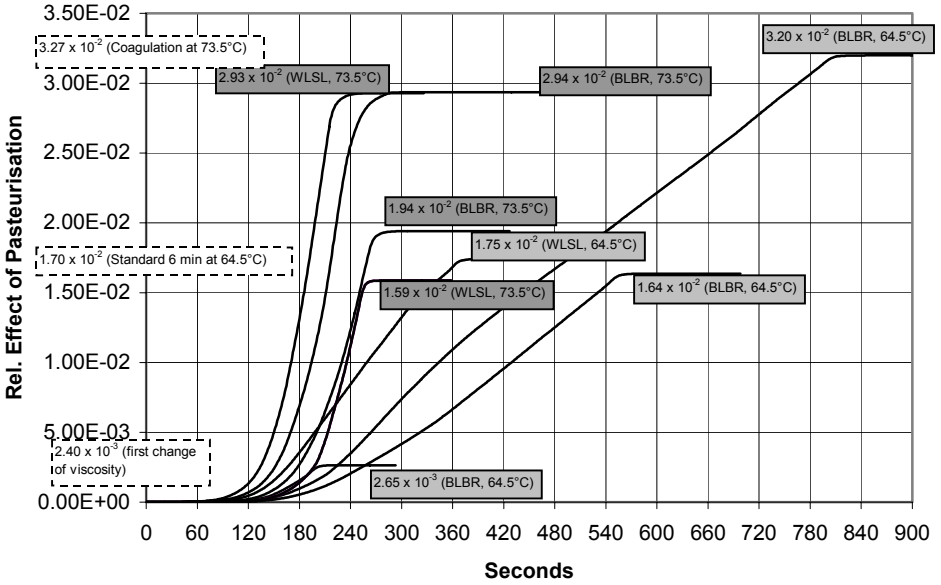

Figure 1. Relative pasteurisation (P-)effect (relative to 1 min at 90°C) on liquid whole egg heated to different target temperature (at 6 K min^{-1}) while stirring (100 g sample, final cooling in ice bath down to 24°C); genetic origins (hens): WLSL: Lohmannns Selected Leghorn; BLBR: Lohmanns Brown.

These heat processed samples were tested for spectral changes due to the intensity of thermal treatment and the results are shown exemplarily in Figure 2. The tested samples are characterised by the different pasteurisation (P-)effects.

No pattern related to test conditions can be established (Figure 2): It is not possible to distinct samples of both target temperatures and it is proved that samples of very different thermal treatment seem randomly distributed within the individual clusters. Even a P-value of $>> 3.6 \times 10^{-2}$ does not cause a sample distinction. This leads to the conclusion that no separate calibration model is mandatory for heat treated liquid whole egg. One single calibration set for native and heat treated samples will be sufficient.

Thus, no separate NIR method developments for the respective sample collectives had to take place in each case and all egg origins and qualities can be covered by one single NIRS method which could be applied by all prospective users.

The data records which were established by the united sample material were used as basis of NIR method developments. The sets were additionally extended with the data of model mixtures. These models remained spectrally inconspicuous within the test collectives. This fact allowed to expand the concentration spans sufficiently for the five egg constituents which are to be determined. Table 1 displays the properties of the sample set used for method developments.

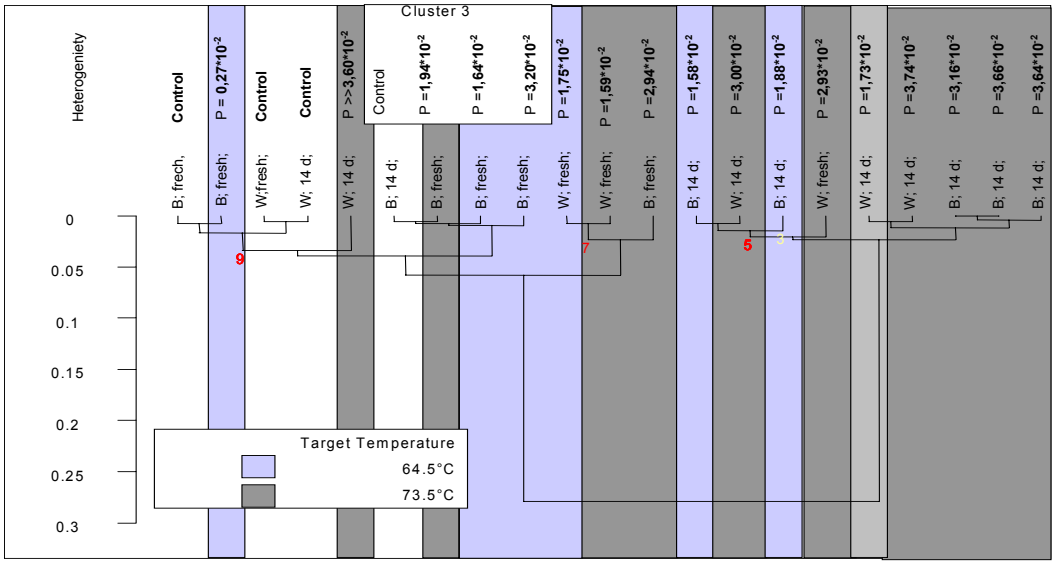

Figure 2. Cluster analysis (Ward's algorithm): spectra of heat treated liquid whole egg (Lohmanns Brown (B) and Lohmanns Selected Leghorn (W), fresh and after 14d storage; Bruker FT-NIR spectrometer Vector 22 N. Opus NT).

Table 1. Properties of the calibration and validation sample sets.

Calibration set, samples of liquid shell egg (*n*) and model mixtures (*m*)					Validation set, samples of liquid shell eggs (*n*)			
Constituent	*n* + *m*	Range (g 100 g^{-1})	Mean (g 100 g^{-1})	*SD*	*n*	Range (g 100 g^{-1})	Mean (g 100 g^{-1})	*SD*
Dry matter	140+39	17.3–44.4	25.7	4.49	43	21.4–26.2	24.2	0.95
Crude protein	145+47	7.0–15.2	12.3	1.16	41	10.8–13,7	12.3	0.57
Fat	140+48	2.7–28.7	11.8	4.30	43	9.1–13.0	11.0	0.70
Cholesterol	138+48	0.076–0.993	0.43	0.15	42	0.34–0.46	0.40	0.02
Lecithin phosphate	136+48	0.067–0.825	0.35	0.122	42	0.28–0.37	0.32	0.02

Table 2 gives an overview of the achievable performance parameters for the NIR analysis of liquid shell eggs: The obtained NIR methods are to be regarded as robust and efficient and the most important *SEP* values are to be satisfactory compared to the performance characteristics of wet chemical reference analysis.

Method testing was performed in two egg product manufacturing companies. With these NIR method for whole egg (together with the appropriate conditions for egg white and egg yolk as well

as the relevant data to whole egg powder) the egg product manufacturers command the option of a fast and economical process and product control.

Therefore, now these product ranges can be represented by exact content specifications. Product adjustment (to the needs of the sweets, deli and pasta manufacturers) can take place and these price-oriented diversifications of respective products (defined tolerance margins of individual compositions) are possible.

Table 2. Achievable NIRS-performance parameters for liquid shell egg.

Constituent	R^2_{cal}	*SECV* (g 100 g^{-1})	R^2_{val}	*SEP* (g 100 g^{-1})	Bias
Dry matter	0.99	0.43	0.86	0.35	< 0.1
Crude protein	0.79	0.50	0.60	0.36	< 0.1
Total fat	0.99	0.40	0.83	0.28	< 0.1
Cholesterol	0.98	0.019	0.57	0.015	< 0.001
Lecithin phosphate	0.98	0.015	0.60	0.015	< 0.001

All depends on the fact that the egg product manufacturers note their chance in face of the European competitors and start the investments of an NIR measuring set-up despite the miserable market situation for egg products at present.

Acknowledgement

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