Using of infrared reflectance spectra of sunflower meal for determination its moisture content

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ABSTRACT

In this work we have studied the near-infrared reflectance spectra of sunflower meal to develop of calibration equation for moisture content determination. Sunflower meal samples with different humidity that varied from 5 to 19 % were investigated. Investigations were carried out on the spectrometer „Infrapid - 61" in the range of wavelength 1330-2370 nm through 10 nm. It was detected that 1460 and 1930 nm wavelengths are characteristic for moisture content determination of sunflower meal using reflectance coefficient. Analysis of first and second derivatives from the optical density spectra gave possibility to detect their characteristic wavelengths, which were moved to low wavelengths region and were located at 1400 and 1890 nm for the first derivative of the optical density spectra and at 1370 and 1860 nm – for the second derivative of the optical density spectra. Calibration equations are developed and value of probable approximation are obtained. It is possible to determine moisture content of sunflower meal using wavelength mentioned above.

Introduction

Oil seed cake and meal are the products of their processing with recovering of oil by pressing or solvent extraction respectively. These products contain proteins, fibers, vitamins, minerals and are the important source of feed and edible proteins and are used also directly as feedstuff [1, 2]. Moisture of meal and cake is an important parameter that determined their quality during storage.

Near-infrared reflectance spectroscopy is widespread used now for determination of moisture content in pharmaceutical pellets [3], foliage [4] and other agricultural and food foods [5]. This technique is an informative, rapid and gives possibility to analyze chemical composition of different objects [6 – 10].

Low absorption in near-infrared region and using of diffusion reflectance of samples gives possibility for direct analysis of product and determination in a wide concentration range. This technique does not require complex and continuous sample preparing. The principle of this method is a comparison of spectral properties of investigated sample with a such spectral properties of samples with known chemical composition (standards). That is why using of this methods requires calibration and development of calibration equation on the base of near-infrared reflectance spectra measurement of standards samples.

In this work we have studied the near-infrared reflectance spectra of sunflower meal to develop of calibration equation for moisture content determination.

Material and methods

Sunflower meal near-infrared reflectance spectra at the range of λ = 1330–2370 nm were measured on the infrared spectrometer „Infrapid-61". The spectra were measured through every 10 nm.

The samples were grinded on the lab mill and sifted through the 1 mm hole diameter sieve. Samples with the moisture content from 5 to 19 % were preparing by drying and moistening of industrial sunflower meal. Humidity of series of samples for calibration were determined by drying of samples to the constant mass [SStU ISO 771].

Results and discussions

Near-infrared reflectance spectra of sunflower meal samples with different humidity are given on the Fig.1. It is known that near-infrared spectrum of water has number of characteristic absorbance band and their intensity is used for moisture determination [A.A. Avramenko, M.P. Esel'son, A.A. Zaika. Infrakrasnye spektry pishhevyh produktov. M., 1974]. The main absorbance band of water corresponds to main molecule vibration and is located in the 6000 nm region. Combinational vibration of –OH group is at the λ = 1930 nm and the valence vibration (the first overtone) is at λ = 1450 nm. That is why these wave lengths are used for moisture determination.

According to this characteristic minima of reflectance spectra intensity are in the range λ = 1460–1490 nm and at 1930 nm (Fig. 1). Analysis of reflectance spectra of sunflower meal samples with different humidity have shown that reflectance coefficient increases with decrease of moisture content. Besides that minimum of reflectance intensity in the range λ = 1460–1490 nm is moving to low wave region. Reflectance spectra namely at the λ = 1930 nm are usually using for moisture determination in different dry products (milk powder, seed, flour, hops etc.) [Patent 62607 Ukraine]

After determination of characteristic wave lengths the next stage was development of calibration equation and determination of correlation coefficient (Fig. 2).

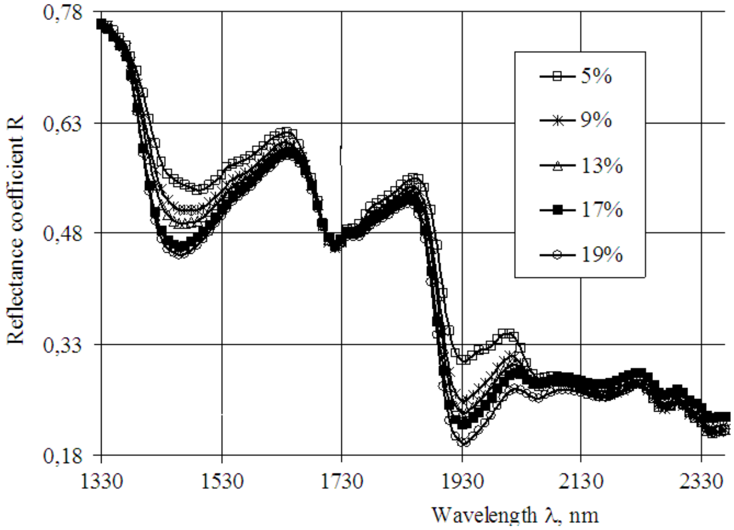

Fig. 1. Dependence of near-infrared reflectance spectra of sunflower meal samples from their humidity

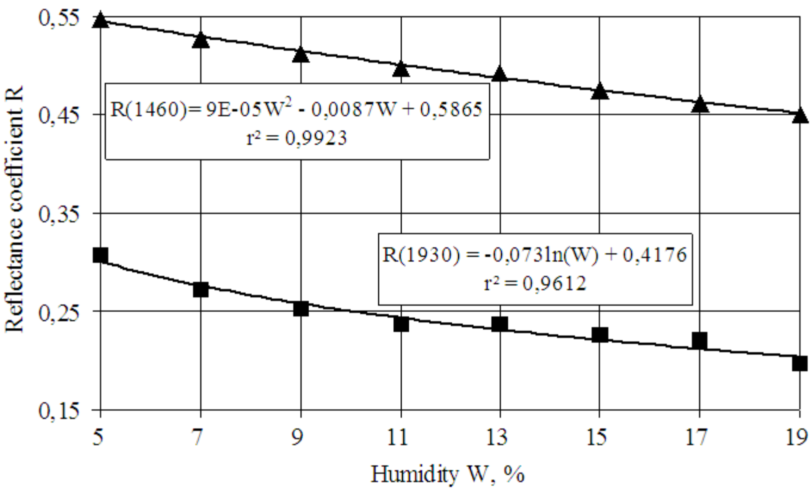

Fig.2. Dependence of the reflectance coefficient from moisture content in sunflower meal

The one calibration equation is calculated for dependence of the reflectance coefficient at 1460 nm from moisture content. This is the polynomic dependence with the assured probability of 99 %. Another one is logarithmic curve and is a dependence of the reflectance coefficient from moisture content at 1930 nm with an assured probability of 96 %.

NIR spectrometer that was used calculates also first (D') and second (D'') derivatives from the optical density spectra. Obtained function are shown on the Fig. 3 and 5. Extremum position on these curve are moved to low wave region in comparion to reflectance spectra. The main extrema of first derivative are at 1400 and 1890 nm.

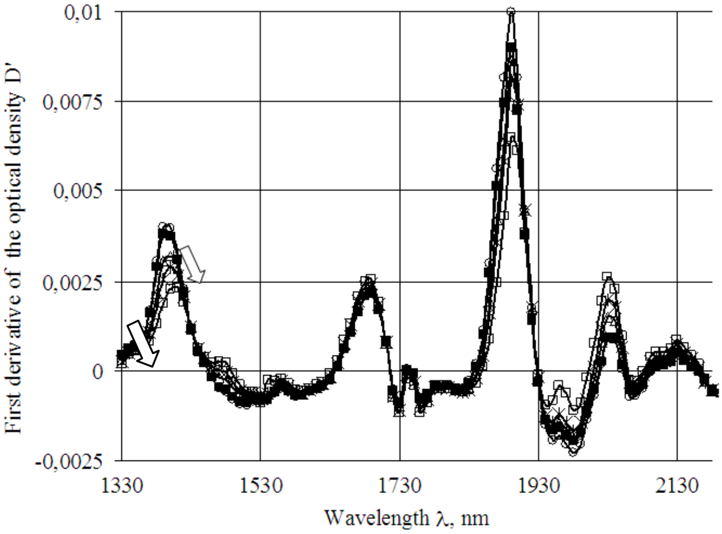

Fig. 3. First derivative of the optical density spectra of sunflower meal samples with different humidity

Calibration equation calculated on the base of first derivative spectra are shown on the Fig. 4. These are almost linear dependence and have highest assured probability that is 99 % at 1400 nm and 97 % at 1890 nm.

It is known that the second derivative (D") of the optical density are used more often for determination of chemical composition [5]. We have calculated the second derivative of the optical density of our samples and have detected that extremum position on these curve are moved to low wave region in comparison with reflectance spectra too. They were located at 1370 and 1860 nm (Fig.5).

Calibration equations calculated on the base of second derivative spectra are shown on the Fig. 6. They reflect a linear dependence of second derivative of the optical density from humidity of sunflower meal. The assured probability of this equation is very high (98 % at 1370 and 98 % at 1860 nm).

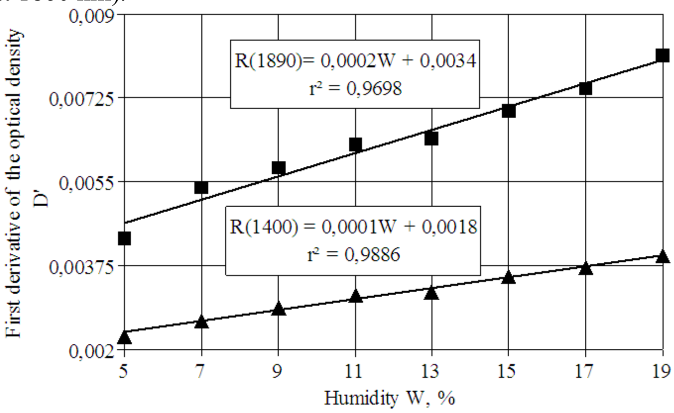

Fig. 4. Dependence of first derivative of the optical density from humidity of sunflower meal

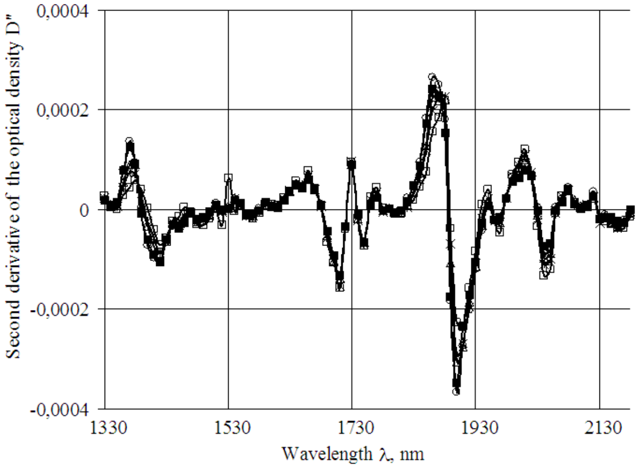

Fig. 5. Second derivative of the optical density spectra of sunflower meal samples with different humidity

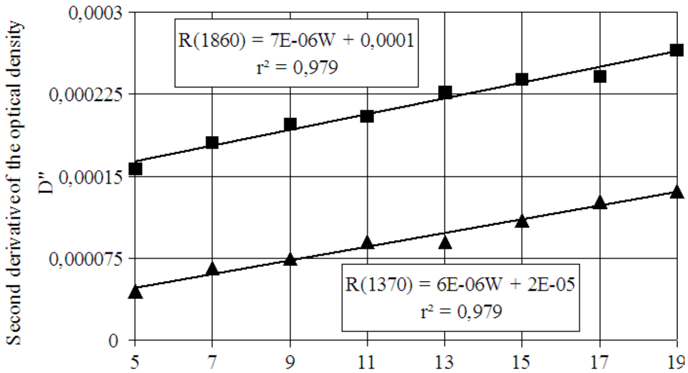

Fig. 6. Dependence of second derivative of the optical density from humidity of sunflower meal

Conclusions

In this study we have analyzed the reflectance spectra in near-infrared region of sunflower meal and detected characteristic reflectance band for humidity determination. They are located at 1460 and 1930 nm for reflectance coefficient spectra, at 1400 and 1890 nm for the first derivative of the optical density spectra and at 1370 and 1860 nm – for the second derivative of the optical density spectra. But the highest precision of analyses with linear dependence was observed under measuring of first and second derivatives of the optical density. It is possible to determine moisture content of sunflower meal using wavelength mentioned above.

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