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Development of Spectral Sensors for Nitrite Content in Edible Bird's Nest

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ABSTRACT
Indonesia is the first exporter of edible bird's nest commodities to China. Therefore, the Agricultural Quarantine Agency is one of the agencies responsible for ensuring the fulfilment of the requirements requested by China. One of these conditions is the upper limit of nitrite content in edible bird's nest commodities. This paper contains the results of research aimed at developing a spectral-based sensor to detect the upper limit of nitrite content and quantitatively measure nitrite content in edible bird's nest commodities. This spectral sensor is applied to the inspection process for edible bird's nest commodities which must meet export requirements to China. The objective of this research is to find the spectrums capable of significantly measuring nitrite levels around the required maximum value of 30 PPM. The experimental methodology started by testing 18 spectrum channels to study their effect on nitrite content in edible bird's nest commodities. The spectrum channels used are in the range from 410 nm to 940 nm with an accuracy of ±12%. The edible bird's nest commodity that was tested, was pre-treated by pre-conditioning it by making it into a powder so that the level of homogeneity of the nitrite measurement in the edible bird's nest commodity increased. The results showed that three response frequencies were the most dominant and had a major influence on the results of the measurement of nitrite content in edible bird's nest commodities around the required maximum value of 30 PPM. The three spectrum channels have wavelengths values of w_1=410 nm, w_2=435 nm, and w_7=560 nm. The three wavelengths mathematically have a linear relationship to the nitrite value measured with an average error value of about 1.88%.

Keywords: *Spectral sensor, edible bird's nest, spectrum, nitrite.*

1. BACKGROUND

Edible bird's nest is one of Indonesia's mainstay export commodities. 90% of Indonesia's Edible bird's nest market is China and the rest is absorbed by the Hong Kong, Singapore, US, and Vietnam markets. Exports of edible bird's nest commodities to China began directly with the signing of a protocol on hygiene, quarantine, and inspection requirements for the importation of edible bird's nest products from Indonesia to China. The signing of the protocol was carried out between the Ministry of Agriculture of the Republic of Indonesia and the General Administration of Quality Supervision, Inspection, and Quarantine of the People's Republic of China in Beijing on April 24, 2012. Therefore, the Agricultural Quarantine Agency as one of the agencies responsible for ensuring the fulfilment of the requirements requested by China strives to meet the requirements set requested.

The main requirements that must be met so that Indonesia's edible bird's nest commodity can be exported to China are (1) traceability, (2) clean with nitrite content below 30 PPM, and (3) has been processed through heating at 70 ^oC for 3.5 seconds.

With the development of a sensor-based nitrite measurement technique in edible bird's nest commodities, the benefits of ease and speed in the inspection process will be obtained. In addition, it is also hoped that there will be no risk of rejection of Indonesian edible bird's nest products because the nitrite content exceeds the maximum allowable limit.

2. LITERATURE REVIEW

2.1. Nitrate Detection Study

Different chemical states of nitrogen exist in various freshwater and marine ecosystems. The nitrate ion is one of the most toxic types of water-soluble nitrogen. The development of an effective and convenient sensing method for continuously detecting nitrite concentrations has been of widespread concern. A near-infrared fluorescent probe shows excellent selectivity and high sensitivity for the detection of nitrite [1]. In addition, the use of unit copper nanowire electrodes sprayed with a thin gold film can be used as a nitrate sensor [2].

Another study with near-infrared spectroscopy was able to detect total nitrogen, ammonia nitrogen, and nitrogen nitrite using a spectral range from 4000 cm^{-1} to 12500 cm^{-1} [3]. The use of ion-selective electrodes and infrared spectroscopy to detect nitrite is also used in conjunction with portable sensors, machine learning, and internet methods to predict 'hot spots' and 'hot moments' in agroecosystems [4]. Another study demonstrated the feasibility of using hyperspectral imaging in the 900 nm to 1700 nm region [5]. There is also a study using a biosensor based on covalently immobilized haemoglobin (Hb) on a succinimide-activated poly (n-butyl acrylate)-graphene composite film [poly(nBA)-rGO] deposited on a carbon-electrode-printed paste (SPE) screen [6]. Microsphere-based opto sensors were developed using microspheres for $NO2^{-}$ ion quantization and were constructed using immobilized Raoutella planticola (R. planticola), a bacterium that expresses the enzyme NAD(P)H nitrite reductase (NiR), isolated from local edible birds' nests through microbial techniques. [7].

2.2. Edible Bird’s Nest

Edible bird's nest is recognized as a nutritious food among the Chinese. The efficacy of edible bird's nest is stated in traditional Chinese medicine records and its activity has been reported in many studies. Indonesia is the first largest edible bird's nest exporter in the world. For years, edible bird's nest trade to China was not regulated until August 2011. China banned imports of edible bird nests due to high nitrite levels. Possible sources of contaminants can come from swiftlet and swiftlet farms or those that enter during the processing, storage, and transportation of edible bird nests. The design and management of the swiftlet house, as well as the processing of edible bird's nests, affect the quality of the edible bird's nest. The decrease in optical quality has an impact on the selling price, and the colour change is bound to the nitrite content [8]. Overall findings indicate that edible birds' nest quality varies according to production, species, and geographic origin [9]. The researchers identified several approaches to detect and authenticate edible bird nests using advanced technology and sophisticated instrumentation. The approach was enhanced by specific chemometric analysis, which resulted in convincing and reliable data [10] in anticipation of very high market response and fake EBNs starting to appear in the market. So, the problem of authentication is also very necessary [11].

3. OBJECTIVES

This paper contains the results of research at developing a spectral sensor to detect the upper limit of nitrite content and quantitatively measure nitrite content in bird's nest content. This spectral sensor is applied to the inspection process for edible bird’s nest commodities which must meet export requirements to China. The purpose of this study was to find a spectrum capable of significantly measuring nitrite levels around a minimum value of 10 PPM and a maximum value of 30 PPM.

4. METHODOLOGY

The experimental methodology began by testing the response of the 18-channel spectral sensor to study its effect on the nitrite content of edible bird's nest commodities. The spectral sensor used is from a wavelength of 410 nm up discretely by 18 levels up to 940 nm with an accuracy of ±12%. The edible bird’s nest commodities tested were conditioned by making them in powder form to increase the level of homogeneity of the measurements. The 18 spectral channel was chosen because of the availability of component technology that can be used optimally by considering the costs involved in this test. Technically, these 18 spectral channels have covered all the expected spectral requirements.

Furthermore, the eighteen spectral channels will detect the intensity of the reflected light. The intensity is then compared against the reference value. The reference value is a standard nitrite solution whose value has been determined through enhanced laboratory measurements. Through testing the Pearson's correlation coefficient value, the correlation coefficient value for each channel will be obtained. The spectrum of the channel that has a very strong correlation coefficient with the reference value will be the coefficient constant in the multiple linear regression equation.

5. RESULTS

Figure 1 shows the spectral sensor device resulting from the development of research activities, which consists of two parts, namely (1) the sensor section and (2) the processor section. The sensor section is capable of transmitting 18 spectrum channels at once.

The sensor is connected to the processor via a USB cable. The eighteen spectral data are then processed by the processor, as shown in Figure 2. The object to be measured is placed under the sensor and by pressing push bottom capture, then the sensor will send data to the processor. The data sent is then analysed statistically using Pearson's correlation coefficient.

Figure 1 Spectral sensor device developed from research results. (1) Sensor, (2) Processor.

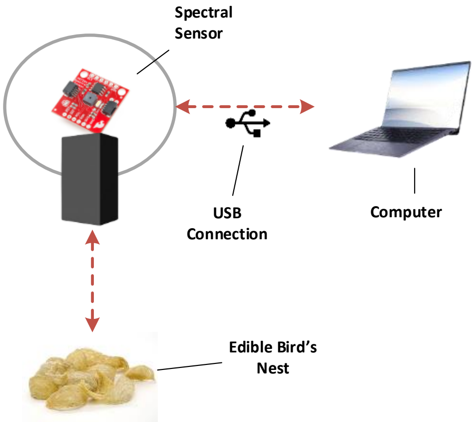

Figure 2 Diagram of the sensor and data processing system.

Meanwhile, in Figure 3, the product of the edible bird's nest that is ready to be exported is the object of measurement in this research. There are only 3 types of edible bird's nests whose nests can be consumed and sold, namely Collocalia fuciphagus, Collocalia maximus, Collocalia esculenta. Collocalia fuchiphagus will produce a white edible bird's nest or called a silver nest, which is characterized by a yellowish-white nest, this nest can come from a cave or house. A nest from a house or building is whiter and cleaner than a nest from a cave.

Figure 3 White edible bird's nest (C. fuciphagus).

The results of the response test for 18 spectral channels are obtained as shown in Figure 4. Through the Pearson's correlation coefficient test, the three channels provide the most significant responses, namely three spectra that have a wavelength value of w1=410 nm, w2=435 nm, and w7=560 nm, as shown in Figure 5. This figure explains the relationship between the results of measurements of nitrite concentrations in edible bird's nest commodities using standard laboratory equipment compared to the results of measurements of three spectrum channels through Equation (1). The three wavelengths mathematically have a linear relationship as described in Equation (1).

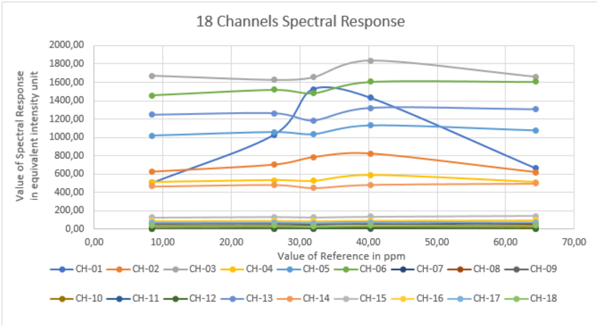

Figure 4 18 Channels Spectral Response observed.

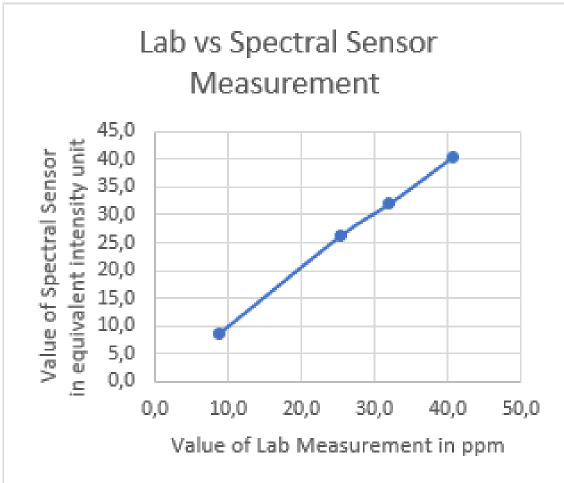

Figure 5 Measurement Result of Comparison between Lab and Three Spectral Sensors Equation.

$$N_m = 0.04w_1 - 0.16w_2 + 1.52w_3 \quad (1)$$

where:

N_m	The value of nitrite is measured by the spectral sensor.
w_1, w_2, w_7	The response value of the spectral sensor channel 1, channel 2, and channel 7.

The average error of the measurement results of the spectral sensor with the results of measurements using laboratory equipment is 1.88% as shown in Table 1, where N_m is the value of the measurement results of the spectral sensor and L_m is the measurement result of the laboratory equipment.

Table 1. Value of Lab Result vs Spectral Sensor Measurement

N_m	L_m	Error
8.7	8.5	3.38%
25.4	26.2	2.94%
32.0	31.9	0.36%
40.6	40.3	0.82%
	Mean	1.88%
	Max	3.38%
	Min	0.36%

6. CONCLUSION

The spectral sensor is very sensitive and responds well almost linearly in the 410 nm, 435 nm, and 560 nm spectrum. The initial nitrite concentration was expected to be around 10 ppm to 30 ppm, but finally, the test concentration was obtained between 8.7 ppm to 40.6 ppm. The relationship between these equations is expressed linearly by three selected spectral waves to the results of Nitrite measurements in edible bird's nest commodities, as stated in Equation (1).

7. RECOMMENDATIONS WITH RELATED REFERENCES

Total nitrogen, ammonia nitrogen, and nitrogen nitrite can be detected and measured by near-infrared spectroscopy using a back-propagation neural network in the spectral region of 4000 cm^{-1} to 12500 cm^{-1}. The six main components were extracted by a back-propagation neural network model from total nitrogen, ammonia nitrogen, and nitrite nitrogen [3]. In addition, the non-destructive hyperspectral imaging method uses hyperspectral imaging in the range of 900 nm to 1700 nm [5]. In this study, only three spectral waves of 410 nm, 435 nm, and 560 nm were proposed using a linear equation to the output of the spectral sensor.

AUTHORS' CONTRIBUTIONS

In this study, it is proposed only three waves in the violet, indigo, and yellow regions detecting the quality of edible bird's nest commodities. This wave is a wave that can be obtained relatively easily.

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