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Analytical Chemistry

Chemical Analysis of Chicken Nuggets Using Near-Infrared (NIR) Spectroscopy

Tsitsino Sikharulidze[*], Lali Tabatadze[**], Qristine Lobjanidze[**], Maka Makharoblidze[**], Darejan Gulbani[**], Indira Sharia[**], Ketevan Ebralidze[§]

[*] *Veterinary-Diagnostic Laboratory "SANA" of LTD Chirina, Tbilisi, Georgia*
[**] *Faculty of Natural Sciences, Mathematics, Technologies and Pharmacy, Sokhumi State University, Tbilisi, Georgia*
[§] *P. Melikishvili Institute of Physical and Organic Chemistry, Ivane Javakhishvili Tbilisi State University, Georgia*

(Presented by Academy Member Guram Aleksidze)

Abstract. The demand for poultry meat and meat products has been increasing in the consumer market of Georgia. According to the Food/Animal Feed Safety, Veterinary and Plant Protection Code, the information provided on the product label must be complete and understandable to consumers, which implies an increased requirement for comprehensive analysis to determine the product's chemical composition and nutritional value. Laboratory "Sana" conducts research on individual batches of meat and meat products. The study was carried out on chicken fillets and nuggets made from minced meat. For a high-quality, fast, simple, and comprehensive evaluation of meat, the modern instrumental method of Near-Infrared (NIR) Spectroscopy was used. The study confirmed the results of chemical analyses conducted using different methodologies at the testing laboratory of "Etalon" and at "Sana," and demonstrated the advantages of NIR spectroscopy: sample data are measured by a single method, the research is carried out quickly and non-destructively, less material is used for testing, and the results are almost equivalent to those obtained under various standards. For a quick, simple and comprehensive assessment of meat quality, a modern instrumental method was used – the method of NIR. The study confirmed the results of chemical analysis conducted using different methodologies in the Etalon and Sana testing laboratories, and demonstrated the advantages of the NIR method of near-infrared spectroscopy: sample data are measured using a single method, analyses are performed quickly and non-destructively, trace material is used and the results are almost identical to those obtained by other methods. © *2025 Bull. Natl. Acad. Sci. Georg.*

Keywords: macronutrients, chicken nuggets, chemical analysis, nutritional value, NIR

Introduction

The molecular diversity of biopolymers (proteins, fats, carbohydrates, and their derivatives) ensures their wide range of applications. In food technology, properties such as solubility, sweetness, hygroscopicity, as well as the texture and consistency of food are determined by the energy and nutritional values of bio-organic products (Małecki et al., 2021; Tabatadze et al., 2005; Pachulia et al., 2016). In pharmaceutical technology, macronutrients are

potentially important in the development of medicinal preparations (Sidamonidze et al., 2022; Sidamonidze et al., 2023; Tabatadze et al., 2007). Carbohydrate macromolecules, due to their biodegradability and biocompatibility, are widely used in environmental and industrial technologies. (Mtchedlishvili et al., 2024; Ramaprabla et al., 2024).

Poultry meat and its derived products represent one of the fastest-growing sectors and an efficient source of protein in the food industry, both worldwide and in Georgia. Consequently, the demand for high- quality products is increasing. The quality of the products, in turn, depends on laboratory research, well-functioning production technology, and the use of modern instrumental methods.

In recent years, the consumer market has seen an increase in the consumption of poultry products, including nuggets, which are a minced version of chicken parts coated with a breading layer. Nuggets are made from both chicken fillets and minced meat, and the demand for this product is growing accordingly (Yavari et al., 2011; Kazemi et al., 2006; Prevolnik et al., 2004). Therefore, it is important that the production of products is carried out on high-performance equipment to minimize contamination risks associated with the consumption of semi-finished products.

Since the 1990s, Near-Infrared Spectroscopy (NIR) has been one of the fastest-growing analytical techniques. NIR spectrophotometry is widely used in the analysis of food and agricultural products, medicinal products and pharmaceutical substances, quality control of industrial materials, and environmental analysis; it is also applied in the fields of chemistry, biology, medicine, and other sscientific fields. It is a rapid, non-destructive, and cost-effective analytical method that provides information on the activity of substances and the percentage of specific macronutrients in a given product.

Using NIR spectroscopy, a chemical analysis of chicken nuggets available on the Georgian consumer market was conducted, and the content of the main macronutrients in the product was determined. This method was chosen for its high accuracy, rapid result acquisition, and non-destructive nature, which is crucial in practical-technological control processes. The chemical analysis of chicken nuggets was carried out using various methods at the veterinary-diagnostic laboratories of “Etalon” and “Sana”.

Materials and Methods

Equipment and instrumentation: Near-infrared spectrometer – (NIR, Hyper Scan, Find), with specialized mini-probes, meat holders, and spatulas designed for the device. The chemical analysis was conducted using NIR in the wavelength range of 1000-1900 nanometers. The NIR spectrum is based on the overtone and combination absorptions of molecular vibrations of O–H, C–H, and N–H bonds. The NIR spectrometer features a certified robust design and uses Fraunhofer MEMS scanner lattice technology. Sample measurement begins only after turning on the instrument and a 40-minute warm-up period. The device requires reference control every 15-20 minutes, which includes two types of controls – black and white – allowing for monitoring of the measurement process. Another essential condition is the accurate input of sample characteristics before starting the measurement.

Research methodology: The use of NIR spectroscopy involves selecting the appropriate equipment, preparing the sample, collecting the spectrum, analyzing the data, and interpreting the results. NIR spectroscopy is based on the absorption, reflection, or scattering of light in the near-infrared region of the spectrum (0.75-2.5 μm) by the molecules of the sample.

Sample material: Chicken fillets and nuggets made from minced meat (fillets nuggets, nuggets with consevants, minced meat nuggets).

Chemical analysis. *Sample preparation:* The preparation of chicken nuggets begins with mincing

the meat to a size of 1-4 mm, followed by mixing in a mincing device with various flavor-enhancing additives. The next stage is nugget forming, where the mass is cut into nuggets by a forming machine. In the final step, the nuggets are coated and quickly frozen using a blast chiller. For analysis, 100 g of the nugget sample is minced using a meat grinder. Using a spatula, the sample is placed on a 94 mm glass Petri dish so that the bottom is fully covered and the dish is filled to the top. The sample is initially stored in a refrigerator at +2°C, and finally placed in the analyzer. Within a few minutes, the device provides quantitative information on the content of fat, protein, carbohydrates, and other parameters in the product.

Results and Discussion

Analysis of the study results shows that the nutritional values vary significantly among different samples (fillets nuggets, nuggets with conservans in fillets, minced meat nuggets). The fat content is highest in minced meat nuggets (9.09%) and lowest in fillet nuggets (5.36%). Protein content also increases from fillet nuggets to minced meat nuggets, indicating better meat quality. Moisture levels are almost the same across samples (68%-69%), reflecting a standard technological process. Collagen content is highest in minced meat nuggets, which is associated with meat quality and processing methods.

The variability in carbohydrate content (3.97%-6.47%) indicates diversity in product composition, influenced by different additives and coating ingredients. The energy value is highest in minced meat nuggets, which is expected due to the combined increase in fat, protein, and carbohydrate content. Based on the results, it can be concluded that fillets nuggets are the lowest-calorie and least fatty product, while minced meat nuggets are characterized by higher energy value, protein, and carbohydrate content. Variations in collagen and protein among different samples indicate that both the type of meat used and the processing technology affect the product quality. For comparison, a parallel study was conducted to determine the chemical composition of minced chicken nuggets at the “Etalon” testing laboratory (Table). The results confirmed the findings of the chemical analyses carried out at the veterinary-diagnostic laboratories of “Chirina” and “Sana.”

Table Analysis of chicken fillets, conservants and minced meat nuggets using NIR.

The chemical composition of 100 g of chicken fillet nuggets was analyzed using NIR spectroscopy (Fig.).

Table. Analysis of chicken fillets, conservants and minced meat nuggets using NIR

Chemical components of nuggets, %	Laboratory Sana			Laboratory Etalon	Methods	Instrument
	Fillet nuggets	Conservantes in Fyle’s nuggets	Nuggets of mince	Nuggets of mince		
Fat	5.36	5.86	9.09	13.0	GOST 8786.13-86	NIR
Saturated fat	1.05	1.12	1.05	1,1	SST ISO 12966-4	NIR
Protein	21.15	20.86	16.05	16.2	GOST 26889-86	NIR
Collagen	3.7	3.1	4.1			NIR
Ash	3.17	3.1	3.24	1.1	GOST 15113.8-77	NIR
Salt	1.72	1.59	1.28	0.4	GOST 23268.8-78	NIR
Moisture	69.52	68.52	68.38	69.4	GOST 9793	NIR
Carbohydrates	3.97	4.75	6.47			NIR
Sugar	0.8	1.66	3.24	0		NIR
Energy value (kcal)	148.76	155.22	176.95	181.8	MUK №294	NIR

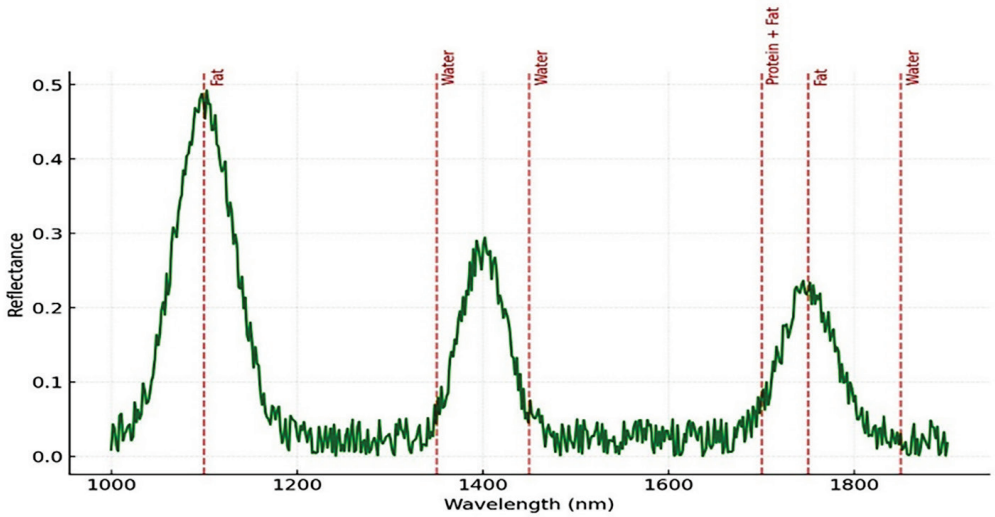

Fig. NIR spectrophotometer of chicken fillet nuggets.

Interpretation of the spectrum (1000-1900 nm range): In the 1000-1200 nm region – a sharp peak of fat molecules at 1100 nm. In the 1200-1400 nm region – low water absorption (O–H bonds) is observed. In the 1400-1500nm region – strong water absorption is observed. Since the water content in chicken fillet is high (~70%). In the 1700-1800nm region – a specific absorption zone of proteins and fats is observed at 1750 nm.

Conclusion

The chemical analysis of nuggets demonstrated that NIR spectroscopy allows non-destructive testing and enables the determination of key macronutrients (moisture, protein, fat, and carbohydrates) in the product within a very short time.

The study at the testing laboratory “Etalon” conducted from 03.03.2025 to 11.03.2025. Each sample parameter was determined separately according to the relevant standards. The use of independent standards required a significant amount of time, and only a limited number of parameters could be measured, resulting in incomplete knowledge about the product. In contrast, at the “Sana” laboratory all parameterswere analyzed on 03.03.2025 and completed the same day, which significantly reduced both time and resource expenditure.

ანალიზური ქიმია

ქათმის ნაგეთსის ქიმიური ანალიზი ახლო ინფრაწითელი (NIR) სპექტროსკოპიის გამოყენებით

ც. სიხარულიძე*, ლ. ტაბატაძე**, ქ. ლობჟანიძე**, მ. მახარობლიძე**, დ. გულბანი**, ი. შარია**, ქ. ებრალიძე§

* *ვეტერინარულ-დიაგნოსტიკური ლაბორატორია „სანა", თბილისი, საქართველო*
** *სოხუმის სახელმწიფო უნივერსიტეტი, საბუნებისმეტყველო მეცნიერებათა, მათემატიკის, ტექნოლოგიებისა და ფარმაციის ფაკულტეტი, თბილისი, საქართველო*
§ *ივანე ჯავახიშვილის სახ. თბილისის სახელმწიფო უნივერსიტეტი, პეტრე მელიქიშვილის ფიზიკური და ორგანული ქიმიის ინსტიტუტი, საქართველო*

(წარმოდგენილია აკადემიის წევრის გ. ალექსიძის მიერ)

სასურსათო პროდუქტების უვნებლობა და მისი მართვა საერთაშორისო მნიშვნელობის საკითხია. მაკრონუტრიენტები განსაზღვრავს კვების პროდუქტების ენერგეტიკულ და კვებით ღირებულებას, უზრუნველყოფს პროდუქციის ხარისხსა და უვნებლობას. ნაშრომში აღწერილია სხვადასხვა სახეობის ნაგეთსის შედარებითი შეფასება. კვლევის აქტუალობა განპირობებულია სურსათის უვნებლობისა და ხარისხის კონტროლის მზარდი მოთხოვნებით, რაც კრიტიკულად მნიშვნელოვანია კვების მრეწველობასა და სამომხმარებლო ბაზარზე ხორც-პროდუქტების უსაფრთხოებისთვის. პროდუქციის ტექნოლოგიური და კვებითი ღირებულების ხარისხის სტაბილურობისათვის ახლო ინფრაწითელი სპექტროსკოპიით (NIR) ჩატარდა ქიმიური ანალიზი (ტენიანობა, ცილები, ცხიმები და ნახშირწყლების რაოდენობრივი განსაზღვრა). სხვადასხვა ლაბორატორიაში გამოყენებულმა კვლევამ აჩვენა ახლო ინფრაწითელი სპექტროსკოპიის უპირატესობა, რომ თანამედროვე NIR მეთოდი მეტად ეკონომიური და ტექნოლოგიურად მაღალეფექტუნარიანია. კვლევაში ცალსახა იყო ვადების მონიტორინგი, რაც გავლენას ახდენს პროდუქტის ხარისხის მაჩვენებელზე.

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