Ability of NIR spectroscopy to predict meat chemical composition and quality – a review

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ABSTRACT: In contrast to conventional methods for the determination of meat chemical composition and quality, near infrared spectroscopy (NIRS) enables rapid, simple and simultaneous assessment of numerous meat properties. The present article is a review of published studies that examined the ability of NIRS to predict different meat properties. According to the published results, NIRS shows a great potential to replace the expensive and time-consuming chemical analysis of meat composition. On the other hand, NIRS is less accurate for predicting different attributes of meat quality. In view of meat quality evaluation, the use of NIRS appears more promising when categorizing meat into quality classes on the basis of meat quality traits for example discriminating between feeding regimes, discriminating fresh from frozen-thawed meat, discriminating strains, etc. The performance of NIRS to predict meat properties seems limited by the reliability of the method to which it is calibrated. Moreover, the use of NIRS may also be limited by the fact that it needs a laborious calibration for every purpose. In spite of that, NIRS is considered to be a very promising method for rapid meat evaluation.

Keywords: NIR spectroscopy; meat chemical composition; meat quality

CONTENTS

1. Introduction

Near infrared spectroscopy (NIRS) is an analytical technique that uses a source producing light of known wavelength pattern (usually 800–2 500 nm) and that enables to obtain a complete picture of the organic composition of the analysed substance/material (Van Kempen, 2001). It is based on the principle that different chemical bonds in organic matter absorb or emit light of different wavelengths when the sample is irradiated. Nowadays NIRS is widely and successfully used in many different fields, also for feed and food analysis. NIRS offers a number of important advantages over conventional methods such as rapid and frequent measurements, fast and simple sample preparation, suitability for on-line use and simultaneous determination of different attributes. The main disadvantages of the method

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are its dependence on reference method, weak sensitivity to minor constituents, limited transfer of calibration between different instruments and complicated spectral data interpretation (Büning-Pfaue *et al*., 2003). In forage analysis, the transfer has been shown to be limited for calibrations obtained on material of different origin (Míka *et al*., 2003). Although the first attempts to use the method were done more than forty years ago, the majority of research work on meat was carried out in the past decade (Byrne *et al*., 1998). In spite of its great potential for the assessment of meat quality for industrial use, studies attempting to prepare calibration for the on-line use are not very frequent. In published studies, most attention has been paid to the investigation of the ability of NIRS to predict meat chemical composition and meat quality traits in different species. For pork, the majority of research aimed at evaluating the possibility of determination of meat technological quality or its indicators (pH, water-holding capacity) and meat chemical composition, i.e. intramuscular fat, protein and moisture content (Brøndum *et al*., 2000b; Meulemans *et al*., 2003; Geesink *et al*., 2003). Most studies carried out on beef were focused on meat chemical composition and tenderness, which is the most important sensory attribute affecting consumers' acceptance of beef (Hildrum *et al*., 1994; Byrne *et al*., 1998; Park *et al*., 1998; Leroy *et al*., 2003; Liu *et al*., 2003). The research was also conducted on meat of other species e.g. poultry meat (Valdes and Summers, 1986; Cozzolino *et al*., 1996) and lamb (Cozzolino *et al*., 2000) assessing NIR performance for the determination of chemical composition and some quality characteristics of meat. Only few studies exist dealing with the ability of NIRS for the categorisation of meat such as discriminating strains (Fumière *et al*., 2000), discriminating feeding regimes (Cozzolino *et al*., 2002a), detecting frozen-thawed meat (Thyholt and Isaksson, 1997) and finding RN^-gene carriers (Josell *et al*., 2000).

Modern NIRS equipment offers different statistical (regression) methods to prepare calibrations (equations); multiple linear regression, partial and modified partial least square (PLS), principal component (PCR) and also a new technique that allows for non-linear relationship, neural networks (i.e. Win ISI, Infrasoft International, LLC, 2000). In the initial studies (Valdes and Summers, 1986; Eichinger and Beck, 1992) samples were separated in two sets: calibration and prediction set. In contrast to this, the software of modern instruments like WinISI estimates the prediction accuracy by means of cross-validation using the same sample set which was previously used for the calibration. Cross validation is a method where each sample in the calibration is predicted; prediction sets are made by removing one (or more) sample from the calibration set and the process is repeated until all samples have had one turn in a prediction set. Error of cross-validation thus represents a true estimate of the prediction accuracy. The prediction ability of NIRS is generally judged by statistical parameters: coefficient of determination (R^2) and standard error (SE) of calibration and/or prediction.

According to the researchers NIRS is considered as one of the most promising techniques for evaluating meat quality. In the present article we would like to make an overview of published researches that dealt with the ability of NIRS to predict different meat properties.

2. Ability of NIRS to predict meat chemical composition

The ability of NIRS to predict chemical composition of meat was examined by a number of researchers. To date, numerous calibrations have been developed for analysing beef (Eichinger and Beck, 1992; Tøgersen *et al*., 2003; Alomar *et al*., 2003), pork (Tøgersen *et al*., 1999; Brøndum *et al*., 2000b) and poultry meat (Valdes and Summers, 1986; Renden *et al*., 1986; Abeni and Bergoglio, 2001). There are also a few studies made on rabbit (Masoero *et al*., 1994) and lamb meat (Cozzolino *et al*., 2000). While the majority of the studies focused on predicting one or more major ingredients such as fat, moisture and protein (Cozzolino *et al*., 1996; Tøgersen *et al*., 1999; Cozzolino *et al*., 2000), some of them aimed at determining collagen (Young *et al*., 1996; Alomar *et al*., 2003), ash (Masoero *et al*., 1994; Alomar *et al*., 2003), fatty acids (Windham and Morrison, 1998; Molette *et al*., 2001; Ripoche and Guillard, 2001; Gonzales-Martin *et al*., 2002) and cholesterol (Masoero *et al*., 1994).

The ability of NIRS to predict (expressed in terms of R^2 and SE) chemical composition of meat (fat, protein, moisture content) gathered from different studies is summarised in Table 1. Depending on the study, the results for prediction ability are either obtained on prediction sample set or by cross-validation on the same, calibration sample set; in some studies only calibrations were made. Based on the

Table 1. The review of the published results on accuracy of NIRS (determination coefficients – R^2 and standard errors – SE) for the determination of meat chemical traits

Meat	Parameter	Calibration		Prediction		Reference
		R^2	SE	R^2	SE	
Poultry						
chicken carcass	fat in DM (%)	0.91	2.48	0.68	2.32	Valdes and Summers (1986)
	protein in DM (%)	0.98	0.94	0.91	1.03	
breast muscle	fat in DM (%)	0.78	3.54	0.60	3.26	
	protein in DM (%)	0.85	2.67	0.73	2.04	
Poultry	fat (%)	0.92	1.29	0.96	0.92	Renden *et al*. (1986)
dwarf hens' carcasses	moisture (%)	0.94	1.01	0.95	0.95	
Beef – LD						
homogenized	fat (%)	0.98	0.31	0.98	0.28	Eichinger and Beck (1992)
intact	fat (%)	0.85	1.03	0.81	0.90	
Poultry	fat (g/kg)	0.95	4.55			Cozzolino *et al*. (1996)
chicken thigh and	protein (g/kg)	0.98	2.11			
breast muscles	moisture (g/kg)	0.96	2.40			
Sheep SM and BF	collagen (%)	0.29	0.06–0.18			Young *et al*. (1996)
	collagen solubility (%)	0.50–0.83	1.19–5.36	> 0.6	1.33–2.95	
Beef, pork	fat (%)	0.76–0.86	1.40–1.48	0.88–0.96	0.82–1.49	Tøgersen *et al*. (1999)
ground meat	protein (%)	0.38–0.61	0.56–0.78	0.46–0.81	0.35–0.70	
	moisture (%)	0.71–0.86	1.09–1.25	0.85–0.92	0.94–1.33	
Pork LD and ST	fat (%)	0.49	1.32			Brøndum *et al*. (2000b)
	water (%)	0.21	1.13			
Lamb – six muscles						
homogenized	fat (g/kg)	0.73	4.4	0.71	4.7	Cozzolino *et al*. (2000)
	protein (g/kg)	0.83	5.0	0.79	5.5	
	moisture (g/kg)	0.76	9.4	0.72	10.4	
intact	fat (g/kg)	0.34	6.9	0.19	8.1	
	protein (g/kg)	0.71	6.6	0.50	8.8	
	moisture (g/kg)	0.55	12.9	0.36	15.5	
Beef – LD	fat (%)			0.61–0.72	1.2–1.4	Rødbotten *et al*. (2000)
Poultry						
breast muscle	fat in DM (%)	0.98	0.20	0.97	0.24	Abeni and Bergoglio (2001)
Beef – LD						
homogenized	fat (g/kg)	0.92	43.3			Cozzolino *et al*. (2002b)
	protein (g/kg)	0.71	20.5			
	moisture (g/kg)	0.41	16.1			
intact	fat (g/kg)	0.89	46.9			
	protein (g/kg)	0.48	23.9			
	moisture (g/kg)	0.09	15.6			
Beef – three muscles	fat (%)	0.82	0.44			Alomar *et al*. (2003)
	protein (%)	0.82	0.48			
	dry matter (%)	0.77	0.58			
Beef – ground meat	fat (%)			0.94	0.97	Tøgersen *et al*. (2003)
	protein (%)			0.64	0.46	
	moisture (%)			0.92	0.87	

DM – dry matter; LD – *longissimus dorsi* muscle; ST – *semitendinosus* muscle; SM – *semimembranosus* muscle; BF – *biceps femoris* muscle presented results, we can conclude that the ability of NIRS to predict meat chemical traits is mainly remarkable, as in the majority of the published studies high determination coefficients (above 0.80) were obtained. The highest calibration and/or prediction accuracy is reported for intramuscular fat content and somewhat lower for protein and moisture content. The reported results for prediction of collagen content in meat using NIRS were much lower; it could be due to either weak sensitivity of NIRS to minor constituents (Büning-Pfaue *et al*., 2003) or to the reliability of the reference method (colorimetric), which is sometimes criticised for tissues low in collagen, like meat (Etherington and Sims, 1981). Several studies have also demonstrated NIRS as a good predictor of fatty acid content (Table 2).

The results published in different studies vary considerably and these differences could be explained by many factors. The initial studies (Valdes and Summers, 1986; Eichinger and Beck, 1992) worked with NIR spectrophotometers with numerous filters (up to 19) to obtain the light of different wavelengths. Modern equipment has monochromators that act as wavelength selectors, thus allowing sam-

Table 2. The review of the published results on accuracy of NIRS (determination coefficients – R^2 and standard errors – SE) for the determination of fatty acids

Meat	Fatty acids (%)	Calibration		Prediction		Reference
		R^2	SE	R^2	SE	
Beef longissimus dorsi	SFA			0.77	1.10	Windham and Morrison (1998)
	UFA			0.77	1.13	
	palmitic (16:0)			0.69	0.94	
	oleic (18:1 n-9)			0.78	0.97	
Pork	SFA, MUFA, PUFA					Ripoche and Guillard (2001)
back and	palmitic (16:0), stearic (18:0),					
breast fat	oleic (18:1 n-9), linoleic (18:2 n-6)					
in fat extract				0.85–0.96		
on fat slices				0.69–0.79		
Pork subcutaneous fat	lauric (12:0)	0.84	0.007			Gonzalez-Martin *et al*. (2002)
	myristic (14:0)	0.70	0.091			
	palmitic (16:0)	0.89–0.93	0.36–0.48			
	palmitoleic (16:1 n-7)	0.70–0.75	0.14			
	stearic (18:0)	0.85–0.88	0.42–0.44			
	oleic (18:1 n-9)	0.90–0.91	0.72–0.77			
	linoleic (18:2 n-6)	0.83–0.88	0.31–0.33			
	γ-linoleic (18:3 n-6)	0.63–0.77	0.08–0.09			
	arachidic (20:0)	0.85	0.02			
	gadoleic (20:1 n-9)	0.66	0.15			
	PUFA	0.82–0.90	0.31–0.39			
	MUFA	0.89–0.92	0.69–0.70			
	SFA	0.92–0.95	0.56–0.68			
Goose	palmitic (16:0)	0.886	0.882	0.466	1.696	Molette *et al*. (2001)
fatty liver	palmitoleic (16:1 n-7)	0.940	0.180	0.503	0.529	
	stearic (18:0)	0.967	0.368	0.733	1.067	
	oleic (18:1 n-9)	0.988	0.199	0.720	0.948	
	linoleic (18:2 n-6)	0.914	0.021	0.165	0.070	
	myristic (14:0)	0.850	0.070	0.513	0.127	

SFA – saturated fatty acids; UFA – unsaturated fatty acids; MUFA – monounsaturated fatty acids; PUFA – polyunsaturated fatty acids ples to be scanned at a single wavelength at a time over the entire NIR region usually in 2 nm intervals. The majority of research was made on the whole spectrum including visible (400–800 nm) and NIR region (800–2 500 nm) (Eichinger and Beck, 1992; Cozzolino *et al*., 1996; Molette *et al*., 2001; Alomar *et al*., 2003), some of them only on the NIR region or a part of the NIR region (1 308–2 388 nm) (Abeni and Bergoglio, 2001). Furthermore, the definition of NIR region varies between different studies: 800–2 500 nm (Pfuhl and Glodek, 1996; Brøndum *et al*., 2000b) or 1 100–2 500 nm (Rødbotten *et al*., 2000; Tøgersen *et al*., 2003). Studies also differ in the number of samples used to develop calibrations: mainly between 30 and 150 samples. The number of samples is important for creating the sufficient variation range for a particular ingredient. Sample preparation has also an important effect on the predicting accuracy. According to the published results efficiency of predicting chemical composition is bet-

Table 3. The review of the published results on accuracy of NIRS (determination coefficients R^2 and standard errors – SE) for the determination of meat technological characteristics

Meat	Property	Calibration		Prediction		Reference
		R^2	SE	R^2	SE	
Pork	WHC					Brøndum *et al*. (2000)
LD and ST	drip loss (%)			0.41	2.43	
	filter paper test (%)			0.38	16.01	
Pork – LD	colour					
	XYZ (%)	> 0.91	< 0.96	> 0.88	< 1.2	Chan *et al*. (2002)
Beef – LD	colour					
	L*			0.64–0.85	1.53–2.39	
	a*			0.19–0.49	1.15–2.51	
	b*			0.44–0.75	0.77–1.54	Leroy *et al*. (2003)
	WHC					
	drip loss (%)			0.38–0.54	0.82–0.99	
	cooking loss (%)			0.25–0.47	1.81–2.31	
Pork – LD	WHC					
	drip loss (%)			0.50–0.55	1.0–1.1	Geesink *et al*. (2003)
Pork – LD	colour					
	L*	0.62	2.53	0.18	4.47	
	a*	0.40	1.22	0.15	1.87	
	b*	0.38	1.18	0.32	1.34	Meulemans *et al*. (2003)
	WHC					
	drip loss (%)	0.54	1.41	0.11	2.35	
	pH24	0.12	0.09	0.07	0.08	
Beef – LD	colour					
	L*	0.55	1.90			
	a*	0.90	1.38			Liu *et al*. (2003)
	b*	0.78	1.16			

LD – *longissimus dorsi* muscle; ST – *semitendinosus* muscle; WHC – water-holding capacity; L*, a*, b* are CIE (1976) colour parameters ter on minced samples than it is on intact samples (Eichinger and Beck, 1992; Cozzolino *et al*., 2000; Cozzolino and Murray, 2002). The effect on the predicting accuracy has even been reported for different grinding sizes: the finer the grinding, the higher the prediction accuracy (Tøgersen *et al*., 2003). As we could perceive, some calibrations were developed for a single muscle (Eichinger and Beck, 1992), some of them for several muscles together (Cozzolino *et al*., 2000) or even for a mixture of ground muscles of different species (Tøgersen *et al*., 1999).

Most of the studies dealing with the ability of NIRS to determine the chemical composition of meat aimed at exploring the possibility to replace expensive and time-consuming chemical analysis, and were thus made under the laboratory conditions. Only three studies (Tøgersen *et al*., 1999; Tøgersen *et al*., 2003; Anderson and Walker, 2003) explored the predicting ability of NIRS to determine meat chemical composition under industrial conditions (on-line). The results obtained on intact meat samples are of greater relevance for industrial use, but according to the literature they are often insufficiently correlated with reference chemical methods (Brøndum *et al*., 2000a; Cozzolino *et al*., 2000; Cozzolino *et al*., 2002b). The prediction results are much better for minced than for intact meat, most likely because minced samples represent a more homogeneous mixture. As indicated by Rødbotten *et al*. (2000), in the case of intact samples, the prediction accuracy might be improved by increasing the number of NIR scans per sample.

In conclusion, although the published results obtained in different studies vary considerably, they mainly confirm good ability of NIRS for predicting meat chemical traits. However, its performance depends on the reliability of the reference method and methodological approach to preparing calibrations. NIRS as an alternative to analytical methods has a practical importance particularly where numerous determinations are needed continuously, for example in animal selection (i.e. intramuscular fat content).

3. Ability of NIRS to predict meat quality

3.1. Technological characteristics

Studies that were interested in the ability of NIRS to predict meat technological quality are not abundant in the literature. It is clear from the overview of published results, presented in Table 3, that the subject appears above all in recent studies. Most often, the goal of these studies was to examine the predicting ability of NIRS to determine water-holding capacity (Brøndum *et al*., 2000b; Geesink *et al*., 2003; Meulemans *et al*., 2003) and colour (Chan *et al*., 2002; Leroy *et al*., 2003; Meulemans *et al*., 2003), but less frequently pH value (Josell *et al*., 2000; Meulemans *et al*., 2003). All studies concerned with prediction of meat technological properties were methodologically similar. The experiments were carried out on *longissimus dorsi* muscle and on intact meat samples, with the only exception (Meulemans *et al*., 2003); in this case homogenisation did not contribute to the accuracy of prediction. Published results on that subject show firstly that the results vary considerably, and secondly that predicting meat technological quality is less accurate compared to the prediction of meat chemical composition. The highest determination coefficient obtained for water-holding capacity amounts to 0.55 (Geesink *et al*., 2003) and for colour parameter L* (CIE, 1976) it is between 0.64 and 0.85 (Leroy *et al*., 2003). The prediction accuracy for other colour parameters and pH value seems weak. The only promising result ($R^2 > 0.91$) was reported by Chan *et al*. (2002) for colour parameters. According to available information, so far nobody has been successful in attempt to determine pH value by NIR spectroscopy. We can draw a conclusion on the basis of the published results that NIRS has only limited ability for assessing technological quality of meat.

3.2. Sensory characteristics

Regarding meat sensory quality there are several reports that examined the ability of NIRS for assessing meat tenderness (Table 4), which is the most important quality property of beef. Only few other studies were interested in predicting other sensory attributes such as juiciness (Liu *et al*., 2003), chewiness (Rødbotten *et al*., 2000), flavour, texture and acceptability (Byrne *et al*., 1998). The actual techniques to determine meat tenderness are rather demanding in time and means. For this reason the use of NIRS is extremely interesting. Simple and rapid assessment could be especially interesting for tenderness, because this property is often implemented in selection programs for cattle. Table 4 summarises the results of different studies made on intact samples of beef *longissimus dorsi* muscle

Table 4. The review of the published results on accuracy of NIRS (determination coefficients – R^2 and standard errors – SE) for the determination of meat texture and sensory properties

Meat	Property	Calibration		Prediction		Reference
		R^2	SE	R^2	SE	
Beef – LD	tenderness			0.64–0.81	0.5–0.7	Hildrum *et al*. (1994)
Beef – LD	WBSF (kg)	0.67	1.2	0.63	1.3	Park *et al*. (1998)
Beef – LD	WBSF (kg)			0.37–0.67	1.50–2.10	Byrne *et al*. (1997)
	tenderness			0.28–0.52	0.71–0.88	
	flavour			0.06–0.26	0.35–0.39	
	texture			0.28–0.50	0.38–0.45	
	acceptability			0.18–0.45	0.46–0.56	
Beef – LD	WBSF (kg/10 cm^2)	0.22–0.30	15.3–18.1			Rødbotten *et al*. (2000)
	tenderness	0.14–0.26	0.96			
	chewiness	0.12–0.19	1.13			
Beef – LD	WBSF			0.29–0.52		Venel *et al*. (2001)
Beef – LD	WBSF (N)	0.12–0.41	7.68 -11.19			Leroy *et al*. (2003)
Beef – LD	WBSF (kg)	0.17–0.72	0.81–1.84			Liu *et al*. (2003)
	chewiness	0.58	0.38			
	juiciness	0.50	0.18			

LD – *longissimus dorsi* muscle; WBSF – Warner-Bratzler shear force

in laboratory conditions. The calibrations were developed by means of wavelengths of NIR spectrum (Park *et al*., 1998; Leroy *et al*., 2003) or only a part of it (Byrne *et al*., 1998; Venel *et al*., 2001). Here again, the reported results vary considerably, but some of them show a potential of NIRS to predict beef tenderness. Better predicting performance is observed when tenderness is assessed as a measurement of meat mechanical resistance (Warner-Bratzler shear force). In contrast to somewhat promising results for predicting beef tenderness, researchers could not demonstrate the ability of NIRS for predicting pork tenderness (Chan *et al*., 2002; Geesink *et al*., 2003; Meulemans *et al*., 2003). The reason for this might be related to the limited variability of pork tenderness (Meulemans *et al*., 2003; Geesink *et al*., 2003). Another specific area of interest in the use of NIRS was in determining the ability of spectra recorded at various *post mortem* times to predict final tenderness (after 14-days ageing). On the basis of repeated measurements on the same piece of meat during ageing, Byrne *et al*. (1998) found out that spectra recorded within 24 h *post mortem* had the highest potential to predict final tenderness. On the other hand, results of Rødbotten *et al*. (2000) did not support the suitability of early *post mortem* NIRS (before or during rigor mortis, until 24 h *post mortem*) for this purpose. For other sensory properties such as juiciness, chewiness, flavour and acceptability, NIRS proved unreliable. Most of the coefficients of determination were low (Byrne *et al*., 1998; Rødbotten *et al*., 2000), in some cases it was even impossible to develop useful calibrations (Meulemans *et al*., 2003).

3.3. Categorisation into quality grades

Some studies examined the possibility of using NIRS for classification of meat on the basis of quality, i.e. discriminating the strains or feeding regimes, detecting between fresh from frozen-thawed meat or even detecting a gene (Table 5). Most studies were carried out on intact or minced samples of *longissimus dorsi* muscle in different species (Park *et al*., 1998; Fumière *et al*., 2000; Josell *et al*., 2000; Cozzolino *et al*., 2002a; Geesink *et al*., 2003). In all cited studies the categorisation accuracy (% of cor-

Table 5. The review of the published results on accuracy of NIR spectroscopy for the categorisation of meat

Meat	Research purpose	Categorisation accuracy (%)[1]	Reference
Beef – LD	differentiation of frozen and unfrozen beef	90–100	Thyholt *et al*. (2003)
Pork – LD	categorisation of meat according to water holding capacity (drip loss < 5% or > 7%)	100	Geesink *et al*. (1997)
Beef – LD	categorisation of meat according to tenderness (WBSF < 6 kg or > 6 kg)	79–89	Park *et al*. (1998)
Pork – LD	determination of RN^- phenotype	96	Josell *et al*. (2000)
Poultry thigh, skin, carcass, breast	assessment of origin (slow growing and industrial chicken strains)	80–100	Fumière *et al*. (2000)
Beef – LD	assessment of feeding regime (pasture and silage)	86–90	Cozzolino *et al*. (2002a)

LD – *longissimus dorsi* muscle; RN – abbreviation for «rendement napole»
[1]% of correctly classified samples

rectly classified samples) was very high. Particularly interesting are the results on the application of NIRS for determining RN^- carriers (RN is the abbreviation for "rendement Napole"; named by French authors who first signalled the possible existence of major gene) in pigs. By using NIRS together with neural networks, Josell *et al*. (2000) managed to predict in 96% of cases the presence of RN^- gene, which is responsible for the increased muscle glycogen content (Leroy *et al*., 1990). Fumière *et al*. (2000) demonstrated good ability of NIRS to separate between meat of slow-growing and industrial chicken strains. Cozzolino *et al*. (2002a) similarly constructed a model for discriminating beef of different feeding regimes. Thyholt and Isaksson (1997) examined the possibility to discriminate between fresh and frozen-thawed meat. There are some studies about the classification of meat with regard to defined characteristics of meat quality; e.g. water-holding capacity in pork (Geesink *et al*., 2003) or meat tenderness in beef (Park *et al*., 1998). The results of studies which dealt with meat classification (Table 5) are promising. The categorisation accuracy in the published studies was between 80 and 100%.

To summarize, research results presented in Tables 3 and 4 demonstrate only limited ability of NIRS to predict meat quality. On the other hand, NIRS seems more powerful when used for meat categorisation (Table 5) on the basis of quality traits. In our opinion, the main reason for essentially lower accuracy of NIRS for predicting meat quality, as compared to predicting meat chemical composition, is related to the reliability of the method to which it is calibrated. Reference methods used for evaluating meat quality properties are often simple, rapid, subjected to environmental factors, less repeatable and accurate. Namely, the prediction ability of NIRS is limited by the accuracy of the reference method (Monin, 1998). Moreover, low accuracy obtained for sensory traits could be related to the fact that these are not linear measures. Perhaps in that case, different statistical approach (i.e. neural networks) could work better. There is also a need for more research regarding the industrial use.

4. Conclusion

In spite of the extensive research work on the predicting ability of NIRS for assessing meat properties, in practice it is used to a limited extent only. Although variable in results, studies dealing with the predicting ability of NIRS to determine meat chemical properties show its good potential to replace analytical procedures which can be time-consuming, expensive and sometimes hazardous to health or environment. On the other hand, results of NIRS prove only limited ability for predicting various meat quality properties. This could be explained by the fact that the predicting ability of NIRS depends upon reference methods which are, in the case of meat quality properties, less reliable and repeatable compared to chemical analysis. According to the literature, the predicting ability of NIRS seems more efficient when assessing meat quality in terms of categorisation. The practical significance of NIRS for meat quality evaluation resides also in its ability for simultaneous determination of numerous traits. However, more information on its capabilities for industrial use is still needed. In animal breeding, NIRS could be very useful for selection purposes, i.e. when a large number of determinations is needed continuously, like determining intramuscular fat or tenderness, thus replacing time-consuming and expensive analysis. In spite of its great potential, the practical use of NIRS may well be limited by the fact that it needs a laborious calibration for every purpose.

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ABSTRAKT

Schopnost metody NIRS predikovat chemické složení a kvalitu masa – literární přehled

Na rozdíl od tradičních metod pro stanovení chemického složení a kvality masa metoda blízké infračervené spektroskopie (metoda NIRS) umožňuje rychlé, jednoduché a současné vyhodnocení více vlastností masa. Tento článek uvádí přehled uveřejněných studií, které se zabývaly schopností metody NIRS predikovat jednotlivé vlastnosti masa. Metoda NIRS má dle uveřejněných výsledků vysoký potenciál nahradit drahou a časově náročnou chemickou analýzu složení masa. Naproti tomu pro predikci jednotlivých atributů kvality masa je tato metoda méně přesná. Z hlediska hodnocení kvality masa se použití metody NIRS jeví jako perspektivnější pro kategorizaci masa do tříd kvality na základě znaků kvality masa, které např. rozlišují krmné režimy, rozlišují čerstvé maso od masa zmrazeného a rozmrazeného, rozlišují jednotlivé linie atd. Výkonnost metody NIRS predikovat vlastnosti masa může být omezená spolehlivostí metody, vůči níž se provádí kalibrace. Použití metody NIRS může dále omezovat to, že ke všem účelům vyžaduje pracnou kalibraci. Přesto je NIRS považovaná za perspektivní metodu pro rychlé hodnocení masa.

Klíčová slova: metoda NIRS; chemické složení masa; kvalita masa

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