KONDUKTOMETRISCHE UNTERSUCHUNG DES PENETRATIONS DER SALZLAKE-INGREDIENZEN (JON Na^+UND JONISCHEN GRUPPEN) IN M.LONGISSIMUS LUMBORUM ET THORACIS

Slobodanka Stanković, B. Draganović, M. Nađ

Z u s a m m e n f a s s u n g

In vorherigen Untersuchungen in den Verhältnissen der einfachen Diffusion und Osmose der einzelnen Ingredienzen der Salzlake in das Muskelgewebe wurden bestimmte Unterschiede im Penetration Na^+ Jons in den einzelnen Muskeln der hinteren Schweins-Extremitäten festgelegt. Ebenfalls wurde auch die selektive Diffusion anjonischen $^{32}PO_4^{-3}$ Gruppe festgestellt. Mit dieser Arbeit wollten wir die Unterschiede festlegen in der Penetration Na^+ Jons aus der Salzlake in die einzelnen Teile M.longissimus lumborum et thoracis, wie auch feststellen was für einen Einfluss hat die Qualität und die Dicke des Muskels, sowie die Lage der Muskelfasern auf das Durchdringen Na^+ Jons und jonischen Gruppen aus der Salzlake in das Muskelgewebe.

Um die Antwort auf diese Fragen zu bekommen wurden zuerst Grund-anatomische-topographische Benehmungen und makro-morphlogische Charakteristiken M.longissimus et thoracis der Schweine untersucht.

Im zweiten Teil dieser Arbeit wurde die Diffusion Na^+ Jons und jonischen Gruppen aus der Salzlake in diesen Muskel mit Anwendung der konduktometrischen Methode registriert. Gelegentlich Verfolgung der Penetration von einzelnen Komponenten der Salzlake in den lumbo-torakalen Teil dieses Muskels wurden die differenzialen Koeffizienten der Permebialität für gesamte Jons Na^+,festgelegt, sowie auch deren Werte für jede Jons-Gruppe.

Auf Grund der ergebenen Daten für das Penetration Na^+ Jons (mol. cm^{-2} $sec.^{-1}$) ist der Einfluss der Qualität und der Dicke des Muskels und die Lage der Muskelfasern auf die Geschwindigkeit des Penetrations von Na^+ Jons und jonischen Gruppen aus der Salzlake in das Muskelgewebe dargestellt.

INVESTIGATION CONDUCTOMETRIQUE DE LA PENETRATION DES INGREDIENTS DE LA SALINE (LE ION DU Na^+ ET LE GROUPE DES IONS) EN M. LONGISSIMUS DORSI ET THORACIS

Slobodanka Stanković, B. Draganović, M. Nadj

R e s u m e

Dans nos recherches precedentes nous eûmes determine les differences du Na^+ ion flux en musculature de jambon de porc sous les conditions de diffusion et de l osmose des ingredients de la saline. De même, on a determiner la diffusion selective de groupe PO_4^{-3}. Dans cette contribution nous eûmes essaye constater les differences de la penetration du Na^+ ion de la saline dans les regions de m. longissimus lumborum et thoracis, ainsi que les influences de la qualite et de la directon des miofibriles sur le phenomène de la penetration. D abord nous eûmes etudie les caracteristiques anatomo-topographiques et macro-morphologiques de m. longissimus dorsi et thoracis. Ensuite, la diffusion du Na^+ ion est examinee par la conductometrie, $^{32}PO_4^{-3}$ par la radiometrie determinant le coefficient differenciel de la permeabilite des Na^+ ion de la saline et de chaque ingredient de la saline. Les resultats obtenus montrent que l influence de la qualite, de la grandeur et de la direction des miofibriles est très significante sur la penetration des Na^+ ions et des groupes de ions (PO_4^{-3}) de la saline en muscles.

CONDUCTOMETRIC EXAMINATION OF BRINE INGREDIENTS PENETRATION (Na^+ IONS AND IONIC GROUPS) INTO M. LONGISSIMUS LUMBORUM ET THORACIS

Slobodanka Stanković, B. Draganović, M. Nađ

S u m m a r y

In authors' previous examinations, in the conditions of simple diffusion and osmosis of individual brine ingredients ingredients into muscular tissue, certain differences in the flux of Na^+ ions through individual muscles of swine hind extremity were established. In addition, selective diffusion of the anionic group $^{32}PO_4^{-3}$ was also established.

The aim of this work was to establish differences in the penetration of Na^+ ions from brine into certain parts of m.longissimus lumborum et thoracis as well as to establish how the quality and thickness of muscles and the site of muscle fibers influence the penetration of Na^+ ions and ionic groups from brine into muscular tissue.

With the purpose of obtaining an answer to these questions, basic anatomic-topographic characteristics and macro-morphologic characteristics of m. longissimus lumborum et thoracis in swine were examined at first.

In the second part of the work, diffusion of Na^+ ions and ionic groups from brine into this muscle was registered by the application of condutometric method. On occasion of following the penetration of individual brine components into lumbo-thoracic part of this muscle, differential coefficients of permeability for total Na^+ ions, as well as their values for each ionic group, were determined.

On the basis of the obtained data for the flux of Na^+ ions (mol. cm^{-2} $sec.^{-1}$), the authors present the influence of muscle quality and thickness, as well as of muscle fiber site, on the penetration rate of Na^+ ions and ionic groups from brine into muscular tissue.

КОНДУКТОМЕТРИЧЕСКОЕ ИССЛЕДОВАНИЕ ПРОНИКНОВЕНИЯ ИНГРЕДИЕНТОВ ЗАСОЛА /ИОНОВ Na^+ И ИОННЫХ ГРУПП/ В M. LONGISSIMUS LUMBORUM ET THORACIS

Слободанка Станкович,Б.Драганович и М.Надь

С о д е р ж а н и е

В предыдущих исследованиях в условиях простой диффузии и осмоса отдельных ингредиенций засола в мышечную ткань установлены определенные различия во флюксе Na^+ ионов в отдельных мышцах задней конечности свиней.Утверждена также и селективная диффузия анионной $^{32}PO_4^{-3}$ группы.Этим трудом мы хотели установить различия в пенитрации Na^+ ионов из засола в отдельные части m. longissimus lumborum et thoracis и установить,каково влияние качества и толщины мышцы,а также положения мышечных волокон на проникновение Na^+ ионов и ионных групп из заслола в мышечную ткань.
В целях получения ответа на эти вопросы прежде всего были исследованы анатомо-топографические свойства и макро-морфологические характеристики m.longissimus lumborum et thoracis свиней.

Во второй части этого труда диффузия Na^+ ионов и ионных групп из засола в эту мышцу зарегистрирована применением кондуктометрического метода.При исследовании пенетрации отдельных компонентов засола в лумбо-торокальную часть этой мышцы определены дифференциальные коэффициенты проникновения для общих ионов Na^+,а также и их величины для каждой ионной группы.
На основании полученных данных для флюкса Na^+ ионов /mol.cm^{-2} $sec.^{-1}$ / показано влияние качества и толщины мышцев и положения мышечных волокон на скорость проникновения Na^+ ионов и ионных групп из засола в мышечную ткань.

CONDUCTOMETRIC EXAMINATION OF BRINE INGREDIENTS PENETRATION (Na^+ IONS AND IONIC GROUPS) INTO M. LONGISSIMUS LUMBORUM ET THORACIS

Slobodanka Stanković, B. Draganović, M. Nadj

Institute for the application of nuclear energy in agriculture, veterinary medicine and forestry - Beograd

Yugoslav institute of meat technology - Beograd

The dynamics of the penetration of particular brine ingredients into individual ham and shoulder muscles was established in our previous examinations (2, 3, 5), using brine marked with active isotopes. Applying the conductometric method, the changes of specific permeability were followed in different muscles of hind hog extremity (1, 3), whereby the values for the flux of Na^+ ions were obtained. In addition, the selective diffusion of anionic group $^{32}PO_4^{-3}$ was also extablished (1).

By this work, we wanted to establish the differences in the penetration of Na^+ ions from the brine into individual parts of m.longissimus lumborum et thoracis and to establish the influence of muscle quality and thickness, as well as of the site of muscle fibers, on the penetration of Na^+ ions and ionic group $^{32}PO_4^{-3}$ from the brine into muscular tissue. For that purpose, we set the following tasks:

- to examine anatomic-topographic properties and macromorphologic characteristics of m. longissimus lumborum et thoracis in meaty hogs,
- using the conductometric method, to follow the penetration of individual brine components into lumbal and thoracis part of m. longissimus and to determine differential coefficients of permeability for Na^+ ions, and

- applying radiotracers, to establish the concentration change and the penetration rate of marked anions ($^{32}PO_4^{-3}$) from the brine through the examined muscular tissue.

MATERIALS AND TECHNIQUE

All examinations were carried out with the separated lumbal and dorsal part of m. longissimus of white meaty hogs of domestic breed (95-100 kg in liveweight), after slaughter and side cooling for 18-24 hours.

Anatomic-topographic examinations were performed by the usual anatomic technique of muscle preparation.

On occasion of electro-chemical examinations, the "Philips" conductometer was used in the way described in our previous works (1, 4). Segments of m.longissimus lumborum were taken from the 1st and the 2nd lumbal vertebrae and segments of m. longissimus thoracis from the 7th and the 8th dorsal vertebrae. Measurements were done on muscle models of 0.5 and 1.0 cm in thickness, on cross and longitudinal sections. On that occasion, changes of the concentration and flux of Na^+ ions from each individual brine ingredient ($NaNO_2$ and polyphosphate preparation "Polytal"), as well as from the brine in whole, were followed.

Brine with marked phosphate group (radiophosphor 32) in the form of sodium ortophosphate, the activity of which was 1 mCi, was used for radiometric examinations. The cell used in this examination was identical to that used in conductometry,whereby the muscle model of 3 - 3.5 cm in thickness was on one side multiply injected with brine in the quantity of 10% on the model weight base. Samples for radiometric examination were taken from the cell with distilled water, each 10 minutes within two hours after brine injection, and then measured on the "Philips" radiometric set. The results are presented as the percentage of initial activity of injected brine.

RESULTS AND DISCUSSION

Anatomic-topographic examinations show that the most important muscle of hog dorsum - m. longissimus - extends bilaterally-simetrically on the dorso-lateral side of the columna vertebralis. It starts from the sacrum and the pelvis and extends to the last neck vertebrae, representing the longest body muscle. The muscle fills the space between thornlike and transversal continuations of lumbal and thoracic vertebrae, and on the thoracic part it also leans on the proximal rib parts. This muscle, being unique regarding its structure, is topographically divided into lumbal and dorsal parts.

The lumbal part - pars lumbalis seu m. l o n g i s s i m u s l u m b o r u m - is characterized by well developed muscle mass of uniform rosy colour, being covered with strong aponeurosis on the dorsal side. In the lumbal region, the cross section of this muscle is of irregularly triangular, rounded form and shows homogenous macromorphologic structure. The muscle mass of m. longissimus lumborum consists of longitudinally placed thin and tender muscle fibers. Between thes fibers is a considerably badly developed and tender structure of connective tissue elements - perimisium internum, the deposition of intramuscular fatty tissue being therefore less expressed.

Cranially, the lumbal part continues into dorsal part - pars thoracalis seu m. l o n g i s s i m u s t h o r a c i s, which considerably differs from the lumbal part regarding colour, form, structure and development of muscle mass. In the cranial direction, this muscle changes its form - it becomes narrower and more roundish. On the dorsal surface of proximal rib parts, the muscle is flat and its cross section is more eliptic in form. The muscle mass of m. longissimus thoracis becomes plate-like by its end and finally it turns into its insertion aponeurosis.

Considering the lumbal part and the dorsal part of m. longissimus as a whole, there can be observed a gradual but clearly visible reduction of the muscle mass. Cranially, from the very well developed lumbal part, the muscle mass gradually becomes less meaty and increasingly thinner. As a consequence of this morphologic change, there appear changes in macromorphologic structure, too. Starting from the 10th thoracic vertebra towards the neck part, changes on the cross section are distinctly observed. Between longitudinal muscle fibers becoming increasingly coarser, the intramuscular connective tissue is more developed resulting in more expressive development and deposition of intramuscular fatty tissue. Simultaneously with the change of macromorphologic structure, the colour of this muscle is changed, too. In relation to the lumbal part, the colour becomes lighter and deviates to a large extent from the darker colour of adjacent muscles.

The results of conductometric examinations are presented in Fig. 1 and in Table 1. Results of the change of Na^+ ion concentration in NaCl show that the increase of concentration is higher on the longitudinal section of lumbal muscle part, whereas it decreases with the increase of the layer thickness.Changes of Na^+ ion concentration in polyphosphate preparation do not show any more considerable differences in relation to the layer thickness, muscle part and section kind, except in the case of longitudinal section of lumbal muscle part of 0.5 cm in thickness. This statement refers also to some extent to $NaNO_2$, except that the Na^+ ion concentration is lower for 10^{-2}. The concentration of Na^+ ions from the brine is higher on longitudinal sections of lumbal part, whereas it decreases with the increase of the muscle layer thickness. From the change of Na^+ ion flux it can be observed that there is a regularity and uniformity in the penetration of brine ingredients (NaCl, $NaNO_2$ and polyphosphate preparation), whereby the ion flux is higher on longitudinal sections of lumbal muscle parts and lower on

thicker layers. As for the brine, Na^+ ion flux does not show any considerable differences regarding the muscle thickness. However, the differences appear regarding the site of muscle fibers: flux is higher on longitudinal sections of lumbal part of m. longissimus.

The results of radiometric measurements of the brine activity in m. longissimus lumborum et thoracis injected 24 and 48 hours after cooling of sides are presented in Tables 2 and 3. The obtained results show that the marked phosphate group from the brine penetrates with similar rate in both cases; however, the penetration rate of phosphate anion $^{32}PO_4^{-3}$ is higher through longitudinal sections, specially in the case of the lumbal part of m. longissimus.

CONCLUSIONS

From the presented results, the following conclusions can be drawn out:

1) m. longissimus in hogs, although a unique muscle of the columna vertebralis regarding its structure, can be divided into lumbal (m. longissimus lumborum) and dorsal (m. longissimus thoracis) parts not only topographically but also morphologically and macromorphologically, as well as according to its quality, colour and development of the muscle mass.

2) On occasion of applying individual brine ingredients (NaCl, $NaNO_2$ and polyphosphate preparation) and the brine as a whole, the concentration of Na^+ ions is most quickly increased from NaCl, then follow polytal and nitrite, and at last the brine. The highest flux of Na^+ is shown by ions from NaCl, and then by ions from the brine.

3) In both cases, 24 and 48 hours post mortem, the ionic group $^{32}PO_4^{-3}$ passes through muscular tissue with almost the same speed, but the highest penetration rate is obtained through longitudinal sections of the lumbal part of m. longissimus.

LITERATURE

1) Draganović B., S. Stanković and M. Nađ: Diffusion of certain ions of brine ingredients through ham muscles of hogs, XIX European Meeting of Meat Research Workers, Paris, 1973; 2) Nađ M., V. Đorđević and B. Draganović: Penetration-dynamics of ingredients of intravascullary injected pickle into ham muscles, XI European Meeting of Meat Research Workers, Beograd, 1965; 3) Tadić R., M. Nađ and B. Draganović: Characteristics of intramuscular injection of brine into ham muscles of hogs, XIX European Meeting of Meat Research Workers, Paris, 1973; 4) Tadić R., M. Nađ., N. Mašić and M. Milanović: Some characteristics of intraarterial and intramuscular injection of brine into ham muscles of hogs, Tehnologija mesa, 2, 1974; 5) Penetration of intravascullary injected brine ingredients into shoulder muscles, XVIII Meeting of Meat Research Workers, Guelph, Canada, 1972.

CHANGES OF CONCENTRATION AND Na^+ ION FLUX

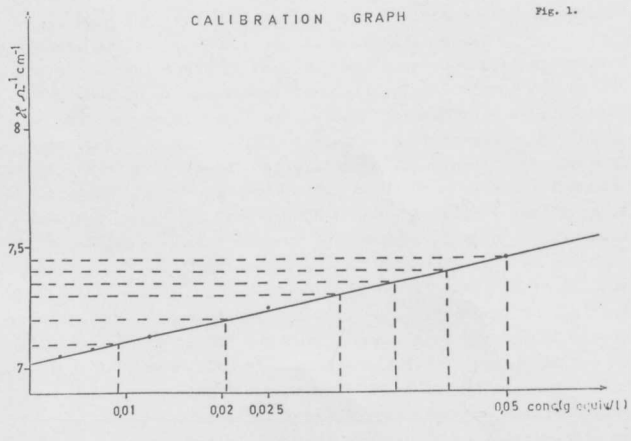
Table 1.

SORT OF ELECTROLYTE		MUSCLES							
		LONGISSIMUS LUMBORUM				LONGISSIMUS THORACIS			
		longitudinal section		cross section		longitudinal section		cross section	
		Th = 0,5	Th = 1,0	Th = 0,5	Th = 1,0	Th = 0,5	Th = 1,0	Th = 0,5	Th = 1,0
NaCl	ΔC (g equiv./l)	1,35	0,24	0,19	0,19	0,24	0,24	0,14	0,14
	I_s (mol $cm^{-2}sec^{-1}$)	$6,0.10^{-6}$	$4,0.10^{-6}$	$2,1.10^{-6}$	$1,6.10^{-6}$	$8,0.10^{-6}$	$3,2.10^{-6}$	$9,3.10^{-6}$	$4,6.10^{-6}$
POLYTAL	ΔC (g equiv./l)	0,055	0,037	0,037	0,037	0,037	0,037	0,037	0,037
	I_s (mol $cm^{-2}sec^{-1}$)	$3,6.10^{-6}$	$8,2.10^{-7}$	$1,2.10^{-6}$	$8,2.10^{-7}$	$2,5.10^{-6}$	$1,2.10^{-6}$	$2,5.10^{-6}$	$6,1.10^{-7}$
$NaNO_2$	ΔC (g equiv./l)	3.10^{-5}	1.10^{-5}	1.10^{-5}	2.10^{-5}	1.10^{-5}	1.10^{-5}	1.10^{-5}	9.10^{-6}
	I_s (mol $cm^{-2}sec^{-1}$)	$1,2.10^{-10}$	$3,3.10^{-10}$	$2,2.10^{-10}$	$3,3.10^{-11}$	$3,5.10^{-11}$	$3,3.10^{-11}$	$3,3.10^{-11}$	$5,0.10^{-11}$
BRINE	ΔC (g equiv./l)	0,05	0,02	0,05	0,02	0,04	0,035	0,025	0,03
	I_s (mol $cm^{-2}sec^{-1}$)	$4,2.10^{-7}$	$6,6.10^{-7}$	$4,2.10^{-7}$	$4,4.10^{-7}$	$8,8.10^{-7}$	$6,0.10^{-7}$	$1,7.10^{-6}$	$3,3.10^{-7}$

Th = Thickness in cm

CALIBRATION GRAPH

Fig. 1.



RADIO-ACTIVITY OF BRINE 24 HOURS AFTER INJECTION

Table 2.

TIME	M. Longissimus			
	lumborum		thoracis	
	longitudinal section	cross section	longitudinal section	cross section
min.	%	%	%	%
10	2.35	2.14	0.59	1.00
20	6.21	3.00	1.81	1.11
30	8.59	2.54	3.12	1.76
40	6.35	2.77	3.23	1.18
50	8.17	2.93	5.59	1.59
60	7.11	2.59	5.85	2.72
70	6.50	2.60	4.93	1.97
80	6.64	2.54	4.88	1.98
90	7.03	2.56	4.37	2.99
100	7.33	2.68	4.78	2.17
110	9.00	2.37	3.96	2.14
120	6.08	2.57	4.41	1.92
Mean value %	7.18 ± 1.02	2.34 ± .74	4.54 ± .97	1.87 ± .09
Meat juice	37	20	45	50
Meat	60	56	50	48

RADIO-ACTIVITY OF BRINE 48 HOURS AFTER INJECTION

Table 3.

TIME	M. Longissimus			
	lumborum		thoracis	
	longitudinal section	cross section	longitudinal section	cross section
min.	%	%	%	%
10	1.00	4.42	1.86	1.01
20	1.45	3.55	1.79	.99
30	2.98	6.26	3.43	.99
40	5.04	8.22	3.43	.97
50	2.01	5.16	1.88	1.13
60	3.18	4.27	1.69	1.67
70	3.24	7.01	4.19	1.98
80	3.94	6.01	1.29	2.67
90	3.54	3.97	3.39	2.67
100	3.83	8.69	2.95	1.41
110	7.35*	5.45	2.38	1.63
120	8.30*	5.30	2.00	1.35
Mean value %	2.67 ± .08 7.82 ± 1.41	4.94 ± 1.03	1.98 ± .40	1.50 ± .08
Meat juice	14	20	33	31
Meat	83	71	66	65