

Institut für Hygiene und Technologie des Fleisches,
Tierärztliche Fakultät, Universität Gent, Belgien.

J.VAN HOOF

Abbau von Diphosphat und Tripolyphosphat im M.long.dorsi vom
Schwein.

ZUSAMMENFASSUNG

Der Abbau von Diphosphat (DP) und Tripolyphosphat (TP) im Longissimus dorsi-Muskel von Schweinen wurde untersucht. Besonders der Einfluss der Fleischqualität (normale oder PSE), der Zeitpunkt des Zusetzens (1 oder 48 St.post mortem) und der Erhitzung (roh oder erhitzt auf bzw. 60°C, 65°C und 72°C) wurde geprüft. Die Änderungen des Wasserbindevermögens (WBV) nach DP- und TP-Zusatz, wurden gleichfalls gemessen.

Der Zusatz von DP führte zu einer grösserer Zunahme des WBV im Fleisch der normalen Qualitätsgruppe ($\text{pH}_{45} 6,0$; niedriger Transmissionswert; hoher GOFO-Wert) wie Zusatz von TP.

Im PSE-Fleisch ($\text{pH}_{45} \pm 5,5$; hoher Transmissionswert; niedriger GOFO-Wert) lagen keine deutliche Unterschiede im Effekt beider Polyphosphaten vor. In den beiden Qualitätsgruppen wurde, hinsichtlich des Zeitpunktes der DP- oder TP-Zusatzes post mortem, keine wesentliche Unterschiede in dem WBV beobachtet.

DP sowie TP wurde in normalem Fleisch schneller abgebaut wie im PSE-Fleisch. Eine beschleunigte DP-Hydrolyse in den schlachtwarm hergestellten Proben wurde nur in der normalen Fleischqualitätsgruppe festgestellt. Auch nach Erhitzung bis auf 72°C wurde eine weitere Abnahme des Rest-DP Gehaltes nicht völlig unterbunden.

Die TPase Aktivität war in den beiden Qualitätsgruppen höher als die DPase Aktivität. Im Gegensatz aber zu DPase war die TPase Aktivität 48 Stunden post mortem höher als 1 Stunde post mortem. Während der TP-Hydrolyse nahm die DP Menge allmählich zu, um in normalem Fleisch innerhalb von 72 Stunden und in PSE-Fleisch innerhalb von 120 Stunden wieder völlig zu verschwinden. Nach Erhitzung bis auf 72°C trat während der darauffolgenden Lagerung bei +4°C keine weitere Abnahme des Rest-TP Gehaltes ein.

Department of Meat Hygiene and Meat Technology,
Faculty of Veterinary Medicine, State University of Ghent, Belgium.

J.VAN HOOF

Break-down of Diphosphate and Tripolyphosphate in Pork.
SUMMARY

The break-down of diphosphate (DP) and tripolyphosphate (TP) in porcine longissimus dorsi muscles was followed. Attention was payed especially to the effect of different factors, such as the meat quality type (normal versus PSE), the time of addition of the polyphosphates (1h versus 48h post mortem) and heating (unheated versus heated at 60°C, 65°C and 72°C). Changes in waterholding capacity (WHC), following DP or TP addition at different times post mortem, were also measured.

In the normal meat quality groups ($\text{pH}_{45} 6,0$; low transmission-value; high GOFO-value) DP was more effective in increasing WHC than TP. However, in the PSE-meat ($\text{pH}_{45} \pm 5,5$; high transmission-value; low GOFO-value) differences between both polyphosphates were not obvious. Also, differences related to the time of addition (1 or 48h post mortem), could not be measured.

DP hydrolysis was higher in normal than in PSE-meat. Only in the normal meat quality group the rate of break-down was higher in the samples prepared within 1 hour post mortem.

Heating to an internal temperature of 72°C was unable to inhibit further hydrolysis of DP during storage at +4°C.

TP hydrolysis was also higher in normal than in PSE-meat. However, TPase activity was higher than DPase, whereas, in contrast with DPase, TPase activity increased with time post mortem. During hydrolysis of TP, DP appeared and increased simultaneously with further hydrolysis of TP. DP, however, decreased again and disappeared approximately within 72 hours and 120 hours for the normal and the PSE-meat respectively.

Heating to an internal temperature of 72°C completely inhibited further hydrolysis of residual TP during storage at +4°C.

Institut d'Hygiène et de Technologie des Denrées Alimentaires d'Origine Animale, Faculté de Médecine Vétérinaire, Université de Gand, Belgique.

J.VAN HOOF

L'Hydrolyse de Diphosphate et de Tripolyphosphate dans le m. Longissimus Dorsi du Porc.

RESUME

L'Influence de quelques facteurs sur l'hydrolyse de diphosphate (DP) et de tripolyphosphate (TP) a été étudiée dans la viande porcine (m.longissimus dorsi). L'Attention s'est portée en particulier sur l'influence de la qualité du tissu musculaire (PSE ou normal), sur le délai entre l'abattage des animaux et l'adjonction des polyphosphates à la viande (1 ou 48 heures) et le traitement thermique (viande crue ou chauffée à 60°C, 65°C ou à 72°C). En plus, les variations dans la teneur en eau liée, dues à la présence de DP ou de TP ont été mesurées.

Comparativement au TP, l'utilisation du DP augmentait davantage le pouvoir de liaison d'eau dans les muscles normaux. Par contre, dans les muscles PSE, l'effet des deux espèces de polyphosphates était à peu près identique. Tant dans les muscles PSE que normaux, le moment de l'addition après l'abattage n'avait pas d'influence notable sur la liaison d'eau.

L'Hydrolyse du DP était plus rapide dans les muscles normaux que dans les muscles PSE. Seulement dans les muscles normaux, l'hydrolyse du DP se terminait plus rapide dans ^{les} échantillons préparés 1 heure au lieu de 48 heures après l'abattage. Même après échauffement à 72°C, l'hydrolyse du DP résiduel n'était pas complètement arrêtée.

De même que pour le DP, l'hydrolyse du TP se terminait également plus tôt dans les muscles normaux, tandis que l'activité de la TPase musculaire était plus élevée que celle de la DPase. Par ailleurs, l'activité de la TPase était nettement supérieure 48 heures après l'abattage, que 1 heure après celui-ci.

Le DP, résultant de l'hydrolyse du TP, s'accumulait pendant une première phase mais disparaissait à nouveau dans un délai de 72 heures (viande normale) ou de 120 heures (viande PSE) après l'addition de TP.

Après un échauffement jusqu'à 72°C, l'hydrolyse du TP résiduel n'était pas complètement arrêtée.

дк. Йан Хоф,

Институт др. Гигиена эн Технологии ван Этверен ван дирликсе
ооспронт . Факультет диргентескунда . Рейксуниверситет Гент .

Распад прибавленного дк. остатка и триполифосфата в свинине.

Продолжались исследования о распаде дифосфата /ДФ/ и триполифосфата /ТФ/ в широкомышечной мышце спины свиньи. Исследования были в частности направлены на влияние некоторых факторов, как качества мяса /ПСД-мясо или обыкновенное/, времени прибавления / один или сорок восемь часов после убоя/ и температуры / сырое или нагрето до 60,65 и 72 градусов Ц /. Кроме того были измерены изменения водосвязывающей способности мяса .

В качественной группе обыкновенного мяса / $\text{pH}_{45} 6,0$, низкая трансмиссионная стоимость и высокая Гоф-стоимость / присадка ДФ вызывала большее увеличение водосвязывающей способности чем прибавление ТФ .

В ПСД-мясе / $\text{pH}_{45} \pm 5,5$, высокая трансмиссионная стоимость и никакая Гоф-стоимость / действие двух полифосфатов на водосвязывающую способность было приблизительно одинаковое . Но наблюдались и различия в увеличении водосвязывающей способности вследствие разных моментов прибавления обоих полифосфатов . Гидролиз ДФ происходил быстрее в мясе обычного качества чем в ПСД-мясе . Желту тем этот гидролиз сделался быстрее всего, когда ДФ прибавлен был один час вместо сорок восемь часов после убоя . Для того, чтобы вполне остановить распад остаточного ДФ нагревание до 72 градусов Ц не было достаточным .

Также гидролиз ТФ происходил быстрее в обыкновенном мясе чем в ПСД-мясе . При всех испытаниях активность ТФ-азы была сильнее чем активность ДФ-азы . В отличие от ДФ-азы активность ТФ-азы была сильнее сорок восемь часов после убоя чем один час после него . Во время гидролиза ТФ содержание ДФ в мясе постепенно возросло, затем скоро уменьшилось и полностью исчезло в течение 72 часов /в мясе обычного качества/ или соответственно в течение 120 часов /в ПСД-мясе/ после прибавления ТФ . Нагреванием мяса до 72 градусов Ц дальнейший распад остаточного ТФ вполне остановился .

Department of Meat Hygiene and Meat Technology,
Faculty of Veterinary Medicine, State University of Ghent, Belgium.
J.VAN HOOF
Break-down of Diphosphate and Tripolyphosphate in Pork.

INTRODUCTION

Polyphosphates, especially diphosphate (DP) and tripolyphosphate (TP), are widely used in meat processing. However, due to enzymatic and chemical hydrolysis, break-down of these polyphosphates may occur when added to meat emulsions (1, 4, 10, 16, 17, 18). The rate of break-down and hence the value of the analytical procedures for the determination and identification of the polyphosphates used, have been shown to be related to the type of polyphosphate (1, 10) and other factors such as pH (10), temperature (1, 9) and concentration of mono- and bivalent cations (17, 18).

Although the rate of break-down is believed to be species dependant (7, 14), little work has been done with regard to pork. No information has been published concerning the effect of the meat quality characteristics, i.e. normal versus PSE-meat, on muscle polyphosphatase activities.

For Beef longissimus dorsi muscle, NERAAL and HAMM (10) showed that DPase activity is higher in pre-rigor meat (pH optimum 7.0) than in post-rigor meat, whereas TPase activity increases during the first 2 or 3 days post mortem (pH optimum 5.7). They also found TPase more sensitive against heat denaturation than DPase. In agreement with the work of other investigators, these results indicate that the alkaline DPase fraction present in the sarcoplasm (8), may be predominant in beef. On the other hand, although muscle ATPase has a pH optimum of about 6.7, the activity of TPase in beef shows some resemblance to muscle ATPase activity (12, 17, 18, 19).

In the present experiment DPase and TPase activity was studied in pork. Besides the effect of the meat quality type, the influence of the time post mortem and the inactivating action of heating was investigated.

MATERIAL AND METHODS

Twelve Belgian Landrace pigs were selected 30 to 45 minutes after slaughter and divided into one of both meat quality groups (PSE or normal) by pH-measurements in the longissimus dorsi muscle. The preliminary selection was confirmed by measurement of the waterholding capacity (WHC) (5), the GÖFO-value (13) and the transmission value (2) 24 hours post mortem.

One part of the longissimus dorsi was ground within 1 hour post mortem, the other part 48 hours later. Both were mixed with 1% of an aqueous solution of $\text{Na}_4\text{P}_2\text{O}_7$ or $\text{Na}_3\text{P}_3\text{O}_{10}$ and stored at +4°C. The amount of polyphosphates added to all meat samples, expressed as P_2O_5 , was 0.3%.

(*) The work was supported by a grant from the IWONL, Brussels, Belgium.

At different times up till 120 hours after the addition of the polyphosphates, unheated samples were extracted with TCA for determination of the residual amounts of DP and/or TP in the meat.

From the longissimus dorsi muscles, prepared 48 hours post mortem, samples (+ 150 g) were air-tight packed in PVC-bags, heated for 15 minutes at 60°C, 65°C and 72°C without any delay and then cooled and stored at +4°C. Up till 5 days following this procedure, samples were also examined for residual DP and/or TP. The amounts of both polyphosphates were determined by the TLC-method described by NERAAL and HAMM (9). 24 Hours after the polyphosphate addition, WHC was measured in the unheated samples.

RESULTS AND DISCUSSION

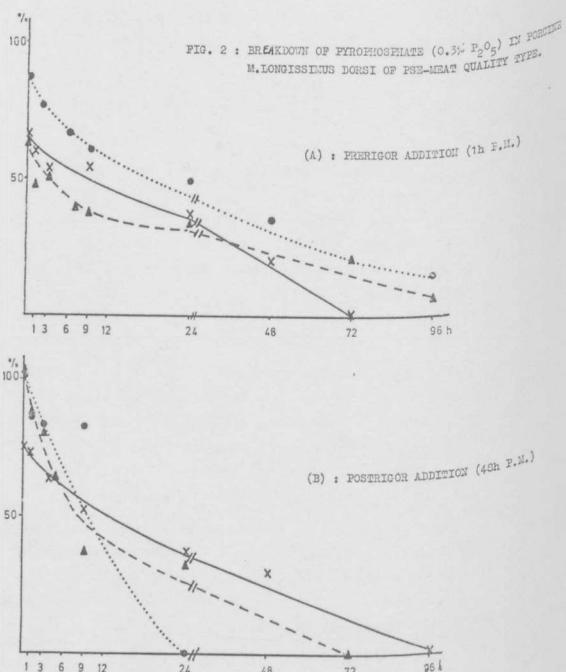
DPase and TPase activities were measured by the rate of breakdown of DP and TP in the meat samples. Break-down is expressed by the residual amount, in percent, of the polyphosphates initially added to the meat (= 100%).

1-Meat quality characteristics of the selected muscles

Mean pH₄₅, GOFO and transmission values (n=3) as well as WHC are shown in table 1.

polyphosphate added	DP	normal	PSE	x	pH ₄₅	GÖFO-value	Transm. value	WHC (24 h post mortem) + polyphosph.(0.3%)		
								control	1h p.m.	48h p.m.
				x	5.45	28.0	60.6	49.9	57.5	51.5
				x	5.35	37.7	55.0	48.1	53.9	50.7
				x	5.45	31.0	50.5	43.1	49.2	56.0
				x	6.03	71.0	7.3	44.1	56.3	52.7
				x	6.30	64.3	5.3	48.0	59.7	58.6
				x	6.10	77.7	9.0	55.9	61.2	63.6
				x	6.14	71.0	7.3	49.3	59.0	58.3
				x	5.45	52.0	75.2	47.8	54.5	47.6
				x	5.50	52.5	90.7	48.2	49.9	50.1
				x	5.45	22.6	54.0	39.6	47.5	56.1
				x	5.47	42.4	73.3	45.2	50.7	51.3
				x	5.90	58.0	2.5	54.4	61.7	60.0
				x	6.30	48.0	12.5	52.3	58.1	60.0
				x	6.30	57.0	3.5	48.4	53.9	53.2
				x	6.17	54.3	6.2	51.7	57.8	57.7

TABLE 1 : Meat quality characteristics of the selected longissimus dorsi muscles. pH₄₅ = pH value 45 minutes post mortem. WHC is expressed as percent water bound to the meat.



The increase in WHC due to the addition of DP was more pronounced in the normal (9% increase) than in the PSE-meat quality group (5 to 6% increase). Addition of TP resulted in an increase of approximately 5 to 6% in both meat quality groups.

In according to the work of other investigators with beef (3), it can be concluded that also in pork DP is more effective in increasing the WHC than TP, providing, however, the muscle proteins are not being denatured.

In contrast with the results of earlier experiments (11, 16), time of addition of both polyphosphates had no distinct effect on WHC.

2-Hydrolysis of DP and TP in unheated pork

DP-Hydrolysis was higher in the normal (Fig.1) than in the PSE-meat (Fig.2). Time of addition of the polyphosphates post mortem also affected the rate of DP hydrolysis in the normal meat quality group. In the meat samples from this group, prepared within 1 hour post mortem, 50% of the added DP were already hydrolysed within 5 minutes, whereas a complete break-down occurred within 5 to 24 hours. When DP was added 48 hours post mortem, complete hydrolysis was obtained only 9 to 72 after addition.

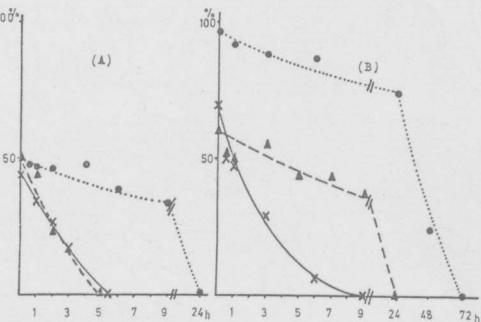


FIG. 1 : BREAKDOWN OF PYROPHOSPHATE (0.3% P_2O_5) IN PORCINE M. LONGISSIMUS DORSI OF NORMAL MEAT QUALITY TYPE. (A) : PRERIGOR ADDITION (1h P.M.) (B) : POSTRIGOR ADDITION (48h P.M.)

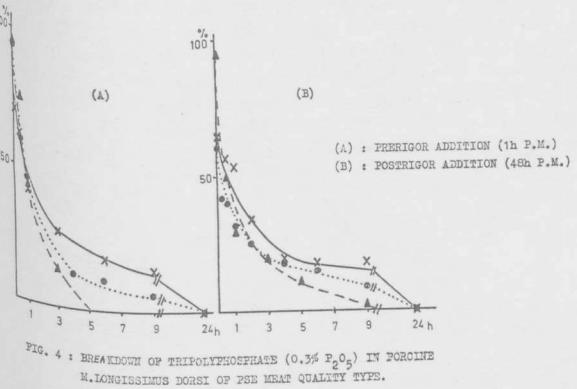
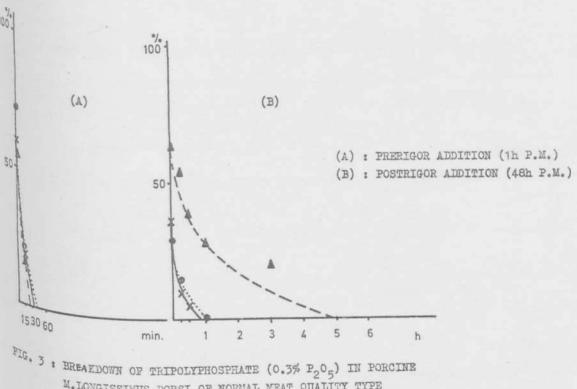
In the PSE-meat DP hydrolysis was clearly delayed. However, differences in the rate of hydrolysis due to the time of addition, were not obvious (Fig. 2A, 2B).

Although low initial pH may reduce DPase activity, the lower activity of DPase in the PSE-meat may be caused mainly by partial enzyme denaturation due to the "thermo-protonic stress" (15).

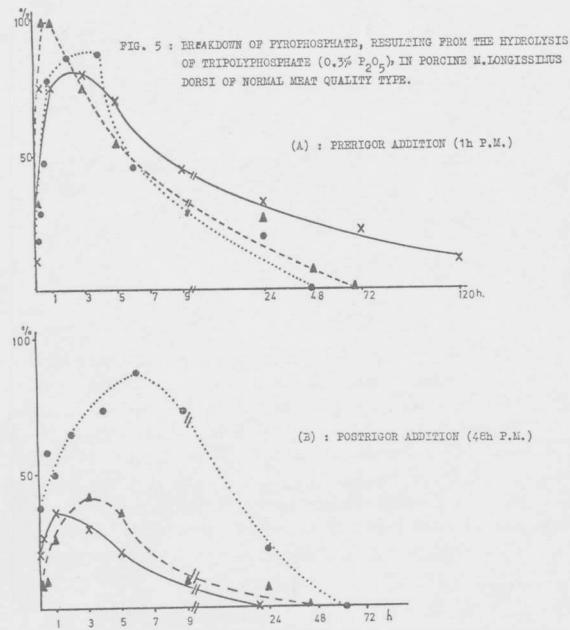
TP-Hydrolysis: TPase activity increased with time post mortem and decreased when PSE-condition occurred. These changes were also described for ATPase activity in pig muscle post mortem (6). The results also indicate that in pork as well as in beef (16) TPase activity is higher than DPase activity.

Depending on the time of addition of TP to the normal meat samples, i.e. 1 or 48 hours post mortem, TP hydrolysis was completed ultimately within 5 hours and 30 minutes respectively (Fig. 3A, 3B).

In the PSE-muscles, the time-course increased in some cases up to 24 hours (Fig. 4A, 4B). Although the pH optimum for TPase (pH 5.7) is different from that for ATPase (pH 6.9), the results point to some accordance between both enzyme systems.



During hydrolysis of TP, DP appeared and increased inversely with the TP content. Maximum DP concentrations were measured between 2 and 6 hours for the normal meat (Fig. 5A, 5B). In the post-rigor prepared samples (48 hours post mortem), DP increased to 80-98% of the maximum amount (=100%, stoichiometrically calculated from the added TP).



DP, however, decreased again and disappeared almost within 72 hours after addition of TP.

In accordance with the hydrolysis of DP directly added to the meat, hydrolysis of produced DP was delayed in the PSE-group (Fig. 6A, 6B). With exception of one sample, DP disappeared only 96 to 120 hours after addition of TP.

3-Hydrolysis of DP and TP in heated pork (Table 2)

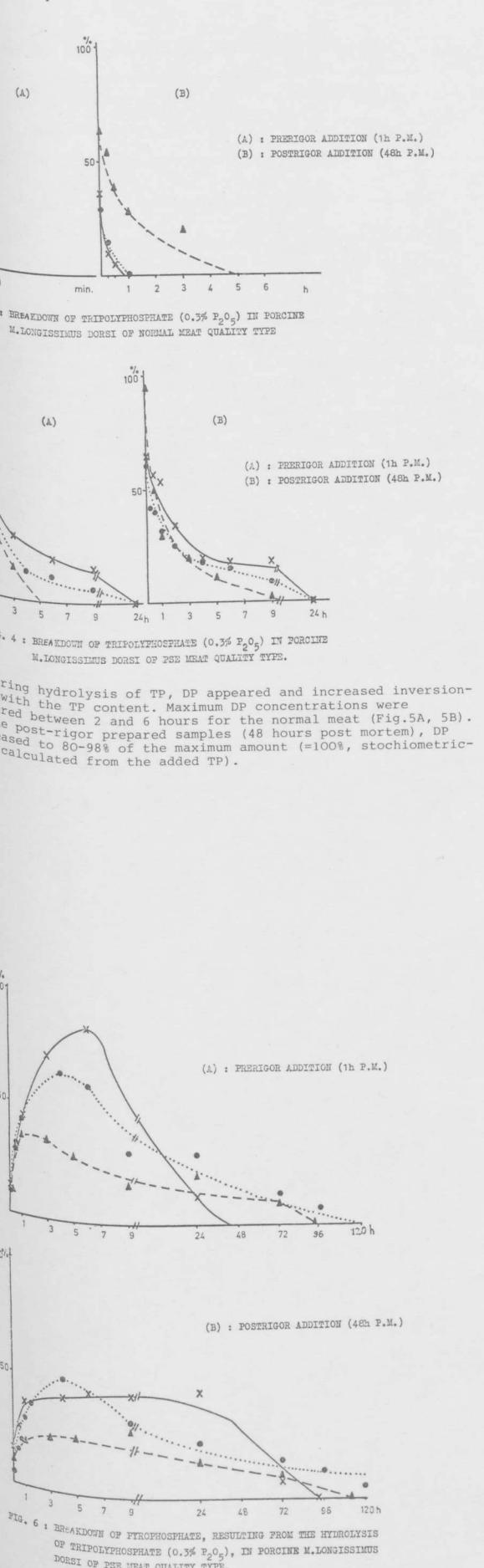
As in beef, TPase in porcine longissimus dorsi muscles is more sensitive against heating than DPase, the former being completely inactivated at 72°C. The results also indicate that during heating at temperatures between 60°C and 72°C, considerable losses of the added polyphosphates occur.

Quality group	Polyphosphate used (0.3% P_2O_5)	Diphosphate		Tripolyphosphate			
		DP hydrolysis normal	DP hydrolysis PSE	TP hydrolysis normal	TP hydrolysis PSE	DP hydrolysis normal	DP hydrolysis PSE
Heating	60°C a	29.5	27.1	76.4	55.3	41.7	75.7
	b	40.0	59.5	85.0	75.0	73.4	78.0
	65°C a	24.8	3.4	74.6	53.6	56.0	62.6
	b	39.4	26.5	78.0	61.0	64.3	74.0
	72°C a	15.4	14.6	71.2	48.4	38.8	53.1
	b	24.0	22.2	72.7	48.8	50.4	54.9

TABLE 2 : Mean hydrolysis (n=3) in percent of initial amounts of DP and TP in porcine longissimus dorsi muscles of different meat quality type (PSE or normal).
a = immediately after heating.
b = after heating and storage at +4°C for 5 days.

LITERATURE

- Awad, M.: in "Analysis of Phosphates in Foods": Deman, J. and Melnychin, P. - AVI, Westport, Connecticut, 1971, p.42.
- Dekker, T. and Hulshof, H.: Proceed. 2nd int. Symp. Condition Meat Quality of Pigs, Zeist, 1971, p.79.
- Fukazawa, T., Hashimoto, Y. and Yasui, T.: J.Food Sci., 26, 541 (1961).
- Gassner, K. and Ender, S.: Dtsch. Lebensm.-Rdsch., 53, 228 (1957).
- Grau, R. and Hamm, R.: Fleischwirtsch., 5, 295 (1953).
- Greaser, M., Cassens, R., Briskey, E. and Hoekstra, W.: J.Food Sci., 34, 120 (1969).
- Mahon, J., Schlambock, K. and Brotsky, E.: in "Analysis of Phosphates in Foods": Deman, J. and Melnychin, P. - AVI, Westport, Connecticut, 1971, p.158.
- Nakamura, S., Namoru, Y., Morita, J. and Yasui, T.: J.agric.Food Chem., 17, 633 (1969).
- Neraal, R. and Hamm, R.: Fleischwirtsch., 52, 1171 (1967).
- Neraal, R. and Hamm, R.: Proceed. 19th European Meeting of Meat Research Workers, Paris, 1973, p.1419.
- Raheljic, S., Rede, R. and Pribis, V.: Rec. Industr. Mesa, 2, 27 (1971).
- Shults, G., Russel, D., Wierbicki, E.: J.Food Sci., 37, 860 (1972).
- Steinlauf, D., Weiss, F. and Weniger, J.: Fleischwirtsch., 46, 39 (1966).
- Sutton, A.: J.Food Technol., 8, 185 (1973).
- Van Hoof, J. and Dedeken, L.: Vlaams Diergeneesk.Tijdschr., 37, 25 (1972).
- Van Hoof, J.: Thesis Fac.Diergeneesk.Gent, 1974, p.175.
- Yasui, T., Sakanishi, M. and Hashimoto, Y.: J.agric.Food Chem., 12, 392 (1964).
- Yasui, T., Fukazawa, T., Takahashi, K., Sakanishi, M. and Hashimoto, Y.: J.agric.Food Chem., 12, 399 (1964).
- Yount, R. and Kashland, D.: J.Biol.Chem., 238, 1708 (1963).



In accordance with the results of unheated samples, losses are higher for TP than for DP and are higher in normal than in PSE-meat. The absence of further decrease of the residual TP-content following heating at 72°C, indicates that chemical hydrolysis may be of minor importance in adequately heated semi-preserved meat products. However, residual DP may be subjected to slight hydrolysis during consequent storage at +4°C.