Functional properties of comminuted and salted hot-boned pork and beef

N.NESTOROV, A.GROZDANOV, N.DIMITROVA, N.DILOVA, M.TANTIKOV and D.PETROVA

Meat Technology Research Institute, Sofia, Bulgaria

Recently, hot-meat processing attracts increasingly the attention of both meat scientists and technologiests because of the energy shortages and the excellent functional properties of prerigor meat. Some difficulties arize, however, in the implementation of this technology on a large factory scale, since a strict synchronization of slaughtering, boning, grinding, salting and cooking is indispensable. One possible way to obviate this disadvantage is to postpone the processing till the following day, or even further, by presalting comminuted hot-boned muscles (Hamm, 1981).
The high water binding capacity of prerigor beef can be retained for several days if grinding and salting are completed before the onset of rigor mortis, and the resultant mixture is kept under refrigeration (Hamm and Grabowska, 1979). The same result can be obtained by a rapid freezing or freeze-drying of the ground and salted prerigor beef(Fischer et al., 1980, Hamm, 1978).The application of such a technology with pork would be of limited importance due to the faster glycolysis and earlier onset of rigor in porcine muscles, but this is still highly desirable.
The fat emulsifying capacity of muscle proteins is another important factor in meat processing. It has been shown that the salt-soluble proteins are the major emulsifying components and are greatly influenced by the time postmortem (Trautman, 1964). Prerigor normal pH muscles contain much more extractable salt-soluble proteins than the prerigor ones. The addition of up to 3% of sodium chloride to meat 24 hr before protein extraction increases extractable salt-soluble protein content in prerigor normal pH porcine muscles (Johnson and Henrickson, 1980).
This study was initiated to establish whether the positive effect of presalting on the water-binding capacity of prerigor beef is accompanied by any changes in the other important functional properties of meat. Similar experiments with hot-boned porcine muscles were also included herein.

EXPERIMENTAL

Bovine and porcine semimembranosus muscles were excised from the hind qurters within one hr after slaughter. One third of the muscles was ground immediately, and then subjected to the functional property tests. The second third was ground at the same time, but salted with sodium chloride (final concentration, 2.4%), and then kept at +4°C for 24 hr before being tested. The remaining third of the muscles was chilled intact for 24 hr, then ground and tested

After the completion of the respective treatments, the ground meat samples were blended in a modified Hasselbach-Schneider solution, containing 0.6M NaCl instead of KCl. Pyrophosphate was omitted with the warm meat, as well as with the presalted ground meat. The salt added to the latter was taken into account, so less sodium chloride was included in the respective extracting medium. After blending, the resultant slluries were allowed to stay for 30 min at +4°C, and then centrifuged to remove the excess fat and undissolved residue. Total extractable protein content was measured by the dye-binding method elaborated by Dilova et al.(1981). The emulsifying capacity test and the least concentration gel test were performed as described elsewhere in these Proceedings (Grozdanov et al., 1982).
The water binding capacity was determined by heat treating homogenates of meat, water and salt with different water/meat ratios, as described by Gumpen and Martens(1977). Water solutions of sodim chloride were added to the ground meat samples in such a way that that the salt content was approximately constant but water varied from 0.5 to 2.5 ml of added water per g of lean meat. Thus prepared homogenates were subjected to heat treatment until an internal temperature of 78°C was reached, then cooled, and the released juice measured to the nearest 0.1 ml.
The cured colour formation rate was determined as follows: One ml of a solution containing 0.5 mg of sodium nitrate was added to 10 g of ground meat sample in a Thunberg tube. Triplicate samples were prepared in all cases. The content of the tubes was thoroughly mixed by a glass rod, and the air was evacuated for 30 sec. After deairation, tubes were incubated at 37°C for 15 min. Then the tubes were transfered to an ice-water bath, and coooled down to 0°C in the dark. The nitrosylmyoglobin formed was determined by the modified method of Hornsey's (1956). The content of Thunberg tubes was transferred to a dark bottle by means of 40 ml of acetone (two portions of 20 ml each). Aftermixing, samples were stored at -5°C for 30 min, then filtered. Ten ml of the filtrate were added to o.1 ml of conc. HCl, and the absorbtion of the solution was read off at 530 nm.

RESULTS

The water binding capacity (WBC) of beef depended on both rigor state and the treatment. These data are presented in Figure 1. The WBC of beef was the highest with the hot meat, and the lowest with the chilled meat. The ground and salted prerigor muscles showed intermediate WBC values after chilling for 24 hr.
Rigor and the various treatments did not influence significantly the water binding capacity of pork (Figure 1B).
Diluted solutions of the total extractable proteins were heated, cooled down, and the gels obserued. As shown in Table 1, the protein concentrations where a stable homogeneously gelled protein was formed differed for the various treatments of beef. Chilled beef was slightly

superior to the hot-boned one. The least stable gels were produced by the extracts from ground and salted beef. With pork, none of the treatments influenced significantly gel formation.

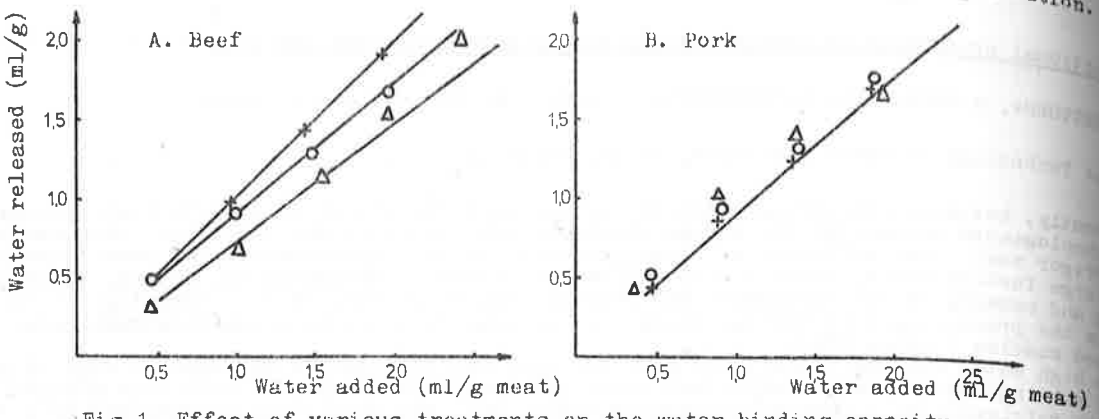

Fig. 1. Effect of various treatments on the water binding capacity ; (Δ) - "hot" meat ; (o) - ground & chilled meat ; (x) - chilled meat

The results determining the fat emulsifying capacity of the total protein extracts are shown in Table 2. The proteins extracted from the "hot" beef emulsified the largest quantity of oil before their emulsion broke. Both chilled intact or ground and salted beef samples were inferior to the hot meat with respect to their emulsifying capacity. No differences were observed between the various treated pork samples.

Table 1. Effect of various treatments on gel stability

Protein concentration, mg/ml	Beef			Pork		
	"Hot"	Ground & salted	Chilled	"Hot"	Ground & salted	Chilled
10	+	+-	+	+	+	+
8	+-	-	+	+-	+-	+-
6	-	-	+-	-	-	-
4	--	-	-	-	-	-
2	--	--	--	--	--	--

Table 2. Effect of various treatments on emulsifying capacity

Treatment	ml oil per mg protein	
	Beef	Pork
"Hot"	1.30	1.45
Ground & salted	1.35	1.42
Chilled	1.51	1.47

The rates of nitrosylmyoglobin formation as influenced by the various treatments of bovine and porcine muscles are shown in Table 3. Colour-forming ability of both beef and pork strongly depended on their respective pH values. Lower pH-values resulted in a more rapid pigment transformation into their nytrisyl derivatives. With pork, a dependance was also demonstrated on whether it was chilled intact or after being ground and salted.

Table 3. Effect of various treatments on cured colour formation rate

Type of meat	$\Delta E_{530\ nm} \cdot 10^4 \cdot min^{-1}$		
	"Hot"	Ground & salted	Chilled
Beef	97 pH = 6.7	140 pH = 5.6	130 pH = 5.6
Pork	18.4 pH = 6.1	19.5 pH = 5.4	26.7 pH = 5.3

DISCUSSION

As our results indicated, the "presalting" effect on the water binding capacity, as it is the case with beef, could not be obtained when porcine muscles were ground and salted at 1.5 hr postmortem. Moreover, the cooking losses of the so called "hot" pork were similar to the ones of chilled pork without any polyphosphates added. Whether the addition of pyro- or polyphosphates to still warm ground pork would improve the WBC was not determined. With pre- and post-chill cured hams and loins, van Hoof(1974) observed that weight losses during curing with polyphosphates were significantly in favour of the post chilled processed pork. An earlier (less than 1.5 hr) boning and processing of pork is hardly possible since the obligatory meat inspection takes at least 1 hr , therefore the salting of prerigor ground pork appears to be of no practical importance.

As far as beef is concerned, we did confirm that salting of ground bovine muscles in the prerigor state can secure against the loss of WBC which occurs concurrently with the pH fall and rigor development. Irrespective of the other advantages, this is the only way to be followed if polyphosphates have to be omitted in the curing mixtures conventionally used with chilled meat.

Grinding and salting of prerigor beef, however, did not provide for better extractability of salt-soluble muscle proteins. On the contrary, less quantities of proteins are dissolved in high ionic strength solutions despite of improved swelling and water retention. These data conform to the results reported by Hamm and Grabowska(1979), who have suggested an explanation of the observed phenomenon.

Being poorer in the salt-soluble myofibrillar proteins, these extracts are less capable of emulsifying fat and forming stable gels. Despite of the lack of a direct evidence that this is the case, this might be the most probable explanation of the observed inferior emulsifying

Lawrie, R., 1981. Post-mortem changes in muscle affecting the quality of comminuted meat products. In ~~Dose~~ R.A. Lawrie (ed.): Developments in Meat Science-2. Applied Science Publishers, London and New Jersey. p 94.

Henrickson, R.L. 1966.

and cooking method

1966: 107-109

T.L. & Weiss, G.M. 1977

ne processing:

2 and loins.

9,923.

EFFECT OF PRE-RIGOR SALTING ON THE WATER-BINDING CAPACITY OF BEEF

E. PUOLANNE and P. TURKKI
University of Helsinki, Institute of Meat Technology
Helsinki, Finland

INTRODUCTION

The use of hot boned beef has been more thoroughly studied than that of hot boned pork. The loss of ATP takes place faster in pork than in beef, but otherwise the ~~two~~ reactions are similar (Hamm 1981, Netorov 1982). Moore et al. (1966), van Hoof (1974), Nestorov (1982) and Stillwell (1978) did not find any marked differences between products made of hot processed pork and those made of cold processed pork. Mandigo et al. (1977) however, found a better product yield in hot processed pork products.

Puolanne and Terrell (1983) found that the water-binding capacity can be significantly enhanced by presalting pork with 2-4 % NaCl and 15 % added water within 1 h of stunning. The high water-binding capacity was retained in the meat even in cooked sausage, provided the salt content of the sausage was kept over 1.5 % NaCl when other ingredients were added to the mixture. Nestorov et al. (1982) concluded that the hot processing of pork (within 1.5 h post mortem) is hardly possible in the industry because of the time needed for slaughtering and meat inspection (including the trichina test).

The purpose of this study was to compare the water-binding capacity (WBC) of hot salted (less than 45 minutes post mortem) pork to that of cold salted (22 h post mortem) pork using the laboratory sausage method. Special attention was given to whether the disadvantages of fast glycolysing muscles (PSE) could be avoided by using hot boning and pre-rigor salting.

MATERIAL AND METHODS

Thirtysix pig ~~carcasses~~ weight ≤ 70-72 kg) were obtained from a slaughterhouse. Six pigs at the time were taken for tests on each day of sampling. The pigs were slaughtered by the usual procedure, with the time from stunning to weighing averaging 25 minutes. Immediately after weighing the left hind leg was cut off and the M. gluteus medius (GM) was excised. The

samples were then quickly homogenized in a Moulinex Moulinette homogenizer (Moulinex, France) with 3 % NaCl. The time elapsed from stunning was no more than 40 minutes. The following day the GM muscles of the right-hand sides were excised and salted in the same way (post-rigor salting).

The pH values were measured directly using a Knick Portamess 55/pH meter (Knick Elektronische Messgeräte, FRG) with a meat electrode (Ingold type 10-404-3041, W. Ingold AG, Switzerland). The pH values of the left-hand GM muscles were measured immediately after homogenization (before adding salt), after adding salt and finally 22 h post mortem (salted homogenate). The pH values of the right-hand GM muscles were measured 45 min post mortem (pH_1), 22 h post mortem, after salting and after 22 h of salting. If the pH_1 value was ≤ 5.8 the pig was considered to be a PSE pig.

The WBC was measured using the laboratory sausage method of Puolanne and Ruusunen (1978). Each test was run in duplicate. The sausage mass contained 51.5 g of GM-salt mixture (50 g meat), 50 g pork back fat, 130 g water and 3.1 g NaCl. The salt content of the sausage mass was 2 %. Eighteen samples were processed without added phosphate and 18 samples with added phosphate (Carafos, 0.15 % calculated as P_2O_5). The sausage mass was chopped in a Moulinex homogenizer, stuffed into a casing and cooked for 40 min at 75 °C to an internal temperature of 72 °C. After cooking the sausage was peeled and the excess water released was removed.

WBC was determined as the difference between the weight of the stuffed sausages (weight of casing excluded) and the weight of the cooked and peeled sausages after removing released water and jelly. No fat was released. These weight differences were subtracted from the 130 grams of water added to the original recipe and represent the weight of water retained by the sausage after cooking and chilling. The results were expressed as g water/100 g meat.

RESULTS AND DISCUSSION

The WBC of hot salted sausages without added phosphate was $\bar{x} = 92.8 \pm 4.9$ g water/100 g meat. The pH value of the meat at the time of presalting was $\bar{x} = 6.6 \pm 0.3$. The WBC of cold salted sausages was $\bar{x} = 53.7 \pm 17.0$ g water/100 g meat and the pH value of the meat $\bar{x} = 5.6 \pm 0.2$. The WBC of hot salted sausages with added phosphate was $\bar{x} = 107.7 \pm 3.9$ g water/100 g meat and the pH value $\bar{x} = 6.5 \pm 0.3$. In cold salted sausages the corresponding values were $\bar{x} = 104.5 \pm 7.0$ g water/100 g meat and pH $\bar{x} = 5.7 \pm 0.3$.

The linear regression between ΔpH (Δ pH = pH at the time of hot salting - pH_{22}) and Δ WBC (Δ WBC = WBC hot salted meat - WBC cold salted meat) in the sausages without added phosphate was WBC = 32.25 pH + 7.38; r = 0.530, and in the sausages with added phosphate WBC = 7.95 pH - 2.85; r = 0.615.

DISCUSSION

The effect of hot salting is not marked when phosphate is added, but without added phosphate a significant increase in WBC can be achieved. In the latter case the pH_{22} value seems to be very important (Figure 1). When the pH_{22} value was ≥ 5.85, the decrease in WBC compared to hot salted samples was $\bar{x} = 9.5 \pm 3.1$ g water/100 g meat (N = 4), which was very much smaller than when the pH_{22} value was ≤ 5.8 ($\bar{x} = 46.9 \pm 4.8$ g water/100 g meat; N = 14). The number of samples with $pH_{22} \geq 5.85$ was too small to permit any difinite conclusions, but this finding suggests that more research is needed in this area.

Only three PSE GM muscles were found in this study ($pH_1 \leq 5.8$), and there was no consistent indication that the formation of PSE could be prevented by very rapid pre-rigor salting.

Other studies conducted in our laboratory revealed that very rapid salting, within 1 h, is needed in most cases for a marked effect of pre-rigor salting. The beneficial effect of hot processing can be achieved only when the meat is salted before onset of rigor mortis. The temperature of the meat at time of salting is not important.

According to Nestorov et al. (1982) the time needed for slaughtering, including meat inspection, is at least 1.5 h, which probably prevents the effective use of pre-rigor salted pork. Nevertheless, more research is needed into the biochemistry of different muscles and into the technological prospects of using pre-rigor salting.

EFFECT OF PRE-RIGOR SALTING ON THE WATER-BINDING CAPACITY OF BEEF

E. PUOLANNE and P. TURKKI
University of Helsinki, Institute of Meat Technology
Helsinki, Finland

INTRODUCTION

The use of hot boned beef has been more thoroughly studied than that of hot boned pork. The loss of ATP takes place faster in pork than in beef, but otherwise the two reactions are similar (Hamm 1981, Nestorov 1982). Moore et al. (1966), van Hoof (1974), Nestorov (1982) and Stilwell (1978) did not find any marked differences between products made of hot processed pork and those made of cold processed pork. Mandigo et al. (1977) however, found a better product yield in hot processed pork products.

Puolanne and Terrell (1983) found that the water-binding capacity can be significantly enhanced by presalting pork with 2-4 % NaCl and 15 % added water within 1 h of stunning. The high water-binding capacity was retained in the meat even in cooked sausage, provided the salt content of the sausage was kept over 1.5 % NaCl when other ingredients were added to the mixture. Nestorov et al. (1982) concluded that the hot processing of pork (within 1.5 h post mortem) is hardly possible in the industry because of the time needed for slaughtering and meat inspection (including the trichina test).

The purpose of this study was to compare the water-binding capacity (WBC) of hot salted (less than 45 minutes post mortem) pork to that of cold salted (22 h post mortem) pork using the laboratory sausage method. Special attention was given to whether the disadvantages of fast glycolysing muscles (PSE) could be avoided by using hot boning and pre-rigor salting.

MATERIAL AND METHODS

Thirtysix pig carcasses (70-72 kg) were obtained from a slaughterhouse. Six pigs at the time were taken for tests on each day of sampling. The pigs were slaughtered by the usual procedure, with the time from stunning to weighing averaging 25 minutes. Immediately after weighing the left hind leg was cut off and the M. gluteus medius (GM) was excised. The

samples were then quickly homogenized in a Moulinex Moulinette homogenizer (Moulinex, France) with 3 % NaCl. The time elapsed from stunning was no more than 40 minutes. The following day the GM muscles of the right-hand sides were excised and salted in the same way (post-rigor salting).

The pH values were measured directly using a Knick Portaness 55/pH meter (Knick Elektronische Messgeräte, FRG) with a meat electrode (Ingold type 10-404-3041, W. Ingold AG, Switzerland). The pH values of the left-hand GM muscles were measured immediately after homogenization (before adding salt), after adding salt and finally 22 h post mortem (salted homogenate). The pH values of the right-hand GM muscles were measured 45 min post mortem (pH_1), 22 h post mortem, after salting and after 22 h of salting. If the pH_1 value was $\leq$ 5.8 the pig was considered to be a PSE pig.

The WBC was measured using the laboratory sausage method of Puolanne and Ruusunen (1978). Each test was run in duplicate. The sausage mass contained 51.5 g of GM-salt mixture (50 g meat), 50 g pork back fat, 130 g water and 3.1 g NaCl. The salt content of the sausage mass was 2 %. Eighteen samples were processed without added phosphate and 18 samples with added phosphate (Curafoss, 0.15 % calculated as P_2O_5). The sausage mass was chopped in a Moulinex homogenizer, stuffed into a casing and cooked for 40 min at 75 °C to an internal temperature of 72 °C. After cooking the sausage was peeled and the excess water released was removed.

WBC was determined as the difference between the weight of the stuffed sausages (weight of casing excluded) and the weight of the cooked and peeled sausages after removing released water and jelly. No fat was released. These weight differences were subtracted from the 130 grams of water added to the original recipe and represent the weight of water retained by the sausage after cooking and chilling. The results were expressed as g water/100 g meat.

RESULTS

The WBC of hot salted sausages without added phosphate was $\bar{x}$ = 92.8 ± 4.9 g water/100 g meat. The pH value of the meat at the time of presalting was $\bar{x}$ = 6.6 ± 0.3. The WBC of cold salted sausages was $\bar{x}$ = 53.7 ± 17.0 g water/100 g meat and the pH value of the meat $\bar{x}$ = 5.6 ± 0.2. The WBC of hot salted sausages with added phosphate was $\bar{x}$ = 107.7 ± 3.9 g water/100 g meat and the pH value $\bar{x}$ = 6.5 ± 0.3. In cold salted sausages the corresponding values were $\bar{x}$ = 104.5 ± 7.0 g water/100 g meat and pH $\bar{x}$ = 5.7 ± 0.3.

The linear regression between ΔpH (Δ pH = pH at the time of hot salting - pH_{22}) and Δ WBC (Δ WBC = WBC hot salted meat - WBC cold salted meat) in the sausages without added phosphate was WBC = 32.25•pH + 7.38; r = 0.530, and in the sausages with added phosphate WBC = 7.95•pH - 2.85; r = 0.615.

DISCUSSION

The effect of hot salting is not marked when phosphate is added, but without added phosphate a significant increase in WBC can be achieved. In the latter case the pH_{22} value seems to be very important (Figure 1). When the pH_{22} value was ≤ 5.85, the decrease in WBC compared to hot salted samples was $\bar{x} = 9.5 \pm 3.1$ g water/100 g meat (N = 4), which was very much smaller than when the pH_{22} value was ≤ 5.8 ($\bar{x}$ = 46.9 + 4.8 g water/100 g meat; N = 14). The number of samples with $pH_{22} \geq 5.85$ was too small to permit any definite conclusions, but this finding suggests that more research is needed in this area.

Only three PSE GM muscles were found in this study ($pH_1 \leq 5.8$), and there was no consistent indication that the formation of PSE could be prevented by very rapid pre-rigor salting.

Other studies conducted in our laboratory revealed that very rapid salting, within 1 h, is needed in most cases for a marked effect of pre-rigor salting. The beneficial effect of hot processing can be achieved only when the meat is salted before onset of rigor mortis. The temperature of the meat at time of salting is not important.

According to Nestorov et al. (1982) the time needed for slaughtering, including meat inspection, is at least 1.5 h, which probably prevents the effective use of pre-rigor salted pork. Nevertheless, more research is needed into the biochemistry of different muscles and into the technological prospects of using pre-rigor salting.

and gelling properties of total protein extracts derived from ground and salted prerigor beef. Apparently, pyro- and polyphosphates additions to chilled ground beef give rise to an improved solubility of the myofibrillar proteins, which results in a better emulsifying capacity. However, whether the increased extractability of salt-soluble meat proteins is a decisive factor for meat product quality is still not quite clear (Hamm and Grabowska,1979).

The exact contribution of each functional property to the overall quality of meat products needs further research efforts.

Cured colour formation appears to be adversely affected by hot-meat processing, but this problem could be easily overcome by the addition of ascorboc acid or its sodium salts.

It is to be noted that there are still unsolved problems with regard to hot-meat processing before its large-scale implementation into practice. The general opinion is, however, that none of the problems existing would discourage the future use of this technology.

REFERENCES

1. Dilova,N., Grozdanov.A., Nestorev,N., Petrova,D., Dikova,G., and Tabakova,R.1981. Studies on the content of total and muscle protein in perishable sausages.Proc.27th EMMRW,Wien
2. Fischer,C., Honikel,K.O., and Hamm,R. 1980. Einfluss der Geschwindigkeit des Einfrierens von Rindfleisch prae rigor auf Muskelstoffwechsel und Wasserbindungsvermögen. Z.Lebensm. Unters-Forsch. 171:105
3. Grozdanov.A., Dimitrova,N., Nestorov,N., Dilova,N,and Dikova,G. 1982. Effects of low-dose irradiation and subsequent storage on the technological properties of beef. These Proceedings.
4. Gumpen,S. and Martens,H. 1977. On water binding capacity and sausage texture properties. Proc. 23d EMMRW, Moskow .
5. Hamm,R.1978. The use of freeze-dried prerigor beef in sausages. Proc.Meat Ind.Res.Conf., Amer.Meat Institute, Chicago.
6. Hamm,R. and Grabowska,J.1979. Proteinlöslichkeit und Wasserbindung unter den in Brühwursträten gegebenen Bedingungen.V Mitt. Fleischwirtschaft,59:1338.
7. Hamm,R.1981. Postmortem changes in muscle with regard to processing of hot-boned beef.Proc Int.Symp."Advances in hot-meat processing",Poland.
8. Hornsey,H.C.1956.The colour of cooked cured pork.Part I. J.Sci.Food Agric. 7:534
9. Johson,R.G. and Henrickson,R.L.1970. Effect of treatment of pre-and postrigor porcine muscles with low sodium chloride concentrations on the subsequent extractability of proteins. J.Food Sci. 36:268
10. Trautman,J.C.1964. Fat emulsifying properties of prerigor pork proteins.Food Technol.18: 1065
11. van Hoof,J.1974. Enkele biochemische en technologische aspecten bij de verwerking van rund- en varkensvlees. Mededelingen van de Faculteit Diergeneeskunde Rijksuniversiteit Gent. 18:1.

4* (Ref Nestorov Nat, 1982)