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PENETRATION DYNAMICS OF INGREDIENTS OF INTRAVASCULLARY INJECTED PICKLE INTO HAM MUSCLES

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Curing and curing techniques are fields in the meat technology in which, in spite of the results achieved so far, there still are problems to which no definite answer has been given yet. The curing itself, which essentially represents a series of complex biochemical and biophysical changes, is influenced by numerous factors causing changes in the colour, consistency, and flavour of cured meat. These factors may be divided into three groups.

1. Meat.- The penetration of pickle ingredients depends largely on the quality of cured meat; sodium chloride for instance penetrates much quicker into muscles than into fat tissues (15). The postmortem autolitic changes in meat i.e. the state of muscle cells at the moment of the pickle - meat contact plays certainly one of the decisive roles in the curing process (1,2,6,14). T e temperature and the cooling rate causing larger or smaller changes in muscular structure (11) may likewise influence the penetration of pickle ingredients. Both the anatomic situs (4,12) and the extent of vascular system and muscular tissue are also the factors influencing the curing process.

2. Pickle.- The pickle ingredients are acting in two ways: on the one haund by increasing the swelling power of muscle proteins they influence the water (sodium chloride and polyphosphate preparations) and on the other hand they make possible the appearance of the desired colour of cured meat (nitrates, nitrites, glucose). The Redox potential and the pH of the pickle (3,5,7,8,9) belong also to factors influencing the curing process. Regular course of the osmoticodiffusional processes (lo) within the curing procedure depends largely on the temperature of injected pickle. The volume of injected pickle on the other hand, is responsible for the homogenous and uniform distribution of pickle ingredients (13).

3. Curing methods.- The methods of hams curing for canned hams production, being most applied nowadays; are intravascular injection of pickle and direct injection into muscular tissue. Whilst in some countries the latter method is being applied in Yugoslavia hams are being cured almost exclusively by intravascular injections. Both methods, however, produce the same results: in a relatively short period of time meat is entirely penetrated by the used pickle.

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Though numerous reports on the influence of ionizying radiations on the quality and bacterial flora of

meat have been published so far, in the literature we have been able to consult on the subject, we have found no data on the utilization of radioactive tracers during the curing process . Literature reports speak also very scarsely on the influence of ham vascularization on the curing process.

Our task was therefore to analyse the correlation between the vascular system, the pickle and the muscular tissue and to find out the extent to which the ham vascularization influences the dynamics of the pickle ingredients penetration.

Our research work was aimed at:

- the determination of the anatomic situs of the artherial system, i.e. detail analysis of the vascularization in certain ham muscles - by means of radiography;

- tracing the penetration and distribution of pickle ingredients within the ham muscles - by chemical methods, and

- examination of the penetration of pickle ingredients by the application of radioactive tracers.

MATERIALS AND METHODS

Radiographic Examinations

The artheriography of the hind extremity i.e. of the ham was carried out by means of positive contrast solutions. Prior to injection a native radiogram in order to get

control or test picture was taken, whereafter the minium gelatine and iodine contrast mixture were injected.

In the first phase concerning the examination of the anatomic ham blood vessels situs it was used the minium gelatine (after Jojić) which was injected under screen by syringe into the a.iliaca externa. After the injection, this ham was x-ray photographed from lateral view by means of fluoroscent folia.

In the second phase in which our task was to determine the speed and the extent of diffusion from the visible blood vessels, the positive "Joduron" contrast (7o%) was injected together with the pickle (21°Be, o.2oo kg $NaNO_2$, o.o8o kg $NaNO_3$, 1.5oo decstrose and 4.oco kg polyphosphate preparation) in the ratio 1:1o in the same way as previously. These preparation were x-ray photographed immediately after the injection, after 2 and 12 hours and after 4 days. In the second case the same mixture was injected by monopump under 1.5 Atm. The diffusion speed rate was followed radiographically immediately, 4, 6 and 12 hours after the injection.

C h e m i c a l E x a m i n a t i o n s

For curing we used hams derived from white pigs aged 8 to 1o months. Prior to the treatment the hams were cooled for 18 - 2o hours. The internal temperature prior to injection amounted to cca 3.5°C. The pickle (24.8oo kg NaCl, o.2oo kg $NaNO_2$, o.o8o kg $NaNO_3$, 1.5oo kg detrose and 4.ooo kg

polyphosphate preparation in 1oo l water) was injected into hams through a. iliaca externa under 1.8 Atm - to the amount of 7 percents of the ham weight (bones included).

The movement of water, NaCl and $NaNO_2$ was followed in intervals of o, 6, 12, 24 and 48 hours after the injcetion in the following muscles: quadriceps femoris, biceps femoris, semimembranosus and semitendinosus. To learn more about the dynamics of the penetration and distribution of the pickle ingredients each muscle was transversally divided into four cuts. In this way from two examined series (eight hams each) we chemically analysed 64o samples.

The total water was determined by dessication up to the constant weight at 1o5°C. The free water was determined by Grau method modified by Karan-Djurdjić.

The NaCl content was determined after Mohr - silver nitrate titration.

The $NaNO_2$ determination was effected by the colorimetric method ("Lovibond" comparator).

Radiometric Examinations

In our examinations pickle containing marked phosphates was used. The pickle was marked by tracing doses of radioactive phosphate P-32, in form of sodium orthophosphate $Na_2H\ (^{32}PO_4)$ the activity of which amounted to o,1 μCi/ ccm. Prior to injection of radioactive pickle, aa. poplitea, saphena

and truncus pudendo - epigastricus were blocked in order to prevent the marked pickle to let out. The pickle which was injected by monopump under 1.5 Atm into a.iliaca externa to the amount of 7 percents of the ham weight (bones included).The activity of the taken samples was determined by the "Philips" GM counter immediately after the injection and 6.12 and 24 hours after the injections.

RESULTS

Radiographic Examinations

The artheriography (Fig.1) shows the distribution and situs of blood vessels within the ham. The a. iliaca externa through which the contrast was injected lies, on the pelvis inlet, enters the canalis femoralis and continues as a.femoralis along the femoral canal and passes from the medial over to the posterior side of the femur. From fossa intercondylica it continues on as a.poplitea.

The a. profunda femoris is separated from a. iliaca externa before this has entered the canalis femoralis and quite close to the os pubis it gives the common trunk of the truncus pudendo - epigastricus of which the starting part is only visible. More backward ramus obturatorius with several smaller branches separates from the profunda femoris. At the modial border of the caudal part of femur the a. profunda femoris gives the a. circumflexa femoris medialis, and then it

continues ventrally forming quite a lot of larger and smaller branches.

More on the distal part of profunda femoris out of a.femoralis goes a chorter common trunk of the aa.circumflexa femoris lateralis and femoris cranialis, with many larger and smaller branches, and with a very developed capillar network (radiograms: easily noticable terminal arteries). Distally, before passing over to the caudal side of femur it gives a smaller branch a.genus suprema, and then over fossa intercondylica it ensues a more marked vessel - a.femoris caudalis which branches immediately giving ascendens and descendens vessels with smaller branches.

The radiogram vascularization scheme of the examined muscles shows the main branches of the artherial system with smaller vessels. The vascularization of the examined muscles (Scheme 1) is as follows:

- for m.quadriceps femoris: aa.femoris cranialis, circumflexa femoris lateralis and femoris caudalis,
- for m.biceps femoris: aa.circumflexa femoris lateralis, femoris caudalis and circumflexa femoris medialis,
- for m.semimembranosus: aa.femoris cranialis, femoris caudalis, circumflexa femoris medialis and profunda femoris,
- for m.semitendinosus: aa.profunda femoris, femoris caudalis and circumflexa femoris medialis.

In addition to the mentioned larger arteries , within the examined muscles there is - (in some radiograms even visible to a very outstanding extent) - a lot of branches, small branches, anastomosis, terminal arteries and in dependance of muscles, a variably developed capillary network.

The results of the radiologic examinations show that pickles and contrast solutions (Fig 2) injected by monopump did not diffuse from blood vessels immediately after the injection but after a certain period of time. The radiograms show only the contours of large blood vessels whilst smaller branches are clearly visible. Four hours after the injection the sharp contours of aa.femoris cranialis, circumflexa femoris lateralis and femoris profunda begin to fade away. Six hours after the injection of the contrast-pickle mixture radiologically can be seen only blood vessels traces and overshadowing of the muscles. After twelve hours the muscles are intensively and homogenously overshadowed while the blood vessels are not visible.

The series of radiograms eith blocked a.profunda femoris (Fig. 3) much better illustrates the dynamics of the penetration of the contrast-pickle mixture into the muscular tissue. Only two hours after the injection the lumen of a.femoralis starts narrowing whilst the sharp contours of smaller blood vessels fade away. After twelve hours a.femoralis is only visible, with beginning parts of the truncus of aa.femoris cranialis, circumflexa femoris lateralis and

femoris caudalis. On the fourth day after the injection the a.femoralis is visible only up to the middle of femur. The intensity of the muscles shades is intensified so that the whole ham is homogenously overshadowed.

C h e m i c a l E x a m i n a t i o n s

Examining the content of water, NaCl and $NaNO_2$ in given intervals there were obtained data on the penetration and distribution of said pickle ingredients in examined muscles.

The changes of the total water content (Graph.1) show that the decreasing rate is at the beginning of a almost progressive nature with minimal differences between the particular examined muscles. The richest in water content are m.quadriceps and biceps femoris. In the following intervals, however, the moisture rate is gradually decreasing so that already 48 hours after the pickle injection ensues a certain stabilization.

The content of free water (Graph. 1a) also shows a degree of regularity. The average value after the injection amounts to 3.93 percents varying from 3.17 to 4.89. Six hours after the injection ensues a rapid, after twelve hours - increasing and after 48 hours stabilization. Unlike the total water content results show, however, larger differences in the free water content of examined muscles. The lowest content have been found in the m.quadriceps femoris and the highest in the m.semimembranosus.

The examinations of NaCl content show that the middle cuts of muscles in the course of curing always contain more salt than those at the ending parts. The changes in the content of salt occur simultaneously in all cuts. The NaCl content of salt occur simultaneously in all cuts. The NaCl content decreases after the pickle injection (Graph.2) with noticable variations with individual muscles. The NaCl content drop is visible in all muscles in the following 12 hours, whereafter a slight increase occurs and after 48 hours a slight drop with immediate stabilization takes place. The only exception is with m.quadriceps femoris in which a second rise occurs 48 hours after the pickle injection. The richest NaCl content has been found in mm.quadriceps femoris and semitendinosus which values were far above those found in other examined muscles.

The curves of the $NaNO_2$ content show the decrease (Graph.3) in all examined muscles. The middle cuts, like in NaCl content examinations, contain more nitrites than ending parts. However, the changes of the $NaNO_2$ content i.e. the drop were seen in all cuts simultaneously. The highest nitrite content was found in m.quadriceps and m.semitendinosus whilst the nitrite content in other examined muscles was almost twice as low.

Radiometric Examinations

The results of radiometric examinations (Graph.4) show that the activity of some cuts in examined muscles were not significant - for which reason in our analyses we have taken into account only the average values of muscles radioactivity. The maximum radioactivity in all examined muscles was established immediately after the injection of the marked pickle solution. The highest value, like in all other examinations, was found in the m.quadriceps femoris. In all cases the muscles radioactivity decreases 6, 12 and 24 hours after the injection of marked pickles but with different intensity. In curves showing the decrease of radioactivity in examined muscles it may be noticed a "plane" which in m.quadriceps femoris was present between 0 and 6 hours and in other muscles between 6 and 12 hours after the injection of the radioactive pickle. From the slope of the curve showing the decrease and from the difference in the number of impulses in the examination intervals it may be seen that the rate of the radioactivity decrease was at the highest level between 0 and 6 hours after the injection of the radioactive pickle, decreasing thereafter up to 24 hours. After 24 hours the radioactivity drop curve is stabilized in all four examined muscles.

DISCUSSION

Having in mind the fact that our task was to find the influence of the vascular system on the dynamics of penetration and distribution of pickle ingredients, the interpretation of the achieved results as well as the discussion will therefore be based, mainly, on the anatomic situs of the blood vessels and ham muscles. The results of chemical and radiometric examination were used for better understanding of the pickle ingredient kinetics in regard to the muscle tissue i.e. for intermediate and detailed determination of the influence of the wascularisation in the course of curing.

R a d i o g r a p h i c E x a m i n a t i o n s

The scope, the rate and the course of byochemical and byophysical processes during the curing, disregarding all other factors, is dependent to a great extent on the contact of meat - pickle i.e. on the surface on which the pickle ingredients come into touch with the muscular tissue . Analysing the curing process from this aspect one may see that the vascular density i.e. the total lumen of blood vessels within the examined muscles play a decisive role. The differences in cross-sections of the blood vessel lumen in examined muscles are obvious. M.quadriceps femoris has the uncomparably largest blood vessel surface i.e. the largest developed capillar network.

Other muscles, compared with the aforesaid ones, have smaller total lumen though a larger number of blood vessels passes through or end in them.

The radiogram series (Fig.2 and 3) show that the penetration of pickles into the muscle tissue occurs from smaller branches and capillaries which is in correlation with the hystological structure of the blood vessels. Pickles and contrast mixture injected by monopump do nct immediately diffuse from the blood vessels but after a certain period of time. This phenomenon may be explained by supposition that curing by intravascular injection has two phases: 1. forcing the pickle into muscles by compression when the pickle solution is being forced mechanically into the muscles or precisely said into the intermuscular tissue in which the capillaries most probably break. In this way a quicker contact pickle - meat is made possibile, 2. penetration and binding of the pickle ingredients with muscular tissues by means of physico-chemical reactions.

The results of radiologic examinations show the time interval in which the pickle and the contrast leave the blood vessels. Here one may assume that the contrast has covered the vascular network, which on the other, exactely confirms the assumption that pickle leaves the blood vessels passing into muscular tissue. Radiograms show a complete fading of the blood vessels contours and beginning of intensive shading 6 to 12 hours after pickles have been injected. If we accept the assumption that there are two phases in the

intravascular curing the there ends only the visible phase i.e. a homogenous distribution of the pickle in muscular tissue occurs. The intensity of physicochemical processes increases in the following course as the pickle-muscular cells contact has been made possible.

Chemical Examinations

The purpase of these examinations has not been to follow the development of postmortem autolytic changes in meat during the curing but to use the results of chemical examinations in order to put more light, indirectly, into the influence of the vascular system in the course of curing.

Analysing changes in contents of water, salt and nitrites from the vascular system point of view we come to the conclusion that the pickle ingredient kinetics is dependent on the vascular system in examined muscles.

The changes in the total and free water contents show a certain regularity (Graph. 1 and 2) in all examined muscles with slighter or larger differences in the intensity of these changes. Comparing the results obtained from the examined muscles we find the total water content to be the greatest in m.quadriceps femoris and the lowest in m.semimembranosus. As for the free water content the case is just inverse i.e. the lowest content is present in m.quadriceps femoris and the highest in m.semimembranosus. The reason for this phenomenon should in our opinion not be sought for only

in the course of the postmortem autolytic processes nor in the marbling rate but probably in the density of the vascular network i.e. in the total lumen of blood vessels which is the largest just in m.quadriceps femoris and the lowest in m.semimembranosus.

When examining both NaCl content and distribution on the course of curing it is noticed that middle cuts always contain more salt than the ending parts and that changes in NaCl content occur simultaneously in all cuts. It is known that sodium chloride acts on muscular proteins increasing their swelling ability respectively the meat in presence of NaCl binds larger quantities of added water. This means that the meat, at the moment of highest swelling processes the lowest possible quantity of free water. This fact has also been confirmed by our findings. If we analyse the NaCl content in some muscles and compare their values, we shall see that the highest salt content is found in m.quadriceps femoris and the lowest in m.semimembranosus. In this respect mm.semimembranosus and biceps femoris show slight differences and so do mm.quadriceps femoris and semitendinosus. Results obtained by examinations of m.semitendinosus are very interesting. Contrary to what should be expected it was found that this muscles behaved with regard to the free water, NaCl and even nitrites contents in the way very similar to that of m.quadriceps femoris. Though its capillar network is less developed than it would be expected it contains a lot of rami

and terminal vessels of the aa.profunda femoris and femoris caudalis which in turn do not provide an as large lumen cross section as that provided by the vascular system of the m.quadriceps femoris. In any way, however, its total lumen is much larger than that of mm.semimembranosus and biceps femoris. According to the results obtained by examinations this muscle, in final product, would be expected to show, if not the same, then at least similar results to those obtained with the m.quadriceps femoris. However, it is a known a fact that m.semitendinosus shows almost the greatest variations with regard to the achievment of optimal organoleptic properties of the final product. The reason explaining this phenomenon may in our opinion most probably be the marbling being expressed to a large extent.

Our results speak of a great similarity in dynamics of the penetration and distribution of nitrites and salts. Middle cuts namely, like in the case of NaCl, happen to contain more nitrites than the ending ones and the changes in content were observable simultaneously and alike in all cuts. The reasons explaining this phenomenon with regard to both salt and nitrites should most probably be sought in the situs of the vascular network wich total lumen diminishes towards the ending parts, as well as in the fact that the beginning i.e. the ending parts of muscles happen to be richer with connective tissue (tendon endings) than the middle parts.

If we analyse the quantitative correlations of the particular ingredients and the kinetics they develop during the curing procedure, the four examined muscles may be divided into two groups: first group comprising mm.quadriceps femoris and semitendinosus, in wich the vascular network is more expressed than that with the second group comprising mm.semi-membranosus and biceps femoris. Comparing the curves showing the movement of examined pickle ingredients contents in intervals of 0, 6, 12, 24 and 48 hours one finds that the stabilization i.e. the "steady state" of pickle ingredients occurs between 24 and 48 hours after the pickle injection.

Radiometric Examinations

Applying radioactive isotopes we found that m.quadriceps femoris provides, like in other examinations, the highest values and the m.semimembranosus the lowest ones. The difference in the number of impulses found within the examination intervals shows the rate of decrease of the activity in all examined muscles to be of almost equal value exept for the m.quadriceps femoris. The activity decrease in all examined muscles is manifested through different intensities suggesting that the speed of the phosphate reactions in muscles is different. The decrease of the activity after 24 hours is not the result of biological elimination of the radioactive phosphate anymore but the result of physical halftime decomposition ^{32}P.

Analysing comparatively the curves showing the movement of the examined pickle ingredients we found the existence of phase differences in their kinetics in the course of curing. Quite depending on the examined muscle, the penetration and distribution curves differs for particular pickle ingredients - considering the average values it was found that the phosphate and nitrites reach the stabilization within 12 hours and that water and salt contents reached "steady state" about the 48 hours. From all examined pickle ingredients the nitrites were stabilized the first then the phosphates, whilst NaCl and water were similar in this respect. These phenomena, though depending indirectly on the vascular network, were An our opinion more the consequence of biochemical and biophysical processes occurring within muscles in the course of curing (Graph.5).

CONCLUSIONS

On the base of the obtained results and from assumptions and opinions mentioned in discussion we may draw the following conclusions:

Results obtained by radiographic, chemical and radiometric examinations shows that a correlation exists between the distribution and the scope of vascular network on the one hand and the dinamics of the penetration and the distribution of the pickle ingredients within the examined ham muscles on the other hand.

Kinetics of pickle ingredients are most outstanding with the best vascularized ham muscle - m.quadriceps femoris.

Curing method by intravascular injection is carried out in: a/ mechanical forcing of the pickle into muscular tissue up to the intermuscular spaces(the so-called visible phase) and b/ further penetration and binding of the pickle ingredients within muscular cells through biochemical and biophysical reactions(the so-called invisible phase).

The period of time necessary for the pickle penetration is shorter and the content of ingredients always greater in middle cuts of the examined muscles.

Applying radioactive tracers the phase differences were established in the pickle ingredient kinetics with regard to both the individual examined ham muscles and the particular involved ingredients.

PENETRATION DYNAMICS OF INGREDIENTS OF INTRAVASCULLARY INJECTED PICKLE INTO HAM MUSCLES

Summary

The methods that nowdays are mostly applied in technological processing of canned ham are intravascular pickle injection and direct injection into muscular tissue. Since the hams in Yugoslavia are being cured almost exclusively by intravascular pickle injection, the task of this work was to establish the influence of the ham vascular system on the dinamics of the penetration and distribution of pickle ingredients in muscles. Examinations were carried out by radiographic, chemical and radiometric methods.

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PENETRATIONSDYNAMIK DER PÖKELLAKEBESTANDTELLEN IM SCHINKENMUSKELN BEI DER INTRAVASKULÄREN LAKEINJICIERUNG

Zusammenfassung

Heute,am häufigsten angewandten Methoden bei der Herstellung von Dosenschinken sind die Aderspritzung der Pökellake sowie deren Einspritzung in das Muskelgewebe. Mit Rücksicht dass die Schinken in Yugoslawien gepökelt, fast ausschliesslich durch intravaskuläre Einspritzungen werden, unsere Aufgabe war den Einfluss von Vaskulärsystem das Schinkens auf die Penetrierungdynamik und die Verteilung der Pökellakebestandteilen in Muskeln zuerforschen. Die Untersuchungen wurden mit radiographischen, chemischen und radiometrischen Methoden durchgeführt.

Die radiographische, chemische und radiometrische Untersuchungen zeigen auf das Vorhandensein der Korrelation zwischen der Verteilung und des Adersystemvolumens einerseits und der Penetrationdynamik und der Verteilung der Pökellake - bestandteilen in den untersuchten Schinkenmuskeln anderseits.

Die Kynetik der Bestandteilen der Pökellake ist am besten in den am stärksten vaskularisierten Schinkenmuskel - im m.quadriceps femoris - ausgeprägt.

Pökelprocess bei der intravaskulären Injicierung erfolgt in zwei Phasen: 1. mechaniche Einprägung der Pökellake in das Muskelgewebe bis zur intermuskulären Zwischenräumen, 2. weitere Penetration und Bindung von Pökellakebestandteilen

in den Muskelzellen durch biochemische und biophysische Reaktionen.

Die Zeit der Penetration der Pökellake ist kürzer und der Gehalt der Bestandteilen immer gröser im Mittelsegmenten der untersuchten Muskeln.

Durch Anwendung von radioaktiven Markierung der Pökellake waren Phasenunterschide in der Kynetik von Pökellakebestandteilen zwischen den untersuchten Schinkenmuskeln, als auch bei einzelnen Bestandteilen der Pökellake festgestellt.

LA DINAMIQUE DE LA PENETRATION DES INGREDIENTS DE LA SALAISON INJECTEE INTRAVASCULAIRE DANS LES MUSCLES DES JAMBONS

Résumé

Les méthodes des salaison les plus utilisées aujourd'-hui dans les procédés technologiques pour la production des jambons dans des boites en tôle sont l'injection intravasculaire de la salaison et l'injection directe dans les tissues de muscles. Etant donné que les jambons en Yougoslavie sont traités à cet effet presqu' exclusivement par l'injection intravasculaire, la tâche de nos recherches était à savoir quelle est l'influence executée par le système vasculaire du jambon sur la dynamique de la pénétration et de la distribution des ingrédients de salaison dans les muscles traités. A cet effet nous nous sommes servis des méthodes radiographiques, chimiques et radiomètriques.

Les résultats radiologiques, chimiques et radiomètriques de nos recherches font preuve de l'existance de la correlation entre la distribution et le volume du système vasculaire d'un coté et de la dynamique de la pénétration et de la distribution des ingrédients de salaison dans les muscles du jambon de porc examinés de l'autre.

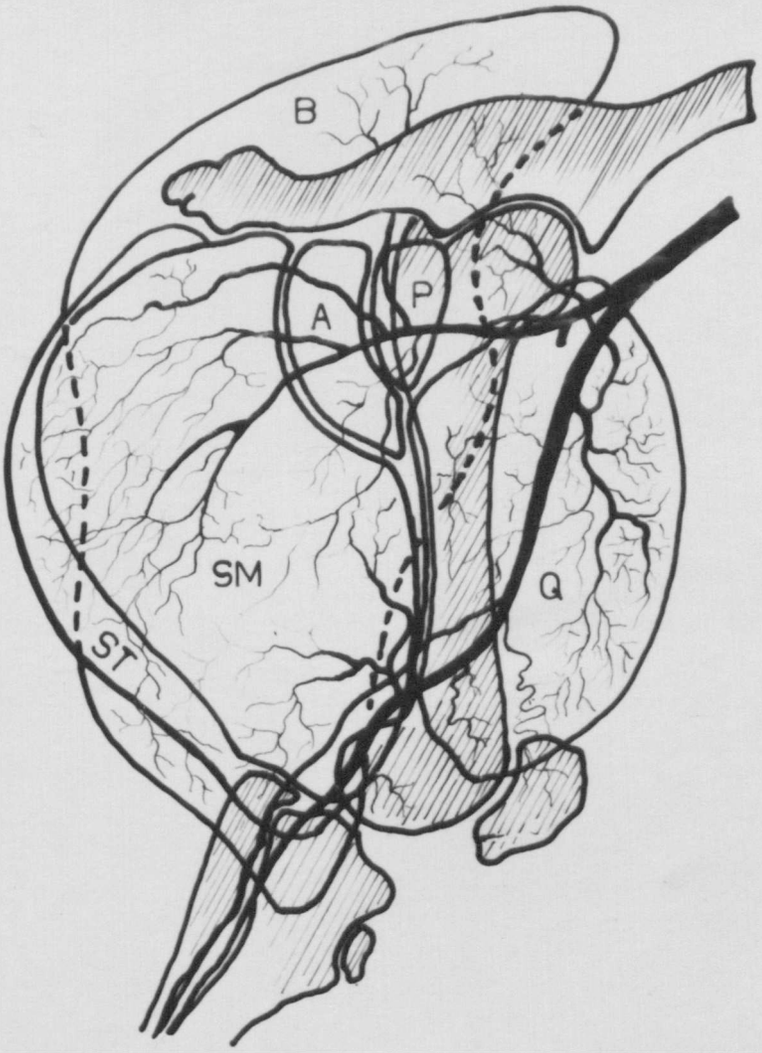
La kynetique des ingrédients de salaison et la plus prononcée dans les muscles du jambon de porc les plus vascularisés m.quadriceps femoris.

L'action de salaison par l'injection intravasculaire se déroule en deux phases: 1. l'enfoncement mécanique de la

salaison dans les tissus musculaire allant jusqu'aux especes intermusculaires, et 2. pénétration au dela de ceux- ci et l'accolement des ingrédients de salaison dans les cellules musculaires à travers des reactions biochemiques et biophysiques.

La Période de temps nécessaire à la pénétration est plus courte mais la teneur des ingrédients toujours supérieure dans les segments moyens aux muscles examinés.

Par l'application des substances radioactives on a déterminé les differences en phase existent dans la kynetique des ingrédients de salaison tant entre les muscles du jambon traités que par rapport aux ingrédients individuels utilisés.



SH. 1 VASCULARISATION OF THE HAM MUSCLES EXAMINED

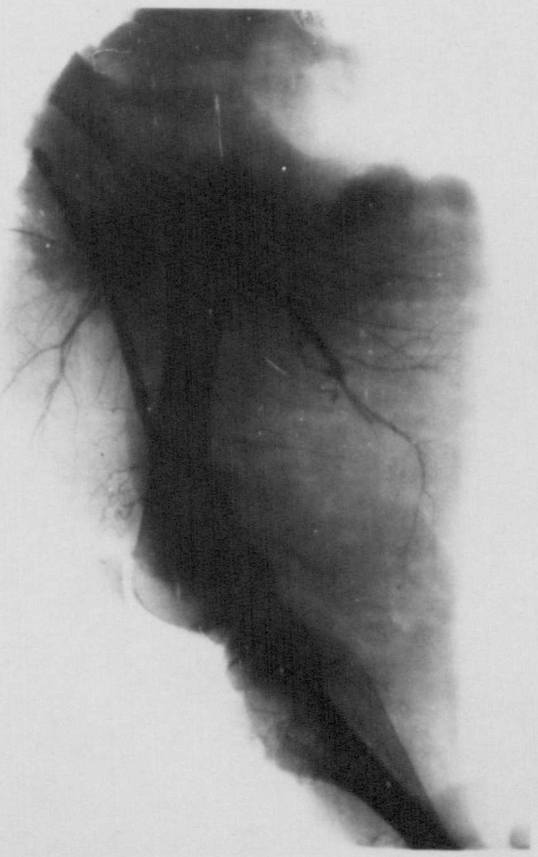


FIG. 1 ARTERIOGRAMME OF THE HAM /LATERO-MEDIAL/

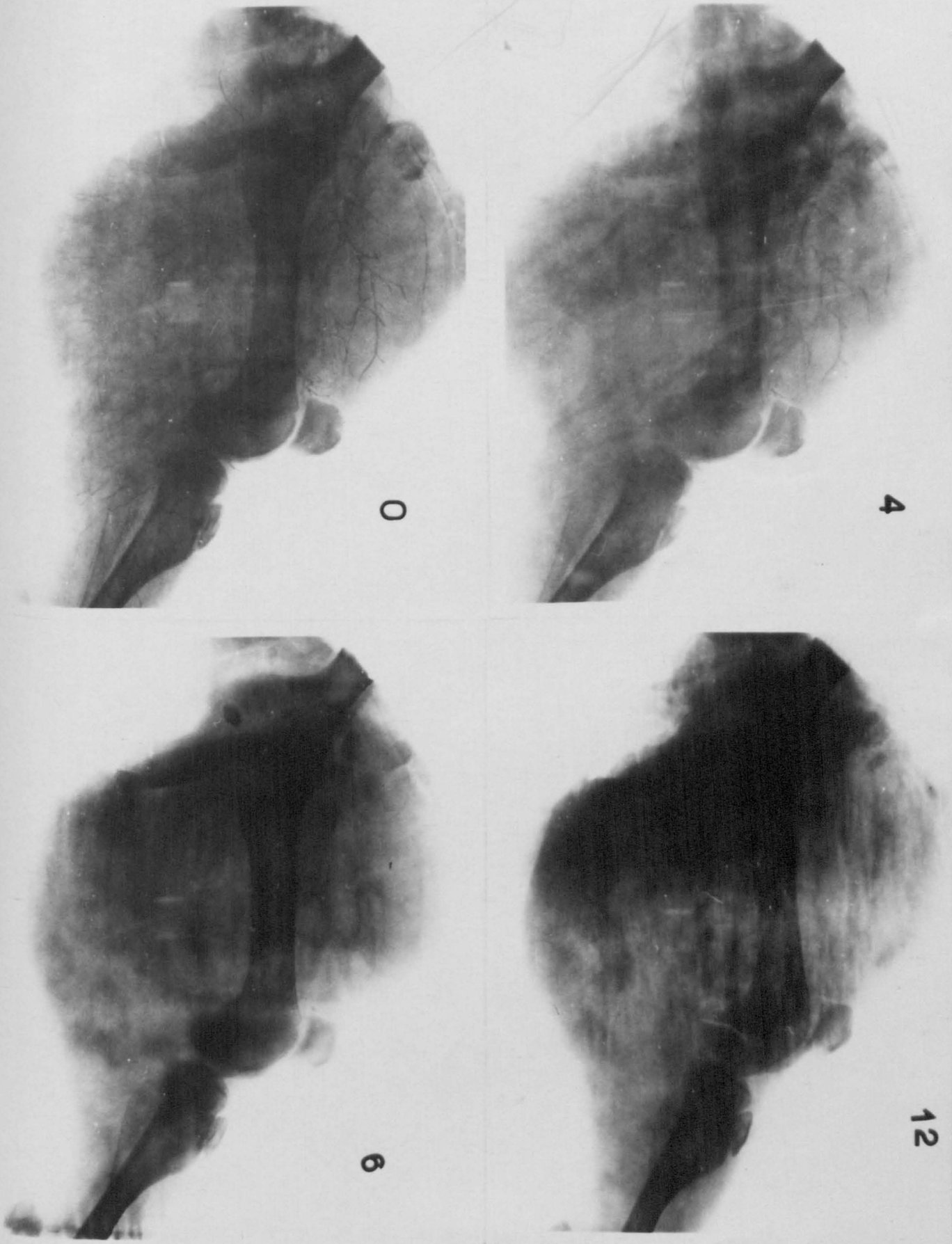


FIG. 2 ARTERIOGRAPHIE TRACING ON THE DIFFUSION OF THE CONTRAST PICKLE MIXTURE WITHIN THE HAM AT 0, 4, 6 AND 12 HOURS AFTER INFUSION

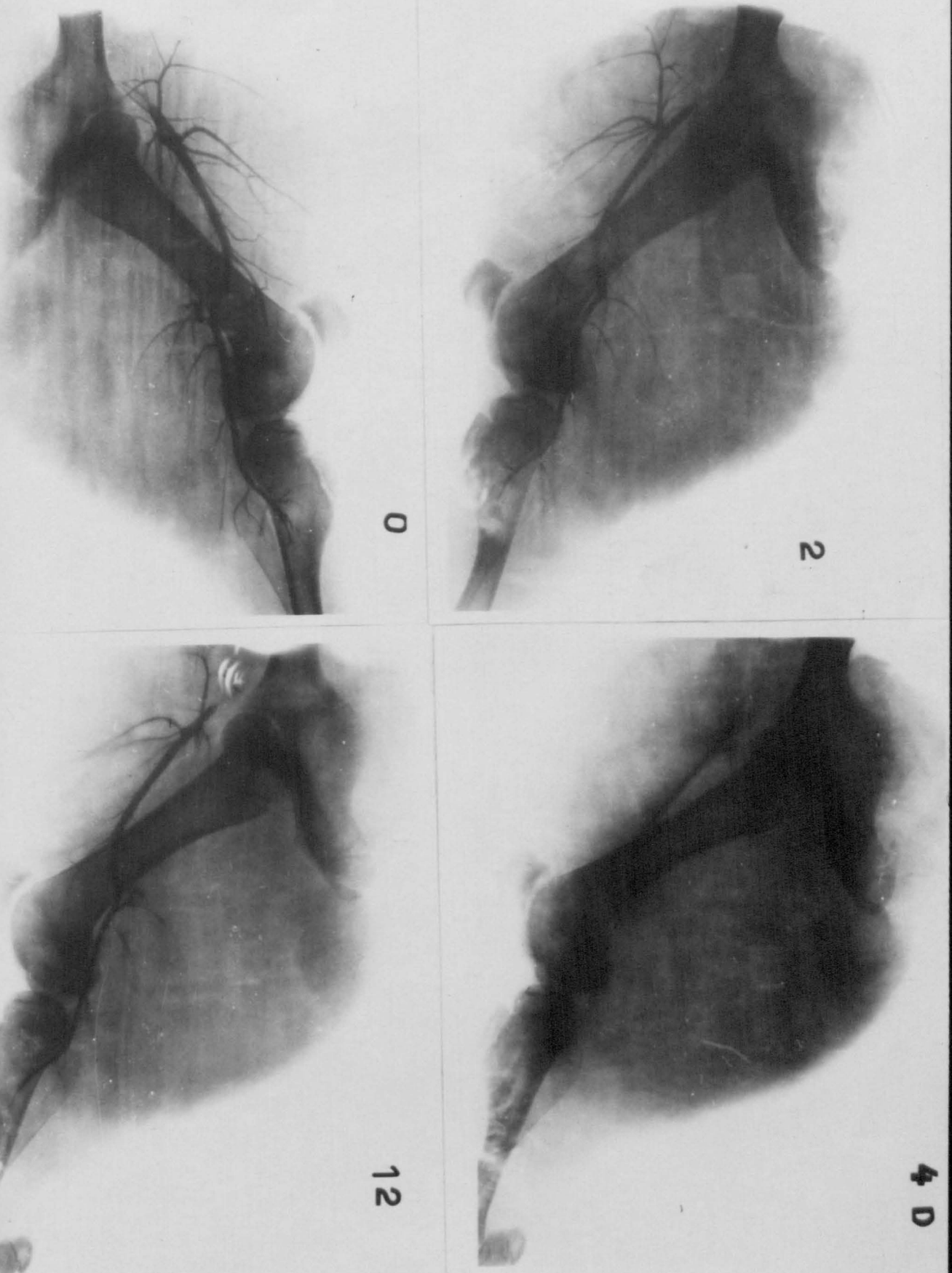
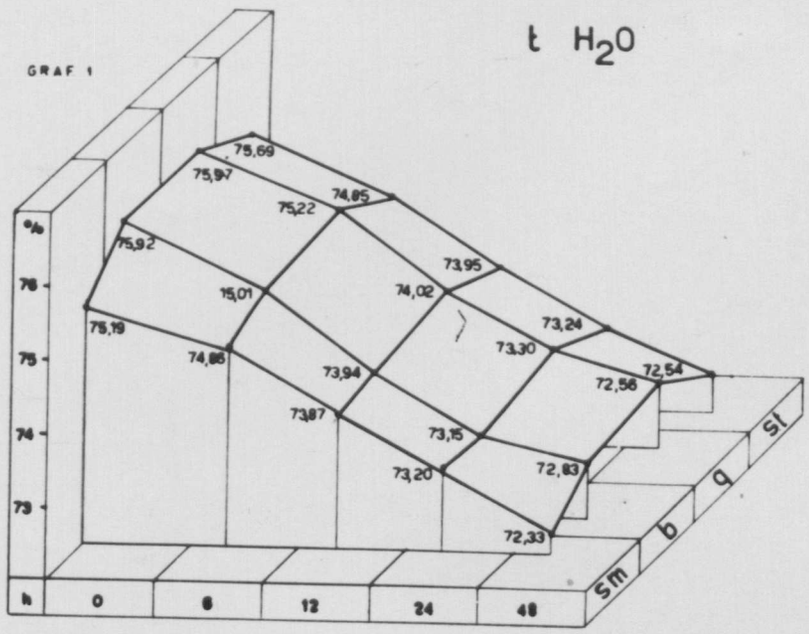
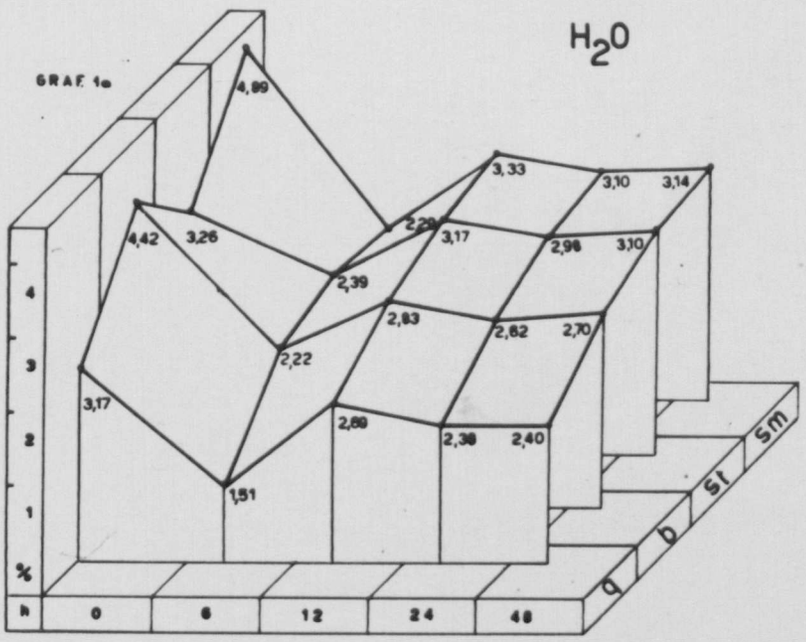
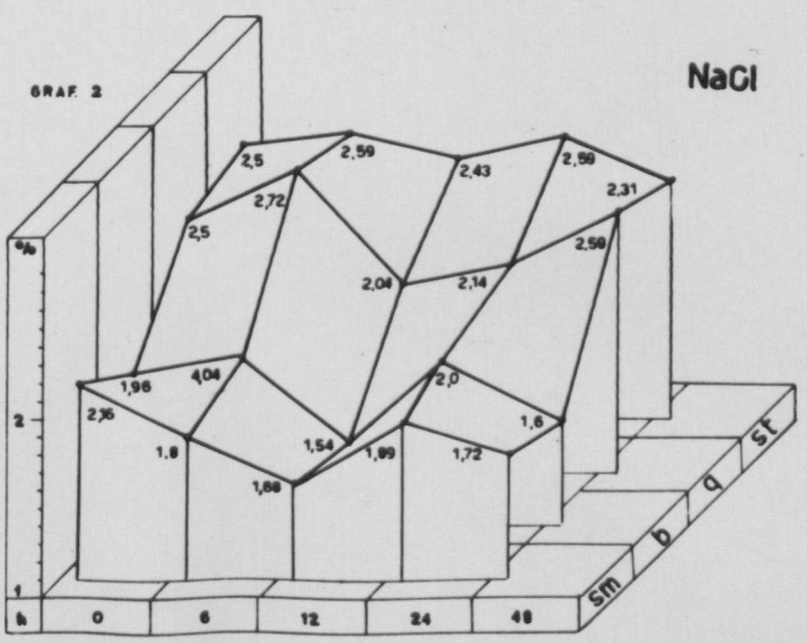


FIG. 3 ARTERIOGRAPHIE TRACING ON THE DIFFUSION OF THE CONTRAST PICKLE MIXTURE IN THE A. FEMORALIS TREE 0, 2, 12 HOURS AND 4 DAYS AFTER INFUSION



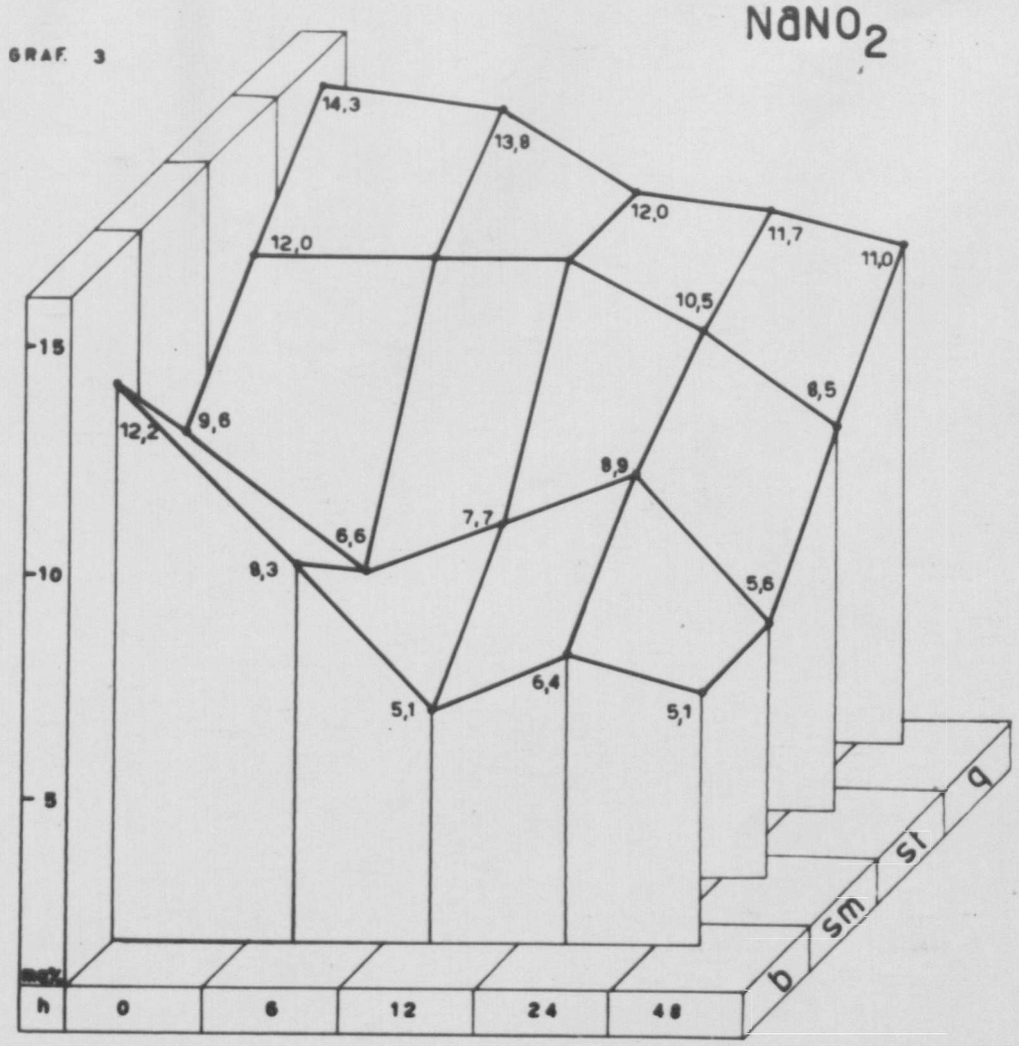




FLOW OF PICKLE INGRADIENTS INVOLVED WITHIN MUSCLES OF THE HAM EXAMINED

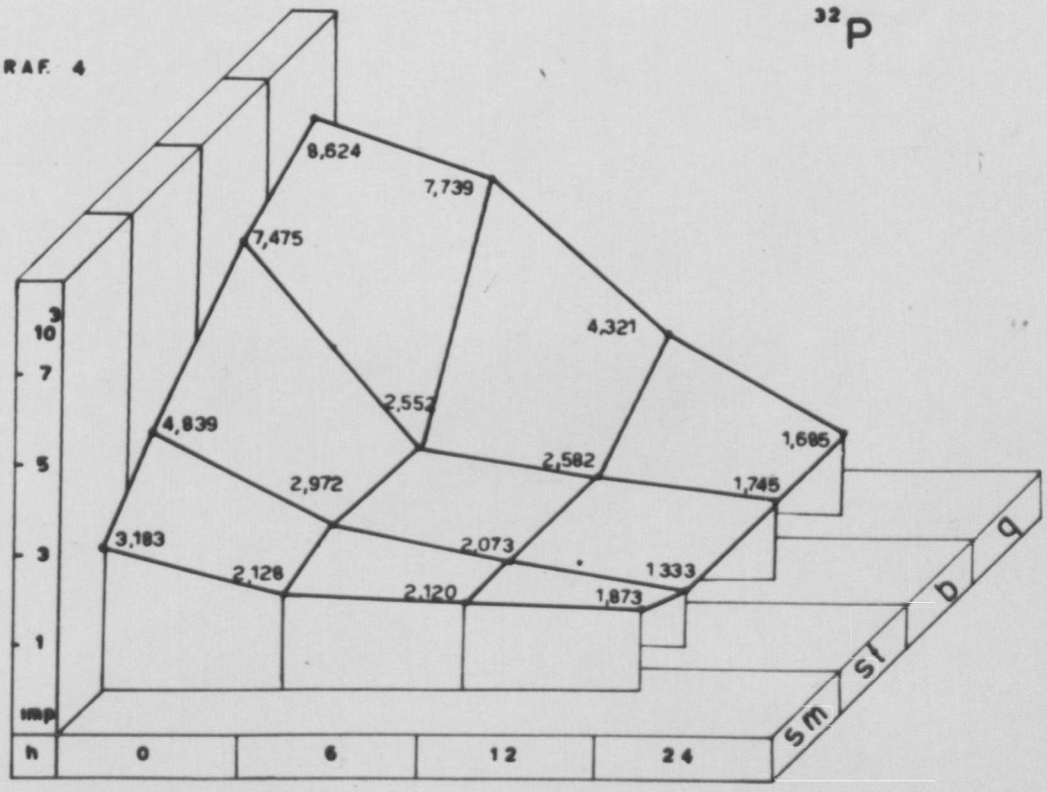
GRAF. 3

$NaNO_2$



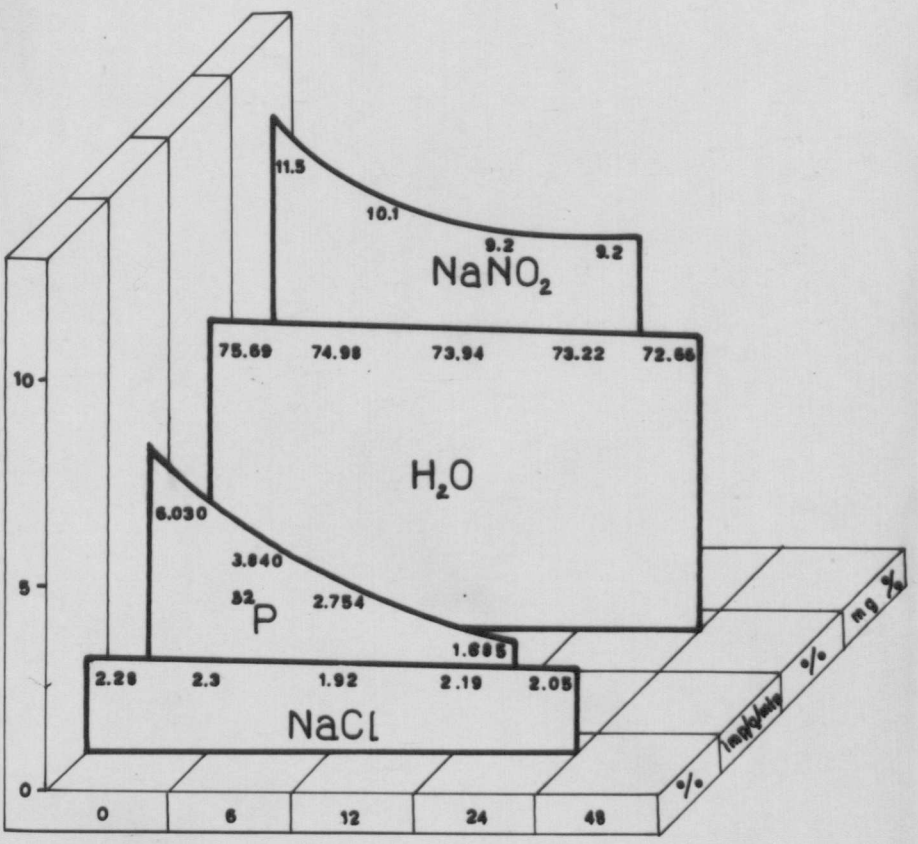
GRAF. 4

^{32}P



FLOW OF PICKLE INGRADIENTS INVOLVED WITHIN MUSCLES OF THE HAM EXAMINED

GRAF. 5 COMPARATIVE TRACING OF THE INGRADIENS EXAMINED IN THE COURSE OF THE CURING PROCESS WITHIN MUSCLES OF THE HAM



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