GLUCONO-δ-LACTONE - INDUCED GELATION OF SOME MEAT COMPONENTS AT CHILLED TEMPERATURES

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ABSTRACT

In this study, 1,5-glucono-δ-lactone, was used to achieve acid-induced gelation of meat, myofibrillar protein and myosin at 4°C. The mechanisms of gelation of myofibrillar protein and myosin were investigated. The effects of addition of sodium chloride and tetrasodium pyrophosphate to myosin and myofibrillar protein, with and without 1,5-glucono-δ-lactone, were also studied. In addition, the presence of other phosphates, orthophosphate, tripolyphosphate and hexametaphosphate, in a myosin system were studied to aid in an understanding of the the observed effects of tetrasodium pyrophosphate on myosin.

At about pH 4.5, it was observed that extraction of the A-band of myofibrillar protein occurred. It was suggested that an impregnated composite system of myosin reinforcing the myofibrillar structure had formed. At about pH 4.0, complete extraction of the A-band occurred. Dissolution of the myofibrillar structure was suggested to result in myosin network formation of weaker Young's Modulus than the impregnated composite system.

Addition of 1,5-glucono-δ-lactone to myosin resulted in the exposure of hydrophobic sites as the pH decreased and it was suggested that acid-induced denaturation had occurred. Gel formation occurred parallel to denaturation. At pH 4.0, the gel became liquid-like and was suggested to be a result of excess repulsive electrostatic interactions. Hydrogen bonding and hydrophobic interactions were shown to be involved in gel formation, whereas sulfhydryl bonding appeared not to be involved in gelation. Sodium chloride was postulated to enhance gel rigidity through its effects on the isoelectric point of myosin. The inclusion of tetrasodium pyrophosphate resulted in network formation prior to acid-induced denaturation and was suggested to enhance hydrogen bonding.

The acid-induced gels appeared to revert to myosin or myofibrillar protein when immersed in quiescent water, a condition where unimpeded diffusion of ions was obtained. However, a slow rate of ion diffusion resulted in the formation of a 'strong', translucent gel which was dense to the point of being effectively impermeable to ion migration. These gels were hypothesized to have formed through the displacement of sodium and potassium ions with protons, enhancing hydrogen bonding. Myosin was observed to have a stronger affinity for sodium than for potassium.

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LIST OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

Abbreviations of units

A	amps
C	coulombs
°C	degrees Celsius
Da	daltons
g	gram(s)
h	hour(s)
Hz	hertz
J	joules
l	litre(s)
m	metre
M	molar
min	minute(s)
mol	mole(s)
N	Newtons
Pa	pascals
rad	radians
rpm	revolutions per minute
s	second(s)
v	volume
V	volts
w	weight
W	watts

Other Abbreviations

A1	alkali light chain one
A2	alkali light chain two
ADP	adenosine diphosphate
ANS	8-anilino-1-naphthalenesulfonic acid
AR	analytical reagent grade
ATP	adenosine triphosphate
bis	N,N'-methylene-bis-acrylamide
BSA	bovine serum albumin
CD	circular dichroism
CPA	*cis*-parinaric acid
DSC	differential scanning calorimetry
DTNB	5,5'-dithiobis(2-nitrobenzoic acid)
DTT	dithiothreitol
e.d.	external diameter
EDTA	ethylenediaminetetraacetic acid

EGTA	ethylene glycol-bis(β-aminoethyl ether) N,N,N',N'-tetraacetic acid
G'	storage moulus
G"	loss modulus
G^*	complex modulus
GdL	glucono-δ-lactone
HMM	heavy meromyosin
HMP	hexametaphosphate
i	imaginary number = $(-1)^{1/2}$
i.d.	internal diameter
ICP	inductively coupled plasma
IEP	isoelectric point
LMM	light meromyosin
MHC	myosin heavy chain(s)
MW	molecular weight
N	total number of monomers
NDIC	Nomarski differential interference contrast
OP	sodium dihydrogen orthophosphate
OR	optical rotary dispersion
Pc	number density of crosslinkers at the point of incipient gelation
PCMB	p-hydroxy-mercuribenzoic acid
PD	denatured protein
PN	native protein
PPase	pyrophosphatase
PVC	polyvinyl chloride
PVDC	polyvinylidene chloride
q	charge
r	distance separating q
RFI	relative fluorescence intensity
S-1	fragment of HMM containing the head portion
S-2	fragment of HMM between the head and LMM
SDS	sodium dodecyl sulfate
SDS-PAGE	sodium dodecyl sulfate - polyacrylamide gel electrophoresis
SEM	scanning electron microscopy
t	time
TEM	transmission electron microscopy
TEMED	N,N,N',N'-tetramethylethylenediamine
T_m	transition temperature
TPP	tripolyphosphate
Tris	tris(hydroxymethyl)aminomethane
TSPP	tetrasodium pyrophosphate
UV	ultra-violet
Vc	number of crosslinked or branched monomers
WHC	water holding capacity
x	number of protein molecules
Xn	weight average degrees of polymerisation

δ	phase angle
γ	shear strain
γ_o	strain amplitude
$\dot{\gamma}$	strain rate
τ	shear stress
τ_o	stress amplitude
ω	angular frequency