The Microbiology of Meat Products:

The meat chain; microbiological safety; scientific gaps and research needs

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Important Microbiological Concerns for Meat and Meat products

A. Concerns with respect to safety from microbiological agents
(This presentation)

B. Concerns with respect to spoilage and market shelf-life
(Following speakers)

EPIDEMIOLOGIC REALITIES

Surveillance systems for foodborne disease problems

What is the efficiency of surveillance programs?

In EU? WHO Program for Europe: 7th and 8th Reports (about 50 countries are submitting data)

Extensive recent improvements

In Greece? Hellenic Center for Infectious Disease Control (K.E.E.L.)

Organizational improvements but not enough to get a realistic picture of what is going on in the county

Why should we be concerned with foodborne and meatborne infectious and toxigenic microbial agents?

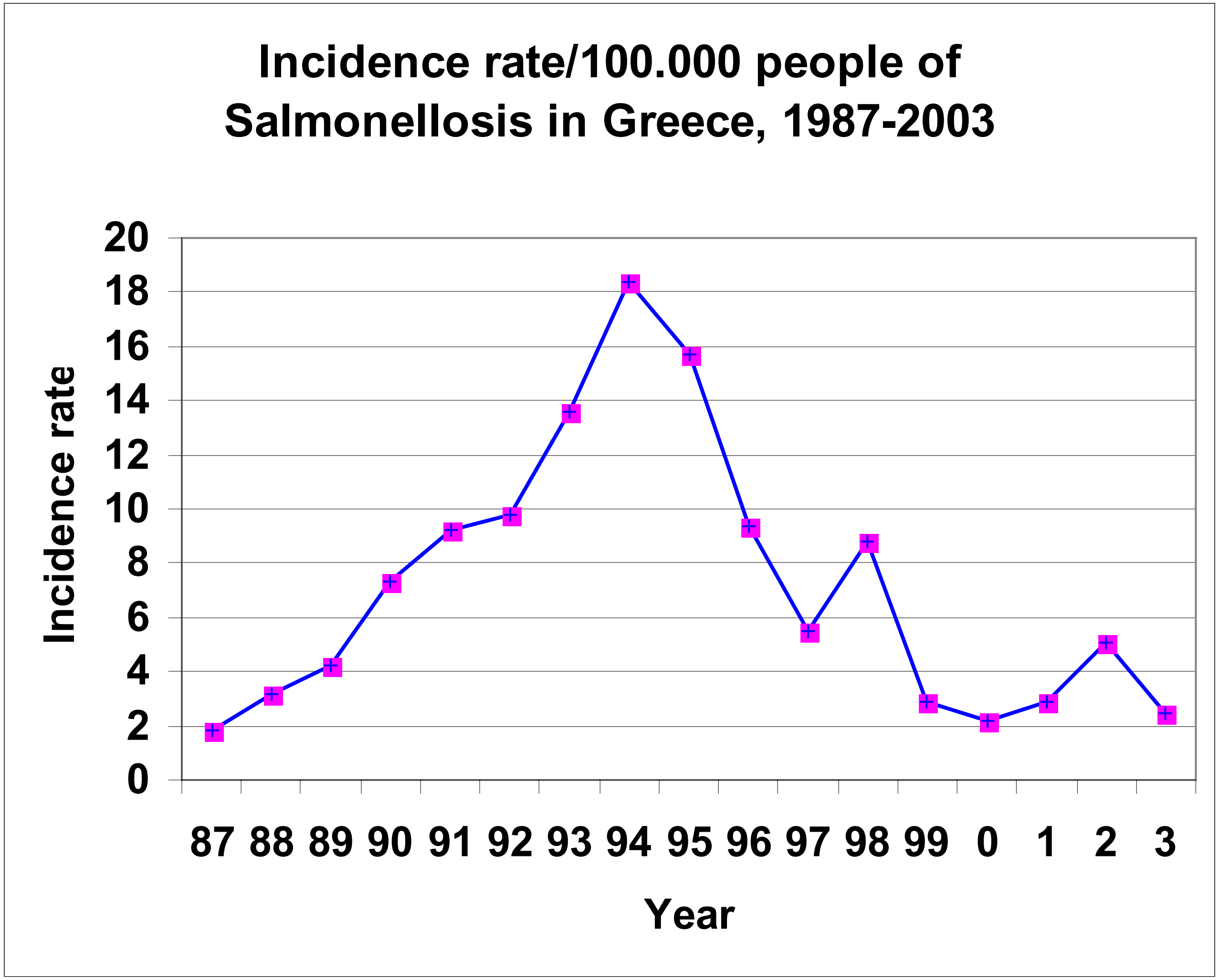
-Collected epidemiologic data do not reflect reality.

-Extensive undereporting: for one recorded case there are 25- 350 cases escaping recording!!

Causative agents: Unknown etiology category most frequently recorded.

Greek Problems in Epidemiologic Surveillance:

- **Broad lack of knowledge of methods for epidemiologic surveillance.**
- **Lack of coordination among Hospital-KEEL-Regulatory Agencies.**
- **Lack of broad application of molecular epidemiology methods.**
- **Slow interventions in investigating and controlling an outbreak.**
- **Lack of a well organized recall system by the industry and regulatory agencies (yet rapidly improving due to EU directives).**
- **Lack of a national bank on the microbiological quality of ingredients and finished products locally produced or imported**
- **Lack of National objectives (targets) for the future.**


Incidence rate/100.000 people of
Salmonellosis in Greece, 1987-2003
Incidence rate
20
18
16
14
12
10
8
6
4
2
0
87 88 89 90 91 92 93 94 95 96 97 98 99 0 1 2 3
Year

Salmonellosis in humans in the European Union in 1997. Incidence rate per 100,000 inhabitants for all cases and share of S. Enteritidis and T.typhimurium.

Country	Incidence		
	Total	S. Enteritidis	S. Typhimurium
Austria	107	90.1	4.7
Denmark	95	69.6	16
Finland	58	21.3	12.8
France	33.5	11.4	11.8
Germany*	128.4	70.6	37.2
Greece	3.2	2.2	0.4
Ireland	29.1	6.3	11.7
Italy	26.5	ND	ND
Portugal	1.8	ND	ND
Spain	7.3	4.9	2.4
Sweden	48.5	21.2	24.6
Netherlands	16.4	7.5	5.1
Scotland	65.5	45.7	11.1
N. Ireland	26	10.2	11.1
England and Wales	61.8	43.8	8.9

Data on the distribution of serotypes is related to parts of Germany only. Genigeorgis 2005

ND: no data available.

MOST COMMON TRAVEL DESTINATIONS OF FINNISH TOURISTS IN 1992 AND NUMBER AND RATE OF IMPORTED SALMONELLA INFECTIONS (PROVIDED BY THE FINISH TRAVEL BUREAU ASSOCIATION)

COUNTRY	TRAVELERS TOTAL	CASES OF SALMONELOSIS	CASES/1000 TRAVELLERS
Thailand	3728	165	44.2
Malaysia	534	78	33.4
Kenya	1641	52	31.7
Egyprt	3370	67	19.9
Tunisia	16529	159	9.6
Marocco	12468	117	9.4
Cyprus	51132	202	4.0
Portugal+ Madeira	52981	200	3.8
Turkey	101933	294	2.9
Spain	86556	200	2.3
Italy	25568	56	2.1
Greece	150433	278	1.8
Israel	20860	30	1.4
Spain (Canary)	283817	197	1.1
USA and Canada	Approx 100000	13	0.1
Japan	Aprox 10000	0	0

PER 100,000 CASES Greece 180, Spain 230, Portugal and Madeira 380 (Genigeorgis 2005)

FOODBORNE DISEASE REPORTING IN THE BALKAN COUNTRIES BASED ON THE 7TH REPORT FROM WHO/BERLIN FOR THE PERIOD 1993-1998 (Genigeorgis 2001)

Epidemiologic Parameters reported	CRO	GR	ROM	SLO	TUR	YU	FIN
Cases/year	8467	2035	29605	492[a]	96034	36884	11111[a]
Inciden. rates	188	19.4	132		153	342	
Popul. in 10^6	4.5	10.5	22.5	2.0	62.9	10.8	5.2
# outbreaks	338	NR	375	171	NR	1548	295
Investigated outbreaks	338	7		171	NR	1548	275
Causative agents	12	9	10	14	6	11	18
Food vehicles	338	1	375	171	9[b]	245	295
Place of mistakes	338	7	375	171	NR	830	282
Contributing factors	338	NR	NR	171	NR	NR	266

[a]Cases in outbreaks only, [b]1996-8 only, NR: not reported Genigeorgis 2005)

FOODBORNE DISEASE OUTBREAKS INVESTIGATED. GREECE 2000

(Genigeorgis 2005)

	Outbreak 1	Outbreak 2	Outbreak 3	Outbreak 4
Agent	Salmonella	Unknown	Salm.ball	Unknown
Persons ill	272	200	5	>12
Persons hospitalized	22	5	0	12
Persons dead	0	0	0	0
Outbreak duration(d)	6	5	12	2
Transmission ways	Food	Food/water	Food	Water
Incriminated food	Meat	Unknown	Unknown	Drinking water
Marketing of food	Non-packaged	Unknown	Unknown	Non packaged
Served and eaten	Kept warm	Unknown	Unknown	Unknown
Place of contamination	Mass catering for special groups	Other	Unknown	Other
Place of acquisition/ consumption	Mass catering for special groups	Other	Other	Other
Contributing factor	Inadequate refrigeration	Other	Unknown	Other

NATIONAL AND INTERNATIONAL EPIDEMIOLOGIC DATA AND TRENDS ON FOODBORNE DISEASES

Principal foodbome infections, as estimated for 1997, by estimated number of cases caused by foodborne transmission each year in the United States (Mead et al., 1999) (values over 1000 are rounded to the nearest 1000)	
Norwalk-like viruses*	**9,200,000**
Campylobacter*	**1,963,000**
Salmonella (non typhoid)	**1,342,000**
Clostridium perfringens	**249,000**
Giardia lamblia	**200,000**
Staphylococcus food poisoning	**185,000**
Toxoplasma gondii	**112,000**
E.coli O157:H7 and other Shiga –toxin producing E.coli*	**92,000**
Shigella	**90,000**
Yersinia enterocolitica	**87,000**
Enterotoxigenic E.coli*	**56,000**
Streptococci	**51,000**
Astrovirus*	**39,000**
Rotavirus*	**39,000**
Those that emerged in the last 30 years are indicated by an asterisk	

Principal foodbome infections, as estimated for 1997, by estimated number of cases caused by foodborne transmission each year in the United States (Mead et al., 1999) (values over 1000 are rounded to the nearest 1000) (continued)

Cryptosporidium parvum*	30,000
Bacillus cereus	27,000
Other E coli	23,000
Cyclospora cayetanensis*	14,000
Vibrio (non cholera)*	5,000
Hepatitis A	4,000
Listeria monocytogenes*	2,000
Brucella	777
Salmonella typhi (typhoid fever)	659
Butulism	56
Trichinella	52
V.cholera, toxigenic*	49
Vibrio vulnificus*	47
Prion*	0

Those that emerged in the last 30 years are indicated by an asterisk

U.S Trends in Incidence of Infection with Pathogens Transmitted Commonly Through Food. Preliminary FoodNet Data (Genigeorgis 2005, Adapted from MMWR, April 15, 2005 / 54(14); 352-356)

Ten sites representing 44.1 million consumers (15.2% of total population)

2004 surveillance data compared to 1996-8:

-Campylobacter: decreased 31% (95% CI = 25%--36%). Close to target.
-Yersinia: decreased 45% (CI = 32%--55%)
-Cryptosporidium: decreased 40% (CI = 26%--52%),
-STEC O157: decreased 42% (CI = 28%--54%). Met target for 2010. Declines follow STEC O157 contamination levels decreases of ground beef reported by the U.S. D.A/FSIS for 2003 and 2004.
-Listeria: decreased 40% (CI = 25%--52%). Close to target for 2005
-Salmonella: decreased 8% (CI = 1%--15%).
-Shigella: did not change significantly.

The declines have occurred concurrently with several important food safety initiatives and education efforts.

Multiple interventions might have contributed to this decline, including:

-industry response to the FSIS 2002 notice to manufacturers to reassess control strategies for STEC O157 in the production of ground beef.

-enhanced strategies for reduction of pathogens in live cattle and during slaughter of poultry.

-educate consumers about safe food-handling practices.

CASES OF FOODBORNE DISEASES NOTIFIED

GREECE 1999-2000 (Genigeorgis 2005)

Disease	1999		2000	
	No of cases	Incidence rate /100.000 people	No of cases	Incidence rate /100.000 people
Salmonellosis	954	9,1	912	8,6
Staphylococcosis	0	0	0	0
Botulism	0	0	0	0
Campylobacteriosis	306	2,9	261	2,5
Shigellosis	93	0,9	73	0,7
E.coli	98	0,9	172	1,6
Listeriosis	7	0,1	6	0,1
Cholera	0**	0	0**	0
Brucellosis	538**	5,1	548**	5,2
Other bacterial foodborne infections& intoxications	0	0	0	0
Hepatitis A	259**	2,5	158**	1,5
Other viral enteritis	0	0	0	0
Echinococcosis	46**	0,4	41**	0,4
Trichinellosis	0	0	0	0
Giardiasis	65	0,6	73	0,7
Amoebiasis	0	0	0	0
Infectious enteritis of unknown origin	0	0	0	0
TOTAL	2366	22,5	2244	21,3

*Cases notified by hospital microbiological laboratories for**, which were notified by district health authorities

Incriminated foods: Mostly foods of animal origin. Yet in recent years there is a increasing incrimination of vegetables and fruits!!

What is the contribution of meat and meat products?
In Greece? Unknown since 1983!

In EU? (WHO/Berlin 7th and 8Report)

In USA?

(Genigeorgis 2005)

Foods of animal origin as percent of total foods incriminated in foodboene disease outbreaks in the European Region (Adapted from data reported by WHO/BGVV-BERLIN for the years 1993-1998)
(Genigeorgis 2005)

Country	Out-breaks	meats	Fish	Eggs	DAIRY	FAO FAO	Unknown
BELGIUM 95-8	227	22.1		41.4	12.5	76	
CROATIA	294	19.2	1.9	13.1	2.8	47	10.6
FINLAND	277	25.3	13		3.6	41.9	22.4
FRANCE	2189	15.4	9.4	32.7	5.3	62.8	23.9
GERMANY	811	20.6	1.4	19.8	3.9	45.7	12
HUNGURY	3546	38.1		24.1	0.6	62.8	2.8
IRELAND 97-8	41	17.1		19.5	4.8	41.4	43.9
ISRAEL	128	32	7.8	15.6*	7.8	63.2	
ITALY	84	8.3	9.5	47.6	6	71.4	
LATVIA	1939	8.8		2.3	52.8	63.9	24.2
LITHUANIA	435	88		2.8	0.2	91	0.7
NETHERLANDS	2524	12.8	5.9	3.5*	5	27.2	0.7
NORWAY	165	20	10.9		6.7	37.6	
POLAND	2558	21.9		4	3.3	29.2	7.3
RUMANIA	375	36	2.1	34.1	18.1	9.3	
SLOVENIA	109	25	1.9	14.8*	1.9	43.6	
SPAIN,1998	942	7.7	6.8	38.2	3.4	56.1	28.6
SWEDEN	526	27	10.5		2.9	40.4	
UK-ENGL/Wales	943	38.6	14	10	3	65.6	

Table Meat and poultry products reported as foodborne vehicles in outbreaks in USA 1993-1997 (Adapted from Olsen et al., 2000) (Genigeirgis2005)

Agent	Beef	Pork	Ham	Chicken	Sausage	Turkey	Unknown meat	Known vehicle	Unknown vehicle	Total
B.cereus	2(3.8)	1		1			1	12	2	14
Campyl	1(1.9)	1						10	15	25
C.botul							2	12	1	13
C.perf	11(21.2)	1				2(16.7)	2	44	13	57
E.coli	21(40.4)						2	52	32	84
Salmon.	14(26.9	4 (	1	6(66.7)		6(50)	6	184	173	357
Shigella				1				18	25	43
S.aureus	4(7.7)	1	7(87,5)	1		4(33,3)		38	4	42
Y.enter		2						2		2
Other bact	2						1	5	1	6
Total bact	52	10	8	9		12	14	384	271	655
Trichina							1	1	1	2
Viral				1				27	29	56
Confirm	52	10	8	10		12	15	559	319	878
Unknown	14	4	4	20	2	10	7	408	1465	1873
Total	66 (6.8)*	14 (1,5)	12 (1.25)	30 (3.1)	2 (0.2)	22 (2.28)	22 (2.28)	967 (35.2)	1784 (64.8	2751 (100)

* of known vehicles total meats 168/967 or 17.4%

FACTORS CONTRIBUTING TO FOODBORNE DISEASE OUTBREAKS

CONTRIBUTING FACTORS:CONTAMINATED EQUIPMENT, CONTAMINATIONN FROM CARRIERS,POOR HYGIENE,CONTAMINATED INGREDIENTS, ΑΝΕΠΑΡΚΕΙΣ ΚΑΘΑΡΙΣΜΟΙ ΩΣ ΠΟΣΟΣΤΟ (%) ΤΟΥ ΣΥΝΟΛΙΚΟΥ POOR CLEANING PRECTICES AS A % OF THE TOTAL FACTORS THAT CONTRIBUTED ΤΟΥ OUTBREAKS OF FOODBORNE DISEASES IN THE EUROPEAN REGION (ADAPTED FROMDATA OF WHO/BGVV-BERLIN FOR 1993-1998) (Genigeorgis 2005)

COUNTRY	# OF FACTORS	CROSS CONTAM	GROWTH	SURVIV AL	OTHER, UNKNOWN
CROATIA	294	34.4	28.1	19	
DENMARK	325	28	31.6		40.4
FINLAND	117	21.4	49.9	17.9	10.8
FRANCE	1381	44.3	36.7	19	
GERMANY	990	33.6	28.3	8	30.1
HUNGURY	2700	23.9	8.4	34.9	32.8
IRELAND	39	41	32.5	25.6	
ICELAND	40	5	15	5	75
ISRAEL	235	22.6	44.2	18.3	14.9
LITHUANIA	435	1.4	5.3	11.5	81.8
SLOVAKIA 1997-8	159	48.6	18	11.3	22.1
SLOVENIA	85	68.3	20	8.2	3.5
SPAIN	4669	46	40.5	5.1	8.4
SWEDEN	526	4	12.3	0.2	83.6
UK ENGLAND /WALES	1162	34.8	27.9	28.7	8.6

ECOLOGY OF PATHOGENS IN FRESH AND PROCESSED MEATS

Using mostly Greek data generated through SMAS

Will discuss:

-Ecology in the slaughterhouse

-Ecology during fabrication

-Raw products

-Imported meats

-Processed meats

ECOLOGY OF SALMONELLA IN PIG SLAUGHTERHOUSES

PREVALENCE OF SALMONELLA SPP., IN GREEK SLAUGHTERHOUSES A & B AND C BY SITE OF SAMPLING AND PERIOD OF THE YEAR

(Limpitakis et al., 1999)

Period Slaughter house	COLD A+B	HOT A+B	BOTH A+B	C CRETE
Type of samples	**samples (% +)**	**samples (% +)**	**samples (% +)**	**samples (% +)**
A. Before the onset of slaughter				
Floors	56 (16.1)	55 (32.7)	111 (24.3)	15(33.3)
Worker hands	56 (0)	55 (5.5)	111 (2.7)	ND
Laraige area				9 (44.4)
Knives	56 (0)	55 (7.3)	111 (3.6)	9 (11.1)
Saw				3 (0)
Aprons				9 (22.2)
Plastic doors				12 (8.3
Offal baskets				9 (11.1)
Total	168 (5.4)	165(15.2	333(10.2)	66 (21.2)

Slaughterhouse A+B in N.Greece: Cold period 1/11-30/4 Warm period 1/5-31/11. (1996-1999)
Slaughterhouse C in Crete: Before the onset of slaughter 12/3/01-11/6/02 (3 samplings)

TABLE 4. PREVALENCE OF SALMONELLA SPP., IN GREEK SLAUGHTERHOUSES A& B & C BY SITE OF SAMPLING AND TIME OF YEAR (Limpitakis et al., 1999)

Period Slaughterhouse	COLD A+B	HOT A+B	BOTH A+B	C CRETE
Type of samples	Samples (% +)	Samples (% +)	Samples (% +)	Samples (% +)
B. After the onset of slaughter				
Floors	121 (13.2)	80 (22.5)	201 (16.9)	9 (11.1)
Worker hands	96 (2.1)	80 (12.5)	176 (6.8)	21 (0)
Worker Knives	96 (0)	80 (6.3)	176 (2.8)	21(0)
Scalding tank overflow				7 (14.2)
Liver tank				6 (0)
Total	313 (5.8)	240 (13.8)	553 (9.2)	64(3.1)
Carcasses	196 (0.5)	176 (14.8)	372 (7.3)	40 (2.5)
Livers	100 (1)	100 (14)	200 (7.5)	20 (5)
Tongues/larygx	98 (1)	98 (10.2)	196 (5.6)	20 (5)
Total	394 (0.8)	374 (8.8)	768 (6.9)	80(3.8)
Caecal content	40 (5)	59 (22)	99 (15.2)	20 (35)
Lymphnodes	63 (17.5)	58 (24.1)	121(20.7)	20 (15)
Total	103 (12.6)	117 (20.5)	220 (18.2)	40(25)
Total B	810 (4.2)	731(15)	1541 (9.3)	184 (8.2)
GRAND TOTAL	978 (4.4)	896 (15)	1874 (9.5)	250 (11.6)

Slaughterhouse A+B in N.Greece: Cold period 1/11-30/4 Warm period 1/5-31/11. (1996-1999)
Slaughterhouse C in Crete: After the onset of slaughter, 30/11-27/5 (4 samplings)

PRESENCE (%) OF SALMONELLA SPP., IN THE ENVIRONMENT OF A PIG SLAUGHTERHOUSEAND THE PRODUCTS DURING WORKING HOURS (Crete)(Stathopoulou et al., 1993)

Type of sample	Date of sampling				
	30/11/01	14/01/02	15/04/02	27/05/02	Pos/total (%)
Knives	0/5	0/5	0/6	0/5	0/21
Hands	0/6	0/5	0/5	0/5	0/21
Scalding tank water	0/1	0/2	0/2	1/2	1/7 (14.2)
Drains	0/2	0/2	1/2	0/3	1/9 (11.1)
Liver tanks		0/2	0/2	0/2	0/6
Caeca	3/5 (60)	4/5 (80)	0/5	0/5	7/20 (35)
Lymphnodes	0/5	2/5 (40)	1/5 (20)	0/5	3/20 (15)
Carcasses	0/10	1/10 (10)	0/10	0/10	1/40 (2.5)
Livers	1/5 (20)	0/5	0/5	0/5	1/20 (2.5)
Larygx	0/5	0/5	1/5 (20)	0/5	1/20 (2.5)
TOTAL	1/20 (5)	1/20 (5)	1/20 (5)	0/20 (0)	3/80 (3.75)
GRAND TOTAL	4/44 (9.1)	7/46 (15.2)	3/47 (6.4)	1/47 (2.1)	15/185 (8.1)

ECOLOGY OF LISTERIA SPP IN PIG SLAUGHTERHOUSES

Presence of Listeria monocytogenes and other Listeria spp in the environment of a pig slaughterhouse before and after the beginning of theoperations (Panoulis et al., 2003).

Type of sample	No of samples In two visits		Listeria spp Number +(%)		L.monocytogenes Number +(%)	
	A	B	A	B	A	B
A. Environment before initiation of slaughtering						
Floor drains	4	4	2 (50)	0	2 (50)	0
Hooks	2	2	0	0	0	0
Saw	1	1	0	0	0	0
Plastic separators in contact with carcasses	5	6	0	0	0	1 (16.7)
Individual offal containers	1	2	0	0	0	0
Total	13	15	2 (13.3)	0	2 (15.4)	1 (6.25)
B. Environment after initiation of slaughtering						
Floor drains	3	3	1 (33.3)	0	1(33.3)	0
Knives	2	3	0	0	0	0
Saw	1	1	0	0	0	0
Total	6	7	1	0	1(16.6)	0
Grand Total A +B	19	22	3 (15.8)	0	3 (15.8)	1 (4.54)

Presence of Listeria monocytogenes and other Listeria spp. on pig carcasses during slaughtering operations(Stathopoulou et al., 2003)

Type of sample	No of samples in two visits		Listeria spp number +(%)		L.monocytogenes number +(%)	
	A	B	A	B	A	B
Carcasses (back, thigh, neck)						
Before scalding	3,3,3	3,3,3	1,1,0 (22.2)	0,0,0	1,0,0 (11.1)	0,0,0
After scalding	3,3,3	3,3,3	0,0,0	0,0,0	0,0,0	0,0,0
After defeathering	3,3,3	3,3,3	0,0,0	0,0,0	0,0,0	0,0,1(11.1)
Half carcasses	3,3,3	3,3,3	0,0,0	0,0,0	0,0,0	0,0,0
Half carcasses after final wash	3,3,3	3,3,3	0,0,0	0,0,0	0,0,0	0,0,0
Total	45	45	2 (4.4)	0 (0)	1 (2.2)	1 (2.2)

ECOLOGY OF SALMONELLA SPP IN CHICKEN SLAUGHTERHOUSES

Salmonella spp. IN THE ENVIRONMENT AND PRODUCTS DURING PROCESSING IN SLAUGHTERHOUSE 1 (1999)

	Sampling date (Alexandridou et al., 2001)					
	14/3	29/3	19/4	6/5	26/6	TOTAL+/total-%
Poultry Farms	N 1	N 2, 3	N 4	N 5	N 4, 5	N 1-5
Personnel hands						
Hangers	0/2	0/3	2/2	0/3	0/3	2/13-15.4
Butchers	0/2	1/2	0/1	1/2	0/2	2/9 -22.2
Eviscerators	1/3	0/3	0/3	0/3	0/3	1/15 -6.7
Meat cutters	0/2	0/3	2/3	0/3	0/3	2/15 -13
Packagers	0/2	0/3	0/3	0/3	0/3	0/15 –0
Water						
Scalding tank overflow	0/3	0/3	3/3	0/3	0/3	3/15 -20
Defeathering	0/3	1/3	2/3	0/3	0/3	3/15- 20
Carcass cooling tank	0/3	0/3	0/3	0/3	0/3	0/15 -0
Gutters	0/3	0/3	1/3	0/3	3/3	4/15 -26.7
Water treatment pool					3/3	3/3 -100
Ceca	0/3	0/3	2/3	0/3	0/3	2/15-13
Products						
Livers	2/3	1/3	3/3	0/3	0/3	6/15 -40
Necks	0/3	0/3	0/3	1/3	0/3	1/15 -6.7
Ground meat			2/3	0/3	3/3	5/9 -55.6
Surfaces						
Cutting tables	0/2	0/3	3/3	0/3	2/3	5/14- 35.7
Packaging tables	1/2	0/6	1/3	0/3	0/3	2/15 -13
Plastic crates	0/3	1/3	0/3	0/3	2/3	3/15 -20
Evisc. spoon			0/1			0/1
Grand Total	4/39	4/47	21/46	2/47	13/51	42/229
%	10.2	8.5	45.7	4.2	25.5	18.3

SURVIVAL OF PATHOGENIC MO. IN POULTRY SCALDING TANK WATER (Genigeorgis 2005)

POULTRY TYPE	TEMP.^{o}C	+,- or %+	COMMENTS
CAMPYLOBACTER			
Chicken	49	+	Wempe et al., 1983
Chicken	53	+	>>
Chicken	60	+	>>
Chicken	60	8.3	Genigeorgis et al., 1986
Turkeys	60	5.7	>>
Chicken	60		SLAVIC et al.,1995, 0.6 DR more than at 52 or 56 C
SALMONELLA spp.			
Chicken	56	+	MULDER eta al., 1973
>>	60	-	>> 2-3 DR decrease of TPC
>>	60		Slavic et al., 1995, 0.3-0.5 DR more that at 52 or 56 C
Chicken	?	66.7	Cason et al., 2000 Geometric mean 10.9 cells/100ml
Chicken	57-59	11	Waldroup et al., 1993
Chicken	56-60	20-100	Alexandridou et al., 2001
Turkey	58-60	18	Nivas et al., 1973
L.MONOCYTOGENES			
Chickens	55.5	-	Genigeorgis et al., 1989
Turkeys	58.9	-	Genigeorgis et al., 1990

Prevalence of Campylobacter jejuni/coli in poultry meat (Genigeorgis 2005)

Country	Product	Prevalence	Author
		Chicken meat	
US	Retail parts	44-79	Kinde et al., 1983
US	Retail :fresh old	64.3-98 11-22	Wempe et al.,1983
US	Skin on parts	80-100	Berrang et al., 2001
US	Retail parts without skin	80-100	Berrang et al., 2001
Belgium	Carcasses, parts	20-40	Uyttendaele et al., 1999
Wales, UK	Carcasses, parts	70.2-72.8	Meldrum et al., 2004
		Turkey meat	
US	Retail parts	41-74	Reyes et al., 1983
US	Parts at slaughter	0	Yusufu et al., 1983
Belgium	parts	12.8	Uyttendaele et al., 1999
Denmark	meat	0-100	Borck & Pedersen, 2005
		Duck meat	
US	Carcasses, parts	6-34	Kasrazadeh& Genigeorgis 1987

Prevalence (%) of L.monocytogenes in poultry meat (Genigeorgis 2005)

Country	Product	Prevalence	Reference
		Chicken meat	
Finland	Retail parts	50-68	Miettinen et al., 2001
UK	Carcasses	60	Pini & Gilbert, 1994
US	Parts	7-22	Genigeorgis et al., 1990
US	Parts	0-84	Franco et al.,1995
US	Retail carcasses	23	Bailey et al., 1989
Norway	Carcasses	61	Rorvik & Yndestad,1991
Denmark	Carcasses	0-64	Loncarevic et al., 1994
Greece	Retail parts	10-80	Genigeorgis et al., 1991
Spain	Carcasses	64	Franco et al.,1997
Belgium&France	Carcasses	10-15	Uyttendaele et al., 1997
Belgium	Carcasses & parts	18-81	Uyttendaele et al., 1999
		Turkey meat	
US	Retail parts	6.7-16.7	Genigeorgis et al., 1990
Belgium	parts	3	Uyttendaele et al., 1999

Prevalence of Salmonella spp. in poultry meat (Genigeorgis 2005)

Country	Product	Prevalence	Author
Chicken meat			
Belgium	Carcasses	18-56.2	Uyttendaele et al., 1999
Belgium	parts	27.2	Uyttendaele et al., 1999
Brazil	Carcasses	66.7-100	Fuzihara et al., 2000
Wales,UK	Carcasses,parts Fresh, frozen	6.8-9.1	Meldrum et al., 2004
US	Carcasses	21	Jones et al.,1991
US	broilers	10.9	FSIS, 2003
US	Ground chicken	19.8	FSIS, 2003
Turkey meat			
Belgium	parts	82.9	Uyttendaele et al., 1999
US	Ground turkey	26.6	FSIS, 2003

ECOLOGY OF LISTERIA SPP IN THE ENVIRONMENT DURING FABRICATION

Presence of L.monocytogenes and other Listeria spp. in the environment of further processing of fresh pork meat marketed in whole sale and consumer size cuts (Panoulis et al., 2003)

Type of sample	Date	No of samples	Listeria spp	L.mono cytogens
A. Deboning room before initiation of work (saw, floor drains, teflon cutting boards, plastic baskets)	14/9/00	1,2,3,3	0,2,0,3	1,01,1 (33.3%)
B. Deboning room during operation (teflon cutting boards, hands, floor drains).	14/9/00	3,3,2	3,3,2	0,1,0, (12.5%)
A. Deboning room before initiation of work (as above)	19/9/00	1,2,5,4		0,0,0,1 (8.3%)*
B. Deboning room during operation (teflon cutting boards, hands, floor drains, knives).	19/9/00	5,6,2,1		0,0,0,1 (7.1%)*
C. Special products room before initiation of work (Teflon cutting boards, meat cutting equipment, floor drains)	14/9/00	3,3,2	1,1,2	0,0,0, (0%)
D. As in C	19/9/00	4,7,2		0(0%)

Presence of L.monocytogenes and Listeria spp on surfaces in the deboning room before and during processing in six sampling visits(Panoulis et al., 2003)

Sampling site	Total number of samples per visit	L.monocytogenes Total +/visit (%+)	Listeria spp Total +/visit (%+)
Before processing operations were initiated			
Saws	1,2,0,0,4,4	1,0,0,0,0,0, (9.1)	0,0,0,0,2,0 (18.2)
Teflon cutting boards	3,5,0,0,16,16	(0)	0,0,0,0,1,0 (2.5)
Drains	2,2,0,0,2,0	1,0,0,0,0,0 (16.7)	2,0,0,0,2,0 (66.7)
Crates	3,3,0,0,5,5	1,1,0,0,0,0 (12.5)	3,1,0,0,0,0 (25)
Knives sharpener	0,0,0,0,3,3	(0)	0,0,0,0,0,2 (33.3)
Knives	0,0,0,0,5,5	(0)	(0)
Workers hands	0,0,0,0,10,10	(0)	0,0,0,0,4,2 (30)
Total 109	7,12,0,0,45,43	3,1,0,0,0,0 (3.7)	5,1,0,0,9,4 (17.4)
2-3 hours after processing operation started			
Saws	0,0,0,0,4,0	(0)	0,0,0,0,2,0 (50)
Teflon cutting boards	3,5,0,0,16,16	(0)	3,0,0,0,14,7 (60
Drains	2,2,0,0,2,2	0,0,0,0,1,0 (12.5)	2,0,0,0,1,0 (37.5)
Crates	0,0,0,0,5,5	(0)	0,0,0,0,2,0 (20)
Knife sharpeners	1,0,0,0,3,3	0,1,0,0,0,0 (14.3)	0,1,0,0,1,1 (42.3)
Knives	0,0,0,0,5,5	(0)	0,0,0,0,2,2 (40)
Workers hands	3,6,0,0,10,8	3,0,0,0,1,0 (14.8)	1,0,0,0,8,5 (51.9)
Total 104	9,13,0,0,45,37	3,1,0,0,2,0 (5.8)	6,1,0,0,30,15 (50)

MICROBIAL ECOLOGY OF FRESH MEATS

Presence of *L.monocytogenes* and other *Listeria* spp in wholesale and consumer size pork meat cuts prepared in different rooms of a processing plant (September-October 2001) (Panoulis et al., 2001)

	Date	Number samples	Listeria spp Number (%+)	L.mono Number (%+)
I.Wholesale meat cuts (8-10kg) (vacuum packaged) prepared in the deboning room*				
Visit A	11/9/	25	12 (48)	10 (40)
Visit B	14/9/	10	2 (20)	2 (20)
Total A+B		35	14 (40)	12 (34.3)
II. A. Large pieces of meat before cutting into consumer sizes in the special products room				
Visit A	3/9/	40	5 (12.5)	2 (5)
III. Consumer size cuts (MAP) prepared in the special product room (no hamburger)				
Visit A	14/9/	30	13 (43.3)	2 (6.6)
Visit B	19/9/	25	0 (0)	0 (0)
Visit C	21/9/	25	2 (8)	0 (0)
Visit D	27/9/	81	24 (29.6)	8 (9.9)
Visit E	3/10/	45	24 (53.3)	1 (2.2)
Visits A-E		206	63 (34.8)	11 (5.3)

*Deboning room is used also to process imported pork the microbiology of which is not controlled by the company.

Table . Prevalence and numbers (log/g) of L.monocytogenes, Listeria spp, and Salmonella spp, in three types of fresh pork produced in Crete, packaged under MA in consumer portions and sampled during the years 2003, 2004

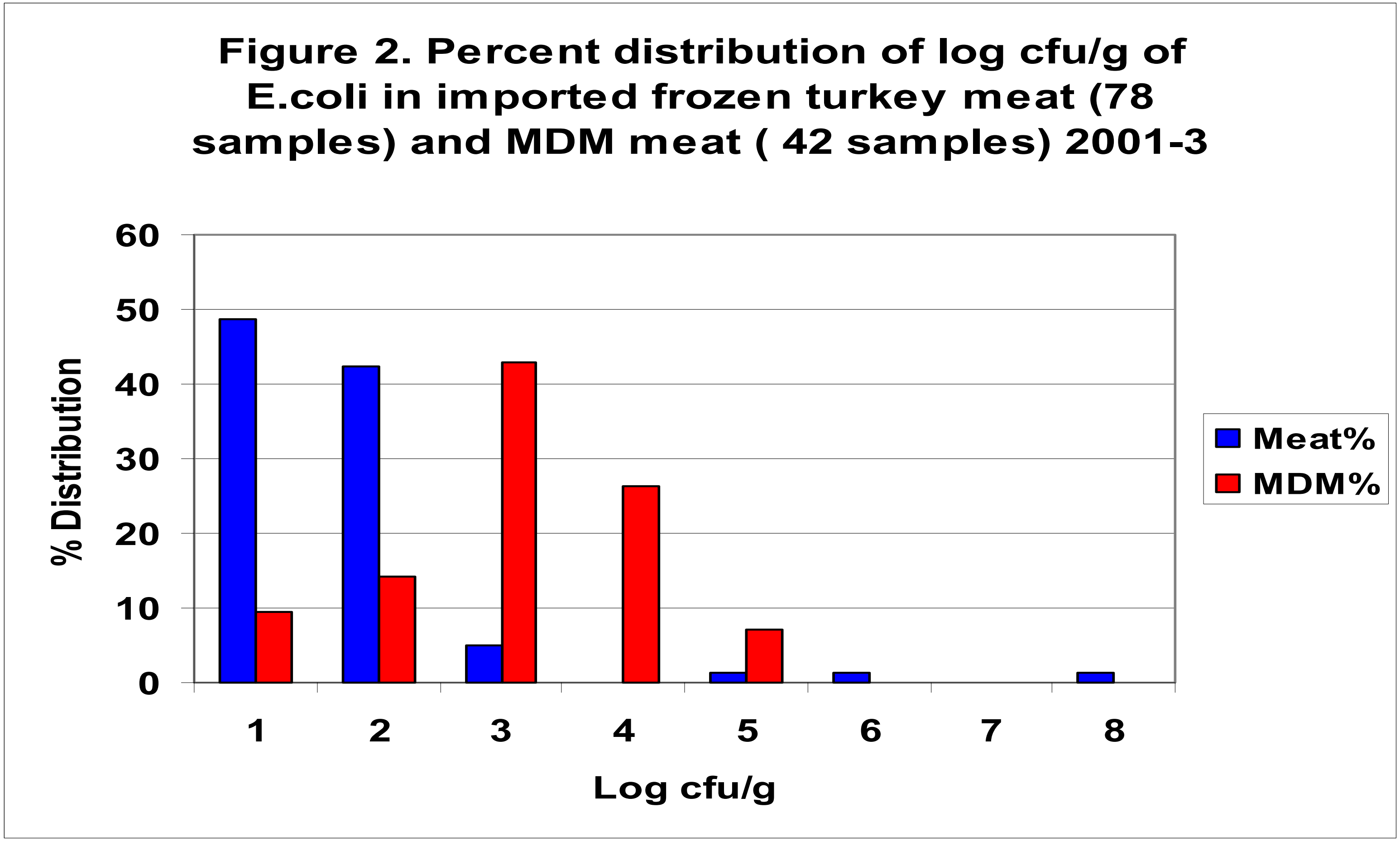
Measured Parameter	Type of pork meat (Genigeorgis et al., 2005)								
	Deboned chops			Small pieces			Hanburger patties		
	Samples	+ (%)	Range	Samples	+ (%)	Range	Samples	+ (%)	Range
Lmo /03	44	6.82		44	13.6		44	29.5	
Lmo /04	53	5,7		53	11,3		53	35,9	
TOTAL (%)	97	6,2		97	12,4		97	33	
Lmo numb/ 03		<1	<1-<1		<1	<1-<1		<1	<1-2.32
Lmo numb/ 04		<1	<1-<1		<1	<1-<1		<1	<1-<1
Lspp 03	44	6.8		44	27.3		44	20.5	
Lspp 04	53	0		53	1,9		53	9,4	
TOTAL (%)	97	3,1		97	13,4		97	14,4	
Lspp numb/03		<1	<1		<1	<1-1.69		<1	<1-2.07
Lspp numb/04		<1	<1	<1-<1	<1	<1-<1		<1	<1-<1
Salmo/03	44	0		44	0		44	4.5	
Salmo/04	53	0		53	0		53	0	
TOTAL (%)	97	0		97	0		97	2,1	

MICROBIAL ECOLOGY OF IMPORTED MEATS IN GREECE FROM 7 EU COUNTRIES AND 32 COMPANIES

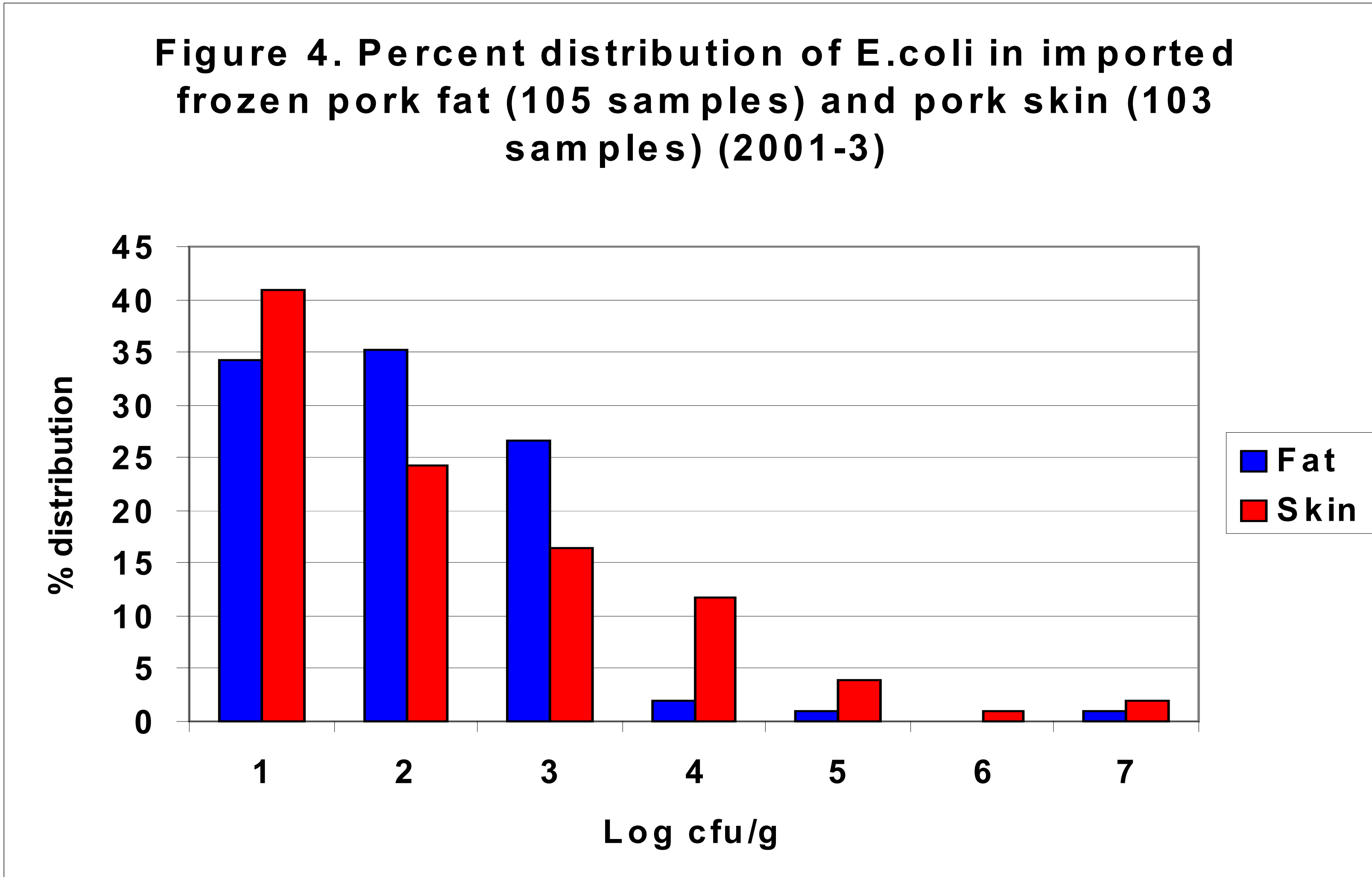
TABLE . Presence of *Salmonella* spp., in imported and Greek meats during the period of 2001-4 (Genigeorgis et al 2005)

Type of meat	Period	# samples analyzed	Number of samples +	% positive
Frozen turkey Imported	2001-3 (2003 only)	200 (71)	4 (0)	2 (0)
	2004	93	0	0
Frozen turkey MDM imported	2001-3 (2003 only)	78 (18)	9 (2)	11.54 (11.1)
	2004	12	0	0
TOTAL TURKEY	2001-4	383	13	3,4
Frozen pork Imported	2001-3 (2003 only)	550 (184)	4 (2)	0.73 (1.09)
Fresh pork imported		110 (79)	5 (1)	4.55 (1.27)
Pork skin imported		101 (9)	4 (0)	3.96 (0)
Pork fat imported		114 (8)	0 (0)	0 (0)
TOTAL PORK		875 (280)	13 (3)	1.49 (1.07)
Frozen pork imported	2004	186	1	0.52
Frozen trimmings,fat, skins imported		46	0	0
Fresh pork imported		100	1	1
Fresh Greek pork (1/2, parts)		358	0	0
Fresh Greek (trims,fat skin tongues)		84	0	0
TOTAL PORK	2004	774	2	0,26

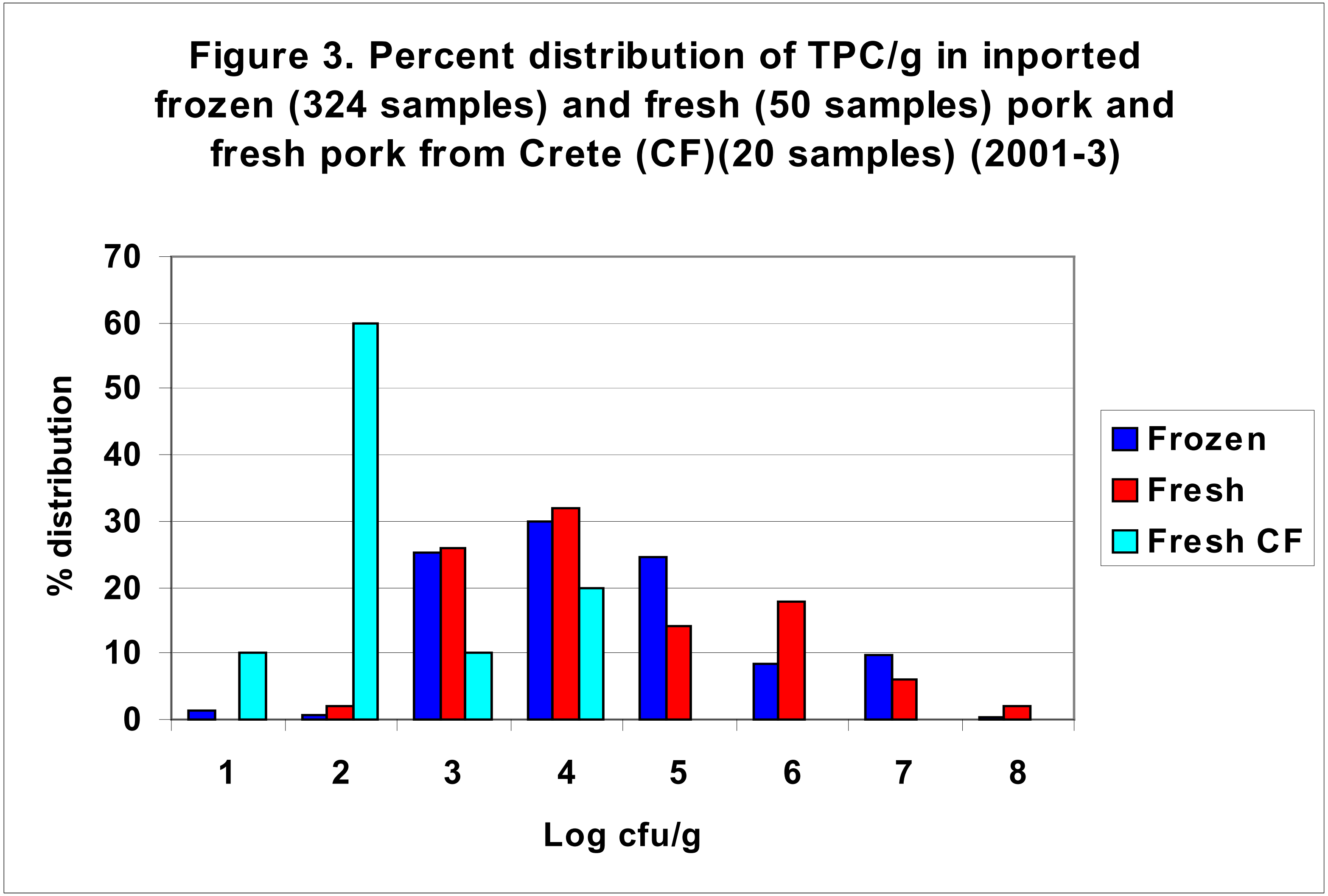
(Genigeorgis et al., 2005)



(Genigeorgis et al., 2005)



(Genigeorgis et al., 2005)



MICROBIAL ECOLOGY DURING MARKETING

MICROBIAL CHANGES DURING COLD STORAGE OF MAP PRODUCTS

Presence and log numbers/g of *Listeria* spp and *L.monocytogenes* in three types of fresh pork stored under MAP at 4, 8, and 12 C for up to 18 days (Panoulis et al 2005)

Day	Tigania (small pork pieces)						Snitzel		Chops	
	Storage temperature									
	4		8		12		8		8	
	List	LM	List	LM	List	LM	List	LM	List	LM
0	<1,00	-	<1,00	<1,00	-	-	-	-	<1,00	<1,00
0	<1,00	<1,00	-	<1,00	-	-	-	-	<1,00	-
2					<1,00	-				
2					<1,00	-				
4	<1,00	-	<1,00	-	-	-	-	-	<1,00	<1,00
4	<1,00	-	<1,00	-	-	-	-	-	<1,00	-
6			-	-	-	-	-	-	<1,00	<1,00
6			<1,00	<1,00	<1,00	<1,00	-	-	<1,00	-
8	<1,00	-	<1,00	<1,00	-	<1,00	-	-	<1,00	<1,00
8	<1,00	-	-	-	-	<1,00	<1,00	<1,00	<1,00	-
10					<1,00	<1,00	-			
10					-	<1,00	-			
12	<1,00	-	1,00	-			-	-	-	-
12	<1,00	<1,00	<1,00	2,68			-	-	<1,00	-
14	<1,00	-	-	-			-	-	<1,00	-
14	2,46	<1,00	-	2,94			-	-	-	-
16	-	-	-	<1,00			-	-	-	<1,00
16	-	-	<1,00				-	-	-	-
18	<1,00	-							-	-
18	<1,00	<1,00							<1,00	-

Pork chops, Snitzel: No *Listeria* spp. Or *L.m* at 4 and 12 C up to 18 days storage. No *Salmonella* spp detected in any of the

Table 1 Prevalence and number (log/g) of *Listeria* and *Salmonella* in consumer size fresh meats (in duplicate) packaged under MA and stored at 3-4°C for up to 10 days in duplicate (5-11-2004) (Panoulis et al 2005)

Storage day	Listeria spp	L.monocytogenes	Salmonella
PORK CHOPS			
2,2,5,5,10,10	-	-	-
PORK CHOPS WITH BONE			
2,2,5,5,10,10	-	-	-
HAMBURGER			
2	-	2,87	*S.Colorado*
2	2,41Li	-	*S.Colorado*
5	2,30Li	-	-
5	2,60Li	-	-
10,10	-	-	-
PORK NECK MEAT			
2	-	-	-
2	<1.00 Li	-	-
5,5,10,10	-	-	-
TIGANIA (Small pork meat pieces)			
2,2,5,5	-	-	
5	<1.00 Li	-	-
10,10	-	-	-
Total (%)	5/30 (16,67)	1/30 (3,33)	2/30 (6,67)

Microbial ecology of pork snitzel (1 Kg) during storage under MAP at 4 ºC (6-28/2) (Panoulis 2003)

Storage day	E.coli	Coliform	L.mono	APC	LAB	pH
2	1.0, 1.48	2.94, 2.96	-,<1	3.98, 3.00	3.18, 2.95	5.86, 5.90
3	1.48, 1.6	3.04, 3.15	<1,<1	4.49,,4.62	3.43, 3.85	5.92, 5.86
4	1.48, 1.3	3.07, 3.03	<1,<1	4.87,,5.07	4.53, 4.90	5.91, 5.95
6	1.7, 1.48	3.38, 3.38	<1,<1	5.4,,5.65	5.2, 5.34	5.88, 5.87
7	1.48, 1.6	4.04, 4.1	<1,-	6.04,,6.02	5.62, 5.78	5.92, 5.90
8	1.1, 1.1	4.11, 4.08	-,<1	6.5,,6.44	6.23, 6.04	5.82, 5.87
9	1.5, 1.5	4.12, 4.07	-,<1	6.54, 6.68	6.32, 6.46	5.88, 5.80
10	1.4, 1.6	4.15, 4.16	-,-	6.64, 6.71	6.60, 6.67	5.81, 5.88
12	1.1, 1.48	4.2, 4.19	-,<1	6.81, 6.90	6.85, 6.86	5.78, 5.80
15	1.7, 1.6	4.16,4.14	-,-	6.97, 7.22	7.02, 7.32	5.72, 5.70
18	2.0, 1.7	4.15, 4.29	-,<1	7.10, 7.3	7.30, 7.43	5.70, 5.63
21	1.70, 1.48	4.29, 4.35	- -	7.38, 7.46	7.51, 7.56	5.67, 5.69

PATHOGENS IN PROCESSED MEATS

Pathogen testing of ready-to-eat meat and poultry products collected at federally inspected establishments in the United States, 1990 to 1999. *L.monocytogenes* (Adapted from Levine et al., 2001). Percent prevalence

Product	1990	1994	1996	1998	1999
Cooked,roast corned beef	6.32	2.09	3.35	2.15	2.71
Sliced ham and luncheon meats	7.69	5.46	7.69	4.18	4.48
Small cooked sausages	4.21	4.81	3.74	3.49	1.76
Large cooked sausages	5.32	1.14	0.95	1.19	0.43
Cooked poultry products	2.79	2.37	3.17	2.22	1.44
Salads/spreads/pates	5.48	2.41	2.17	3.11	1.15
Fermented sausages	N/A	N/A	N/A	2.87	2.09

No E.coli O157:H7 in 452 fully cooked meat patties and no Staphylococcal enterotoxin in 1,668 dry and semidry fermented sausages have been detected

Presence (%) and Number of Listeria spp in cooked and sliced meat products (Panoulis et al., 2000)

Sliced products	ETAIPEIA				
	A	B	C	D	A+B+C+D
	Positive/ total(%)				
Franks pork	6/20	0/10	5/10	6/10	17/50 (34)
Franks Turkey	8/20	4/10			12/30 (40)
Pariza	4/10	0/10	5/10	3/10	12/40 (30)
Mordadella	3/10	0/10	2/10	4/10	9/40 (22.5
Bacon		0/10	5/10	10/20	15/40 (37.5)
Ham	4/10	2/10		8/10	14/30 (46.7)
Dry salami	1/10	0/10		9/20	10/40 (25)
Turkey ham	4/20	6/10	6/10	8/20	24/60(40)
	Positive/total (%)				
Listeria spp.	30/100 (30)	10/80(12.5)	23/50 (46)	48/10 (48)	111/330 (33.6)
L.monocytogenes	20/100 (20)	4/80 (5)	14/50 (28)	25/100 (25)	63/330 (19.1)
L.inocua	10/100 (10)	6/80 (7.5)	9/50 (18)	23/100(23)	48/330 (14.5)
Number (cells/g) in positive samples/total samples (%)					
<10*	15/30 (50)	7/10 (30)	7/23 (30.4)	30/48 (6.5)	59/111 (53.2)
10-100	15/30 (50)	3/10 (30)	16/23 (69.6)	18/48 (37.5)	52/111 (46.8)

*Direct plating 1ml intriplicate PALCAM Agar

Incidence of L.monocytogenes and lactic acid bacteria ($\log_{10}$cfu/g) in 404 meat products samples collected from hotels, restaurants, taverns, catering and military outlets and manufactured by 8 companies. 2003-5 (Panoulis 2005)								
Type of product	Product age since production (days)							
	0-15		16-30		31-45		46-60	
	LAB	LMO*	LAB	LMO	LAB	LMO	LAB	LMO
Ham, slices	5,09-6,07	1/8	6,16-7,27	2/19	6,85-8,04	1/7	6,25-8,93	0/6
Shoulder,slices	4,74-6,41	2/11	5,65-6,84	2/16	7,04-7,71	1/17	6,90-8,88	0/13
Picknic, slices	4,73-5,92	2/13	6,14-7,39	2/19	7,04-7,83	1/19	7,87-8,91	1/18
Frankfurters	3,87-5,79	5/21	5,67-6,74	3/39	6,71-7,91	1/20	7,17-8,96	1/20
WIENERS	3,62-5,76	2/19	5,44-7,09	2/14	6,73-7,41	0/14	6,94-8,96	0/7
Farmers, sausage	4,07-6,14	0/12	5,85-6,76	1/10	6,90-7,39	1/8	6,73-8,24	0/11
Bacon, slices	2,44-4,00	0/10	4,65-5,25	1/12	5,39-6,75	0/12	5,73-6,76	0/9
Total (%)		12/94 (12.77)		13/129 (10)		5/97 (5.15)		2/84 (2.38)
* number positive /number samples. Total (%+)/number of samples:32/404 (7.93%)								

Prevalence of L.monocytogenes in sliced cooked meats in Greece (Adapted from Angelidis and Koutsoumanis, 2006)			
Product category	**Number of companies**	**Number +/ Total samples**	**% positive**
1.sliced products	**27**	**17/209**	**8.1**
Sliced Cooked		**13/160**	**8.13**
Sliced fermented		**4/49**	**8.2**
Sliced in slices		**9/196**	**4.6**
Cut in cubes		**8/13**	**61.5**
Same manufacturer	**1**	**8/22**	**36.4**
All other companies	**26**	**9/187**	**4.8**
Bacon	**17**	**12/49**	**24.5**
All other 15 products		**5/160**	**3.13**

Influence of packaging location on the prevalence of *L.monocytogenes* in ready-to-eat foods (Gombas et a., 2003)				
Product category	**% of samples packaged:**		***L.monocytogenes* prevalence (%) for samples packaged:**	
	By manufacturer	**In store**	**By manufacturer**	**In store**
Luncheon meats	**77**	**23**	**0.4**	**2.7**
Deli salads	**48**	**52**	**1.4**	**3.6**
Seafood salads	**40**	**60**	**1.4**	**6.9**

THERMAL PROCESSING AND COOLING

RISK ASSESSMENT OF THE EFFECTIVENES OF THERMAL PROCESSING OF MEAT PRODUCTS
(Genigeorgis et al 2005)

- **Heat penetration curves were constracted and the cummulative FP_{70} in minutes for the heating phase and the cooling phase of the process was calculated automatically and recorded. The FP_{70} were added to get the FP_{70} of the total thermal processing.**

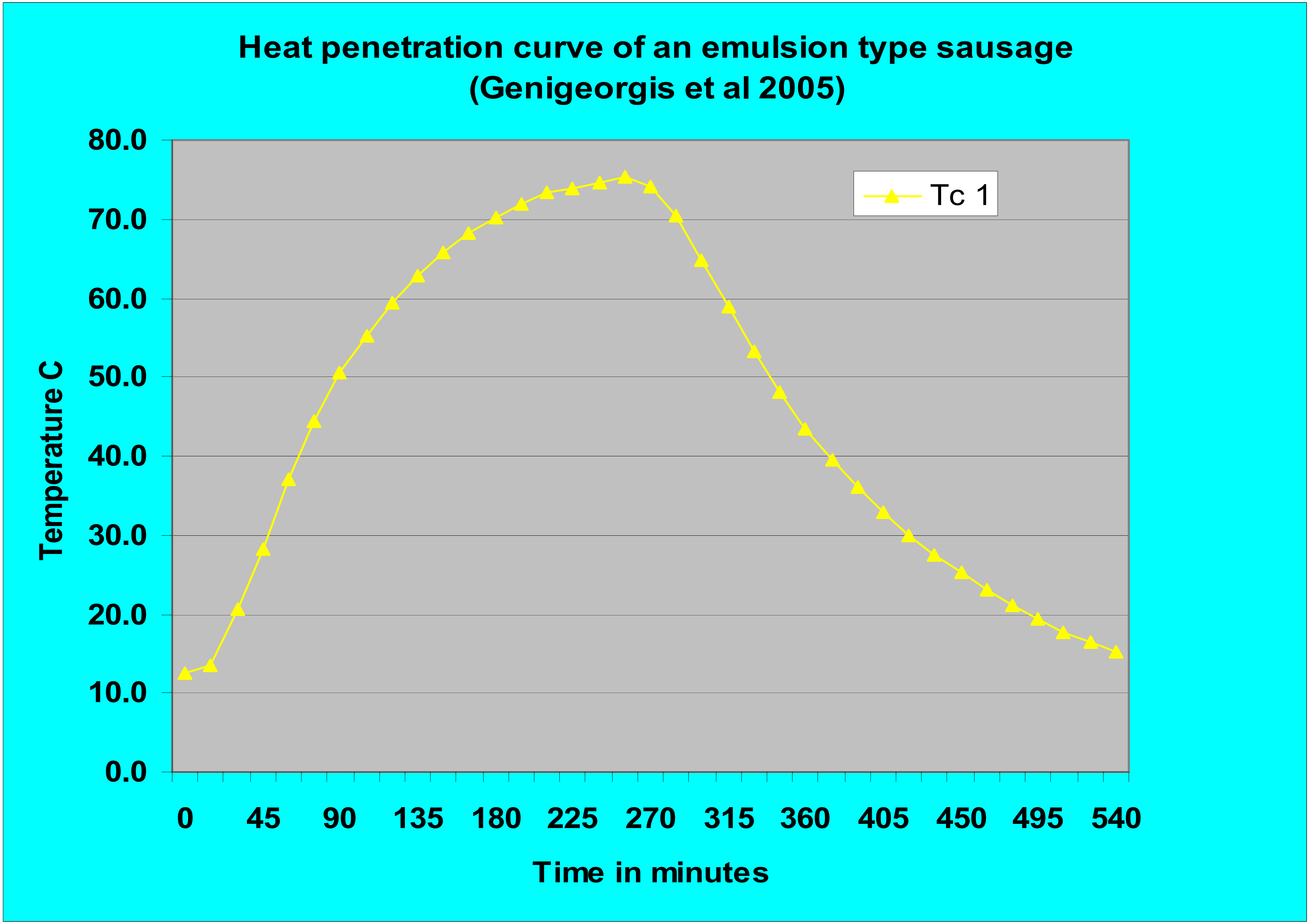
- **Products tested: 9**
- **Replications: 3**
- **Probes per replication: 6**
- **Total product heat penetration curves evaluated:162**
- **Total oven heating temperature curves evaluated: 54**

- **SUMMARY OF RESULTS**

RISK ASSESSMENT OF THE EFFECTIVENES OF THERMAL PROCESSING OF MEAT PRODUCTS

(C.Genigeorgis et al 2005)

- **During cooking and cooling we used 6 probes to get the heat penetration data as well as 2 probes to measure the oven temperature**
- **Product probes were placed at the geometric center of the product in six fixed locations inside the oven to detect any deficiencies in uniform heating and cooling**
- **During a run of a single probe in a single sausage or meat product the core temperature of the product from the beginning of the process to the end (over 30 measurements) was taken and recorded.**


Heat penetration curve of an emulsion type sausage
(Genigeorgis et al 2005)
Tc 1
Temperature C
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
45
90
135
180
225
270
315
360
405
450
495
540
Time in minutes

Potential Decimal Reductions for *L.monocytogenes* During the Cooking and Cooling of the Emulsion Type Sausage (Genigeorgis et al 2005)		
FP $_{70}$	**Cooking**	**139.5**
FP $_{70}$	**Cooling**	**39.08**
TOTAL FP $_{70}$		**178.57**
L.monocytogenes D_{70} = 0.27		
Potential Decimal Reductions with an FP $_{70}$ = 178.57 min equals to: 178.57: 0.27 = 661.4 DR !!!WHO NEEDS THIS??		

Table. Effectiveness of thermal processing in FP_{70C} units (equivalent time in minutes at 70 C) to destroy three pathogens in Frankfurter and Pariza cooked sausages (Sergelidis et al., 2000)

Microorganism	FP_{70C} minutes	Decimal reductions of initial population
Frankfurter		
Salmonella spp.	≥2.28	≥ 7.3
L.monocytogenes	≥ 1.76	≥ 7.3
E.coli O157:H7	≥ 1.76	≥ 6.2
Pariza		
Salmonella spp.	≥ 2.54	≥ 7.3
L.monocytogenes	≥ 1.95	≥ 7.3
E.coli O157:H7	≥ 1.29	≥ 6.2

Product : Ham Snack (Genigeorgis et al 2005)						
Probe	**1**	**2**	**3**	**4**	**5**	**6**
	LOT 4182329/ 1-7-2004					
FP_{70} heating	**125.8**	**11.7**	**125.5**	**208.6**	**106.8**	**130.1**
FP_{70} cooling	**20.2**	**58.4**	**34**	**64.2**	**23.3**	**25.7**
FP_{70} total	**146**	**170.1**	**163.5**	**272.8**	**130.1**	**155.8**
	LOT 4266319/ 23-5-2004					
FP_{70} heating	**105.4**	**112.1**	**99.6**	**94.4**	**59.6**	**101.1**
FP_{70} cooling	**57.1**	**36.6**	**30.6**	**27.1**	**22.1**	**40.1**
FP_{70} total	**162.5**	**148.7**	**130.2**	**121.5**	**81.7**	**141.2**
	LOT 4278329/10-5-2004					
FP_{70} heating	**90.4**	**247.8**	**124**	**63**	**61.4**	**125**
FP_{70} cooling	**54.2**	**8.4**	**31.3**	**30**	**27.5**	**51**
FP_{70} total	**144.6**	**256.2**	**155.3**	**93**	**88.9**	**176**

Microbiological data of experimental GYROS after slow cooling (11-15/9/2002) (Genigeorgis et al 2002)

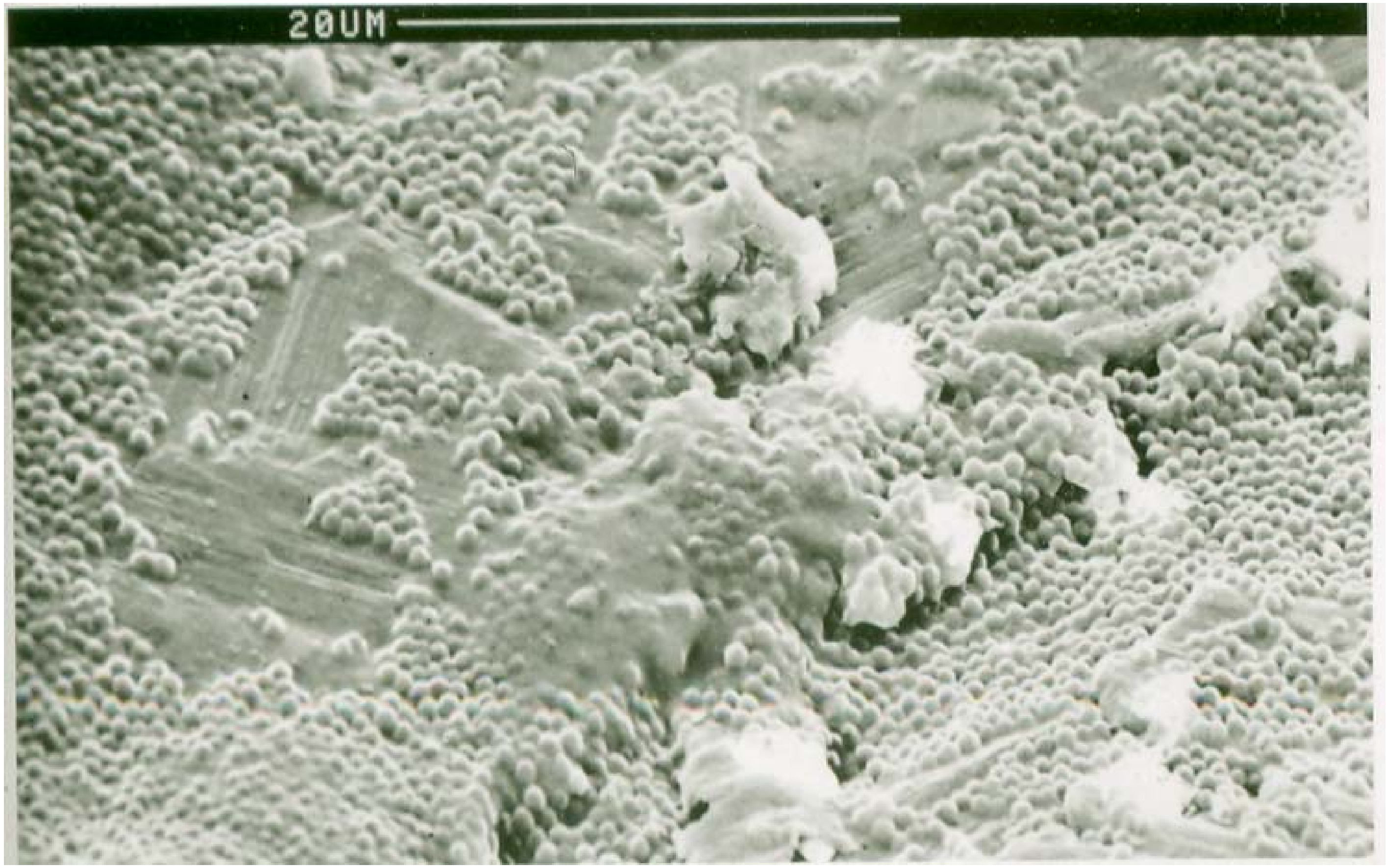
Production date	Aerobic	LAB	Clostridia	ENTERO	pH
11/9 (swollen +++)	$3,2 \times 10^5$	$4,1 \times 10^2$	$1,7 \times 10^8$	$2,1 \times 10^2$	5,56
11/9/ Swollen ++	$3,5 \times 10^4$	$<0,5 \times 10^2$	3×10^4	$<0,5 \times 10^2$	6,29
11/9/(swollen+)	$3,0 \times 10^4$	$<0,5 \times 10^2$	$1,5 \times 10^3$	$<0,5 \times 10^2$	6,22
11/9	$2,8 \times 10^4$	$<0,5 \times 10^2$	$4,5 \times 10^2$	$<0,5 \times 10^2$	6,24
11/9	$4,4 \times 10^4$	$<0,5 \times 10^2$	$3,5 \times 10^3$	$<0,5 \times 10^2$	6,23
12/9	$1,5 \times 10^3$	$<0,5 \times 10^2$	$1,2 \times 10^3$	$<0,5 \times 10^2$	6,24
12/9/(swollen+)	$4,8 \times 10^3$	$<0,5 \times 10^2$	$0,8 \times 10^2$	$<0,5 \times 10^2$	6,27
12/9(swollen+)	$3,3 \times 10^3$	$<0,5 \times 10^2$	$7,1 \times 10^3$	$<0,5 \times 10^2$	6,28
12/9(swollen+)	$5,0 \times 10^3$	$<0,5 \times 10^2$	$7,0 \times 10^3$	$<0,5 \times 10^2$	6,26
12/9(swollen+)	$1,9 \times 10^3$	$<0,5 \times 10^2$	$6,5 \times 10^3$	$<0,5 \times 10^2$	6,27
13/9)	$2,0 \times 10^3$	$<0,5 \times 10^2$	$6,0 \times 10^2$	$<0,5 \times 10^2$	6,45
13/9	$2,2 \times 10^3$	$<0,5 \times 10^2$	$4,0 \times 10^2$	$0,5 \times 10^2$	6,37
13/9	$2,0 \times 10^4$	$<0,5 \times 10^2$	$<0,5 \times 10^2$	$<0,5 \times 10^2$	6,32

E.coli $<0.5 \times 10^2$ /g, Coliforms $<0.5 \times 10^2$ /g, L.monocytogenes: absent

SCIENTIFIC GAPS AND RESEARCH NEEDS

-Improvements in slaughtering technologies and decontamination

S.aureus clumping strain. Biofilm on poultry equipment



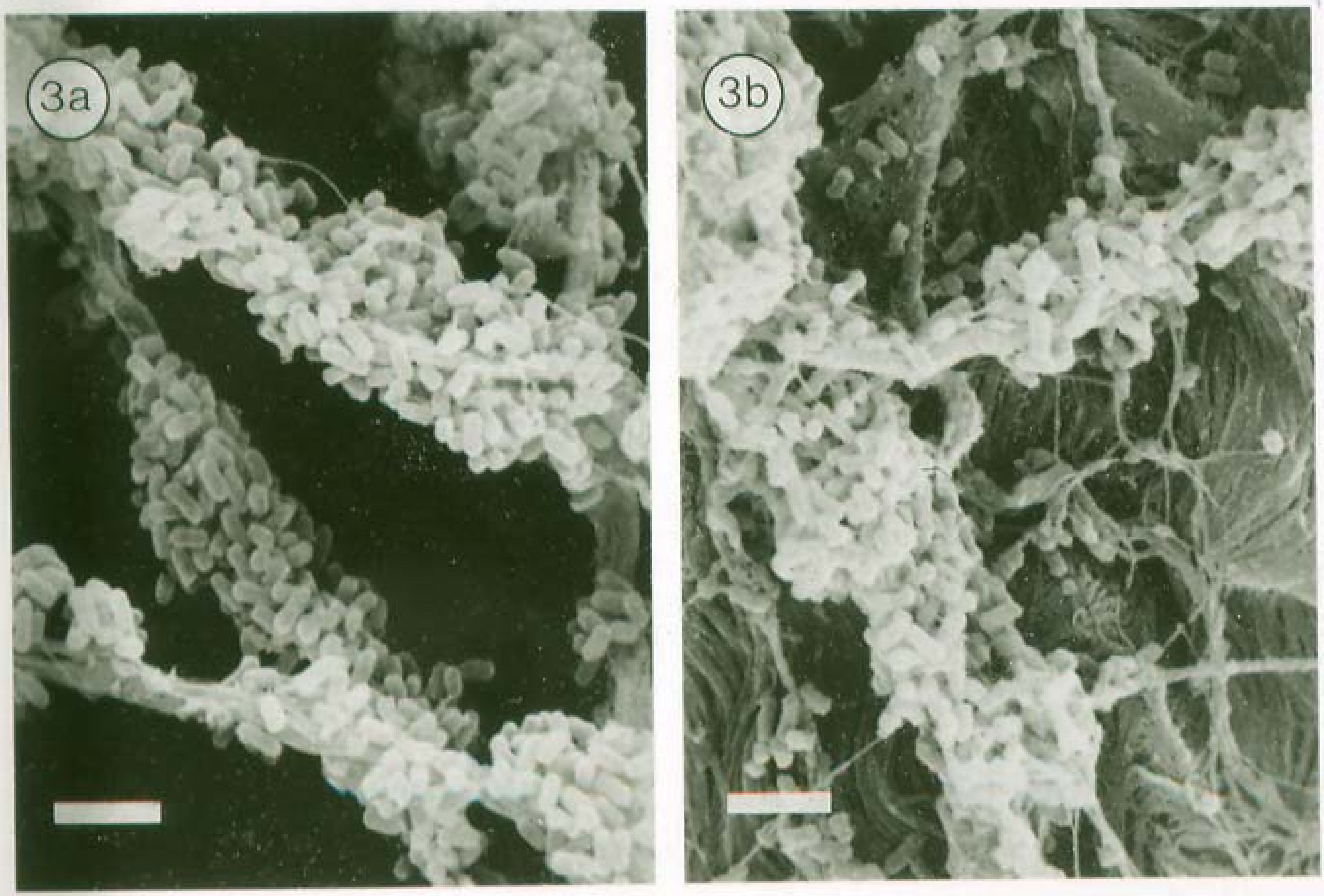


Fig. 3 SEM of *Salmonella* attached to the expanded collagen fibre network on the surface of fascia previously immersed in water containing these bacteria (*ca* 10^8 cells·ml^{-1}) for 30 min prior to fixation. (a) *S. typhimurium*; (b) *S. singapore*. Bar = 3 μm.

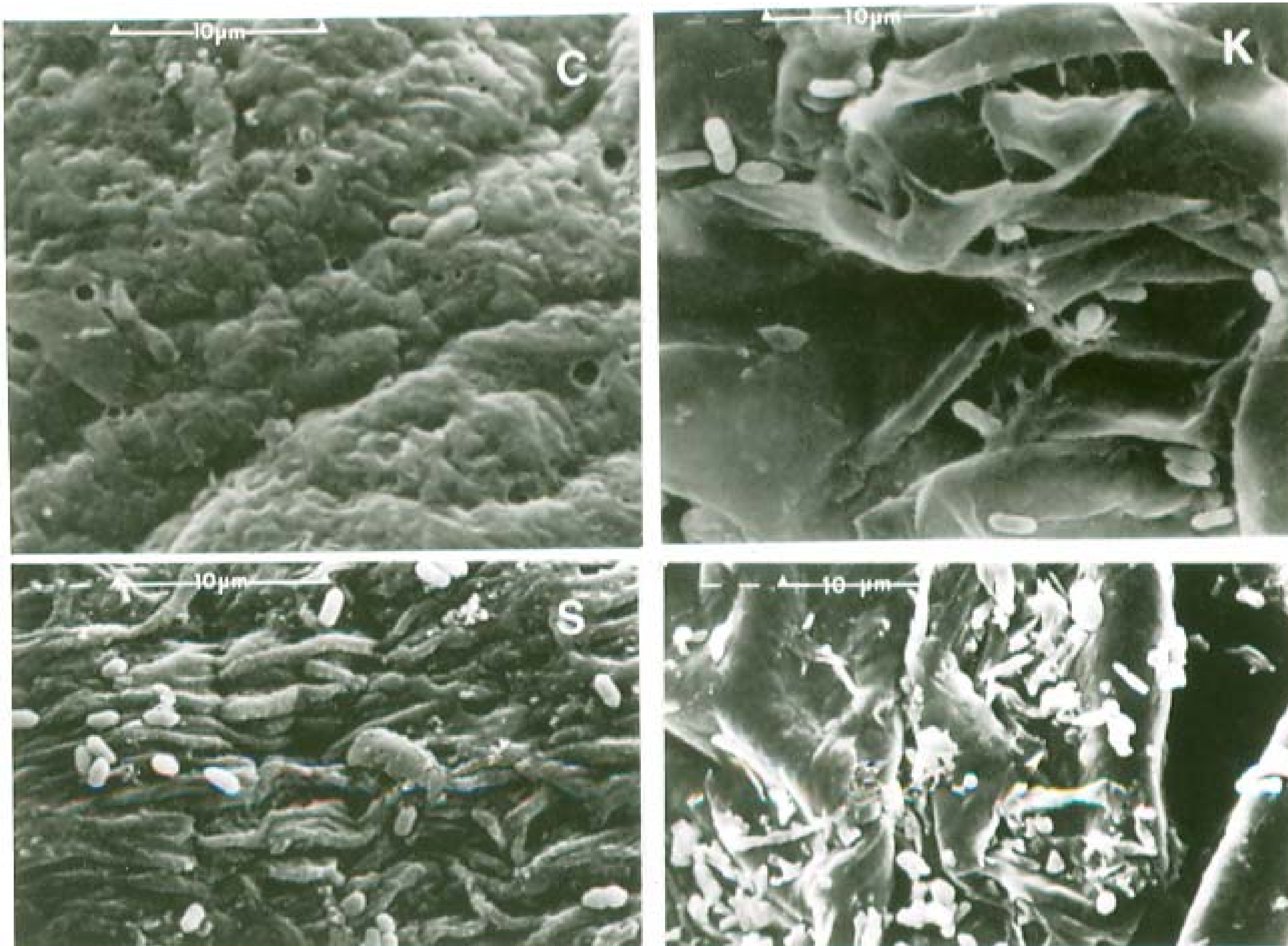


Figure 1. *Microtopography of turkey skin from three different defeathering systems and of unprocessed skin observed by SEM: conventional (C); kosher (K); steam-spray (S); unprocessed (UP) skin.* KIM & DOORES JFP 56: 286 1993

TABLE 3. Reductions[1] in numbers of inoculated bacteria on unchilled drumettes treated[2] 1 min with commercial antimicrobials and stored at 4°C for 2 h

Mehyar et al., 2005

	Reductions (log_{10} CFU/g)		
	Salmonella cocktail[3]	*Campylobacter*	*E. coli* O157:H7
TSP (10%)	1.56[a4]	1.89[a]	2.70[a]
Sanova	1.11[b]	1.56[b]	1.31[b]
$Safe_2O$	1.20[a]	1.72[ab]	0.71[cd]
Cecure	1.36[a]	1.40[a]	1.11[bc]
Inspexx 100	0.04[c]	0.32[c]	0.63[d]

[1]Reduction = log_{10} CFU/g of control - log_{10} CFU/g treated sample

[2]Drumettes were treated before bacterial inoculation. Initial inoculated number was 4–5 log CFU/g

[3]Cocktail consisting of one strain of *S.* Heidelberg and two strains of *S.* Typhimurium

[4]Means within the same column with different letters are significantly ($P < 0.05$) different, n = 6

PEELED AND SLICED PROCESSED MEATS

Mean log numbers ± standard deviation (log cfu/cm²)of Listeria monocytogenes on pork frankfurters formulated with antimicrobials and not dipped or dipped in organic acid solutions and stored for 0, 10, 20, 30 and 40 days at 10 C. (Adapted from Stopforth et al., 2005, IJFM 99:309)

Antimicrobials in the product	Day 0	Day 10	Day 20	Day 30	Day 40
			No dipping		
None (control)	2.3 ± 0.3	6.6 ± 0.1	8.7 ± 0.2	8.1 ± 0.2	8.7 ± 0.1
1.8%SL	2.2 ± 0.2	4.2 ± 0.1	6.2 ± 0.9	6.6 ± 0.9	7.6 ± 0.4
0.25% SD	1.8 ± 0.2	3.1 ± 0.2	4.5 ± 0.1	5.6 ± 0.9	6.4 ± 0.9
1.8%SL+0.15% SD	2.0 ± 0.1	2.3 ± 0.3	4.2 ± 0.7	3.9 ± 0.8	3.6 ± 0.5
1.8%SL+0.25% SD	2.3 ± 0.4	1.9 ± 0.1	2.6 ± 0.7	1.9 ± 0.2	2.1 ± 0.4
			Dipping ion 2.5% lactic acid		
None (control)	1.2 ± 0.2	5.4 ± 0.1	7.9 ± 0.1	7.7 ± 0.2	8.1 ± 0.3
1.8%SL	1.5 ± 0.3	0.6 ± 0.1	3.4 ± 0.3	3.7 ± 0.5	4.4 ± 1.2
0.25% SD	1.3 ± 0.2	1.0 ± 0.1	3.2 ± 0.5	3.8 ± 0.9	4.8 ± 0.9
1.8%SL+0.15% SD	1.6 ± 0.5	0.8 ± 0.2	1.4 ± 0.7	0.5 ± 0.3	0.5 ± 0.2
1.8%SL+0.25% SD	1.3 ± 0.2	0.7 ± 0.1	0.9 ± 0.2	0.4 ± 0.2	0.6 ± 0.2
			Dipping in 2.5% acetic		
None (control)	1.7 ± 0.2	2.5 ± 0.3	4.9 ± 0	6.5 ± 0.1	7.6 ± 0.1
1.8%SL	1.3 ± 0.2	0.4 ± 0.3	1.0 ± 0.1	0.6 ± 0.3	1.0 ± 0.1
0.25% SD	1.3 ± 0.4	0.5 ± 0.2	1.1 ± 0.2	1.3 ± 0.1	1.1 ± 1.1
1.8%SL+0.15% SD	1.5 ± 0.2	0.8 ± 0.4	0.8 ± 0.2	0.5 ± 0.3	0.5 ± 0.2
1.8%SL+0.25% SD	0.9 ± 0.5	0.5 ± 0.2	1.1 ± 0.3	0.5 ± 0.2	0.6 ± 0.3

Detection limit 0.1 cfu/ cm²

MINIMALLY PROCESSED WITH EXTENDED DURABILITY (HOW MANY WEEKS ?)

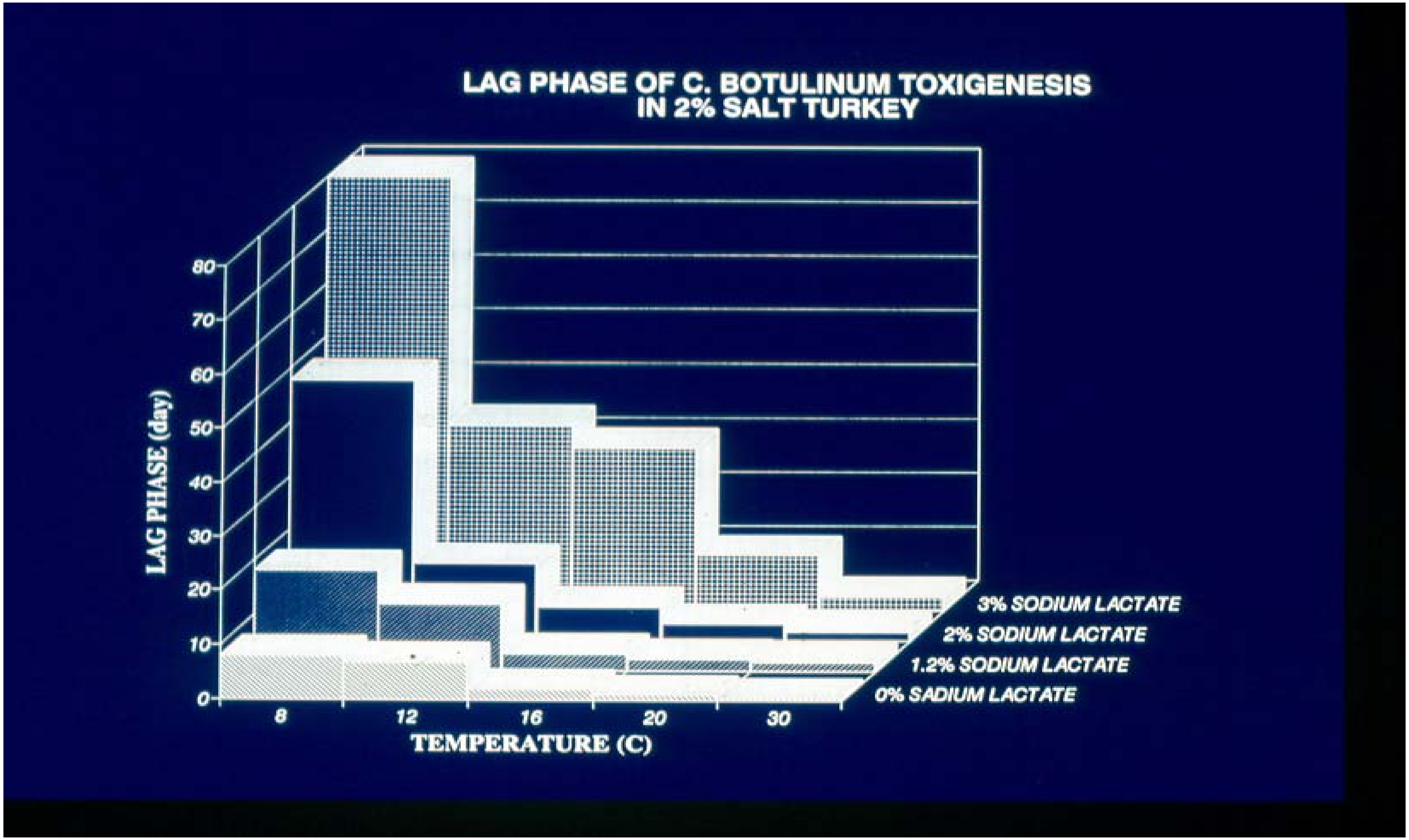
Cooked meats with no Nitrite, Nitrate, with natural ingredients.

Concern for potential germination and outgrowth of non-proteolytic C.botulinum

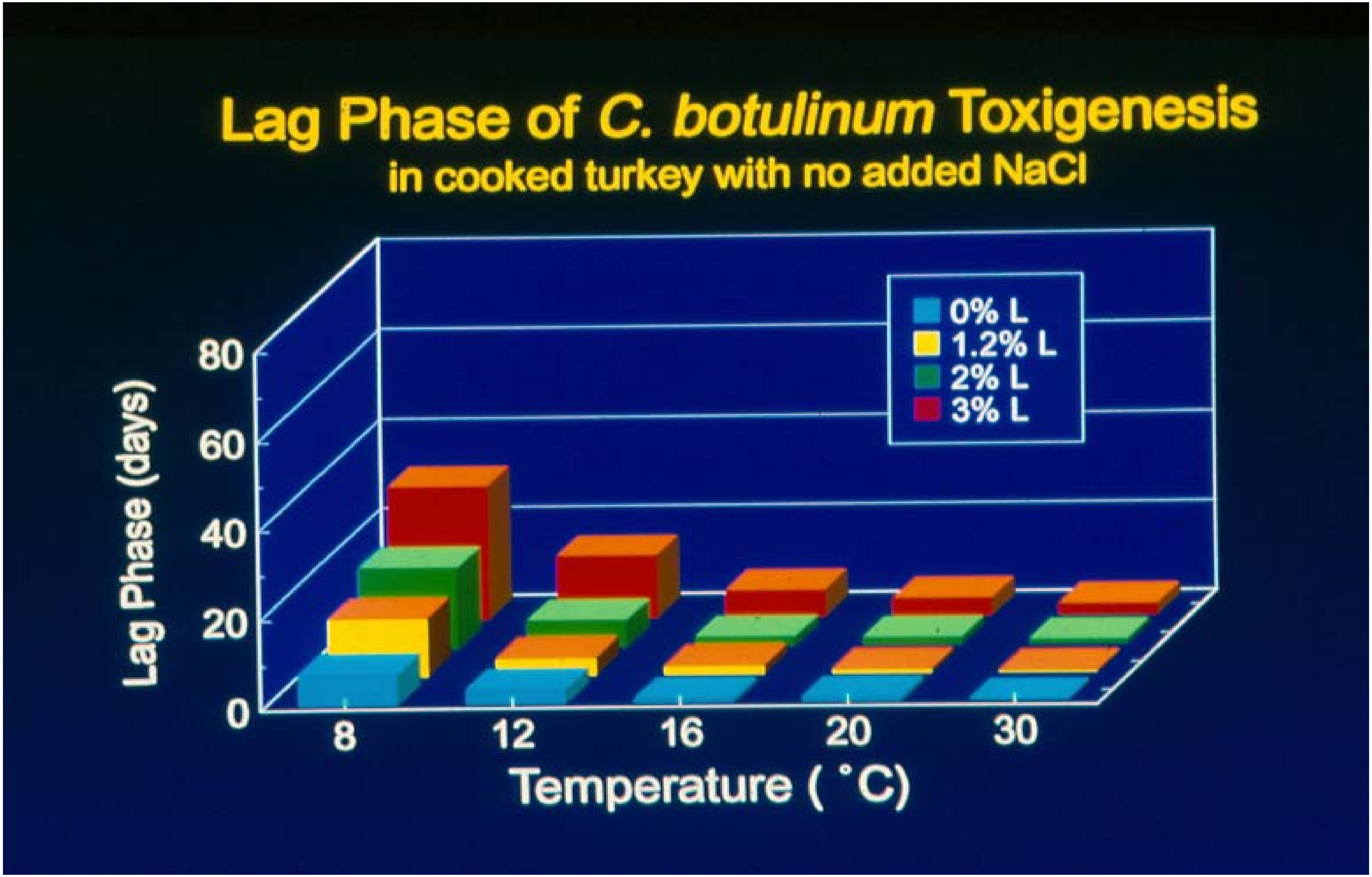
Needed: More realistic modeling approaches to select the levels of various hurdles to be adjusted with natural ingredients

(C.Genigeorgis 2005)

(Meng and Genigeorgis 2003)



(Meng and Genigeorgis 2003)



FERMENTED MEATS

E.coli O157:H7 and other ST E.coli

L.monocytogenes

Salmonella spp.,

S.Aureus

C.Genigeorgis 2005

Inactivation of EHEC during sausage ripening (*Friedrich-Karl Lücke, 2000)*

Type of product	Total ripening time (days)	pH	aw	log reduction of EHEC
„Soft“	3 - 10	> 5.2	0.95 - 0.97	0 - 1
Semi-dry	7 - 14	< 5.2	0.93 - 0.95	1 - 2
Semi-dry	14 - 21	< 5.2	0.92 - 0.94	2 - 3
Dry	> 21	< 5.2	< 0.93	3 - 5

Summarized from data of FAITH *et al.,* 1997; RIORDAN *et al.,* 1998; NISSEN & HOLCK, 1998; KOFOTH *et al.,* 1998; STIEBING *et al.,* 1998; MÜLLER *et al.,* 1998; POZZI *et al.,* 1998

CCP: STARTER CULTURES
The Need for Scientific Knowledge (Genigeorgis 2005)

Production of fermented meats without the use of starter cultures is not considered today safe at least for the control of *Listeria monocytogenes* , *S.aureus* and *E.coli O157:H7*. For safety, special processing conditions are required

-The use of starters assures:
1.Product uniformity.
2. Stable and better quality.
3. Decrease of losses.
4. Increased safety.

-Initial levels of *Listeria monocytogenes* and *E.coli O157:H7* above 103/ g in the paste are difficult to be controlled even with use of starters.

-In many countries lack of legal directives defining production and marketing of starters remains an important hurdle to progress