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Consumptions patterns and consumer risks – an overview of the Danish markets for pork, chicken, and eggs and the consumer risk associated with Salmonella and Campylobacter

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Consumptions patterns and consumer risks – an overview of the Danish markets for pork, chicken, and eggs and the consumer risk associated with Salmonella and Campylobacter

Tove Christensen, Sigrid Denver, Jørgen Dejgaard Jensen, Hanne Rosenquist, Anne Wingstrand, Søren Aabo, Bertel Ifversen

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Preface

In 2005, the Danish government initiated the research programme "The Food Sector of the Future" (Fremtidens Fødevaresektor). The present report is an outcome of collaboration between three projects on meat safety funded by the programme: CAMPY, DECONT and QUALYSAFE.

In the report the authors aim to provide an economic overview of market shares and trends in the Danish markets for pork, chicken and egg, as well as an overview of the main microbiological food hazards in Denmark in terms of *Salmonella* and *Campylobacter* associated with different product categories.

The novelty in the work is the attempt to link information about market sizes and trends in these markets and knowledge about different hazards from publicly available statistics. Thereby, the report seeks to assess the relative importance of the different zoonotic hazards and to assess whether trends in consumption patterns give rise to increasing pressure on food safety.

The report is prepared by Tove Christensen, Sigrid Denver, Jørgen Dejgaard Jensen, Hanne Rosenquist, Anne Wingstrand, Søren Aabo, Bertel Ifversen. In addition, thanks are due to a large number of people who have provided very helpful information - none mentioned, none forgotten.

I want to thank the authors, and in particular the lead author Tove Christensen, for undertaking and successfully completing this important and very difficult task.

Frederiksberg, November 2009

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Summary - dansk

Forbrugsvaner og zoonotiske risici –
En oversigt over Salmonella og Campylobacter risici fra svinekød, kylling og æg

Resumé
De seneste år har Campylobacter været skyld i dobbelt så mange sygdomstilfælde som Salmonella. Billedet er dog ikke så enkelt, da Salmonella til gengæld er skyld i dobbelt så mange dødsfald som Campylobacter. Den altovervejende smittekilde for campylobacteriose er fjerkræ. Salmonellose kommer fra alle husdyrgrupper, hvor især æg og svinekød har været dominerende i de senere år. Dansk svinekød har traditionelt haft en lavere Salmonellarisiko end importeret svinekød – men i 2008 var risikoen i importeret svinekød for første gang på niveau med dansk svinekød. Danske kyllinger har en lavere forekomst af både Salmonella og Campylobacter end importerede kyllinger. Vurderet ud fra situationen i 2005-2007, udgør kylling det største bakterieproblem og især i forhold til Campylobacter, selv om danskerne spiser 3 gange så meget svinekød som kylling. Der er ganske vist en lav risiko for at finde Salmonella i dansk produceret kylling – men der er høj salmonellarisiko i importerede kyllinger og en stor procentdel af både danske og især udenlandske kyllinger har tillige en høj campylobacterrisiko. Til sammenligning menes der stort set ikke at være risiko for at finde Campylobacter i svinekød og æg. Tendenserne mod større forbrug af fjerkræ og mere import af fjerkræ vanskeliggør kampen for at reducere zoonotiske risici forbundet med danskernes fødevareforbrug.

0.1. Indledning

Hvert år bliver tusindvis af danskere smittet med zoonotiske salmonella- eller campylobacterbakterier[1], hvilket medfører betydelige personlige og samfundsmæssige omkostninger. Salmonellose kan relateres til kød fra alle vores produktionsdyr og til æg, mens campylobacteriose hovedsageligt forbindes med fjerkrækød. Det er derfor vigtigt at rette opmærksomheden mod kød og æg i kampen for at reducere disse zoonotiske risici. Siden 1989 har Danmark haft handlingsplaner for bekæmpelse af *Salmonella* og siden midten af 1990-erne har der været frivillige aftaler mellem branchen og myndighederne om at bekæmpe *Campylobacter*. Først i 2008 blev en officiel handlingsplan for bekæmpelse af *Campylobacter* vedtaget. Disse tiltag har reduceret, men de har ikke fjernet, de zoonotiske risici. På den baggrund har Ministeriet for Fødeva-

[1] Salmonella og Campylobacter er zoonotiske bakterier dvs. bakterier der kan overføres mellem dyr og mennesker.

rer, Landbrug og Fiskeri bl.a. finansieret tre forskningsprojekter, hvis overordnede formål er at pege på metoder til at reducere zoonotiske risici i kylling og svinekød. I projekterne inddrages henholdsvis mikrobiologiske, sociologiske og økonomiske evalueringskriterier[2].

Nærværende rapports bidrag består i at give en overordnet beskrivelse af samspillet mellem risici for infektioner med *Salmonella* og *Campylobacter* på den ene side og danskernes forbrug af kød og æg på den anden side. Fremgangsmåden er at udnytte informationer om forbrugsvaner og udvikling i markederne for animalske produkter og sammenholde disse med udviklingen i omfanget af salmonellose og campylobacteriose samt smittekildedata for *Salmonella* bakterier[3].

For at få et bud på risikoen forbundet med at sætte tænderne i en kylling, et stykke svinekød eller et æg, er det nødvendigt med en række input. Først og fremmest, er det nødvendigt at kende omfanget af humane tilfælde forårsaget af henholdsvis *Salmonella* og *Campylobacter*. [4] Salmonellatilfældene bliver så vidt muligt fordelt på produkter, og på om produkterne er dansk producerede eller importerede. Dernæst har vi brug for at kende eventuelle forskelle i zoonotiske risici i henholdsvis svinekød, kylling og æg, hvor vi ligeledes skelner mellem henholdsvis danskproducerede og importerede produkter. Herudover har vi også forsøgt at få et overblik over dokumenterede forskelle i risici i kød og æg fra forskellige produktionssystemer (eks. økologisk vs. konventionel) og forskellige forarbejdninger (eks. kølet vs. frost). Sidst men ikke mindst, inddrages oplysninger om danskernes forbrug af forskellige typer af kød. På baggrund af disse data har vi forsøgt at opsummere sammenhænge mellem produktkategorier og zoonotiske risici for herigennem at give et fingerpeg om, hvilken betydning forbrugernes præferencer for forskellige produktkvaliteter har for den offentlige sundhed (og dermed for de samfundsmæssige omkostninger forbundet med sygdom).

Rapporten er afgrænset til at fokusere på svinekød, kylling og æg. Derfor behandles oksekød og andre typer fjerkræ end kylling kun nødtørftigt, hvor det forekommer na-

[2] I 2005 finansierede Ministeriet for Fødevarer, Landbrug og Fiskeri forskningsprogrammet "Fremtidens Fødevaresektor". Nærværende rapport er knyttet til projekterne CAMPY (at bekæmpe *Campylobacter* i fjerkræ), DECONT (at minimere risikoen for bakterieinfektioner fra svinekød') og QUALYSAFE (at udvikle nye fødevaresikkerhedsstrategier for produktionssystemer for animalske fødevarer), se http://ferv.fvm.dk/Projekter.aspx?ID=33727

[3] Smittekilde data for *Campylobacter* bakterier er endnu ikke til stede.

[4] I nærværende rapport benyttes antallet af sygdomstilfælde som en indikator for de samfundsmæssige omkostninger forbundet med *Salmonella* og *Campylobacter*.

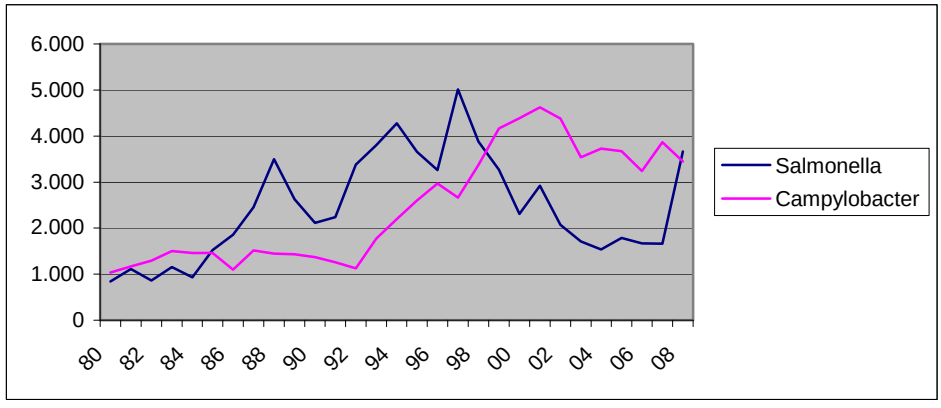
turligt for at opnå et helhedsbillede. Rapporten er opbygget på følgende måde: Efter indledende bemærkninger (kapitel 1), gives en overordnet beskrivelse af sammensætningen af fødevareproduktionen (kapitel 2). De efterfølgende tre kapitler fokuserer på at beskrive forbrugsmønstre samt vigtigheden af handel med udlandet for henholdsvis svinekød (kapitel 3), kyllingekød (kapitel 4) og æg (kapitel 5) hvorefter kapitel 6 forsøger at opsummere og perspektivere. Databeskrivelser er henlagt til appendiks.

0.2. Humane tilfælde

I alt blev der registreret 1.647 tilfælde af salmonellose og 3.868 tilfælde af campylobacteriose i 2007 (Anonymous, 2009). Af salmonellatilfældene menes ca. 33 dødsfald (2 % af de registrerede tilfælde) at kunne relateres direkte til infektionen med *Salmonella* (Helms & Korsgaard, 2008), og blandt campylobactertilfældene menes ca. 19 dødsfald (0, 5 % af de registrerede tilfælde) at kunne relateres direkte til infektionen med *Campylobacter* (Korsgaard, 2007). Lignende sygdomsomfang er registreret de seneste par år (et meget stort salmonellaudbrud i 2008 betragtes i denne analyse som atypisk). Langt fra alle sygdomstilfælde registreres, og det skønnes, at det faktiske antal sygdomstilfælde er mellem 5 og 20 gange større end det registrerede antal (Korsgaard et al., 2005). Det synes at være en rimelig antagelse, at graden af underrepræsentation er ens for *Salmonella* og *Campylobacter*. I så fald viser tallene, at ca. dobbelt så mange danskere bliver syge, men halvt så mange dør af *Campylobacter* sammenlignet med *Salmonella*. Udviklingen i antallet af registrerede tilfælde af salmonellose og campylobacteriose i perioden 1980-2008 fremgår af figur 0.1 (Anonymous, 2009, s. 14).

Overordnet set er der sket et markant fald i antallet af salmonellosetilfælde fra et niveau på godt 5000 i 1997 til ca. 1600 de seneste år. Fordelt på smittekilder toppede salmonellose fra kylling i 1988, fra svin i 1994 og fra æg i 1997. Campylobacteriose toppede i 2001 med 4620 humane tilfælde (Anonymous, 2009, s. 6).

Figur 0.1. Udvikling i antallet af registrerede humane tilfælde af salmonellose og campylobacteriose i perioden 1980-2008



Note: Stigningen i antal salmonellatilfælde i 2008 kan forklares med flere vedholdende udbrud hvor kilden endnu ikke er kendt.

Kilde: http://www.dfvf.dk/Files/Filer/Zoonosecentret/Overv%c3%a5gningen/Web_diverse_humane.xls

0.2.1. Salmonella

Zoonosecenteret ved DTU Fødevareinstituttet udarbejder årligt et smittekilderegnskab, hvor de registrerede salmonellatilfælde relateres til en smittekilde (Hald et al., 2004). Disse offentliggøres i den årlige rapport om zoonoser i Danmark (Anonymous, 2009). I tabel 01 ses resultaterne for 2005-2007.

Tabel 0.1. Fordeling af registrerede humane tilfælde af *Salmonella* fra hhv. fjerkræ, oksekød, svinekød og æg (dansk produceret eller importeret), 2005-2007 (i %)

	2005	2006	2007
Samlede antal reg. tilfælde	**1.775**	**1.658**	**1.647**
Dansk produceret svinekød	12,1	6,1	6,5
Dansk produceret oksekød	1,5	1,4	0,8
Dansk produceret kylling	4,1	0,5	0,8
Dansk produceret and	0,7	0,7	-
Æg	12,1	6,2	11,0
Importeret svinekød	2,5	1,6	1,3
Importeret oksekød	3,7	1,3	1,2
Importeret kylling	10,9	9,2	3,7
Importeret kalkun	1,0	5,2	0,7
Importeret and	0,4	0,7	-
Rejser	24,0	24,7	46,3[1)]
Ukendt i alt (inkl. udbrud med ukendt kilde)	27	42,3	27,8
Hovedgrupper (produkt) – i alt	**49**	**33**	**26**
Svinekød i alt	14,6	7,7	7,8
Oksekød i alt	5,2	2,7	2,0
Kylling i alt	15,0	9,7	4,5
Andet fjerkræ i alt	2,1	6,6	0,7
Æg	12,1	6,2	11,0
Hovedgruppe (land) – i alt	**49**	**33**	**26**
Dansk kød	18,4	8,7	8,1
Importeret kød	18,5	18,0	6,9
Æg	12,1	6,2	11,0

1) Registreringen af rejserelaterede tilfælde blev forbedret væsentligt i 2007. Hermed blev flere tilfælde tilskrevet rejse og færre tilfælde tilskrevet importeret kød.

Kilde: Anonymous (2009). Sammentællinger i hovedgrupper er egne beregninger.

Hvis der ses bort fra det store udbrud i 2008, har antallet af humane salmonellatilfælde ligget nogenlunde konstant de senere år, men der er sket en forskydning i hovedkilderne. Bl.a. er det i 2007 blevet muligt at lave en mere nøjagtig registrering af salmonellose, der er relateret til rejseaktiviteter, hvilket har ført til en kraftig stigning i denne kategori (fra ca. 24 % af de registrerede tilfælde i 2005 og 2006 til 46 % i 2007). Denne stigning skete på bekostning af især det importerede kød (som faldt fra godt 18 % af de registrerede tilfælde i 2005 og 2006 til knap 7 % i 2007) og til dels den ukendte pulje (som udgjorde 27 % af de registrerede tilfælde i 2005, godt 42 % i 2006 og knap 28 % i 2007).

Ses der udelukkende på danske produkter, er svinekød ansvarlig for flere salmonellatilfælde end kylling. I perioden 2005-2007 skete et markant fald i salmonellatilfælde knyttet til både dansk svinekød og kylling, mens antallet af salmonellatilfælde fra æg ikke faldt tilsvarende. Ses der udelukkende på importerede produkter, står kylling for flere salmonellatilfælde end svinekød, selv om der også på importsiden er sket en markant reduktion i antallet af salmonellatilfælde knyttet til kylling i perioden.

Ses der på produktvise forskelle i salmonellaforekomst uden hensyntagen til oprindelsesland, har svinekød og kylling i perioden 2005-2007 stort set været kilde til lige mange sygdomstilfælde. Den største forskel er estimeret i 2007, hvor svinekød stod for 7,8 % af salmonellatilfældene mod 4,5 % fra kylling. Og ses omvendt på oprindelsesland uden hensyntagen til produkt, er dansk og importeret kød i grove træk kilde til lige mange sygdomstilfælde.

Æg, der ikke er indregnet som en del af kødforbruget, bidrog i 2007 til en ganske betragtelig del af salmonellatilfældene, nemlig 11 %. Det kan umiddelbart synes overraskende, idet risikoen i danske æg anses for at være lille. Studier viser, at salmonellaforekomsten typisk er større i udenlandske end i danske æglæggerflokke (se tabel 02, tabelnote 3) men den nuværende import af æg vurderes som sådan ikke at udgøre en stor risiko, da importerede æg i dag stort set kun anvendes i fødevareindustrien og varmebehandles. Der er dog fundet eksempler på, at udenlandske skalæg optræder i danske butikker og en stigende import vil sandsynligvis udgøre en risikofaktor. I smittekilderegnskabet vil tilfælde fra importerede æg dels blive tilskrevet danske æg, dels ukendt kilde, da oplysninger om salmonellaforekomst i de partier, der importeres, ikke haves. Både forbrugernes håndtering af æg og en højere salmonellaforekomst i importerede æg er formentlig væsentlige årsager til ægbårne infektioner med *Salmonella.*

Med den grove pensel kan vi konkludere, at stort set lige mange tilfælde af salmonellose i 2007 kunne henføres til henholdsvis æg, dansk kød og importeret kød.

Det bør nævnes, at der er nogle væsentlige usikkerhedspunkter i forhold til smittekilderegnskabet. Først og fremmest relateres en forholdsvist stor andel af salmonellatilfældene til smittekilden *ukendt* (27,8 %). Hvis eller når det bliver muligt at få denne klump af salmonellatilfælde fordelt på smittekilder, samt hvis eller når registreringsraten kan bestemmes mere præcist, kan der naturligvis ske forskydninger i den pro-

duktvise fordeling. Det skal ligeledes nævnes, at bidraget fra de forskellige produktkategorier varierer betydeligt fra år til år.

0.2.2. Campylobacter

I perioden 1999 – 2007 har *Campylobacter* været den største enkeltkilde til bakteriel human diarre. Det registrerede antal campylobacteriose tilfælde lå på 3671 tilfælde i 2005, 3242 tilfælde i 2006 og 3868 tilfælde i 2007.

Et detaljeret smittekilderegnskab svarende til det for *Salmonella* findes ikke for *Campylobacter* endnu. Der er dog et par grove fordelingsnøgler at rette sig efter. Ca.1/3 af campylobacteriose tilfældene opstår i forbindelse med udlandsrejser (SSI, 2009). *Campylobacter* kan hovedsagelig relateres til fjerkrækød (Anonymous 2006 s. 23). Nærmere bestemt, så er kølet kylling den største kilde til campylobacteriose i Danmark (Wingstrand et al., 2006).

0.3. Zoonotiske risici i svinekød, kylling og æg

Fødevarestyrelsens overvågningstal for forekomsten af *Salmonella* og *Campylobacter* i forskellige typer af kød og i æg offentliggøres af Zoonosecenteret ved DTU Fødevareinstituttet i deres årlige rapport om zoonoser i Danmark (Anonymous, 2009). Herudover har Fødevarestyrelsen siden 2007 udført øget stikprøvekontrol af danske og importerede fødevarer (ofte kaldet case-by-case kontrollen). 'Et meget vigtigt element i kontrollen er at påvirke de virksomheder, der markedsfører kød, til at stille krav til de virksomheder, som de modtager kødet fra' (DVFA, 2009, s. 3). Svinekød og oksekød bliver undersøgt for *Salmonella*, og fjerkrækød bliver undersøgt for både *Salmonella* og *Campylobacter* (DVFA, 2009, s. 3). På baggrund af disse oplysninger er forekomsten af *Campylobacter* og *Salmonella* i svinekød, kylling og æg opdelt i dansk producerede og importerede produkter forsøgt opsummeret i tabel 02.

Som det fremgår af tabel 02, er der forskel på risici fra henholdsvis danskproduceret og importeret svine- og kyllingekød. Dansk svinekød har traditionelt haft en lavere Salmonellarisiko end udenlandsk svinekød – men i 2008 var risikoen i importeret svinekød for første gang på niveau med dansk svinekød. I 2008 påviste case-by-case kontrollen således *Salmonella* i lidt flere danske partier end importerede (11,9 % af de danske partier mod 10,4 % af de importerede partier (DVFA, 2009, s. 6). Danske kyllinger har en lavere forekomst af både *Salmonella* og *Campylobacter* end importerede kyllinger.

Tabel 0.2. Oversigt over campylobacter- og salmonellaforekomst i svinekød, kylling og æg opdelt i dansk producerede og importerede produkter (så vidt muligt 2007-tal). Det er vigtigt at bemærke, at metoder for prøveudtagning og analyser varierer, hvilket betyder, at forekomsten i de forskellige produktkategorier ikke kan sammenlignes

Salmonella		Prævalens i danske produkter (i procent)	Prævalens i import (i procent)
	Svinekød (slagtekroppe, på slagteri)[1)]	1,1 %	
	Svinekød (partier, case-by case) [1)]	11,3 %	13,1 %
	Kylling (flokke, på slagteri)[2]	1,2 %	
	Kylling (partier, case-by case)[2)]	1,6 %	14,5 %
	Skalæg (æglæggerflokke, i besætning, dansk overvågning) [3)]	1 %	
	Skalæg (æglæggerflokke, i besætninger, EU baseline studie)[3)]	2,4 %	EU gns.30,7 pct. (0-80 pct.)
Campylobacter	Svinekød (prøver af hakket kød)[4)]	0,2 %	?
	Kylling (kødprøver, på slagteri)	8,2 %	
	Kylling (partier, case-by-case) [5)]	15,1 %	27,7 %
	Skalæg[6)]	-	-

Kilder:

1. **Salmonella i svinekød**. I 2007 lå forekomsten af *Salmonella* på slagtesvinekroppene på 1,1 % (Anonymous, 2009, s. 10 og s. 41). Ifølge case-by-case kontrollen i 2007 lå Salmonellaforekomsten i dansk svinekød i detailleddet på 11,3 % af partierne (DVFA, 2008, s. 5). Ifølge case-by-case kontrollen lå Salmonellaforekomsten i 2007 i importeret svinekød på 13,1 % af partierne (DVFA, 2008, s. 5 og Anonymous, 2009, s. 44). Siden indførelse af case-by-case kontrollen i 2007 er Salmonellaforekomsten i importeret svinekød på niveau med det danske svinekød. Faktisk blev der i case-by-case kontrollen i 2008 påvist *Salmonella* i flere danske partier end importerede (DVFA, 2009, s. 6).
2. **Salmonella i kylling**. I case-by-case kontrollen, blev der påvist *Salmonella* i dansk fjerkrækød i 1,6 % partier i 2007 og i 0,3 % i 2008 (DVFA, 2009, s. 5). I 2007 lå Salmonellaforekomsten også på 1,6 % i danske slagtekyllingeflokke (ikke vist i tabellen men forekomsten i slagtekyllingeflokke er beregnet ud fra oplysning om, at der er *Salmonella* i 55 ud af 3486 flokke, Anonymous, 2009 s. 38). På slagterierne lå forekomsten på ca. 1,2 % af slagtekyllingeflokkene (beregnet ud fra at 10 ud af 828 flokke ifølge Anonymous (2009), s. 38). I case-by-case kontrollen i 2007 blev der fundet *Salmonella* i 14,5 % af de importerede partier fjerkrækød (Anonymous, 2009, s. 44 og DVFA 2008 s. 4) og i 15 % i 2008 (DVFA. 2009, s. 5).
3. **Salmonella i æg**. Forekomst i/på æg er meget lav. En undersøgelse fra 2001-2002 fandt at 0,05 % af danske æg var inficeret med *Salmonella* på skallen og 0,02 % var inficeret med *Salmonella* indeni ægget (blommen eller hviden). I importerede æg (fra Holland, Tyskland og Sverige) fandt man *Salmonella* på skallen i 0,55 % af æggene og 0,25 % af de udenlandske æg var inficeret med *Salmonella* indeni ægget (blommen eller hviden), Danish Eggs (2005) s. 10. Forekomsten i 2007 lå under 1 % af danske æglæggerflokke (5 ud af 510 flokke, Anonymous, 2009, s. 37). I følge DVFA (2006) s. 119, er der i et EU-baseline studie fra 2004-2005 af salmonellaforekomsten i æglæggerflokke fundet betydelig variation i salmonellaforekomsten i EU, således at den gennemsnitlige forekomst i æglægger flokke på 30,7 % varierer fra 0 % i bl.a. Sverige, over 2,4 % i Danmark til næsten 80 % i Portugal
4. **Campylobacter i svinekød**. Der er meget lille campylobacterrisiko forbundet med dansk svinekød (0,2 % i hakket svinekød i 2002, Anonymous (2003)). Vi har ikke været i stand til at finde oplysninger om *Campylobacter* risici fra importeret svinekød. Til gengæld er campylobacterforekomsten i levende svin ret høj: I 2007 var *Campylobacter* forekomsten i svinebesætninger på 76,6 % for *C. coli* og 1,9 % for *C. jejuni*. Til sammenligning var *Campylobacter* forekomsten i kvægbesætninger på 3 % for *C. coli* og 67,4 % for *C. jejuni* (Anonymous 2009, s. 44).
5. **Campylobacter i kylling**. Case-by-case kontrollen fandt *Campylobacter* i 15,1 % af danske partier af fjerkræ i 2007 (DVFA, 2008) og i 13 % i 2008 (DVFA, 2009). Der blev fundet *Campylobacter* i 27,7 % af de importerede kyllingepartier i 2007 (DVFA, 2008) og i 20,2 % i 2008 (DVFA, 2009). I Anonymous (2009) s. 39 angives forekomsten i kølet kylling udtaget på slagteriet til 8,2 %.
6. **Campylobacter i skalæg**. Er ikke en del af overvågningen, da skalæg ikke anses for at være et risikoprodukt. Ingen undersøgelser tyder på forekomst af *Campylobacter* indeni æg.

Derfor er importandelen en vigtig faktor i forhold til at vurdere risikoniveauet i det kød, der købes i danske butikker. Det overordnede billede er, at langt den overvejende del af kødforbruget i Danmark er hjemmeproduceret. Det anslås at ca. 40 % af kyllingerne på det danske marked i dag er importeret (se kapitel 4 i rapporten). Angivelsen af importandel af det private forbrug er temmelig usikker, hovedsagelig fordi det ikke er præciseret, hvor stor en andel af importen der er svind (fedt, ben, hoved), og hvor meget der geneksporteres. Det har derfor ikke været muligt at få præcise data for andelen af importeret svinekød. Et rimeligt realistisk bud menes dog at være, at 20-25 % af svinekødet er importeret (se kapitel 3 i rapporten). For æg angives importandelen at være 25-30 % - hvoraf langt den overvejende del anvendes af industrien og derfor varmebehandlet (se kapitel 5 i rapporten). Dvs. langt hovedparten af danskernes forbrug af skalæg er af dansk oprindelse.

Forholdene mellem bakterieforekomst og human sygdomsforekomst afhænger også af hvor ofte og hvor meget, der spises af de forskellige produkttyper. Sidstnævnte ser vi mere på nedenfor.

0.4. Forbrug af kød og æg

Danskernes fødevareforbrug er forsøgt estimeret ud fra to temmelig forskellige metoder – nemlig baseret på en spørgeskemaundersøgelse om kostvaner i befolkningen i perioden 2000-2002 og baseret på Danmarks Statistiks opgørelser af produktion, import og eksport i 2006. Andersen (2007) har sammenlignet de to metoder og finder at beregninger af forbrug baseret på kostundersøgelserne (Lyhne et al., 2005) er noget lavere end forbrug baseret på Danmarks Statistik. Andersen (2007) angiver som en vigtig årsag til forskellen, at Danmarks Statistik ikke indregner svind og geneksport, således at vurderingen af dansk kødforbrug sandsynligvis er overestimeret. Forskelle i tid kan være en yderligere del af forklaringen på forskelle i kødforbrug i de to undersøgelser. Samtidig kan det påpeges at kostundersøgelserne er baseret på selvrapportering, så der kan man forvente en bias mod for lavt kødforbrug, da mange danskere godt kender 'de 8 kostråds' anbefalinger om spise mindre kød (kostrådene er beskrevet i Astrup et al., 2005).

Kødforbruget ifølge Danmarks Statistik lå næsten dobbelt så højt som ifølge kostundersøgelsernes data (97 kg ifølge Danmarks Statistik i 2006 mod 51 kg i kostundersøgelserne i 2000-2002). Til gengæld er fordelingerne mellem kødtyper ikke særlig forskellige. Danmarks Statistik fordeler danskernes kødforbrug på 46 % svinekød, 28 % oksekød, 25 % fjerkræ og knapt 2 % andet (lam, vildt og hestekød), mens kostunder-

søgelserne fordeler kødforbruget på 80 % svine og oksekød og 20 % fjerkræ[5], som vi efterfølgende har estimeret til at være fordelt på 50 % svinekød, 30 % oksekød og 16 % kylling og 4 % andet fjerkræ. Oplysningerne er gengivet i tabel 03.

Vi er hovedsagelig interesserede i fordelingen af forbrug mellem svinekød og kylling og den varierer ikke så meget mellem metoderne. I tabel 03 ses at danskerne gennemsnitligt spiser mellem 2,5 (Danmarks Statistik) og 3,3 (Lyhne et al., 2005) gange mere svinekød end kylling.

Tabel 0.3. Fordeling af kødforbrug på typer

	Danmarks statistik data, Andersen (2007)		Lyhne et al. (2005), kostundersøgelsen	
Produkttype	Forbrug Kg/år[3)]	Fordeling på kød typer (%)	Forbrug Kg/år[3)]	Fordeling på kød typer (%)
Forbrug i år	2006		2000-2002	
Svine- og oksekød[1)]	73	75	41	80
- heraf svin	45	46	26	50
- heraf okse	28	29	15	30
Fjerkræ	22	29	10	20
-heraf kylling[2)]	18	18	8	16
Andet	2	2		
Kød i alt	97	**100**	**51**	100
Svinekød ift. kylling	**3,3**		**2,5**	
Æg	**17**		6	

Note:
1) I kostundersøgelserne opgøres svinekød og oksekød samlet (80 % af samlet kødforbrug). Fordeling ml. svinekød (63 %) og oksekød (27 %) er baseret på kilderne Danish Meat Association (2008), Andersen (2007) og Danish Agriculture (2006): I pågældende kilder ligger svinekødets andel af svine- og oksekød på mellem 62 % og 64 %. Vi anvender 63 %.
2) Beregnet ud fra Danish Poultry Council (2007) s. 118 og 122, hvor det angives at danskerne spiste 23,5 kg fjerkræ i 2006 heraf 18,8 kg kylling hvilket svarer til at kylling udgør 80 % af danskernes forbrug af fjerkræ.
3) I Lyhne et al. (2005) er forbrug angivet i gram/dag – disse er omregnet til kg/år. Begge kilder indeholder i princippet spisning uden for hjemmet.

Vi formoder forbrug af de forskellige kategorier af kød trods alt er 'husket' mere nøjagtigt i kostundersøgelserne end de er estimeret i Danmarks Statistik, på grund af den manglende registrering af svind og genekspert i opgørelserne fra Danmarks Statistik.

[5] I kostundersøgelserne registreres andet kød såsom lam, vildt og hestekød under kategorien svine- og oksekød. Forbruget heraf vurderes at være så lille at fordelingen mellem svinekød og kylling ikke forstyrres.

Vi har derfor valgt at bruge oplysningerne fra kostundersøgelserne 2000-2002 til at opsummere følgende om danskernes forbrug af kød og æg:

Danskere spiser mindst 51 kg kød om året. Den gennemsnitlige dansker spiser ca. 26 kg svinekød, 8 kg kylling og 6 kg æg årligt. Kødforbruget er fordelt på ca. 50 % svinekød, 30 % oksekød og 16 % kylling og 4 % andet fjerkræ. Herudover spiser danskerne ca. 6 kg æg svarende til ca. 120 æg om året. Den typiske dansker spiser således godt 3 gange så meget svinekød som kyllingekød. Disse tal er naturligvis også behæftet med en vis usikkerhed – og der kan være store variationer på tværs af befolkningsgrupper - men det giver dog en klar indikation af at der generelt spises noget mere svinekød end kylling.

0.5. Kvalitetsegenskaber - risici og markedsandele

Vi har allerede set at *Salmonella* og *Campylobacter* risici afhænger af kødkategori og kødets oprindelsesland. Derudover afhænger risici ofte også af produktionsform og forarbejdningsgrad. I tabel 04 opsummeres dokumenteret viden om sammenhænge mellem zoonotiske risici, produktionssystemer, forarbejdningsgrad og oprindelsesland.

Tabel 0.4. Oversigt over zoonotiske risici ved svinekød, kylling og æg kategoriseret i forhold til produktionssystem, forarbejdningsgrad og oprindelsesland

		Produktionssystem	Forarbejdningsgrad	Oprindelsesland
Salmonella	Svin[1)]	Højere forekomst målt i konventionelle svinebesætninger end i både økologiske og ikke-økologiske frilandsbesætninger	Højere forekomst i hakket svinekød end i en steg Højere forekomst i svinekød fra forpart end bagpart Frysning har kun marginal effekt på *Salmonella* i svinekød	Stort set samme forekomst målt i dansk og importeret svinekød
	Kylling[2)]	Ingen data	Frysning reducerer *Salmonella* niveau i kylling med en faktor 5 (reduktion på 0,7 log)	Højere forekomst i importeret kylling
	Æg[3)]	Ingen signifikante forskelle	Pasteurisering reducerer markant forekomst og antal *Salmonella* bakterier i æggeprodukter	Højere forekomst i æglæggere i andre Europæiske lande
Campylobacter	Svin[4)]	Lav campylobacterforekomst i dansk svinekød i detailhandel. Ingen data på produktionssystem og importeret svinekød.		
	Kylling[5)]	Højere forekomst i økologisk kylling	Højere forekomst i køl end frost - seneste data viser dog meget lille forskel. Til gengæld er antallet af *Campylobacter* lavere i det frosne kød	Højere forekomst i importeret kylling
	Æg	Ingen kendt *Campylobacter* risiko forbundet med æg		
Resistente bakterier	Svinekød, kylling og æg[6)]	Lavere forekomst af resistente bakterier i økologisk svineproduktion	.ø	Flere resistente *Salmonella* bakterier i importeret svinekød og kylling Flere resistente *Campylobacter* bakterier i importeret kylling

Noter:

1. **SALMONELLA I SVINEKØD. Produktionssystem**: Zheng et al. (2007) og Wingstrand et al. (2009) viser begge en tendens til at Salmonellaforekomsten er højere i konventionelle besætninger end i alternative besætninger. **Forarbejdning**: Kød fra forparten kontamineres lettere end kød fra bagparten under udtagning af organer. Kød fra forparten er sejere og anvendes oftere til forarbejdede produkter end bagendens kød. Effekt af frysning (Schmidt, 1986). **Import**: Se tabel 02.
2. **SALMONELLA I KYLLING. Produktionssystem:** Ikke tilstrækkeligt med data til at kunne sammenligne på tværs af produktionssystemer. **Forarbejdning**: Notermans et al. (1975). **Import**: Se tabel 02.
3. **SALMONELLA I ÆG. Produktionssystem**: Anonymous (2006) s. 16, Hald et al. (1999); Hald et al. (2002). Tidligere har salmonellaforekomsten været højere i konventionelle æglæggerflokke, det skyldtes problemer i de besætninger, der leverede dyr til de konventionelle besætninger. **Forarbejdning**: s. 15 Anonymous (2006). **Import**: Se tabel 02.
4. **CAMPYLOBACTER I SVINEKØD. Forekomsten i dansk hakket svinekød i detailhandel** var 0,2 % i 2002 **(**Anonymous, 2003, s. 19).
5. **CAMPYLOBACTER I KYLLING**. **Produktionssystem**: Data fra 1998-2000 indikerer, at der er *Campylobacter* i alle økologiske kyllingeflokke og i 37 % af konventionelle kyllingeflokke, Heuer et al. (2001). I 2006 var *Campylobacter* forekomst i konventionelle kyllingeflokke reduceret til 30 % (Anonymous, 2007, s. 24). **Forarbejdning**: 31 % i kølet dansk kylling mod 19 % i frossen dansk kylling. Og 51 % i importeret kølet kylling mod 34 % i importeret frossen kylling,, Anonymous (2009) s. 39. **Import**: Se tabel 02.
6. **ANTIBIOTIKARESISTENS. Produktionssystem:** Struve et al. (2009). **Import**: Pressemeddelelse fra DTU Veterinærinstituttet 26. Januar 2007.

Betydningen for folkesundheden af sammenhængene mellem risiko og kvalitet afhænger i høj grad af, hvor meget forbrugerne køber og efterfølgende indtager af forskellige kødkategorier[6]. Med hensyn til produktionsform, så er markedsandelene for økologisk kyllinge- og svinekød meget små (ca. 1 % i 2004), mens markedsandelen for økologiske æg lå i størrelsesorden 15 % i 2004. For alle produktgrupper er der en tendens til stigende økologiske markedsandele. I forhold til bekæmpelse af salmonellarisici, ser denne trend ud til at være positiv, idet der tenderer til at være en højere salmonellaforekomst i konventionelle svinebesætninger, der har ikke kunnet måles signifikante forskelle mellem salmonellaforekomster i æg fra forskellige produktionssystemer (og prævalensen i æglæggerflokke er i øvrigt generelt meget lav), og der er ikke tilstrækkeligt med data til at kunne dokumentere om der er forskelle i salmonellaforekomster i slagtekyllinger fra henholdsvis alternativ og konventionel produktion (men også her forekomsten i den konventionelle produktion lav). I forhold til bekæmpelse af campylobacterrisici, anses et øget salg af økologiske kyllinger for at være en negativ udvikling, mens der for svinekød og æg ikke er kendte forskelle i campylobacterrisikoen fra forskellige produktionsformer – generelt vurderes campylobacterrisikoen som forsvindende lille i svinekød og æg.

Et blik på markedsandele for kød med særlige sikkerhedsegenskaber tyder på, at zoonoser ikke er noget, der optager forbrugere på købstidspunktet. Der markedsføres i dag sikre varianter i form af salmonellafri og/eller campylobacterfri kyllinger. Hertil skal nævnes, at den særligt sikre variant af æg 'pasteuriserede æg' i 2004 havde en markedsandel på 4 % med en tilsyneladende stigende tendens. Det danske marked domineres godt nok af salmonellafri kyllinger, da den overvejende del af den danske produktion er salmonellafri, men kyllingerne er ikke nødvendigvis anprist som salmonellafrie. Derfor kan man ikke aflæse forbrugernes præferencer ud fra deres købsadfærd. For campylobacterfri kyllinger er markedsandelene så små, at tilgængelighed kan være en reel barriere for efterspørgslen på kort sigt. Dvs. at man heller ikke for *Campylobacter*'s vedkommende direkte kan aflæse forbrugernes præferencer ud fra deres faktiske købsadfærd. Mere generelt gælder der at utilstrækkelig viden og mærkning kan være barrierer for en markedsbaseret udbredelse af sikrere fødevarer.

Da der er zoonotiske risici forbundet med at indtage kød, vil det, alt andet lige, reducere risikoen for en zoonotisk infektion at spise mindre kød. Der har været et aftagende forbrug af svinekød, hvilket isoleret set mindsker risici for infektioner med *Salmo-*

[6] I selve rapporten beskrives sammenhængene i større detaljer ligesom kilderne angives.

nella. Alligevel udgør svinekød stadig ca. 50 % af danskernes kødforbrug. Det mest solgte svinekødsprodukt er hakket svinekød som i perioden 1997-2004 udgjorde ca. 25 % af svinekødssalget.. Endvidere har der været en øget import af kylling, hvilket isoleret set øger risici for infektioner med både *Salmonella* og *Campylobacter*. For at kunne vurdere fødevaresikkerhedsaspekterne af ovennævnte tendenser, skal der ses nøje på eventuelle sammenhænge i danskernes sammensætning af kødforbruget (såsom om nedgangen i danskernes forbrug af svinekød er et udtryk for at de spiser mindre kød eller om de 'bare' skifter svinekød ud med kylling).

0.6. Konklusion og perspektiver

Vurderet ud fra situationen i 2005-2007, udgør kylling det største bakterieproblem og især i forhold til *Campylobacter*. Der er ganske vist en lav salmonellarisiko i dansk produceret kylling – men der er høj salmonellarisiko i importerede kyllinger og en stor procentdel af kyllinger har høj campylobacterrisiko. Til sammenligning er der lille eller stort set ingen kendt campylobacterrisiko forbundet med svinekød og æg.

Forbruget af svinekød er faldet det seneste årti, hvorimod forbrug af æg og især kylling er steget. Alligevel spiser danskerne stadig ca. tre gange så meget svinekød som kylling.

Som nævnt udgør *ukendt smittekilde* godt en fjerdedel af de registrerede salmonellatilfælde i 2007. Mere detaljeret viden om smittekilderne kan naturligvis forrykke de præsenterede fordelinger af risici. For *Campylobacter* er det endnu ikke muligt at etablere et smittekilderegnskab. Fremtidige indsatser for at forbedre smittekilderegnskaberne er derfor et felt, hvor yderligere forskning vil kunne forbedre beslutningsgrundlaget i fødevaresikkerhedspolitikken betydeligt. Her bør også nævnes tydelige gevinster for politikudformningen ved en indsats for at øge præcisionen af registreringsraten (som pt. typisk angives at ligge mellem 5 % og 20 %).

Nærværende beskrivelse af zoonotiske risici har fokuseret på forekomster, dvs. om bakterierne er til stede eller ej. Antallet af *Campylobacter* og *Salmonella* i kødet også uhyre vigtigt for risikoen for at blive syg. En systematisk offentliggørelse af omfanget af bakterier i produkterne (i samme stil som smittekilderegnskabet for Salmonella), ville derfor kunne kaste lys på sammenhængen mellem produktrisici og humane risici.

Der er en stadigt voksende udveksling af fødevarer på tværs af landegrænser. På den ene side har der været en stigende import af svinekød og især kylling, hvilket betyder

at en politik der har til hensigt at forbedre fødevaresikkerheden i Danmark nødvendigvis må forholde sig til at importeret kød ofte indeholder flere og mere resistente bakterier. På den anden side eksporterer Danmark flere kyllinger og svin end der importeres. Det medfører at danske sikkerhedskrav også kommer udenlandske forbrugere til gode. Samlet set betyder den stigende samhandel med udlandet, at fødevaresikkerhed er et problem på tværs af grænser, og at det må inddrages som en præmis i fremtidig fødevarepolitik. Danmarks forventede opnåelse af EU-særstatus på *Salmonella* i æg i 2009 efter dokumenteret lav forekomst og en stærk overvågning af produktionen er et meget aktuelt eksempel på hvordan de internationale institutioner kan bruges til at forbedre fødevaresikkerheden i Danmark[7]. Herudover er der på Europæisk niveau bl.a. restriktioner mod handel med æg fra flokke der er positive for *Salmonella typhimurium* og *Salmonella enteritidis* – disse æg må ikke sælges til konsum[8].

Samlet set signalerer disse tendenser, at det nok må anbefales at tage en flerstrenget strategi i brug til forbedring af fødevaresikkerheden i Danmark: Gør det mere attraktivt at købe varer med reduceret zoonotiske risici (dvs. stimuler efterspørgslen), øg forbrugernes interesse, viden og adfærd om håndtering af kød- og ægprodukter hjemme i køkkenet (dvs. uddan forbrugerne), øg viden om zoonotiske risici (dvs. stimuler forskningen), påvirk produktionen af sikre fødevarer (dvs. stimuler udbud) og samarbejd globalt om zoonosebekæmpelsen (stimuler det internationale politiske miljø).

[7] I skrivende stund har EU imødekommet Danmarks forslag om dansk særstatus for æg, og forslaget skal nu i høring i WTO og Europaparlamentet inden reglerne kan blive endelig vedtaget. Reglerne forventes at træde i kraft til efteråret 2009. Danmark har ligeledes indsendt en ansøgning om EU særstatus for *Salmonella* i kyllinger, men afventer stadig svar (http://www.fvm.dk/Nyhedsvisning.aspx?ID=18483&PID=165853&NewsID=5579).

[8] Jævnfør (EF) Nr. 1237/2007. Forordn. om ændring af Europa-Parlamentets og Rådets forordning (EF) nr. 2160/2003 og af Rådets beslutning 2006/696/EF for så vidt angår markedsføring af æg fra salmonellainficerede flokke af æglæggende høner. Vi takker Gudrun Sandøe, Fødevarestyrelsen for denne henvisning.

Summary

Consumption patterns and consumer risks –
an overview of the Danish markets for pork, chicken, and eggs, and the consumer risk associated with Salmonella and Campylobacter

Resumé

Over recent years Campylobacter bacteria have caused twice as many cases of human infection as Salmonella, but at the same time salmonellosis has caused twice as many premature deaths as campylobacteriosis. Salmonella infections are typically associated with meat and eggs, while Campylobacter infections are mainly linked to poultry meat. Historically, Salmonella prevalence in pork has been higher in imported than domestic pork, but case-by-case control in 2008 showed almost the same prevalence in Danish pork. Danish chicken meat has a lower prevalence of Salmonella and Campylobacter than imported chicken. The situation in 2005–2007 seems to be that chicken pose the largest bacterial problem, especially with respect to Campylobacter, even though Danes' consumption of pork is around three times higher than their consumption of chicken meat. The Salmonella risks associated with Danish chicken are small, but Salmonella risks associated with imported chicken are rather high. In addition, a large proportion of chicken has large numbers of Campylobacter. None, or hardly any, Campylobacter risks are thought to be associated with pork and eggs. The trends towards greater consumption, and more imports, of poultry are hampering efforts to reduce the zoonotic risks associated with food consumption in Denmark.

0.1. Introduction

Every year several thousand Danes are infected by the food-borne bacterial pathogens Salmonella or Campylobacter bacteria. The detrimental impact of this, both on individuals and on society as a whole, is considerable. Salmonella infections are typically associated with meat and eggs, while Campylobacter infections are mainly linked to poultry meat. Since 1989, Denmark has implemented national action plans for the control of Salmonella in poultry, pork, eggs and beef. National surveillance schemes concerning Campylobacter, resistant bacteria, and medical residues in food have also been in place since mid-1990s (www.food.dtu.dk). The first official action plan on Campylobacter was formulated in 2008.[9] These initiatives have reduced, but not eliminated, the risks. As a consequence, the Danish Ministry of Food, Agriculture and

[9] The *Campylobacter* action plan is described in DVFA (2008).

Fisheries financed three research projects in 2005 deploying microbiological, sociological as well as economic evaluation criteria with the overall aim of reducing zoonotic risks in chicken meat and pork.[10]

The purpose of the present report is to describe the relationship between zoonotic risks and trends in the consumption of meat and eggs. To pursue this goal we need, essentially, to answer two questions: 1) What are the risks associated with different types of meat product? 2) In what quantities are the various types of meat product consumed? We use publicly available market data and statistics on consumption patterns to provide an overview of market shares and trends in the markets for various animal products.

We need some inputs to assess the risks associated with consuming chicken meat, pork and eggs. First of all, we need to quantify the size of the problem in terms of the number of human infections caused by *Salmonella* and *Campylobacter*.[11] Using the *Salmonella* source account system, we divide the cases of salmonellosis as far as possible into human infections associated with the consumption of pork, chicken meat and eggs; and into human infections associated with domestic and imported produce. A similar source account system is not yet available for *Campylobacter*. Secondly, it is necessary to obtain information concerning differences in the zoonotic risks presented by pork, chicken meat and eggs. In addition, we try to provide an overview of differences in the risks posed by domestic and imported produce, and between different production systems (e.g. organic vs. conventional) and different processing characteristics (e.g. chilled vs. frozen). Last, but not least, we make use of information on Danes' consumption of different types of meat.

Using these inputs, we try to assess the relative importance of the various kinds of zoonotic hazard, and we ask whether trends in consumption patterns put increasing or decreasing pressure on food safety. Thus the report aims to provide information about consumer preferences for various product qualities as well as highlighting the relative importance of various zoonotic hazards in a public health context.

[10] In 2005, the Danish Ministry of Food, Agriculture and Fisheries financed the research programme "The Food Sector of the Future" (Fremtidens Fødevaresektor). The present report is part of the projects (CAMPY, DECONT and QUALYSAFE). For further information, see http://ferv.fvm.dk/Projekter.aspx?ID=33727

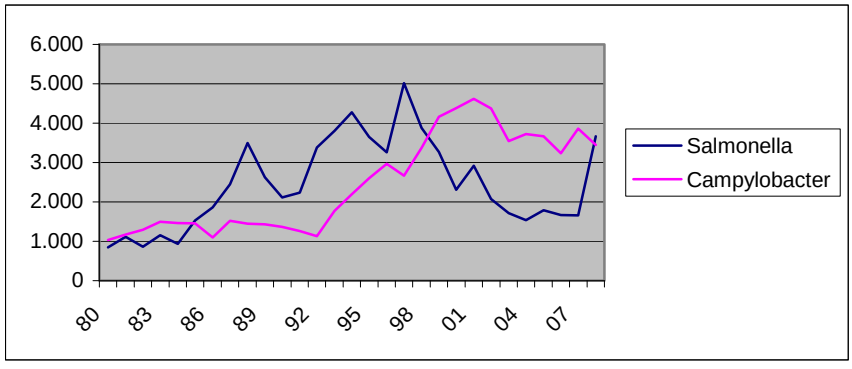
[11] In the present report, the number of human cases of illness is used as an indicator of the social costs generated by *Salmonella* and *Campylobacter*.

Our report focuses on *Salmonella* and *Campylobacter* in pork, chicken meat and eggs. Other types of meat such as beef, turkey, and duck are included in the analysis only when that is found to be necessary in understanding the overall picture. The report is organized as follows: following the introduction (Chapter 1), we provide a general description of production, consumption, and foreign trade in general categories of food and beverage. Detailed analyses are then provided of the markets for pork products (Chapter 3), chicken meat (Chapter 4) and eggs (Chapter 5). Conclusions and perspectives are presented in Chapter 6. Data documentation appears in the appendixes.

0.2. Human cases

In 2007, 1647 cases of salmonellosis and 3868 cases of campylobacteriosis were reported in Denmark. Similar annual figures have been reported over recent years. (It should be noted that the series of large-scale outbreaks of Salmonellosis in 2008 are thought to have been atypical.) It is estimated that around 0.5% of registered campylobacteriosis patients (Korsgaard, 2007) and 2% of registered salmonellosis patients will die prematurely as a result of their infection (Helms & Korsgaard, 2008). Hence, it is estimated that in 2007, 19 and 33 persons died prematurely from campylobacteriosis and salmonellosis, respectively. As only a fraction of infected persons seek medical help, the real number of cases is generally believed to be 5 to 20 times higher than that reported (Korsgaard et al., 2005). It seems reasonable to assume that the same proportions of actual cases of illnesses are registered for *Salmonella* and *Campylobacter*. If this is right, *Campylobacter* bacteria have caused twice as many cases of human infection as *Salmonella* over recent years, but at the same time salmonellosis causes twice as many premature deaths as campylobacteriosis. Figure 1 illustrates the development in registered human cases of salmonellosis and campylobacteriosis.

Figure 0.1. Numbers of reported cases of salmonellosis and campylobacteriosis 1980-2008



Note: The increase in salmonellosis infections in 2008 was due to several lengthy outbreaks with an unknown source.

Source: http://www.dfvf.dk/Files/Filer/Zoonosecentret/Overv%c3%a5gningen/Web_diverse_humane.xls

There has been a significant reduction in the number of cases of salmonellosis, from more than 5000 in 1997 to around 1600 in recent years. The salmonellosis cases attributed to chicken peaked in 1988; those attributed to pork peaked in 1994, and those attributed to eggs peaked in 1997. Campylobacteriosis peaked in 2001, reaching 4620 human cases (Anonymous, 2009, p. 6).

0.2.1. Salmonella

The Danish Zoonosis Centre, Technical University of Denmark, has developed a mathematical model to estimate the contribution of major animal food sources to human *Salmonella* infections (Hald et al., 2004). Findings based on the model are published in annual reports on zoonoses (Anonymous, 2009). Table 05 presents the number of reported human cases of salmonellosis in Denmark in the period 2005–2007. The figures are categorized according to source, i.e. according to type of product and whether it was domestically produced or imported (Anonymous, 2009).

Table 0.5. Number of reported human cases of salmonellosis attributed to pork, beef, chicken, duck, turkey, and table eggs for Danish and imported products (in %)

	2005	2006	2007
Total number of reported human cases	**1,775**	**1,658**	**1,647**
Domestically produced pork	12.1	6.1	6.5
Domestically produced beef	1.5	1.4	0.8
Domestically produced chicken	4.1	0.5	0.8
Domestically produced ducks	0.7	0.7	-
Table eggs	12.1	6.2	11.0
Imported pork	2.5	1.6	1.3
Imported beef	3.7	1.3	1.2
Imported chicken	10.9	9.2	3.7
Imported turkey	1.0	5.2	0.7
Imported duck	0.4	0.7	-
Travels[1)]	24.0	24.7	46.3[1)]
Unknown source, including outbreaks of unknown source[1)]	27	42.3	27.8
Main categories (product) – total	**49**	**33**	**26**
Pork total	14.6	7.7	7.8
Beef total	5.2	2.7	2.0
Chicken total	15.0	9.7	4.5
Other poultry total	2.1	6.6	0.7
Table eggs	12.1	6.2	11.0
Main categories (origin) – total	**49**	**33**	**26**
Danish meat	18.4	8.7	8.1
Table eggs	18.5	18.0	6.9
Imported meat[1)]	12.1	6.2	11.0

1) Registration of travel history was significantly improved in 2007, leading to an increase in travel-related cases and fewer cases being either attributed to imported meat or of unknown source.

Source: Anonymous (2009) p. 14. Aggregations into main categories are own calculations.

Excluding the large outbreaks in 2008, the numbers of human cases have been rather stable over the last couple of years, but the contributions of different sources have changed. In 2007, an improved method for estimating the number of *travel*-related cases of salmonellosis resulted in a significant increase in that number (from around 24% of the registered cases in 2005 and 2006 to 46% in 2007). This increase occurred at the expense of the categories *imported meat* (which fell from around 18% of the registered cases in 2005 and 2006 to less than 7% in 2007) and *unknown* (with 27% of registered cases being categorized as such in 2005, 42.3% in 2006 and 27.8% in 2007).

Within the category of Danish meat and eggs, pork is responsible for more cases of salmonellosis than chicken is. During the period 2005–2007, there was a significant reduction in the cases of salmonellosis from pork and chicken, while no clear trend was observed for salmonellosis from eggs. Within the category of imports, imported chicken accounts for more cases of salmonellosis than imported pork despite a significant reduction in the number of cases of salmonellosis from imported chicken meat between 2006 and 2007.

A comparison of meats, without distinguishing between domestic and imported meats, shows that the numbers of cases of salmonellosis from pork and chicken meat were quite similar in 2005–2007. The largest difference is estimated in 2007, where 7.8% of the cases of salmonellosis are attributed to pork as against the 4.5% attributed to chicken meat. Moreover, when domestic and imported meats are compared without distinguishing between different types of meat, the number of cases of salmonellosis from Danish meat is quite similar to that from imported meat.

Eggs contributed 11% of the cases of salmonellosis in 2007, which is a considerable share. That might at a first sight seem surprising, because the risk carried by any individual egg is thought to be small. Studies show that the prevalence of *Salmonella* is typically higher in layer flocks in other countries (see Table 06, note 3). The importation of eggs is not believed to introduce high levels of risk, because imported eggs are mainly used by the industry and are therefore subjected to heat treatments. However, imported table eggs have been found in Danish shops, and it is likely that increased imports could constitute a risk factor. In the *Salmonella* source account, human cases of salmonellosis from imported eggs would be registered as cases associated with Danish table eggs or an unknown source, as there is presently no account of *Salmonella* prevalence in imported table eggs. Consumer handling and higher *Salmonella* prevalence in imports might be important risk factors in relation to salmonellosis from eggs.

Approximating somewhat, we conclude that similar numbers of human infections of salmonellosis can be attributed to egg, Danish meat and imported meat in 2007.

It is worth noticing that our calculation of the relative importance of different places of origin and different types of meat and egg is based on 72.2% of the registered cases. Hence, identifying the source of the remaining 27.8% of the registered cases and/or increasing the rate of registration could change this picture. In addition, it

should be noticed that the relative contributions to salmonellosis from pork, chicken meat and eggs change considerably from year to year.

0.2.2. Campylobacter

During the period 1999–2007, *Campylobacter* was the leading source of bacterial human diarrhoea. The numbers of registered cases of campylobacteriosis in recent years have been 3671, 3242 and 3868 in 2005, 2006 and 2007, respectively. For *Campylobacter,* a similar source account system with detailed information about sources of infections is not available yet. However, it is estimated that approximately one in three cases of campylobacteriosis is travel-related SSI (2009) and that the majority of cases are related to poultry (Anonymous, 2006, p. 23). More precisely, chilled chicken meat has been identified as the main food source of campylobacteriosis in Denmark (Wingstrand et al., 2006).

0.3. Zoonotic risks in pork, chicken meat and eggs

Surveillance data from the Danish Veterinary and Food Administration on the prevalence of *Salmonella* and *Campylobacter* in different types of meat and in eggs are published each year by the Zoonosis Centre at The Danish Technical University (Anonymous, 2009). Since 2007, the Danish Veterinary and Food Administration has tested samples of Danish and imported food, thus imposing what is often referred to as case-by-case control. An important element in the control is to try to induce Danish firms to require firms from which they receive food to meet a certain safety standard (DVFA, 2009, p. 3). Pork and beef are tested for *Salmonella*, and poultry is tested for *Salmonella* as well as *Campylobacter* (DVFA, 2009, p. 3). Based on this information, the prevalence of *Campylobacter* and *Salmonella* in pork, chicken meat and eggs (domestic or imported) is summarized in Table 06.

Table 0.6. Overview of *Salmonella* and *Campylobacter* prevalence in pork, chicken meat and eggs, categorized according to domestic vs. imported produce (the year is 2007 if no other year is specified). Due to differences in sampling methods, the prevalence in different product categories cannot be directly compared

Salmonella		Prevalence: Danish (%)	Prevalence: imports (%)
	Pork (carcass , slaughter)[1)]	1,1 %	
	Pork (batch, case-by-case) [1)]	11,3 %	13,1 %
	Chicken (flock, slaughter)[2]	1,2 %	
	Chicken (batch, case-by case)[2)]	1,6 %	14,5 %
	Table eggs (layer flocks, Danish surveillance)[3)]	1 %	
	Table eggs (layer flocks, EU baseline study)[3)]	2,4 %	EU gns.30,7 pct. (0-80 pct.)
Campylobacter	Pork (samples of minced meat)[4)]	0,2 %	?
	Chicken (meat samples, slaughter) [5)]	8,2 %	
	Chicken (batches, case-by-case) [5)]	15,1 %	27,7 %
	Table eggs[6)]	-	-

Kilder:

1. **SALMONELLA IN PORK. Danish:** Prevalence on carcasses (at slaughter) was 1.1% (Anonymous, 2009, p. 10 and p. 41). According to the case-by-case control, *Salmonella* prevalence in batches of Danish pork at retail was 11.3% (DVFA, 2008, p. 5). **Imported**: The introduction of case-by-case control suggested that the prevalence in imported pork is at the same level as Danish pork. In case-by-case control in 2007, 13.1% of the imported batches of pork were infected (DVFA, 2008, p. 5). In case-by-case control in 2008, *Salmonella* prevalence in Danish batches exceeded that in imports for the first time: the prevalence figures were 11.9% of the Danish batches as against 10.4% of the imported batches (DVFA, 2009, p. 6).
2. **SALMONELLA IN CHICKEN. Danish:** In the case-by-case control, *Salmonella* in Danish chicken was found in 1.6% of the batches in 2007 (DVFA 2008, p. 3), and in 0.3% of the batches in 2008 (DVFA, 2009, p. 5). In 2007, the *Salmonella* prevalence in Danish broiler flocks was 1.6% (not shown in the table, but calculations based on *Salmonella* in 55 out of 3486 flocks, Anonymous, 2009 p. 38). At slaughter, the prevalence in broiler meat in 2007 was 1.2% (calculations based on 10 out of 828 flocks being infected, Anonymous (2009) p. 38). **Imported**: According to case-by-case control, *Salmonella* prevalence in imported chicken meat was 14.5% in 2007 (Anonymous, 2009, p. 44 and DVFA, 2008, p. 4) and 15% in 2008 (DVFA, 2009, p. 5).
3. **SALMONELLA IN EGGS. Danish:** A very low prevalence is found in eggs. A survey from 2001-2002 found that 0.05% of Danish eggs had *Salmonella* on the shell and 0.02% had *Salmonella* inside the eggs, (Danish Eggs, 2005. p. 10). The prevalence was below 1% in egg-laying flocks (calculations based on 5 out of 510 flocks being infected (Anonymous, 2009, p. 37). According to an EU baseline study in 2004-2005, the prevalence in Danish layer flocks was 2.4% (DVFA, 2006, p. 119). **Imported**: Danish Eggs (2005) p. 10: in imported eggs (from Holland, Germany and Sweden), *Salmonella* was found in 0.55% of the egg shells and inside 0.25% of the eggs. DVFA (2006) p. 119: Considerable variation across countries invalidates the use of common average (the average *Salmonella* prevalence of 30.7% in European egg-laying flocks covers prevalence from 0 (Sweden), through 2.4% (Denmark), to nearly 80% (Portugal).
4. **CAMPYLOBACTER IN PORK. Danish:** The prevalence of *Campylobacter* in Danish pork is very low (0.2% in minced pork according to surveillance in 2002 (Anonymous, 2003). At the same time, the prevalence in pig herds is rather high: in 2007, the prevalences of *C. coli* and *C. jejuni* were 76.6% and 1.9%, respectively (Anonymous 2009, p. 44).
5. **CAMPYLOBACTER IN CHICKEN**. **Danish**: Case-by-case control found *Campylobacter* in 15.1% of batches of Danish poultry in 2007 (DVFA, 2008, p. 3) and in 13% of batches in 2008 (DVFA, 2009, p. 5). According to Anonymous (2009) p. 37, the prevalence in chilled chicken meat at slaughter was 8.2% in 2007. **Imported**: According to case-by-case control, the prevalence in imported chicken was 27.7% in 2007 (DVFA, 2008, p. 4) and 20.2% in 2008 (DVFA, 2009).
6. **CAMPYLOBACTER IN EGGS**. Is not part of the surveillance as the table egg is not considered a risk-product. No known *Campylobacter* risk associated with consumption of eggs.

Table 06 reveals significant differences between Danish and imported pork and chicken meat. Historically, Danish pork has had a lower prevalence of Salmonella than imported pork, but in 2008, the risk in imported pork was the same level as that in Danish pork: in 2008, the case-by-case control reported *Salmonella* in 11.9% of Danish batches as compared with 10.4% of the imported batches (DVFA, 2009, p. 6). The prevalences of *Salmonella* and *Campylobacter* were found to be lower in Danish chicken meat than they were in imported chicken meat (DFVA, 2008).

Information on import share is important in the assessment of risk levels. An estimated 40% of chicken meat is imported (see Chapter 4 of the report). There is considerable uncertainty about the estimated import share, as the shares of fat, bones and head are not specified. A realistic 'guesstimate' of the import share of pork is 20–25% (see Chapter 3 of the report). The importation of table eggs constitutes 25–30% of total consumption of table eggs, but it is hardly expected to be a significant cause of human salmonellosis, since the imports are mainly for industrial purposes. Hence, most meat consumed in Denmark is of Danish origin.

The relationship between product-risk and human illness also depends on how much, and how often, the various products are eaten. We pursue the latter in the following section.

0.4. Consumption of meat and egg

In the present section, private consumption of meat and eggs is described using two rather different methods. A study by Lyhne et al. (2005) is based on a survey of self-reported consumption from 2000–2002. They estimate total meat consumption of 51 kg/year for an adult person incorporating 41 kg of pork and beef and 10 kg of poultry. The other method is to use Statistics Denmark to estimate the meat and eggs available for consumption in 2006 (see Andersen, 2007). They estimate total meat consumption of 97 kg/year (incorporating 46% pork, 28% beef, 25% poultry and 2% other).[12] Andersen (2007) has tried to compare the two methods. The consumed quantities differ by a factor of almost 2. One reason for this is, of course, that the data were collected in different years. However, it might be more important that the estimates from Statistics Denmark do not properly account for imports, exports, re-exports, and the extent to which offal is included; since Denmark is a net-exporter of chicken meat as well as pork, the number is likely to be too high (Andersen, 2007). On the other hand, meat

[12] The category 'other' includes lamb, game, and horse meat (Andersen, 2007).

consumption in Lyhne et al. (2005) is likely to have been underestimated as a result of strategic answering, as official advice on healthy diets includes 'less meat' as one of the main recommendations.[13] The information is presented in Table 07.

Table 0.7. Consumption of meat and eggs in Denmark

	Statistics Denmark data, Andersen (2007)		Lyhne et al. (2005) based on consumer survey of food intake	
	Consumption kg/inhabitant	Relative consumption (%)	Consumption kg/inhabitant	Relative consumption (%)
Year of consumption	2006		2000-2002	
Pork and beef[1)]	73	75	41	80
- of which pork	45	46	26	50
- of which beef	28	29	15	30
Poultry	22	29	10	20
- of which chicken[2)]	18	18	8	16
Others	2	2		
Meat total	97	**100**	**51**	100
Pork relative to chicken	**3,3**		**2,5**	
Egg[3)]	**17**		6	

Notes:
1) In the survey, an aggregate measure of pork and beef consumption is reported (80% of total meat consumption). The division of that aggregate measure into pork (63%) and beef (27%) is based on Danish Meat Association (2008), Andersen (2007) and Danish Agriculture (2006): these sources estimate the share of pork relative to pork and beef to be between 62% and 64%; we use 63%.
2) According to data from Danish Poultry Council[14] (2007, p. 122), the consumption of chicken meat in Denmark in 2006 was 18.8 kg, and the consumption of poultry was 23.5 kg (p. 118); hence chicken meat accounts for 80% of poultry consumption.
3) Danes' consumption of 17 kg according to Statistics Denmark is presented in Danish Agriculture (2007)
4) In Lyhne et al. (2005) consumption is measured in gram/days, which ratios are re-calculated to kg/year. Both sources include dining at home as well as at restaurants, at work, etc.

We are mainly interested in the relative importance of pork and chicken, and this does not differ greatly between the two methods. Table 07 reveals that, on average, Danes eat between 2.5 (Statistics Denmark) and 3.3 (Lyhne et al. 2005) times more pork than chicken.

We presume that the consumption of meat is 'remembered' more accurately than it is estimated in Statistics Denmark. Hence, we use the quantities and distributions found

[13] The eight official pieces of advice for a healthy diet are described in Astrup et al. (2005).
[14] '*Det danske fjerkræråd*'.

in Lyhne et al. (2005) to draw the conclusions set out in the paragraph below about Danes' consumption of meat and eggs.

The 2000–2002 data appear to indicate that the average adult Dane eats at least 51 kg of meat per year. An average adult Dane eats 26 kg of pork, 8 kg of chicken meat and 6 kg of eggs. Hence, around three times more pork than chicken is consumed. Meat consumption can roughly be divided into 50% pork, 30% beef, and 20% poultry (16% chicken and 4% other types of poultry). In addition, each adult Dane consumes around 6 kg of eggs each year (corresponding to around 120 eggs). Of course, these numbers are at best estimates, and there might be considerable variations across demographic groups; but they do indicate that much more pork than chicken meat is eaten.

0.5. Quality characteristics – risks and market shares

We have seen that *Salmonella* and *Campylobacter* risks depend on the type of meat and country of origin. In addition, risks will often be affected by type of production and processing characteristics. Table 08 summarizes the documented knowledge concerning relations between zoonotic risks, production system, processing characteristics and country of origin.

Table 0.8. Overview of zoonotic risks in pork, chicken meat and eggs, differentiated between production system, processing, and country of origin (the year is 2007 if no other year is specified). Due to differences in sampling methods, the prevalence in different product categories cannot be directly compared

		Production system	Processing	Imports
Salmonella	Pork[1)]	Higher prev. in pigs in conventional production	Higher prev. in minced pork than in roast Higher prev. in pork from the front than rear of carcass Freezing has only a marginal effect on *Salmonella* in pork	Case-by-case (batch): 13.1% Historically higher prev. in imported pork – but not so in 2008
	Chicken[2)]	No data	Freezing reduces *Salmonella* risk in chicken	Case-by-case (batch): 14.5% Higher prev. in imported chicken
	Egg[3)]	No significant differences[7)]	Pasteurization of eggs significantly reduces prev. and number of *Salmonella* counts[8)]	Higher prev. in other countries, EU-average: 30.7% (0-80%)[9].
Campylobacter	Pork[4)]	Generally low prev. in pork (0.2% in samples of minced pork). No data on differences in production systems or domestic vs. imported.		
	Chicken[5)]	Conv.: 37% Org.: 100% Higher prevalence in organic chicken	Danish chilled: 31% Danish frozen: 19% Higher prev. in chilled than frozen, but difference has decreased Numbers of *Campylobacter* are higher in hilled meat than frozen meat	Case-by-case (batch): 27.7% Higher prev. in imported Imp. chilled: 51% Imp.: frozen: 34%
	Egg	No known *Campylobacter* risk associated with consumption of eggs		
Resistant bacteria	Pork, chicken meat and egg[6)]	Lower level of resistant bacteria in organic productions pig production		More resistant bacteria in *Salmonella* in imported pork and chicken More resistant bacteria in *Campylobacter* in imported chicken

Notes:

1. **SALMONELLA IN PORK. Production system**: Zheng et al. (2007) and Wingstrand et al. (2009) both tend towards higher prevalence in conventional production. **Processing**: Meat from the front end of the pig is more easily contaminated during slaughter; it is also chewier and therefore often used in processed products. For the effect of freezing, see Schmidt (1986). **Imports**: See Table 2.
2. **SALMONELLA IN CHICKEN. Production system:** Insufficient data for comparison. **Processing**: Notermans (1975). **Imports**: See Table 2.
3. **SALMONELLA IN EGGS. Production system**: Anonymous (2006) p. 16, Hald et al. (1999); Hald et al. (2002). **Processing**: Anonymous (2006) p. 15. **Imports**: See Table 2.
4. **CAMPYLOBACTER IN PORK. Danish:** The prevalence of *Campylobacter* in Danish pork is very low: 0.2% in minced pork according to the 2002 surveillance (Anonymous, 2003). At the same time, the prevalence in pig herds is rather high: in 2007, the prevalences of *C. coli* and *C. jejuni* were 76.6% and 1.9%, respectively (Anonymous 2009, p. 44).
5. **CAMPYLOBACTER IN CHICKEN**. **Production system**: Data from 1998–2000 indicate that all organic chicken flocks were infected with *Campylobacter* as against 37% of conventional chicken flocks (Heuer et al., 2001). In 2006, the prevalence of *Campylobacter* in conventional chicken flocks had reduced to 30% (Anonymous, 2006, p. 24). **Processing**: Prevalence of 31% in chilled Danish chicken and of 19% in frozen Danish chicken in 2007 (Anonymous, 2009, p. 39). The prevalence in imported chilled chicken was 51% and 34% in frozen imported chicken in 2007, Anonym (2009) p. 39. **Imports**: See Table 2.
6. **ANTIMICROBIAL RESISTANCE. Production system**: Struve et al. (2009**). Imports**: Press release from National Veterinary Institute, 26 January, 2007.

The importance of relations between risk and quality characteristics for public health depends on how much consumers eat of the different types of meat and egg.[15] The market shares for organic chicken meat and pork are very small, at around 1% in 2004, whereas the market share for organic eggs was around 15% in 2004. For all categories, the trend is towards higher market shares for organic varieties. Where the reduction of *Salmonella* risks is concerned, this trend seems to be a good thing: first, because *Salmonella* prevalence tends to be lower in non-conventional pig herds than it is in conventional pig herds; second, because no significant differences between Salmonella prevalence in layer flocks from different production systems have been found (and the prevalence is generally very low in layer flocks); and third, because no differences between chicken meat from different production systems have been documented due to lack of data (but the prevalence is generally very low in conventional flocks). When the aim is to reduce *Campylobacter* risks, on the other hand: increased sales of organic chicken meat is a negative thing; increased sales of pork and eggs do not pose any known risks, as there are no known differences in *Campylobacter* risks with respect to different production systems; and, generally, the *Campylobacter* risks are considered to be negligible in pork and eggs.

The small market shares of safer food varieties indicate that consumers are unwilling to pay for safety. Safer variants, such as chicken meat that is free from *Salmonella* and/or *Campylobacter*, are marketed today. It should be noticed that pasteurized eggs had a market share of around 4% in 2004, and that this share is growing. Actually, the Danish chicken meat market is dominated by *Salmonella*-free chicken meat, as Danish production of chicken meat is largely free from *Salmonella*. However, as the chicken meat is not always labelled as *Salmonella*-free, it is not possible to elicit information on consumer preferences from actual purchase data. The market shares of *Campylobacter*-free are so small that availability can be a real obstacle to demand in the short run. Similarly, therefore, consumer preferences for *Campylobacter*-free chicken meat cannot be inferred from actual purchase data. More generally, insufficient knowledge and insufficient labelling can also hinder demand-driven safety improvements in food.

As long as there are zoonotic risks associated with meat, it will be possible to reduce risk by reducing meat consumption – all else being equal. The consumption of pork

[15] The relations between risk and quality are described in greater detail in the report, where full references are supplied.

has decreased, which – all else being equal – is a risk-reducing factor. Still, pork accounts for around 50% of meat consumption in Denmark. The most popular type is minced pork, with a market share of 25% of pork during the period 1997–2004. Rising imports of chicken have also been observed, and – all else being equal – these can increase the risk of salmonellosis as well as campylobacteriosis. Speculation that there had been a shift from frozen to chilled chicken meat could not be verified in data for the period 1997–2004. Of course, the safety impacts of all these risks and trends in consumption are highly dependent on what happens when we relax the assumption that everything else is equal. For example, the safety implications of declining consumption of pork depends on whether the decline is part of a general reduction in meat consumption or a shift towards imported chicken meat.

0.6. Conclusion and perspectives

The situation in 2005–2007 leads us to conclude that chicken poses the most serious bacterial problem, especially with respect to *Campylobacter*. *Salmonella* risks in Danish chicken are small, but in imported chicken they are rather high. In addition, a large share of chicken has large numbers of *Campylobacter*. It is considered that the health risks presented by *Campylobacter* in pork and eggs are at most very small and perhaps zero.

The high level of consumption of pork has a slightly decreasing trend, whereas the consumption of eggs and (in particular) chicken meat has increased over the last 10–15 years. Still, the consumption of pork is around three times greater than that of chicken meat.

The Danish *Salmonella* source account system makes it possible to estimate the source, in terms of type of animal product and place of origin, in one in two registered domestically acquired cases of Salmonella. Further improvement of the system, and the implementation of similar source account systems for *Campylobacter*, would certainly improve the precision and validity of data that are used in political decisions. So would improved precision of the registration rate. It is also worth mentioning that the present report has focused merely on the *presence* of pathogenic bacteria: that is, the aim is to determine whether the tested item (e.g. a carcass) has, or does not have, bacteria in it, and then, given a large enough batch of results, to calculate a percentage figure from this. However, the *number* of Campylobacter and Salmonella bacteria in a food product is also an extremely important determinant of the risk of human illness. Systematic communication of not only prevalence but also the number of bacteria in

different products would therefore shed valuable light on the links between risks in the product and human risks.

Trade and the exchange of food between countries are increasing. On one hand, imports of pork and, even more so, chicken meat have risen; and this means that food safety policy in Denmark has to give more serious consideration to the fact that imported meat typically has higher levels of and more resistant bacteria. On the other hand, Denmark exports more pork and chicken than she imports, which implies that consumers in other countries also benefit from a stringent Danish food policy. Hence, the increased exchange of food between countries must be taken into account in future food safety policies. The Danish expectation that the EU will grant special status to eggs (with a zero tolerance) is a very recent example of how to use international institutions to improve food safety. In addition, at EU level there are currently restrictions on trade with eggs from layer flocks found to be positive for *Salmonella typhimurium* or *Salmonella enteritidis*; such eggs cannot be sold as eggs for private consumption.[16]

No single policy initiative can possibly deal with all of the above hazards and trends. In recognition of this, we shall conclude by suggesting several policy initiatives that might reduce zoonotic risks. First, it could be made easier to buy goods with reduced zoonotic risks (influence demand). Second, the consumer's understanding of zoonotic risks and how to avoid them could be increased (educate consumers). Third, information about the sources of human infections could be developed and improved (stimulate research). Fourth, the supply of safer food could be expanded (manage supply). Fifth, pressure could be put on other countries to mitigate risks (give attention to the international political environment).

[16] See (EF) Nr. 1237/2007. Forordn. om ændring af Europa-Parlamentets og Rådets forordning (EF) nr. 2160/2003 og af Rådets beslutning 2006/696/EF for så vidt angår markedsføring af æg fra salmonellainficerede flokke af æglæggende høner. We want to thank Gudrun Sandøe, of the Danish Veterinary and Food Administration, for this reference.

1. Introduction

1.1. Background and purpose

Every year, several thousand Danes are infected by the foodborne bacterial pathogens *Salmonella* or *Campylobacter*. This leads to considerable losses for the individual as well as society. Over the last decades, *Salmonella* and *Campylobacter* have been the two most frequent human zoonoses[17] although other enteric pathogens (such as *Listeria, Yersinia and E. coli*) also cause human infections.

Salmonella infections are typically associated with meat and eggs, while *Campylobacter* infections are mainly linked to poultry meat. Since 1989, Denmark has implemented national action plans for the control of *Salmonella* in poultry, pork, eggs and beef. National surveillance schemes concerning *Campylobacter,* resistant bacteria, and medical residues in food have also been in place since mid 1990's (www.food.dtu.dk). However, the first official action plan on *Campylobacter* was not formulated until 2008[18]. These initiatives have reduced, but not eliminated the risks. As a consequence, the Danish Ministry of Food, Agriculture and Fisheries financed three research projects in 2005 with the overall aim to reduce zoonotic risks in chicken meat and pork using microbiological, sociological as well as economic evaluation criteria[19].

Consumers can affect their own foodborne risks through their choice of food, depending on their awareness of the risks associated with different food products and the labelling of the food. However, very few products are brought to the market exclusively for their safety attributes - and market shares of 'safer' products are small. Examples of 'safer' products include pasteurized eggs and *Salmonella* and/or *Campylobacter* free chickens. It is interesting to note that the supermarket chain COOP has chosen to sell only Danish chicken meat that is guaranteed Salmonella-free, but often the chicken meat is not labelled Salmonella-free. Small market shares, incomplete product information, and the fact that food risks affect others than the consumers and pro-

[17] Zoonoses are pathogens that can spread from animals to humans

[18] The Campylobacter action plan is described in DVFA (2008).

[19] In 2005, the Danish Ministry of Food, Agriculture and Fisheries financed the research program "The Food Sector of the Future" (Fremtidens Fødevaresektor). The present report is part of 3 of the initiated projects (CAMPY, DECONT and QUALYSAFE). For further information, see http://ferv.fvm.dk/Projekter.aspx?ID=33727

ducers that are directly involved (a so-called externality effect)[20] imply that market data provide little information about consumer and social values of safer food. Hence, market shares are not very precise indicators of consumer (and social) preferences for safety characteristics[21]. Nevertheless, market shares for animal products reflect consumers' actual behaviour. Hence, the market shares of different product groups provide information about the human health risks that are associated with consumers' actual market behaviour. Therefore, we have chosen to focus on market shares in the present study. Analyses of consumers' underlying preferences are included elsewhere in the projects.

A number of studies suggest a relationship between food safety (microbiological, chemical-related, etc.) and other product characteristics such as production system, processing characteristics and country of origin. Even though distinctions between production systems are typically based on animal welfare aspects, differences in safety aspects might occur as side effects. As a consequence, market shares of meat produced within specific production systems, with specific processing characteristics or originating from different countries also provide information about human health risks associated with consumers' market behaviour.

The purpose of the report is to describe the zoonotic risks related to trends in consumption of meat and eggs. To pursue this goal, we basically need to answer two questions: 1) What are the risks associated with different types of meat products? 2) How large is the consumption of the different types of meat products?

We use publicly available statistics of market data and consumption patterns to provide an overview over market shares and trends in the markets for various animal products. By linking information about market sizes and trends in these markets with

[20] Together, these factors might also be denoted as market failures.

[21] Other, and more direct, methods for eliciting consumer preferences for food safety include hypothetical valuations and hedonic pricing. In hypothetical valuation studies, consumers are involved in experiments in which they reveal their preferences for food safety (Bateman et al., 2002). A survey over studies concerning willingness to pay for food safety attributes in meat is found in Mørkbak et al. (2008b). Another approach is to use econometric analyses of market data to extract information about individual characteristics (hedonic valuation). This method is not often used in a food safety context due to small market shares and lack of data. These methods allow a more detailed and thorough investigation of consumer perceptions and behaviour in relation to food safety – but at the same time they are much more time and resource consuming. The method we apply provides a rough overview of trends and links between consumers' market behaviour and zoonotic risks.

scientific knowledge about different hazards, we try to assess the relative importance of different zoonotic hazards and whether trends in consumption patterns pose increasing/decreasing pressure on food safety. Thereby, the report aims at providing information about consumer behaviour as well as highlighting the relative importance of different zoonotic hazards.

Our report focuses on *Salmonella* and *Campylobacter* in pork, chicken meat and eggs. Other types of meat such as beef, turkey, and duck are only included in the analysis when it is found necessary for understanding the overall picture.

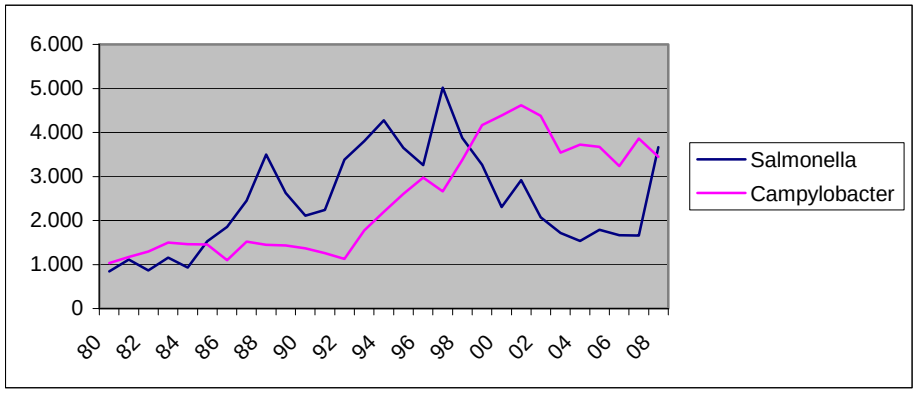
1.2. Zoonoses in Denmark

The symptoms of salmonellosis as well as campylobacteriosis include watery and frequently bloody diarrhoea, fever, abdominal pain and cramps, nausea and vomiting. Sequelae including neurological and joint affection may occur, although less frequent. The Danish Zoonosis Centre at the Danish National Food Institute, DTU, provides annual reports on zoonoses in Denmark (Anonymous, 2009).

In 2007, 3868 cases of campylobacteriosis and 1647 cases of salmonellosis were reported. As only a fraction of infected persons seek medical help, the true number of illnesses is generally believed to be 5 to 20 times higher (Korsgaard et al., 2005). This implies that the actual number of campylobacteriosis might be up to 77000 and that there might be up to 33000 cases of salmonellosis. In addition, it is estimated that around 0.5 % of the registered campylobacteriosis patients (Helle Korsgaard, National Food Institute, The Technical University of Denmark, personal communication, 2007) and 2 % of the registered salmonellosis patients will die prematurely as a consequence of their infection (Helms & Korsgaard, 2008). Hence, it is estimated that in 2007, 19 persons died prematurely due to campylobacteriosis and 33 persons died prematurely due to salmonellosis.

It seems to be a reasonable assumption that the same shares of actual cases of illnesses are registered for *Salmonella* and *Campylobacter,* respectively. In that case, *Campylobacter* bacteria have caused twice as many cases of human infections as *Salmonella* over the recent years, but at the same time salmonellosis causes twice as many premature deaths as campylobacteriosis. Figure 1.1 illustrates the development in registered human cases of salmonellosis and campylobacteriosis.

Figure 1.1. The development in the number of registered cases of salmonellosis and campylobacteriosis in 1980-2008



Note: The increase in salmonellosis infections in 2008 is due to several long lasting outbreaks of unknown source.

Source: http://www.dfvf.dk/Files/Filer/Zoonosecentret/Overv%c3%a5gningen/Web_diverse_humane.xls

Figure 1.1 shows that there has been a significant reduction in the cases of salmonellosis from more than 5000 cases in 1997 to around 1600 cases in recent years. The salmonellosis cases attributed to chicken peaked in 1988, those attributed to pork peaked in 1994, and those related to eggs peaked in 1997. The burden from campylobacteriosis peaked in 2001 reaching 4620 human cases (Anonymous, 2009, p. 6). During the period 1999 – 2007, *Campylobacter* has been the leading source of bacterial human diarrhoea.

The Danish Zoonosis Centre has developed a mathematical model to estimate the contribution from the major animal food sources to human *Salmonella* infections (Hald et al., 2004) which makes it possible to estimate a *Salmonella* source account. Table 1.1 presents the number of reported human cases of salmonellosis in Denmark in 2005-2007, categorised according to source in terms of product and whether it is produced in Denmark or imported (Anonymous, 2009, p. 14).

Table 1.1. Number of reported human cases of salmonellosis attributed to pork, beef, chicken, duck, turkey, and table eggs for Danish and imported products (in %)

	2005	2006	2007
Total number of reported human cases	**1,775**	**1,658**	**1,647**
Domestically produced pork	12. 1	6. 1	6. 5
Domestically produced beef	1. 5	1. 4	0. 8
Domestically produced chicken	4. 1	0. 5	0. 8
Domestically produced ducks	0. 7	0. 7	-
Table eggs	12. 1	6. 2	11. 0
Imported pork	2. 5	1. 6	1. 3
Imported beef	3. 7	1. 3	1. 2
Imported chicken	10. 9	9. 2	3. 7
Imported turkey	1. 0	5. 2	0. 7
Imported duck	0. 4	0. 7	-
Travels[1)]	24. 0	24. 7	46. 3
Unknown source, including outbreaks of unknown source[1)]	27	42. 3	27. 8
Main categories (product) – total	**49**	**33**	**26**
Pork total	14. 6	7. 7	7. 8
Beef total	5. 2	2. 7	2. 0
Chicken total	15. 0	9. 7	4. 5
Other poultry total	2. 1	6. 6	0. 7
Table eggs	12. 1	6. 2	11. 0
Main categories (origin) – total	**49**	**33**	**26**
Danish meat	18. 4	8. 7	8. 1
Table eggs	12. 1	6. 2	11. 0
Imported meat[1)]	18. 5	18. 0	6. 9

1) Registration of travel history was significantly improved in 2007, leading to an increase in travel related cases and fewer cases attributed to imported meat and of unknown source.

Source: Anonymous (2009). Aggregations into main categories are own calculations.

Excluding the large outbreaks in 2008, the numbers of human cases have been rather stable over the last couple of years but the contributions from different sources have changed. In 2007, an improved method for estimating the number of *travel*-related cases of salmonellosis resulted in a significant increase in that number (from around 24 % of the registered cases in 2005 and 2006 to 46 % in 2007). Comparisons between years must therefore be interpreted with caution. Data from 2007 are to be considered as the more valid data. This increase occurred at the expense of the categories *imported meat* (which fell from around 18 % of the registered cases in 2005 and 2006 to less than 7 % in 2007) and *unknown* (27 % of the registered cases were categorised as unknown in 2005, 42.3 % in 2006 and 27.8 % in 2007).

Within the category of Danish meat and egg, pork is responsible for more cases of salmonellosis than chicken. During the period 2005-2007, there was a significant reduction in the cases of salmonellosis from pork and chicken, while no clear trend was observed for salmonellosis from eggs.

Within the category of imported products, imported chicken accounts for more cases of salmonellosis than imported pork despite a significant reduction in the cases of salmonellosis from imported chicken meat from 2006 to 2007.

When comparing pork and chicken meat, without distinguishing between domestic and imported meat, the salmonellosis burdens from pork and chicken meat are quite similar in 2005 – 2007. The largest difference is estimated in 2007 where pork accounts for 1.7 times as many cases of salmonellosis as chicken meat. And, when comparing domestic and imported meats without distinguishing between different types of meat, the burdens from Danish meat is quite similar to the burden from imported meat.

Eggs contributed with 11 % of the cases of salmonellosis in 2007 which is a considerable share. That might at a first sight seem surprising because the risk in the individual egg is considered to be small. The import of eggs is not considered to constitute high risks because imported eggs are mainly used by the industry. However, imported table eggs have been found in Danish shops and it is likely that increased import of table eggs would constitute a risk factor. Studies show that the prevalence of *Salmonella* is typically higher in layer flocks in other countries (see Table 1.2, note 3). In the *Salmonella* source account, human cases of salmonellosis from imported eggs would be registered as cases related to Danish table eggs or unknown source as there is presently no account of the *Salmonella* prevalence in imported table eggs. Consumers' handling of eggs and a higher *Salmonella* prevalence in imported might be risk factors that are worth looking into in relation to reducing the human cases of salmonellosis.

It is worth noticing, that the relative importance of different places of origin and different types of meat and eggs is based on 72.3 % of the registered cases. Hence, identifying the source of the remaining 27.8 % of the registered cases and/or increasing the rate of registration could change this picture. In addition, it should be noticed that the relative importance of sources changes considerably from year to year.

For *Campylobacter,* a similar account system with detailed information about sources of infections is not available yet. However, it was shown that around one third of the cases of campylobacteriosis are travel-related (Anonymous, 2005, p. 22) and SSI (2009) and that the majority of cases are related to poultry (Anonymous, 2006 p. 23). More precisely, chilled chicken meat has been identified as the main food source of campylobacteriosis in Denmark (Wingstrand et al., 2006). The numbers of registered cases of campylobacteriosis within recent years have been 3671, 3242 and 3868 cases in 2005, 2006 and 2007, respectively.

It is clear that a substantial share of the human cases of salmonellosis and campylobacteriosis are obtained during travel outside Denmark, and hence beyond the reach of domestic policy interventions. For another major part of the infections, the sources are unknown and as a consequence, it is not possible to direct any policy measures towards them. At the same time, Table 1.1 highlights that pork, poultry meat and eggs on the domestic market – imported as well as domestically produced - are important sources of the human occurrences of such infections in Denmark.

Antimicrobial resistance has become an increasing problem in recent years. From a Danish perspective, the increasing internationalisation of food markets has given rise to some concern in this respect, as the level of antimicrobial resistance in domestic production is relatively low, compared with other European countries (EFSA, 2007a, pp. 243-244), as well as worldwide. Thus, imported foods play an important and increasingly problematic role for controlling the level of antimicrobial resistance in Denmark. Hazards associated with antimicrobial resistant agents are included in discussions on import-related hazards but are not described in greater detail in the present report.

To sum up, over the recent years *Campylobacter* bacteria have caused twice as many cases of human infections as *Salmonella* but at the same time salmonellosis have caused twice as many premature deaths as campylobacteriosis. *Salmonella* risks are attributed to chicken meat, pork and egg. Roughly the same number of human infections of salmonellosis could be attributed to pork and chicken during the period 2005 - 2007. And, roughly the same number of cases of salmonellosis could be linked to domestic and imported meat in 2007 (18 % each) – in addition, eggs accounted for 11 % of the registered cases of salmonellosis. The remaining 74 % of the registered cases in 2007 were either travel related (46 %) or from unknown sources (28 %). Campylo-

bacteriosis is mainly associated with consumption of chicken meat and one third of the cases are believed to be travel related.

1.3. Hazards and qualities

The zoonotic risks associated with some production systems or products are well-documented whereas risks from other systems or products are more hypothetical. Table 1.2 provides a short overview over known differences in risks categorized according to type of produce (pork, chicken, and egg) and according to quality categorizations in terms of production system, processing and place of origin.

The overall picture is that food safety and animal welfare are closely linked as regards *Campylobacter* in broilers. In broiler production, the prevalence of *Campylobacter* bacteria is significantly higher in organic chicken production than in conventional chicken production. Hence, consumers basically have to choose between *Campylobacter* and welfare for the broilers. For pork and eggs, there are no known Campylobacter risks. Recent studies by Zheng et al. (2007) and Wingstrand et al. (2009) find indications of a lower prevalence of *Salmonella* in pigs from Danish non-conventional production systems (from *Friland* ®) than from conventional systems. Hence, it does not seem to be necessary to trade-off between *Salmonella* and welfare for the pigs. There are no documented differences in *Salmonella* risks in chicken meat (lack of data) or eggs (no differences found) from different production systems. Based on the literature and our own findings, it is our impression though, that consumers' choice of products from a non-conventional production system is motivated by concerns for animal welfare rather than by food safety concerns. A plausible explanation is that the typical consumer is not aware of this link between food safety and production system.

Another safety aspect related to production systems is that regulation in the use of antibiotics in production is stricter in organic production. As the use of antibiotics is considered the single most important factor in the risks of developing resistant bacteria, these risks may be presumed to be lower in organically produced pork. Results from Struve et al. (2009) support this.

Table 1.2. Overview over zoonotic risks in pork, chicken meat and egg differentiated between production system, processing and country of origin (the year is 2007 when no other year is mentioned). Due to differences in sampling, the prevalence in different product categories cannot be directly compared

	Danish	Production system	Processing	Import
Salmonella				
Pork[1)]	Slaughter (carcass): 1.1 % Case-by-case (batch): 11.3 %	Higher prev. in pigs from conventional productions	Higher prev. in minced pork than in roast Higher prev. in pork from the front than rear Freezing has only a marginal effect on *Salmonella* in pork	Case-by-case (batch): 13.1 % Traditionally higher prev. in imported pork – but not so in 2008
Chicken[2)]	Slaughter (flock): 1.2 % Case-by-case (batch): 1.6 %	No data	Freezing reduces *Salmonella* risk in chicken	Case-by-case (batch): 14.5 % Higher prev. in imported chicken
Egg[3)]	1 % (layer flocks, DK surveillance) 2.4 % (layer flocks, EU baseline)	No significant differences	Pasteurization of eggs significantly reduces prev. and number of *Salmonella* counts[8)]	EU-average: 30,7 % (0-80 %)[9].
Campylobacter				
Pork[4)]	Generally low prev. in pork (0.2 % in samples of minced pork)			
Chicken[5)]	Slaughter (meat samples): 8.2 % Case-by-case (batch): 15.1 %	Conv.: 37 % Org.: 100% Higher prevalence in organic chicken	DK chilled: 31 % DK frozen: 19 % Higher prev. in chilled than frozen, but difference has decreased Numbers of *Campylobacter* are higher in chilled meat compared to frozen meat	Case-by-case (batch): 27.7 % Higher prev. in import Imp. chilled: 51 % Imp.: frozen: 34 %
Egg	No known *Campylobacter* risk associated with consumption of eggs			
Resistant bacteria				
Pork, Chicken Egg[6)]		Lower level of resistant bacteria in organic productions pig productions		More resistant bacteria in *Salmonella* in imported pork and chicken More resistant bacteria in *Campylobacter* in imported chicken

Notes:

1. **SALMONELLA IN PORK. Danish:** Prevalence on carcasses (at slaughter) was 1.1 % (Anonymous, 2009, p. 10 and p. 41). According to the case-by-case control, *Salmonella* prevalence in batches of Danish pork at retail was 11.3 % (DVFA, 2008, p. 5). **Production system**: Zheng et al. (2007) and Wingstrand et al. (2009) both show indications of higher prevalence in conv. production. **Processing**: Meat from the front part of the pig is easier contaminated during the slaughter. In addition, it is chewier and therefore often used in processed products. For the effect of freezing, see Schmidt (1986). **Import**: The introduction of the case-by-case control has implied that the prevalence in imported pork is at the same level as Danish pork. In the case-by-case control in 2007, 13.1 % of the imported batches of pork were infected (DVFA, 2008, p. 5). In the case-by-case control in 2008, *Salmonella* prevalence in Danish batches for the first time exceeded imports with *Salmonella* in 11.9 % of the Danish batches against 10.4 % of the imported batches (DVFA, 2009, p. 6).
2. **SALMONELLA IN CHICKEN. Danish:** In 2007, the *Salmonella* prevalence in Danish broiler flocks was 1.6 % (calculations based on *Salmonella* in 55 out of 3486 flocks, Anonymous, 2009 p. 38). At slaughter, the prevalence in broiler meat in 2007 was 1.2 % (calculations based on 10 out of 828 flocks being infected, Anonymous (2009) p. 38). In the case-by-case control, *Salmonella* in Danish chicken was found in 1.6 % of the batches in 2007 (DVFA 2008, p. 3), and in 0.3 % of the batches in 2008 (DVFA, 2009, p. 5). **Production system:** Insufficient data for comparison. **Processing**: Notermans (1975). **Import**: According to the case-by-case control, *Salmonella* prevalence of imported chicken meat was 14.5 % in 2007 (Anonymous, 2009, p. 44 and DVFA, 2008, p. 4) and 15 % in 2008 (DVFA, 2009, p. 5).
3. **SALMONELLA IN EGGS. Danish:** A very low prevalence is found in eggs. A survey from 2001-2002 found that 0.05 % of Danish eggs had *Salmonella* on the shell and 0.02 % had *Salmonella* inside the eggs, Danish Eggs (2005) p. 10. The prevalence was below 1 % in egg laying flocks (calculations based on 5 out of 510 flocks being infected (Anonymous, 2009, p. 37). According to an EU baseline study from 2004-2005, prevalence in DK layer flocks was 2.4 % (DVFA, 2006, p. 119). **Production system**: Anonymous (2006) p. 16, Hald et al. (1999), Hald et al. (2002). **Processing**: Anonymous (2006) p. 15. **Import**: Danish Eggs (2005) p. 10: For imported eggs, *Salmonella* was found in 0.55 % of the egg shells and *Salmonella* was found inside the eggs in 0.25 % of the eggs. DVFA (2006) p. 119: Considerable variation across countries invalidates the use of common average (the average *Salmonella* prevalence of 30.7 % in European egg laying flocks covers prevalence from 0 (Sweden) over 2.4 % in Denmark to nearly 80 % (Portugal).
4. **CAMPYLOBACTER IN PORK. Danish:** The prevalence of *Campylobacter* in Danish pork is very low (0.2 % in minced pork according to the surveillance in 2002 (Anonymous, 2003). At the same time, the prevalence in pig herds is rather high: In 2007, the prevalence of *C.coli* was 76.6 % and 1.9 % of *C. jejuni*. (Anonymous 2009, p. 44).
5. **CAMPYLOBACTER IN CHICKEN**. **Danish**: The case-by-case control found *Campylobacter* in 15.1 % of the batches of Danish poultry in 2007 (DVFA, 2008) and in 13 % of the batches in 2008 (DVFA, 2009, p. 5). According to Anonymous (2009) p. 37, the prevalence in chilled chicken meat at slaughter was 8.2 % in 2007. **Production system**: Data from 1998-2000 indicate that 100% of organic chicken flocks were infected with *Campylobacter* against 37% of conventional chicken flocks (Heuer et al., 2001). In 2006, the prevalence of *Campylobacter* in conventional chicken flocks had reduced to 30% (Anonymous, 2006, p. 24). **Processing**: Prevalence of 31 % in chilled Danish chicken and of 19 % in frozen Danish chicken in 2007 (Anonymous, 2009, p. 39). The prevalence in imported chilled chicken was 51 % and 34 % in frozen imported chicken in 2007, Anonym (2009) p. 39. **Import**: According to case-by-case, the prevalence in imported chicken was 27.7 % in 2007 (DVFA, 2008, p. 4) and 20.2 % in 2008 (DVFA, 2009).
6. **ANTIMICROBIAL RESISTANCE. Production system**: Struve et al. (2009**). Import**: Press release from National Veterinary Institute 26. January 2007.

Many consumers consider the degree of processing as simply an indicator of convenience but processing might also be a relevant categorization in a food safety perspective. The freezing process is known to markedly reduce the contamination level of most bacteria. This is reflected in the data as the prevalence of *Campylobacter* is generally found to be higher in chilled chicken meat than in frozen chicken meat. The gap has decreased in recent years but still, the number of *Campylobacter* bacteria is higher in chilled than frozen. For *Salmonella* in chicken meat, a five fold reduction by freez-

ing has been reported (Notermans, 1975). As a consequence, the Danish broiler industry introduced a logistic slaughtering system in 2002 where Campylobacter-negative flocks were allocated to chilled products and Campylobacter-positive flocks were used for frozen products to the possible extend. In addition, recent research has shown that some marinades might work as decontaminants[22]. Pasteurized egg is probably the product that most distinctively is defined by its safety characteristic – and this is a safety characteristic independent of animal welfare aspects. The level of bacteria is often higher at the cutting surface of the meat than inside the meat. As bacteria from the cutting surface might spread to the inside during processing, there is an increased risk of bacteria in meat the more the meat is handled. Consequently, minced meat is potentially associated with a higher risk. To reduce this risk, special atmosphere packaging has been developed. Another aspect of cut-related safety of meat is that the level of bacteria tends to be higher in cuts from the front of the animal than in cuts from the rear end: Meat from the front part of the pig is easier contaminated during the slaughter. In addition, it is chewier and therefore often used in processed products[23].

Foreign trade is an important economic factor in a small open economy as the Danish. This is also true from a food safety perspective as there are huge differences between food safety standards across countries. The following links between food safety and place of origin are documented on www.food.dtu.dk: 1) The prevalence of *Salmonella* is higher in imported pork and chicken than in Danish pork and chicken 2) Resistant antimicrobial agents in *Salmonella* are more common in imported meat than in Danish meat 3) Relatively speaking, more human cases of *Salmonella* infections are estimated to be related to imported meat than to Danish meat

In summary, the links between production system and zoonotic risks are rather complex. With respect to *Salmonella* in pork, results indicate that outdoor productions tend to have a slightly lower prevalence but there are no documented differences for *Salmonella* in chicken meat (lack of data) or eggs (no significant differences found). With respect to *Campylobacter* in chicken, outdoor productions have a significantly higher prevalence. With respect to *Campylobacter* in pork, there are no data from alternative production systems and therefore we cannot conclude on relations between

[22]These are investigated in the research project CAMPY, see http://www.vet.dtu.dk/Default.aspx?ID=10919

[23] Information concerning hazards and processing characteristics of pork are kindly provided by DVFA (unpublished results).

production system and occurrence of *Campylobacter*. However, *Campylobacter* risks are generally considered to be neglectible in pork and eggs. Freezing significantly reduces the effect on the level of bacteria in chicken meat but not so distinctively in pork (and freezing is not relevant in eggs). With respect to pork, it is documented that there is an increased risk of bacteria the more the meat is handled. No such documentation exists for the effects of handling of chicken. With respect to chicken, *Salmonella* and *Campylobacter* levels are higher in imported products. With respect to pork, *Salmonella* prevalence has traditionally been higher in imported pork but the case-by-case control in 2008 showed almost same prevalence as in Danish pork. With respect to eggs, there are significantly larger Salmonella risks in layer flocks from most other countries but the risk to human health in Denmark has so far been considered to be small as Denmark mainly imports eggs for processing. Antimicrobial resistance in *Salmonella* is more common in imported meat than in Danish meat.

1.4. Organisation of the report

The report focuses on describing market shares and patterns of foreign trade in products that are categorized according to differences in production systems, processing characteristics and place of origin. We seek to include those product categories for pork, chicken meat and eggs that are available and relevant in relation to microbiological food safety. Chapter 2 contains a general introduction to production, consumption, and foreign trade in general categories of food and beverages. Subsequently, detailed analyses are provided for the markets of pork products (Chapter 3), chicken meat (Chapter 4) and eggs (Chapter 5). Discussion of results and conclusions are provided in Chapter 6. A large part of the data documentation is placed in Appendix A to G.

2. The Danish food and beverage markets – focusing on animal products

The importance of food production and food consumption for the Danish economy is described with particular emphasis on meat and egg. The focus is placed on describing structural features of the Danish food and beverage markets on an aggregate level. The supply sides as well as the demand sides are included in the overall analysis of food markets importance for the Danish economy. The three subsequent chapters which constitute the heart of the report contain detailed analyses of consumptions and expenditures of pork, chicken meat and egg markets, respectively. The present chapter contains a short presentation of the food industry (Section 2.1), overall developments in food expenditures (Section 2.2), consumption patterns in quantities (Section 2.3), foreign trade (Section 2.4), and summary and discussions (Section 2.5).

Just to clarify the notation, we use the term *expenditure* when consumption is measured in values (nominal or fixed price) and *consumption* when measured in quantities. Complete lists and descriptions of used statistics are found in Appendix A (a description of the indicators we have used for consumption, production, trade, and prices), Appendix B (an overview of data sources), Appendix C (categorisations in the databases of Statistics Denmark), and Appendix D (description of data used in Chapter 2).

2.1. Production of food and beverages

The relative importance of food and beverage production for the Danish economy is assessed by comparing the value of food and beverage production with the overall value of production in Denmark[24]. Figure 2.1 shows the development in the food and beverage industry in absolute as well as in relative values[25]. In absolute terms, the volume of the food and beverage production increased over the period 1990-2004 whereas the relative importance of the food and beverage production in Denmark was gradually decreasing from 6.5 % of total value of Danish production in 1990 to just over 5% in 2004 (Source: DST1)[26]. In addition to the direct economic influence, the

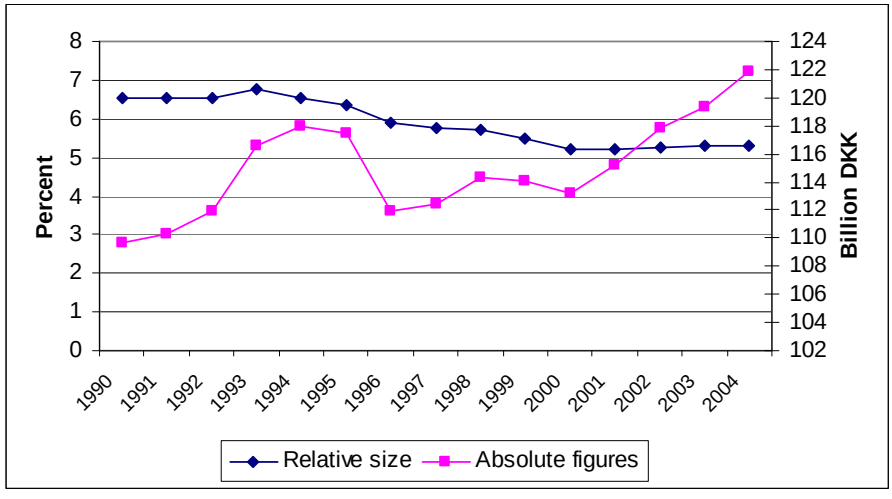
[24] Total production includes production of material as well as immaterial goods, e.g. agriculture, health care, administration, education.

[25] A development in real values isolates the development in production quantities as opposed to a development in nominal terms that includes changes in prices and quantities.

[26] The total value of the Danish agricultural production and processing industry amounted to 122 billion DKK in 2004. Total value-added was around 50 billion DKK, which represents about 4 % of the national value added.

agricultural sector and the food industry have significant impacts on a number of other industries, including construction, production of machinery, and the biotechnology industry.

Figure 2.1. Production of food and beverage in % of the total Danish production (measured in 2000 prices) and in billion DKK



Source: Own aggregations based on DST1.

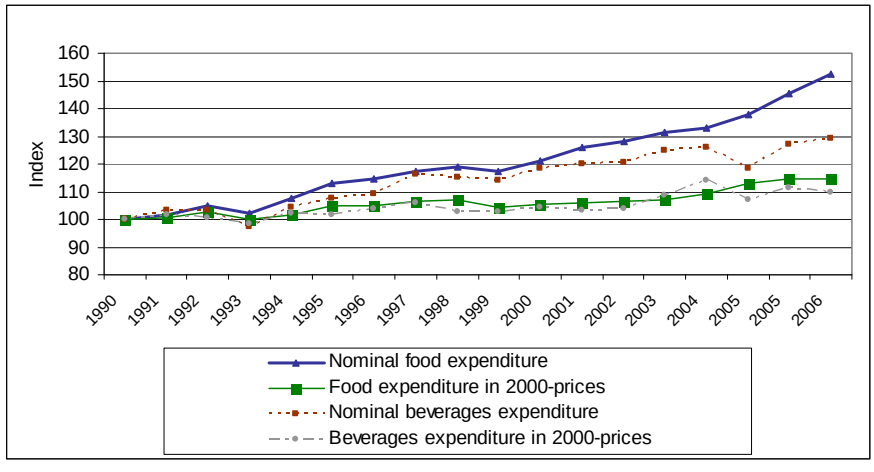
The food and beverage production in the period 1990-2004 can be divided into six main categories (*meat*, *dairy*, *fish*, *fruit and vegetables*, *beverages*, *other)*[27] to analyse the relative importance of different food categories (based on the statistics DST1) – not shown graphically. These are not illustrated graphically. The two largest categories in 2004 were *meat* (33 %) and *other* (30 %). For comparison, the *dairy* industry constituted 19 %, *fish* and *beverages* each accounted for around 8 % and *fruit and vegetables* accounted for around 3 %. Overall, the composition of the food and beverage production has been rather stable with a slight increase in *meat* and *other* at the expense of a slight decrease in the remaining four industries.

[27] The categories are as listed in Appendix C.

2.2. Food and beverage expenditures

The development in private expenditures on food and beverage from 1990 to 2005 are shown in Figure 2.2 in both nominal and real terms[28]. Consumers spent 38 % more money on food in 2006 than they did in 1990. A large part of this increase was due to price increases and the real increase in food consumption was close to 13 %. For beverages, the expenditures and real consumptions have also risen but at slightly lower rates.

Figure 2.2. Development in expenditures of food and beverages by Danish households measured in nominal prices and in 2000-prices. Year 1990=index 100



Source: Own aggregations based on DST1.

Despite an increasing trend, expenditures on food and beverages have fallen relative to other private consumption expenditures (not illustrated graphically). Almost 13 % of the private expenditures in 1990 were spent on food, while the share in 2005 was 10 %. A similar development is seen for beverages as the share of total expenditures spent on beverages decreased slightly and accounted for just below 4 % of total expenditures in 2005 (own calculations based on DST1).

[28] The development in real terms represents development in quantities (by eliminating the effects of changing prices) while the development in nominal terms indicate development in expenditures.

These expenditures can be distributed between different categories of food and beverages (*meat*, *dairy*, *fruits and vegetables*, *non-alcoholic beverages*, *alcoholic beverages, fish, eggs, other*) – not illustrated graphically. Note that beverages are now subdivided into *alcoholic beverages* and *non-alcoholic beverages*. Furthermore, note that *eggs* are now placed in a separate category and include all eggs as opposed to the description of production, where pasteurized and other processed eggs were included in the production values but not table eggs (appendix C provides further details on the categories). The general picture is that the composition of the food and beverage budget has been quite stable over the period 1990-2006. In 2006, *meat* accounted for 15 % of expenditures. For comparison, the categories *dairy*, *fruits and vegetables*, *non-alcoholic beverages*, and *alcoholic beverages* each accounted for around 10 %, *fish* and *eggs* each accounted for 3-4 %, and 25 % of private food and beverage expenditures were spent on *other* (own calculations based on the database DST1).

2.3. Consumption of meat and eggs

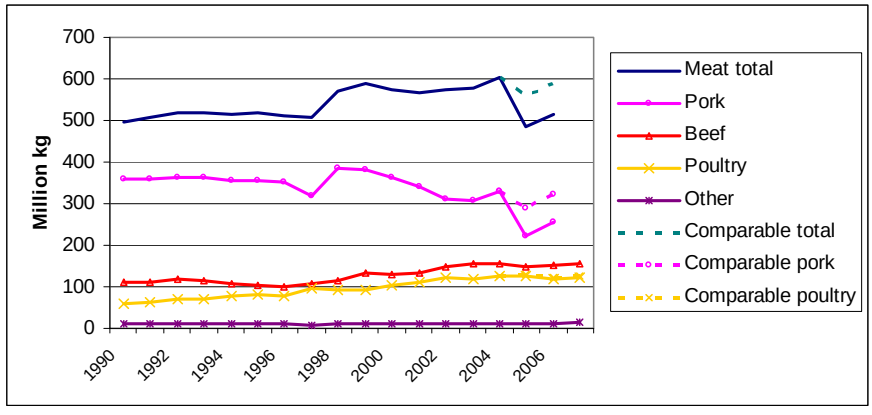
The effects on human health of zoonotic risks naturally depend on product risks but also on consumed quantities and frequencies of consumption. For example, a product that is highly infectious but only consumed in small quantities might cause less private and social costs in terms of life quality and in terms of economic costs than a product with low risk that is consumed in large quantities. In order to be able to include this aspect, consumption patterns with respect to meat and eggs are shown.

Development in meat and eggs consumption

Information concerning the development of meat consumption was found in Statistics Denmark DST2 for the period 1990-2007 for the four main categories: *Pork, beef, poultry,* and *others*[29]. Figure 2.3 illustrates the development in meat consumption (measured in quantities, based on DST2) – but only available as 'meat available for private and industrial consumption'.

[29] The category '*other'* covers sheep, lamb, horse and game. Note that Figure 2.3 cannot be compared directly with Figure 2.2 where only private consumption is included. Note furthermore that the definition of meat for consumption was changed in 2005. Firstly, pig heads sent to destruction were no longer included in the consumption statistics. This change in the definition caused a decrease in the consumption of pork of 54 million kg in 2005. Secondly, the method used to estimate the number of home-slaughtered pigs and poultry was changed in 2005 such that the estimated numbers were lower than in the previous years[29]. To address this problem, Figure 2.3 includes estimates for 2005-2007 using the new as well as the old calculation method.

Figure 2.3. Meat available for consumption in Denmark for private households and the industry is shown for 4 main categories of meat over the period 1990-2007. As estimation methods changed in 2005, comparable data points for 2005-2007 for pork, poultry and total are added



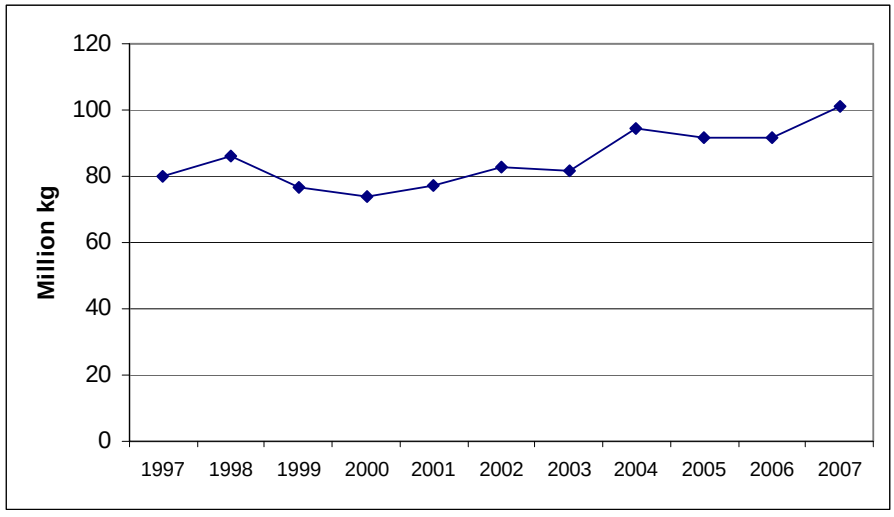
Source: Own aggregations based on DST2.

The meat available for consumption (private plus industry) in Denmark is highly dominated by *pork* even though consumption of *pork* has steadily decreased in importance. In 1990, more than 70% of the meat available for consumption was pork which decreased to 52 % in 2004. In contrast, still more poultry meat is consumed. In 2004, poultry covered 21 % of meat consumption against 12 % in 1990. Also consumption of *beef* has increased from 20 % of meat consumption in 1990 to 25 % in 2004.

Nutritional recommendations (aiming at reducing obesity, risks of diabetes 2, and cardiovascular diseases) have pointed towards less and leaner types of meat in order to decrease the level of, particularly saturated fat in the diet (Jensen et al., 2007). The development in meat consumption indicates that nutritional recommendations of less and leaner meats only partly are followed: Meat consumption has increased but there is a substitution from pork towards the leaner chicken meat.

Consumption of eggs (table and processed eggs to private households and the industry) from 1997-April 2006 is shown in Figure 2.4. The total sales of eggs in Denmark amount to 70-95 million kg per year with an increasing trend such that eggs consumed by private households and the industry was 25 % higher in 2006 than in 1997.

Figure 2.4. Total consumption of eggs in Denmark, 1997-2006



Source DST2.

Overall quantities of meats and eggs available for consumption for private households have increased. The composition of meat consumption has changed towards less pork and more poultry and beef.

Consumption of meat – using two different approaches

In the present section, private consumption of meat and eggs is described using two rather different methods. All information concerning consumption of meat and eggs is summarized in Table 2.1. A study by Lyhne et al. (2005) is based on a survey from 2000-2002 where 4000 Danes have self-reported their food intake over a period of 7 days. They estimate a total meat consumption of 51 kg/year for an adult person covering 41 kg of pork and beef and 10 kg of poultry. The other method is to use Statistics Denmark to estimate meat and eggs available for consumption in 2006 (see Andersen, 2007). They estimate a total meat consumption of 97 kg (covering 46% pork, 28 % beef, 25 % poultry and 2 % other)[30]. Hence, the consumed quantities differ by almost a factor 2. One reason is of course that data are collected in different years. More im-

[30] The category 'other' includes lamb, game, and horse meat (Andersen, 2007). The distribution is rather similar to the one indicated by Figure 2.3 where meat available for consumption in 2004 consisted of 52 % pork, 25 % beef, 21 % poultry, and 2 % others.

portant however is that the estimates from Statistics Denmark do not properly account for imports, exports, re-exports, and to what extent offal is included - and as Denmark is a net-exporter of chicken meat as well as pork, the number is likely to be too high (Andersen, 2007). On the other hand, meat consumption in Lyhne et al. (2005) is likely to be underestimated due to strategic answering as the official recommendations of healthy diets include 'less meat' as one of the main recommendations[31].

According to data from Danish Poultry Council[32] (2007, p. 122), consumption of chicken meat in Denmark in 2006 was 18.8 kg, and the consumption of poultry was 23.5 kg (p. 118), which implies that chicken meat accounts for 80 % of the poultry consumption. We have used that information in Table 2.1.

In Danish Agriculture (2006), the distribution between pork and beef is 63 % pork and 27 % beef. As Lyhne et al. (2005) do not distinguish between pork and beef we have simply adopted the same distribution as that found in Danish Agriculture (2006).

Our main interest in the consumption of different meat products lies in the ratio between pork and chicken rather than the actual quantities. Table 2.1 reveals that Danes on average eat between 2.5 (Statistics Denmark) and 3.3 (Lyhne et al. 2005) times more pork than chicken. It is not quite clear how the above mentioned uncertainties in methods for estimating the consumption of meat might affect the ratio between pork and chicken meat.

We will assume that the relative consumption of pork versus chicken is 'remembered' more accurately in the consumer survey (Lyhne et al., 2005) than in registrations in Statistics Denmark. Hence, the remaining report will use the quantities and distributions found in Lyhne et al. (2005) which is highlighted in Table 2.1.

[31] The official eight advices for a healthy diet are described in Astrup et al. (2005)
[32] '*Det danske fjerkræråd*'

Table 2.1. Consumption of meat and egg in Denmark

	Statistics Denmark data, Andersen (2007)		Lyhne et al. (2005) based on consumer survey of food intake	
Year of consumption	2006		2000-2002	
	Consumption kg/inhabitant	**Relative consumption of different meat products (%)**	**Consumption kg/inhabitant**	**Relative consumption of different meat products (%)**
Pork	45	46	26	50
Beef	28	29	15	30
Poultry (hereof chicken 80 %)	22 (18 kg chicken)	23 (18 % chicken)	10 (8 kg chicken)	20 (16 % chicken)
Others	2	2		
Meat total	**97**	**100**	**51**	**100**
Pork relative to chicken	**2.5**		**3.3**	
Egg	17		6	

Notes:
1. Both sources include in principle dining out etc.
2. In Lyhne et al. (2005) consumption is measured in gram/day – these ratios are re-calculated to kg/year.
3. Danes' consumption of 17 kg according to Statistics Denmark is presented in Danish Agriculture (2007).

Hence, in 2000-2002 an average adult Dane ate at least 51 kg of meat per year. Around 3 times more pork than chicken is consumed. Meat consumption can roughly be divided into 50 % pork, 30 % beef, and 20 % poultry (16 % chicken and 4 % other types of poultry). In addition, each Dane consumes around 6 kg of eggs each year (corresponding to around 120 eggs).

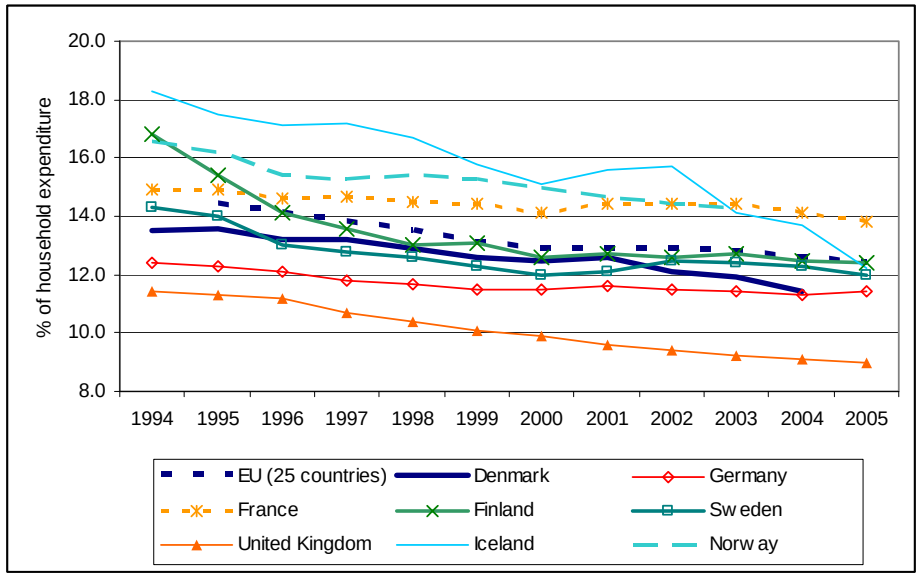
Danish food consumption patterns in a European perspective

Danish food expenditures are compared with those in similar countries (Sweden, Norway, Finland, Iceland, Germany, France, UK, and an average of the EU-25 countries) for the period 1994 - 2005 (Figure 2.5). Due to differences in measurement methods across countries, the results should be interpreted with care.

All countries have spent decreasing shares of their total expenditures on food. We point towards two main explanations for this development: 1) Household's real incomes – and hence the budget available for consumption – have been increasing, and the demand of food has not been increasing to the same extent 2) Foods have become relatively cheaper over time, due to cost-reducing productivity improvements as well as reforms of the agricultural policy. In recent years, Danish households spent 11-12

% of their total expenditure on foods and non-alcoholic beverages[33]. In all years, Danish food expenditures as share of total expenditures have been below the average of the EU-25 countries. In a Nordic perspective, the food expenditure share in Denmark is quite in line with Sweden and Finland, but somewhat lower than in Norway and Iceland, presumably due to relatively high food price levels in the latter two countries.

Figure 2.5. Food and non-alcoholic beverages (% of total household consumption expenditure), at current prices, 1994-2005

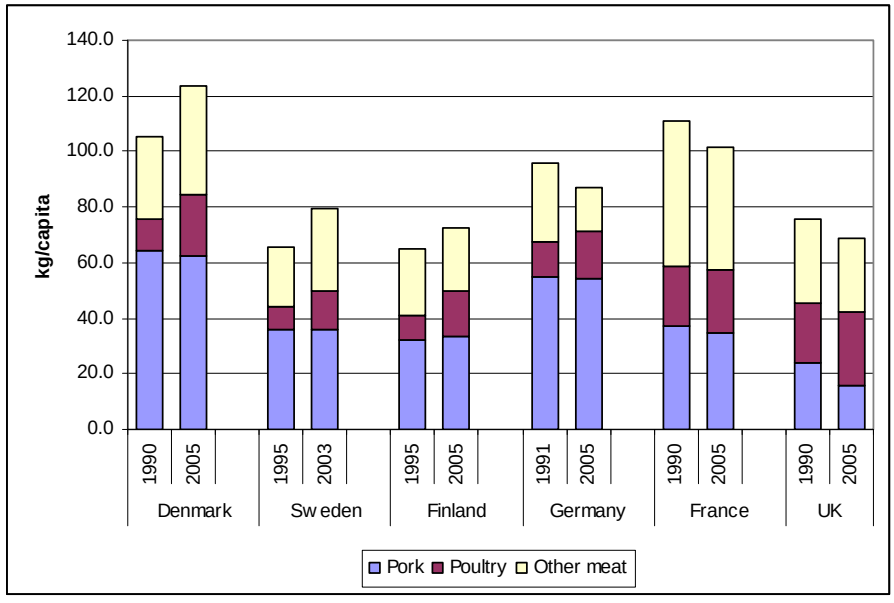


Source: Eurostat.

The consumption of meat products per capita in Denmark and in similar EU member states is illustrated in Figure 2.6 (Denmark, Sweden, Finland, Germany, France, UK).

[33] Note that in Section 2.3, we estimated food expenditures to be around 10% of total expenditures in 2005 and that expenditures on beverages (alcoholic and non-alcoholic) were just below 4%. In the present Section, food and non-alcoholic beverages are estimated to account for 11-12% of total expenditures.

Figure 2.6. Consumption of meat per capita in selected EU member states, 1990-2005



Source: Eurostat

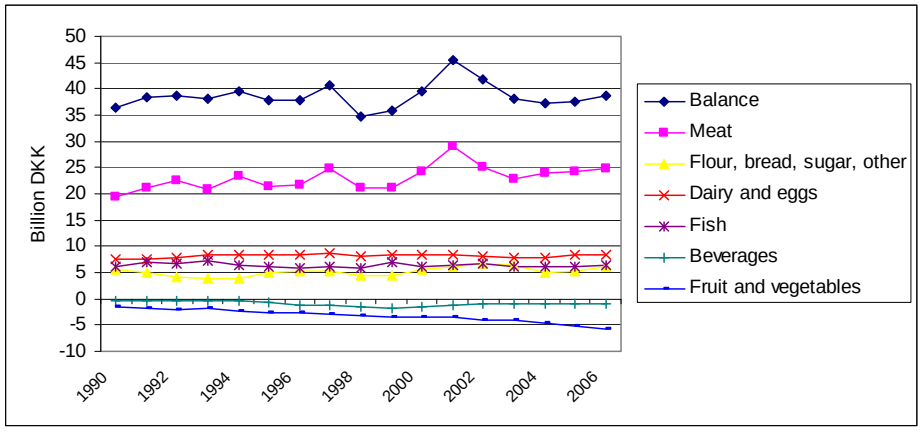
The overall picture is that in 2005, Denmark's consumption of pork meat was among the highest per capita consumption of meat in Europe while the Danish per capita consumption of poultry meat of around 20 kg was around an average across countries. However, uncertainties related to differences between measurement methods across countries and the problem of not properly accounting for offal and re-exports (as mentioned earlier) imply that we are reluctant to make strong conclusions on national differences.

It should also be mentioned (but shown graphically) that the Danish consumption of eggs is estimated to be above the average across Europe (Danish Poultry Council, 207, p. 111).

2.4. Foreign trade in food and beverages

Denmark is a net-exporter of foods and beverages. Figure 2.7 captures the development in net exports of 6 categories of food and beverages. In 2005, the value of the foreign trade of food and beverage trade made up almost 13 % of the total foreign trade in Denmark equivalent to approximately DKK 38 billion (own calculation based on the database DST3). The net export of meat accounted for more than 50% of value of net exports of food and beverages (increased from DKK 19.4 billion in 1990 to DKK 24.2 billion in 2005). Denmark is also a net-exporter of dairy products and eggs (valued jointly), and of fish but a net-importer of beverages as well as fruits and vegetables.

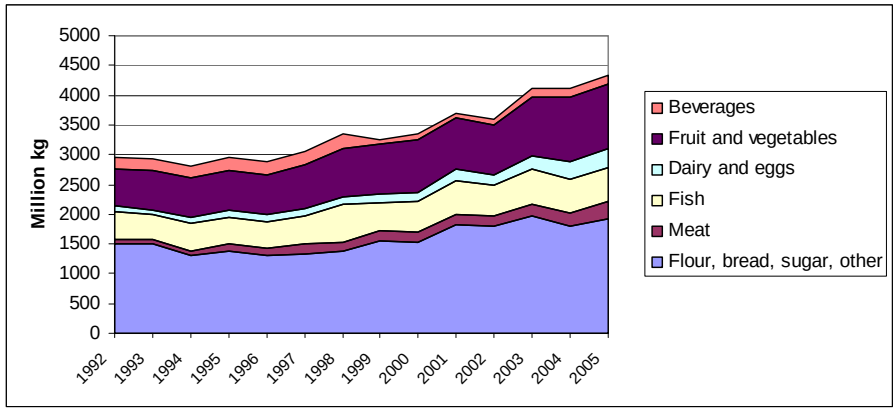
Figure 2.7. Danish trade balance for individual categories of food and beverages in the period 1990-2006 in nominal prices



Source: Own aggregations based on DST3.

Net exports in Figure 2.7 were presented in monetary terms. Imports and exports will be presented in quantities. Figure 2.8 shows the development in imports of food and beverages, measured in quantities.

Figure 2.8. The Danish import of individual categories of food and beverages measured in million kg, 1990-2006



Source: Own aggregations based on DST3.

From 1990 to 2006 the imported quantity of food and beverages increased from 3 million tons to 4.3 million tons – an increase of nearly 50%. The imported quantities of all categories of food increased during the period – only import of beverages decreased slightly.

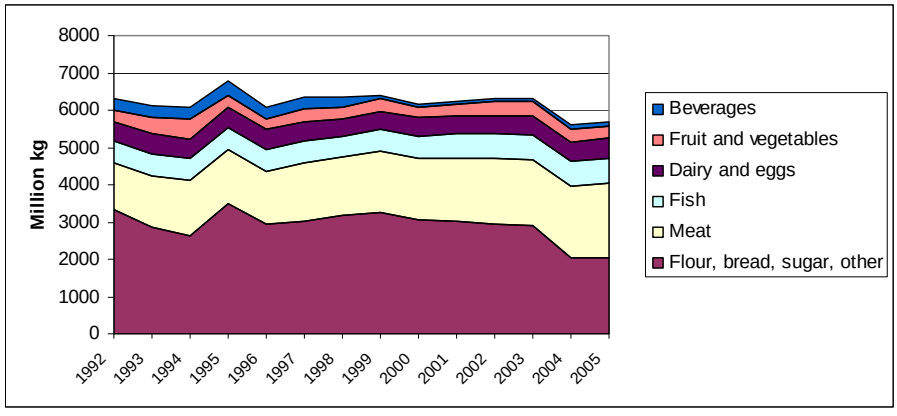
The three largest categories of food and beverage imports in 2006 are *other (45 %)*, *fruit and vegetables (25 %)*, and *fish (13 %)*. In example, the import of *meat* increased from 82 million kg to 283 million kg from 1992 to 2005. This is a large increase in relative terms but as the meat import started from a very low level, the import of meat still only constitutes around 6 % of total food and beverage import in 2005.

In 2005, the meat import could potentially cover 58 % of the Danish meat consumption. However, some of the imported meat is re-exported. The import shares of pork and chicken meat consumed in Denmark are estimated in section 3.2 and 4.2.

In 2005, the total quantity of food exported was approximately 5.7 million tons – a decrease of 12 % as compared to 1990 (see Figure 2.9). The two dominating export groups of food and beverages export are *meat* and o*ther (*a share of 35 % each*)*. For comparison, the shares of exported *fish* and *dairy* each were approximately 10 % while *fruit and vegetables* and *beverages* constituted 6 % and less than 2%, respec-

tively. The decreased export is mainly caused by a sudden drop in 2004 of products in the category *other* and a reduction in the exports of *beverages* in 1999. Export of *meat* increased by 60 % between 1992 and 2005. This corresponds to an increase of 750 million kg (and can be compared to the increased imports of meat of 200 million kg).

Figure 2.9. The Danish export of food and beverages measured in quantities



Source: Own aggregations based on DST3.

2.5. Summary and discussions on food and beverages

The food and beverage industry is an important sector in the Danish economy. Despite a decreasing trend, the production of food and beverages covered just over 5 % of the total value of production in Denmark in 2004. The meat industry covered 33 % of the food and beverage production value in 2004.

The average household in 2005 spent 10 % on food out of their total expenditures compared to 13 % in 1990. A comparison with other European countries indicates that the share of total budget allocated to food in Denmark seems to be below average.

The Danes' relative expenditures on different food categories seem to have been rather stable between 1990 and 2006 with a slight increased demand for meat. Consumptions of poultry and eggs have increased during the period while the demand for pork has fallen. In 2004, meat products covered around 15 % of the food and bever-

age budget. For comparison, around 10 % of the food budgets were spent on fruits and vegetables and around 10 % on dairy products.

It is roughly estimated that an average adult Dane in the period 2000-2002 ate at least 51 kg of meat per year consisting of 26 kg of pork, 25 kg of beef, 8 kg of chicken, and 2 kg of other types of poultry. In percentages, meat consumption can roughly be divided into 50 % pork, 30 % beef, and 20 % poultry (16 % chicken and 4 % other types of poultry). Hence, consumption of meat was highly dominated by pork and, an average Dane consumes around 3 times more pork than chicken.

The Danish food sectors – and in particular the pork and chicken sectors – are highly export oriented, and the position as a large exporter of food has in general been maintained over the last decade. The meat export increased by 60 % between 1992 and 2005. From a food safety policy aspect, the large and increasing export of Danish meat products constitute a challenge as improving the safety of domestic meat products to a large extent will benefit non-domestic consumers and put pressure on domestic producers.

During the same period, the import of food products has increased, most likely due to a strengthened integration of European markets, as well as increased market assess for third countries due to the GATT/WTO agreement in the early 1990's. Especially the imports of meat, egg and dairy products have experienced large growth rates over the last 15 years.

3. Pork markets

Trends in the demand for pork products and their relations to zoonotic risks are investigated. Patterns of pork consumption are described in Section 3.1, foreign trade in Section 3.2 and summary and discussion in Section 3.3. A complete list and description of statistics used can be seen in Appendix E.

3.1. Consumption patterns

Pork consumption has declined since 1999, but it still makes up approximately half of the total meat consumption in Denmark (see Section 2.3). Pork is thus still the dominating type of meat on the Danish meat market.

From a safety perspective, the following categorisations of pork production are of main interest: Production systems (will be described in terms of brands of pork products as production system and brand are closely related), processing characteristics (will be described in terms of cuts and fat categories of minced pork), and trade. The categorizations are described in detail in Appendix E.

Consumption categorized according to production characteristics and brand
Between 2003 and 2008, the sale of organic pork[34] in Denmark increased from 202 tons to 838 tons and in value terms the sales of organic pork increased from around 17 million DDK to around 74 million DDK (Statistics Denmark[35]). Still, the market share of organic pork was less than 1 % in 2004.

The price premium of organic pork was 20 - 30 % in 2004 (own calculations based on GfK data). The estimated price premiums are rather uncertain even after adjusting for differences in cuts as only very limited purchases of organic pork were observed.

Table 3.1 shows different pork brands and their market shares in 2004. Only 6-7 % of the pork consumption refers to brands with special quality characteristics.

[34] Not including bread spread (*pålæg*)
[35] http://www.statistikbanken.dk/OEKO3

Table 3.1. Market shares of different brands of pork

Brand	Budget Share	Image and description
Friland	4	Animal welfare and taste Free range or organic
Antonius/Vitalius	2	Animal welfare and/or taste
Crown of Cooking	0.5	Taste
The store's own brand	35	Standardised quality, often cheap
No information on brand in our data	58	

Note: Data are only available for the last three quarters of 2004.

Sources: GfK, www.dma.dk , and www.crownofcooking.dk

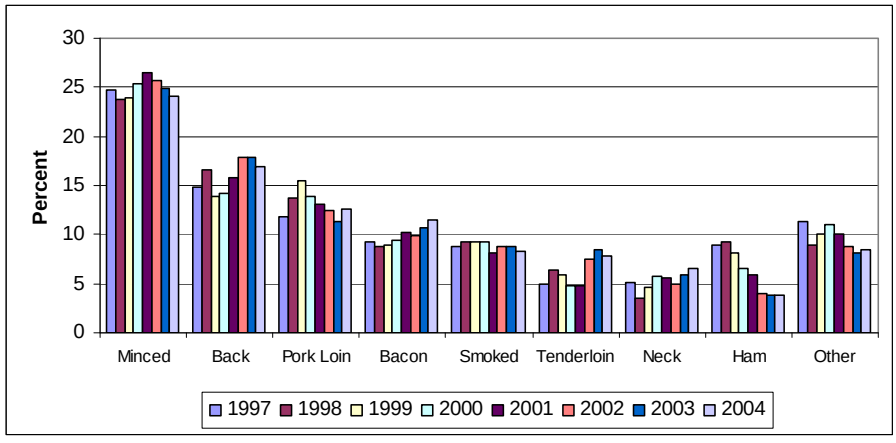
Consumption categorized according to cuts

Figure 3.1 illustrates market shares (in quantities) for different cuts for 1997-2004. The most popular cut is *minced pork.* In 2004, 25 % of pork consumption was minced (after a slightly decreasing trend). Around 15 % of pork consumption is *back* while 10-15 % is *loin. Bacon* and *smoked pork* both hold market share of 10 % each. The categories *tenderloin*, *neck*, and *ham* all hold market shares of approximately 5 %. *Other* represents a residual category of 10 %[36]. Market shares of different cuts are rather stable over time although small increasing trends can be observed for bacon and tenderloin while the domestic sales of ham drops from nearly 10 % in 1998 to around 4 % in 2002 and onwards.

Quantities and prices are typically believed to be inversely related such that small market shares are held by products with high prices. This picture is roughly the case for pork products (not illustrated graphically). *Tenderloin* was the most expensive cut with a price of DKK 65-90 per kg. The cheapest cuts include *other*, *pork loin*, and *minced* pork with prices of DKK 30-45 per kg. The ranking of prices for the different pork cuts appear to be quite stable (own calculations based on GfK).

[36] Sausages have not been included as it was not possible to separate sausages containing pork meat from sausages made of e.g. beef or lamb.

Figure 3.1. Market share (in quantities) for eight different categories of cuts in the period 1997-2004



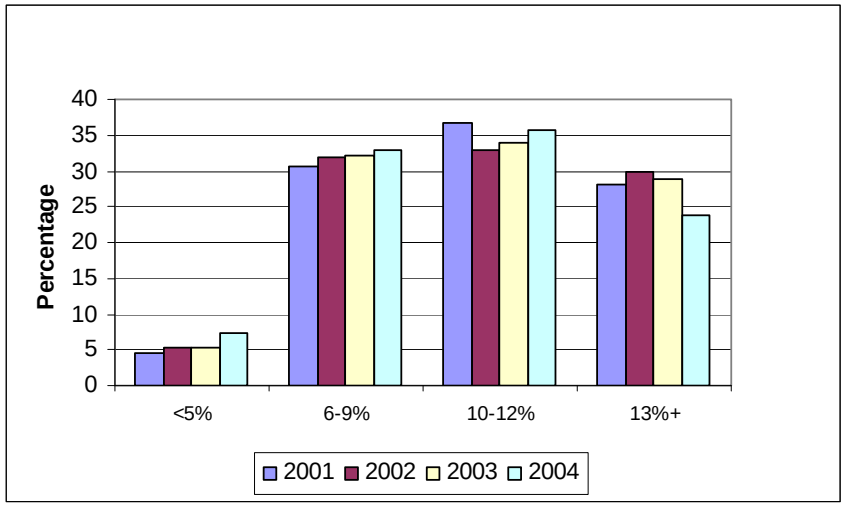
Source: GfK.

Consumption of minced pork categorized according to fat

There is a link between fat levels and *Salmonella* prevalence. More important however, fat level is an important factor from a nutritional aspect. Minced pork is marketed in four categories according to the content of fat. The market shares for different levels of fat in minced pork during the period 2001-2004 are shown in Figure 3.2.

Minced pork with a fat percentage less than or equal to 5 % has a market share around 5 % while the three groups with higher fat content each hold a market share of approximately 30 %. Looking at the results slightly differently, 40 % of the minced pork has a fat content below 10%.

Figure 3.2. Market share (in quantities) for four different levels of fat in minced pork, July 2001–March 2004



Source: GfK.

GfK also provides information concerning the prices paid for four different types of minced pork (Figure 3.3). A slightly decreasing trend in all prices is observed for the period 2001 to 2004 and price is negatively correlated with fat level. Thus, fat content below 5 % is the most expensive and costs DKK 40-50 per kilogram, closely followed by the categories 6-9% and 10-13% while there is a price span of at least 10 DKK down to fat level above 13 % fat.

Figure 3.3. Price of minced pork with different fat content

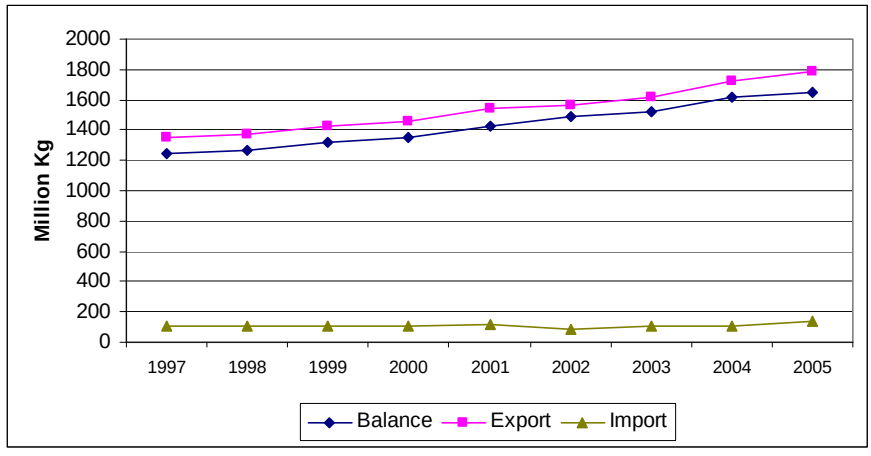
Source: GfK.

3.2. Foreign Trade

More than 85 % of pork produced in Denmark is exported and Denmark has the world's largest export of pork (www.danishmeat.dk). According to Danish Meat Association (2008), the value of pork exports in 2007 constituted 5 % of the total value of Danish exports and 50 % of the agricultural exports. The export, import, and the trade balance for pork are shown in Figure 3.4 (measured in quantities).

The trade balance for pork is clearly dictated by the development in exports. The pork export has increased from 1.4 million tons of pork in 1997 to 1.8 million tons in 2005 (increase of 32%). The pork import is small compared to the export and has been increasing from 0.1 million tons in 1997 to 0.16 million tons in 2005.

Figure 3.4. Trade balance, export, and import of pork



Source: Own aggregations based on DST4.

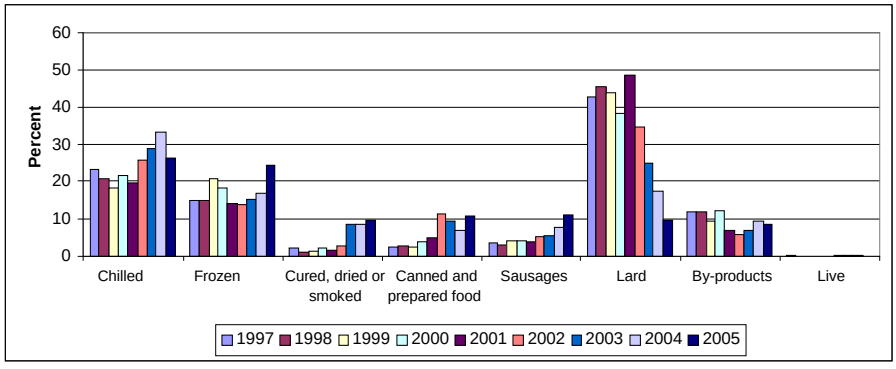
Import

Probably the most important aspect of foreign trade of pork in a safety perspective is the import share of human consumption. Due to difficulties in quantifying the extent of re-exports and non-edible by-products from imported pork, it is hard to obtain precise estimates of this import share, but it is considered that an import share in the area 20-25 % constitutes a realistic order of magnitude (information is kindly provided by Jan Dahl and Karsten Fleming, Danish Meat Association, personal communication).

In Figure 3.5, pork import is divided into the categories *chilled*, *frozen*, '*cured, dried, or smoked'*, *sausages*, *lard*, *by products*, and *live animals*.

Figure 3.5 shows that the composition of pork import has changed over the period 1997-2005 (in value terms). The import of *lard* constituted a large share of the total import in the beginning of the period but has decreased drastically. Leaving *lard* out of the analysis, *chilled* and *frozen* pork have been the most important categories during the whole period with *chilled* pork covering 20-30 % of pork import and *frozen* pork covering 15-25 % of pork imports.

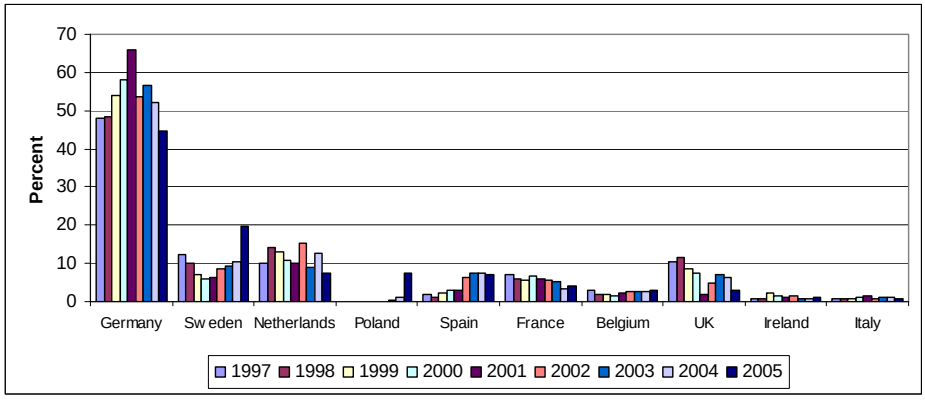
Figure 3.5. Danish pork import for 8 different product categories (in % of the value of pork import)



Source: Own aggregations based on DST4.

Figure 3.6 shows the imported quantity from the ten countries with the highest exports to Denmark.

Figure 3.6. The 10 largest exporters of pork to Denmark



Source: Own calculation based on DST4.

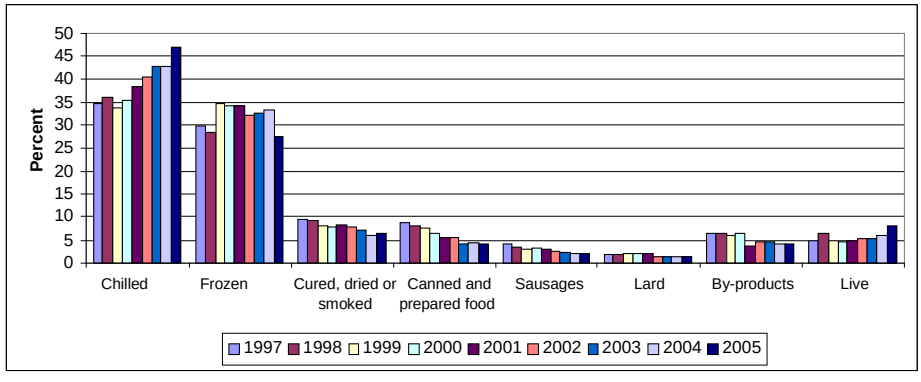
The majority of pork is imported from other EU countries with Germany being by far the largest single exporter of pork to Denmark. Note that some of the imported pork is

from Danish pigs that have been slaughtered and/or processed in other countries. In fact, more than half of the Danish import of pork is imported from Germany followed by Sweden and the Netherlands that each accounted for around 10 % of the Danish pork import. In 2005, the main part of the pork imports from Sweden consisted of *lard*. From 1997 to 2003 only an insignificant share of the pork imported to Denmark came from Poland. However in 2005, 10% of the import came from Poland, which was the only East-European country with any significant export to Denmark. The import from Poland is dominated by *sausages* and *canned and prepared food*, which together made up 79 % of the Polish export to Denmark in 2005 (not illustrated graphically).

Export

Similarly, Figure 3.7 shows the composition of the Danish export (in value terms) of pork. The categories *chilled* and *frozen*, with shares of respectively 40% and 30%, are by far the largest export articles.

Figure 3.7. Danish pork export for 8 different product categories (in value terms)



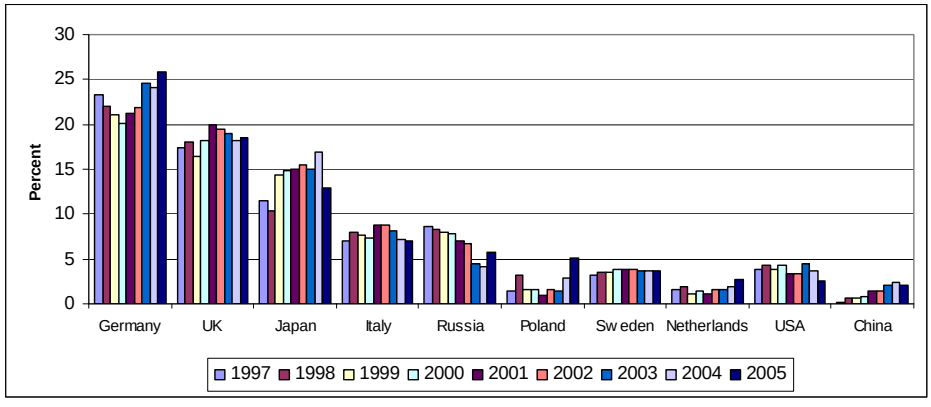
Source: Own calculation based on DST4.

The share of the pork export sold as *chilled* has been increasing in the period 2001-2005 and in 2005 it made up 47% of the export. The share of *frozen* pork has been relatively stable, but decreased in 2005. The exports of processed meat have all been

steadily falling since 1997. Note also that the export of live animals has been increasing the last years[37].

Danish pork products are exported to a large range of countries. Approximately 70 % is exported to other European countries (Danish Meat Association, 2008, p. 28). %). In 2005, the 10 largest export destinations covered 86 % of the total Danish pork export. The ten most important export markets for Danish pork in 1997-2005 are shown in Figure 3.8.

Figure 3.8. The 10 largest destinations for Danish pork export and their respective share of the total Danish export, 1997-2005 (in value terms)



Source DST4.

Germany was the largest buyer of Danish pork over the period with shares between 20 and 25 pct. of the pork export, closely followed by the United Kingdom (20 %) and Japan (15 %).

The shares of export to Germany have been increasing during the last years. Russia is the only country to which the export has declined steadily. Poland is a market that has developed fast in recent years. The trade with Poland is thus increasing as both the import and the export has increased considerably in 2005. Poland however, still im-

[37] The dominating part of the exports of live pigs is sold in Germany (with shares of 83-96 pct of the export of live pigs). In earlier years the export was split evenly between slaughter pigs and piglets but in the last few years, the export of piglets has dominated.

ports far more than it exports to Denmark. Moreover the export to China has increased steadily since 1997 but stil constitutes a minor part of the export.

3.3. Summary and discussion on pork

Even though the Danish consumption of pork has been declining during the last decades, half of all the meat consumed in Denmark is still pork. In 2004, pork from non-conventional production systems had a market share of 6 – 7 %. The sales of organic pork are increasing but still only constituted less than 1 % of the pork consumption in 2004. From a zoonotic risk perspective, an increasing trend in organic pork consumption might be seen as a promising development as results indicate that pigs from outdoor productions tend to harbour at a lower prevalence than conventionally raised pigs. However, the safety implication of consumers' brand choice is not clear. Also, quantitative differences in risk levels associated with different cuts are not clearly documented. The most popular category of pork cuts is *minced* meat accounting for 25 % of pork consumption. The popularity of minced pork could possibly be of concern – all else equal – as it has been processed several times. Large price premiums were noted for low fat relative to high fat minced varieties which might indeed hamper the demand for low fat minced pork.

These market shares, confirmed by various consumer analyses (e.g. Lassen et al., 2002; Mørkbak, Christensen & Gyrd-Hansen, 2008a) suggest that consumers tend to focus more on fat content than on microbiological food safety and animal welfare. Hence, consumers' involvement in safer food can be expected to be fairly low unless they are provoked by public market interventions or other factors that can affect preferences (as for example massive outbreaks of foodborne diseases).

The main trading partner for pork meat is Germany. The import of pork has increased over the period 1994-2005. A few years ago *Salmonella* occurred more often in imported pork than in Danish pork and was therefore likely associated with a higher risk, but recent results show that this difference has diminished which means that the risks from imported and Danish pork are likely to be rather similar (see Table 1.2).

Another type of risk associated with increased imports of pork exists because most other countries experience higher levels of anti-microbial resistance than Denmark.

Denmark has maintained its position as the world's largest exporter of pork. Current trends in pork exports towards less processed products suggest that Danish export to an increasing extent faces international competition on prices and costs. From a regulatory perspective, interventions involving considerable costs for pork producers may impose a challenge in maintaining the current high level of exports.

4. Chicken markets

The objective of Chapter 4 is to describe trends in the demand for chicken and to evaluate the role of these trends in a zoonotic risk context. In particular, we look deeper into patterns of chicken meat consumption (Section 4.1), foreign trade in chicken meat (Section 4.2) and we summarize and discuss the results in Section 4.3. A description of data can be found in Appendix F.

4.1. Consumption patterns

The following categorisations of chicken meat will be investigated: Production systems, convenience characteristics, processing characteristics, and trade. The categorizations are described in detail in Appendix F.

Consumption categorized according to production characteristics
The market share of organic chicken was less than 1% in the period 2001-2004 (own calculations based on GfK data and Baltzer (2002)). During the period, Danish organic chickens were mainly sold through farm shops and delivery routes, while *Dansk Supermarked* typically imported chilled organic chicken from France and *COOP* imported organic chicken from Germany[38].

According to Baltzer (2002), *Campylobacter free, barn* and *organic* jointly accounted for around 6 % in 2000-2002 of chicken expenditures (see Table 4.1). It is apparent from Table 4.1 that a vast majority of the chicken market is held by conventional chicken. As indicated, around 94% of the chicken meat originates from conventional production systems.

One might expect the prices of these differentiated products (shown in the third column of Table 4.1) to depend on differences in production costs and differences in demand. The cheapest variety is the *Campylobacter free* chicken, which on average had a price of DKK 25/kg during the period 2000-2002. However, it is important to emphasize that each category includes several other qualities. Hence, the price of

[38] Information is kindly provided by Helle Bossen, Organic Denmark, personal communication, 2006.

Campylobacter free chicken might be low because it is mainly sold as a whole chicken whereas conventional chicken meat are often more processed (hence, more expensive). The most expensive was the *organic* chicken with an average price of DKK 57/kg. An attempt to use the GfK data set to estimate price premiums for organic chicken during 2001 - 2004 resulted in price premiums from 0 to 26%. However, with a market share below 1 pct., the data from GfK contain a very limited number of organic purchases. As a consequence, the uncertainty of estimated price premiums is large.

Table 4.1. The budget shares and prices for four varieties of chicken production, 2000-2002

Category	Budget share in %	Price per Kg
Conventional – not controlled for Campylobacter	94.0	43,29
Conventional - *Campylobacter* free	4.3	25.25
Barn	0.9	37.90
Organic	0.8	56.64
Total	100	-

Source: Baltzer (2002)

Baltzer (2002) finds that consumers substitute relatively easily between conventional Campylobacter-free chicken and conventional chicken that are not controlled for Campylobacter. Hence, if the price of conventional chicken drops against the price of Campylobacter-free chicken then consumers will increase consumption of conventional chicken at the expense of the Campylobacter-free variety. To the extent that market behaviour is able to capture consumers' preferences[39], this suggests that consumers find the price more important than the Campylobacter-free attribute. Similarly, low market shares of organic chicken suggest that consumers also place more emphasis on the price than on organic attributes such as animal welfare and pesticide free feed.

Consumption categorized according to convenience characteristics

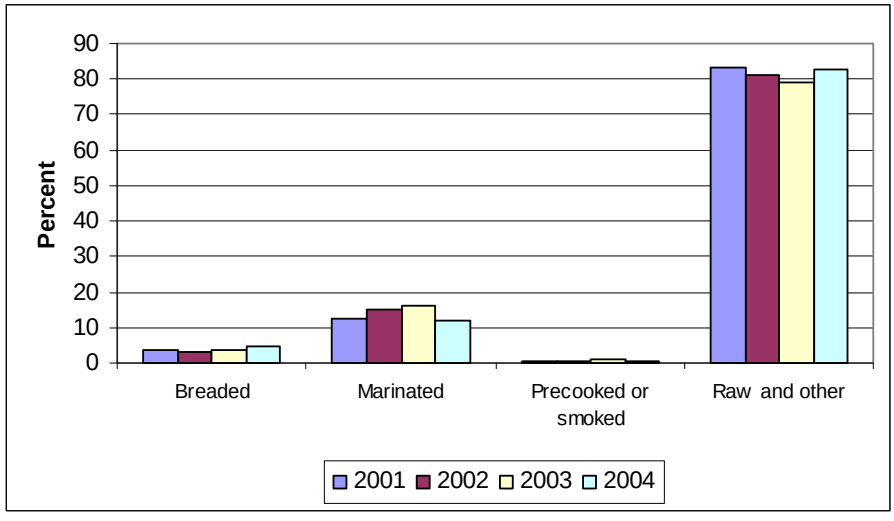
Market shares related to different levels of convenience are illustrated in Figure 4.1 for the period 2001-2004. Available categories in GfK data include *breaded*, *marinated*, *precooked or smoked*, and *raw*[40] *and other*. The large majority (80%) of

[39] The potential market failures are described in Chapter 1.

[40] Chilled chicken meat that is marinated with a of water, salt and sugar (*'neutralmarineret'*) is categorized as raw

chicken for private consumption are sold as *raw and other*. Between 10 and 20% of the products are sold as *marinated*, whereas *breaded* and *precooked or smoked* items constitute very low shares. These shares have been stable over this four-year period.

Figure 4.1. The market share (in quantities) for four convenience categories of chicken meat



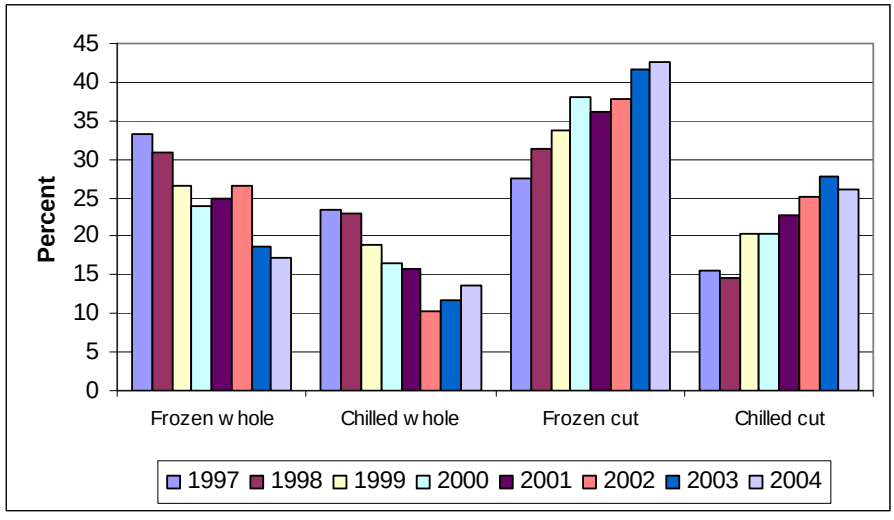
Source: GfK data.

Consumption categorized according to processing characteristics

Chicken consumption can also be categorised according to the four processing categories: *Frozen whole*, *chilled whole*, *frozen cut*, and *chilled cut*, market shares for the period 1997-2004 are shown in Figure 4.2. Chicken consumption has increased (by 22 %) and a shift from whole to cut/processed chicken.

Market investigations have shown that it is mainly busy families with children and young people that demand convenient processed chicken meat, whereas mainly elder consumers still demand whole chicken (Danish Poultry Council, 2005).

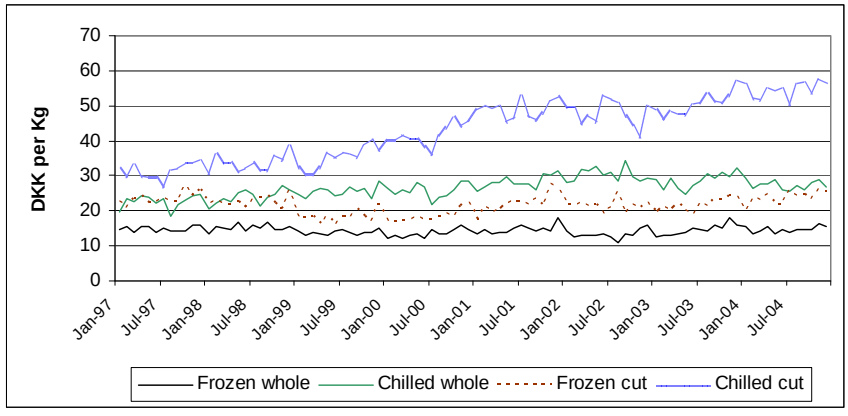
Figure 4.2. The market share of 4 different categories of chicken meat (based on quantities), 1997-2004



Source: GfK data.

Figure 4.3 presents the price development during the period 1997-2004. The prices of frozen chicken (whole as well as cut), and chilled whole have been relatively stable over the period. A clear increase in price is seen for *chilled cut* chicken, especially since early 1999. The average price of *chilled cut* chicken has increased from 31.5 DKK/kg in 1997 to 54.5 DKK/kg in 2004. One explanation could be that the average quality of the chilled cut chicken has increased, e.g. that consumption has shifted from wings towards breast, or that there has been an increased demand for convenience properties of chilled cut chicken during the recent years which has driven up the price.

Figure 4.3. The retail price of 4 categories of chicken meat for the period 1997 to 2004



Source: GfK data.

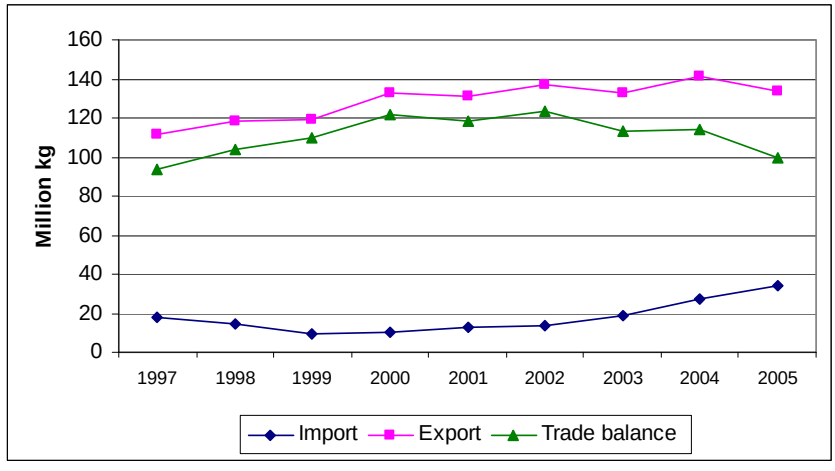
4.2. Foreign Trade

The trade balance, import and the export of chicken (meat and live fowls) are shown in Figure 4.4. Denmark is clearly a net-exporter of chicken but between 2002 and 2005, the net export has been decreasing.

Exports as well as imports of chicken have increased from 1997 to 2005. In 2005, almost 140 million kg of chicken was exported corresponding to a 20 % increase since 1997[41]. In the same period, chicken import increased from 20 million kg to 37 million kg corresponding to an increase of 85%.

[41] According to Danish Poultry Council (2008) p. 190, 19.7 million kg were export of live poultry fowls (hence, not only chicken, but chicken constitute the dominant part of the poultry production in Denmark).

Figure 4.4. Import, export, and trade balance for chicken (meat and live fowls) for the period 1997 – 2005 (in quantities)



Source: Own aggregations based on DST4.

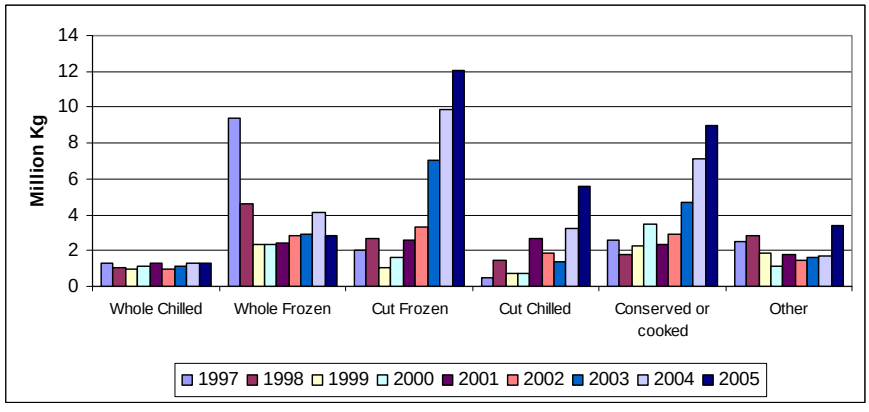
Import

Møller et al. (2008, p. 10), estimate the imported share of Danish chicken meat consumption to be around 40 %[42].

The composition of imported chicken meat has changed towards more processed meat (see Figure 4.5). In the late nineties, the import was dominated by *whole frozen* chicken. In 2005 the import was on the other hand clearly dominated by *cut frozen*, *cut chilled*, and *conserved or cooked* chicken, which all have experienced large growth rates.

[42] This corresponds well with Danish Poultry Council (2008) p. 190, where the imported share of chicken meat consumption in Denmark in 2005 is estimated to be 41,9 % of total consumption (private and industry).

Figure 4.5. Danish import of chicken (meat and live fowls) for 6 different product categories



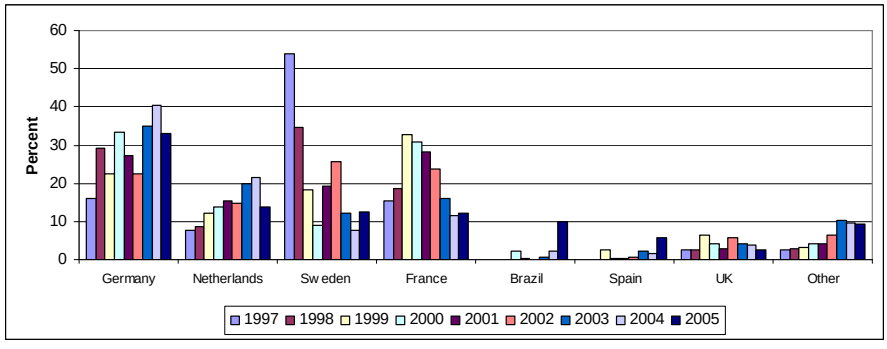
Source: Own aggregations based on DST4.

There have also been some shifts in the relative importance of the countries exporting chicken to Denmark, see Figure 4.6. Over the whole period (1997-2005), the majority of chicken meat is imported from Germany, the Netherlands, Sweden, and France. The last few years, Germany has been the largest contributor to Danish chicken import. Over the period, imports from Sweden and France have decreased and imports from the Netherlands and Germany have increased.

The imports from Brazil are remarkable because they in 2005 suddenly became the 5th largest exporter of chicken to Denmark. There seems to be an increasing number of countries exporting chicken to Denmark. In the period 1997-2002, Germany, Sweden, France and the Netherlands had 85-93 % of the Danish import market, but in 2005 this share had fallen to 72 % of the market. Important newcomers on the market are Brazil and Spain, but the market share of the group other has also been increasing.

Germany dominates the import market for *whole frozen*, *cut chilled*, and *cooked or conserved* chicken. The import from Sweden was in 2005 dominated by offal, while the Netherlands mainly exported various forms of processed chicken. In 2005, France supplied 84 % of the imported *whole chilled* chicken and 31 % of the *cut chilled* chicken. The overseas suppliers, Brazil and Thailand almost only supplied *cut frozen* and *conserved or cooked* chicken (based on DST4).

Figure 4.6. The composition of the Danish chicken (meat and live fowls) import for the period 1997-2005



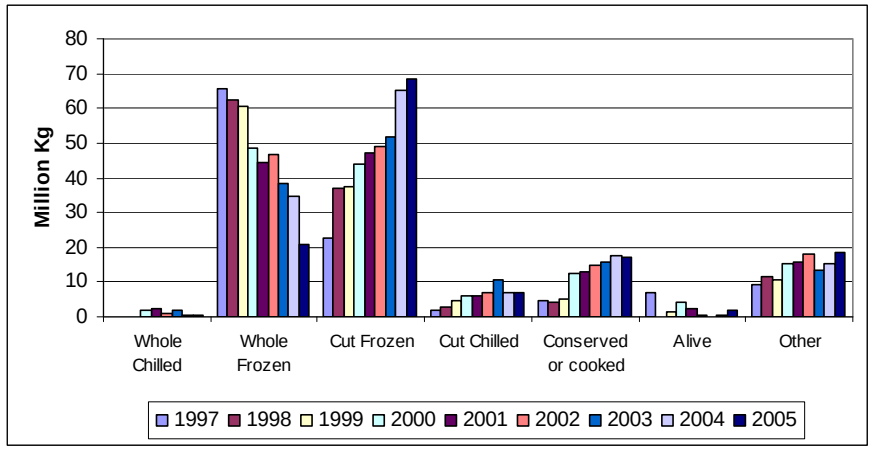
Source: Own aggregations based on DST4.

Export

Around 1/3 of the Danish poultry production are sold at the domestic market. (www.danishmeat.dk/Forside/publikationer/nyhedsbrevet_danishmeat/2009). This leaves around 2/3 of the poultry production to be exported where 10 % of the production is exported alive and almost 60 % of the production is exported as meat (Danish Poultry Council, 2009, p. 190). Denmark exported around 60 % of the production in 2005 (own calculations based on Danish Poultry Council (2007, p. 104).

The processing and convenience characteristics of Danish chicken export are shown on Figure 4.7. The export is highly dominated by frozen products. Frozen products make up 90 million kg out of the total exported quantity of close to 140 million kg in 2005. A clear shift is seen from *whole chicken* towards more processed varieties as *cut frozen*, *cut chilled*, and *conserved or cooked.*

Figure 4.7. Danish export of chicken for 7 different categories

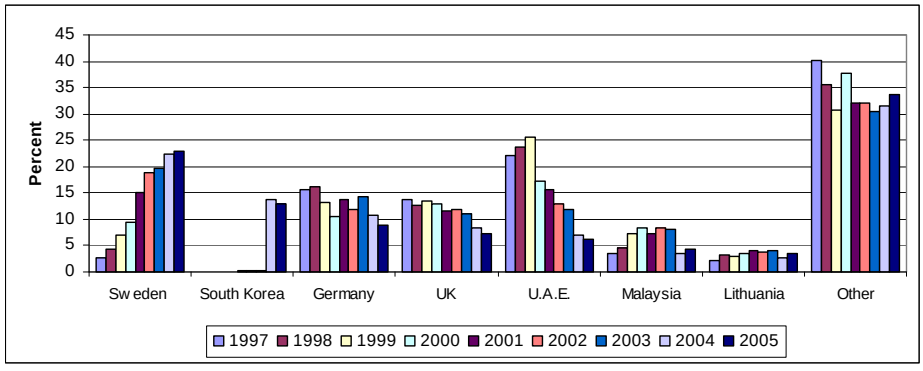


Source: Own aggregations based on DST4.

Figure 4.8 illustrates the development in export destinations for Danish chicken from 1997 to 2005. During that period, Denmark mainly exports to Sweden, Germany, the UK as well as the United Arab emirates (U.A.E), Malaysia and Lithuania. Within the European market the export to especially Sweden has grown fast and in 2005 it was by far the most important single market for Danish chicken export, with a share of nearly 25%. The export to South Korea was nearly non-existent until 2004 where it increased to 15 % of the total quantity exported. Decreasing shares of export are sent to Germany, U.A.E., and the United Kingdom. According to Danish Poultry Council (2005), the export to the United Kingdom has declined due to competition among retail chains, which has led to increased pressure on the price.

Frozen chicken dominates the Danish exports, although the export share of prepared chicken meat is also increasing (from a very low level). The high emphasis on frozen products suggest a potential for expanding export to markets far from Denmark. At the same time, the growth in exports of processed chicken may suggest the development of more high-value markets for Danish chicken meat.

Figure 4.8. The composition of the Danish chicken export distributed on the 7 largest importers of Danish chicken in 2005 and a category containing all other importing countries



Source: Own calculations based on DST4.

4.3. Summary and discussion on chicken

Chicken consumption increased by around 20 % between 1997 and 2005. For private households, especially the consumption of cut and processed chicken has increased, while consumption of whole chicken has decreased.

The sale of conventional chicken clearly dominates the market. Less than 1 % is sold as organic chicken in the period 1997-2004 and the *Campylobacter* free chicken was withdrawn from the market after low sales during the period 2000-2002[43]. These market shares indicate that consumers tend to have higher priorities for price and convenience than for food safety, animal welfare and organic qualities when they buy chicken meat.

Imports increased significantly between 1997 and 2005 and mainly imports of processed chicken. Chicken is mainly imported from Germany but also the Netherlands, Sweden, France and Brazil are important contributors to Danish import of chicken meat. As these imports mainly origin from other European countries with higher risks concerning *Salmonella, Campylobacter* and antimicrobial resistance (except Sweden),

[43] In 2008, Danpo sent 2 new products to the market: A *Campylobacter* free frozen chicken and an organic chicken produced in Denmark (www.danpo.dk).

the increased imports of chilled chicken meat may give rise to concern from a food safety perspective (EFSA, 2007a, 2007b; Anonymous, 2006).

Denmark is also a large exporter of chicken and export increased during the period (1997-2005). Especially the export of processed frozen products have increased while whole frozen have decreased. The main markets for Danish chicken have shifted from the Middle East towards Europe. In 2005, Sweden was by far the most important single market for Danish chicken export. Due to the high export orientation of the Danish chicken sector, food safety-motivated interventions that involve costs for the sector may stimulate export possibilities to foreign markets with a high priority for safety but may hinder export possibilities to those who do not consider safety as an important characteristic. At the same time, food safety interventions in export oriented industries will to a large extent benefit non-Danish consumers.

5. Egg market

Chapter 5 seeks to investigate trends in demand for eggs and egg and to evaluate whether these trends are supportive or destructive for reducing zoonotic risks in Denmark. Descriptions are provided for private consumption patterns (Section 5.1) and foreign trade (Section 5.2). Results are summarized and discussed (Section 5.3). Data are described in Appendix G.

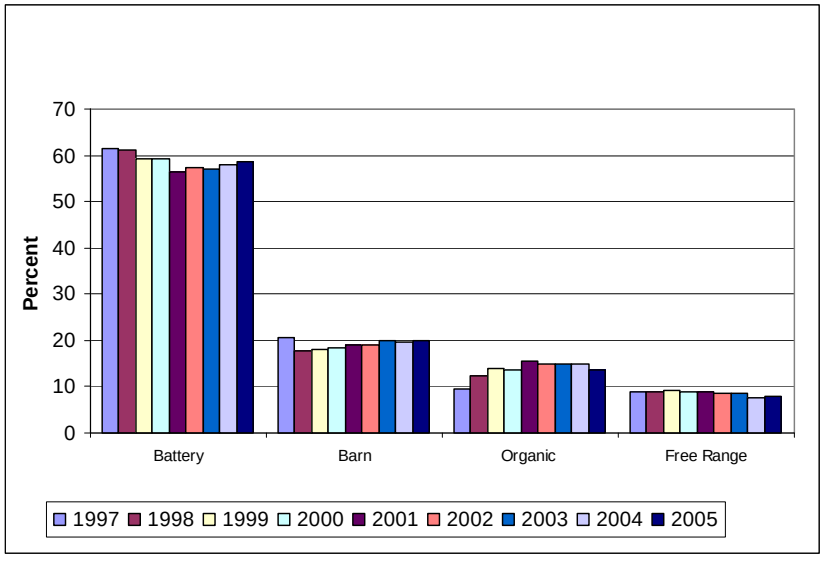
5.1. Consumption patterns

Egg consumption (by private households and the industry) increased around 25 % between 1997 and 2006 (Section 2.3) – with private household consumption accounting for around 80 % (own calculations based on DST2).

Consumption categorized according to production characteristics
The market for table eggs distinguishes itself by 40 % of it being table eggs from non-standard productions. Figure 5.1 presents the market shares of table eggs sold through authorized retailers categorized according to production system (pasteurized eggs and non-authorized farm gate sale are not included). During the period 1997-2005, *battery eggs* are with a market share of nearly 60 % the dominating variety on the Danish retail table egg market, *barn* eggs have a market share of 20 %, 9-16 % of table eggs are *organic,* and eggs from *free range* hens have a market share of a little less than 10 %.

Figure 5.1 indicates that sales of eggs from different production systems have been rather stable, and only a small tendency of substitution away from battery eggs and free range towards barn and organic eggs can be detected. The small market share of free range eggs might be due to problems with distinguishing free range eggs from barn eggs (Baltzer, 2002).

Figure 5.1. Market shares of table eggs from four different production systems, 1997-2005

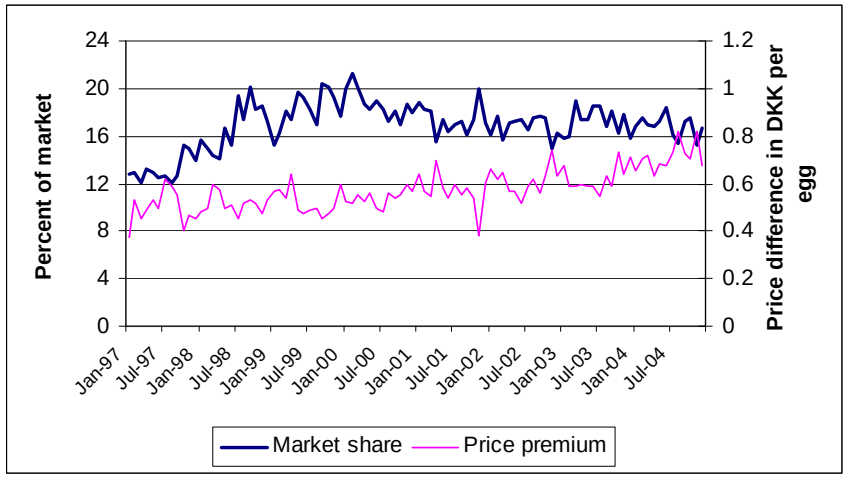


Source: DVFA (2005).

Figure 5.2 uses GfK data to illustrate price premiums and market share for organic eggs in the period 1997-2004.

There is no clear link between price premiums and sales of organic eggs. The price premium for organic eggs (compared to a weighted average of the other types of eggs) has increased over the period from around 8 % to around 12 %. At the same time, the market share of organic eggs increased slightly from around 12 % to 16 %. According to GfK data used in Figure 5.2, organic eggs hold market shares between 12 and 21 % for private consumption whereas using data from DVFA in Figure 5.1, organic market shares lie between 9 and 16 % when industry consumption is included.

Figure 5.2. Market share of organic eggs and the price premium paid for organic eggs, January 1997 - July 2004



Note: Estimated price premiums are compared with the weighted average price of all other egg types on the Danish egg market.

Source: Gfk data.

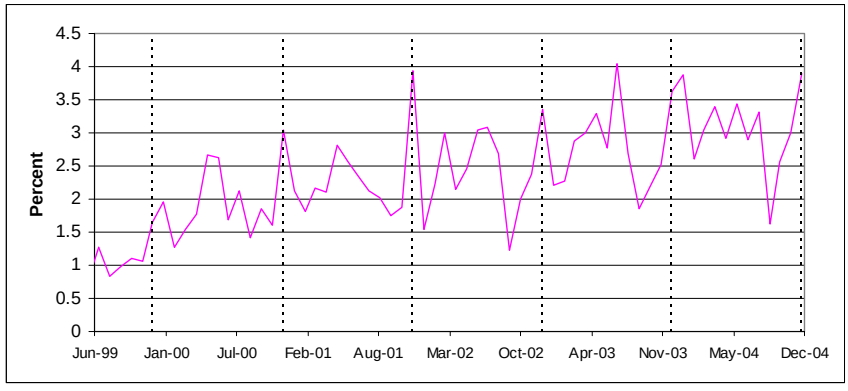
Consumption categorized according to processing characteristics

Figure 5.3 shows the share of pasteurized eggs relative to total quantity of eggs purchased by consumers between 1999 and 2004.

The egg market is heavily dominated by table eggs as the share of pasteurized eggs constitutes 1-4 % of the total sale with an increasing tendency[44]. The market share of pasteurized eggs fluctuates a lot over the year. There is a peak every year around December and January and during the summertime. It is thus clear that pasteurized eggs for a large part are used in seasonal dishes.

[44] The market for pasteurized eggs was kick started in 2000 because two persons died because they had eaten a cake made with raw eggs (Smed, 2002).

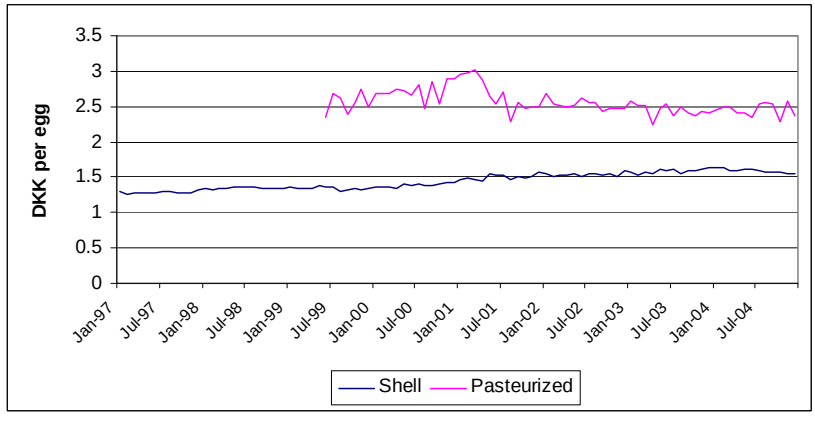
Figure 5.3. The market share of pasteurized eggs. Dotted vertical lines mark the month of December, June 1999 – December 2004



Source: GfK data.

The prices for both pasteurized eggs and table eggs are shown on Figure 5.4. Data for pasteurized eggs are only available from 1999 to 2004 while data for table eggs exist for 1997 and 1998 as well. There is a considerable price premium for pasteurized eggs as price for the pasteurized variety is approximately DKK 2.5/egg and the price for table eggs is in the range DKK 1.3-1.6.

Figure 5.4. The price of respectively table eggs and pasteurized eggs, 1997-2004



Source Gfk data.

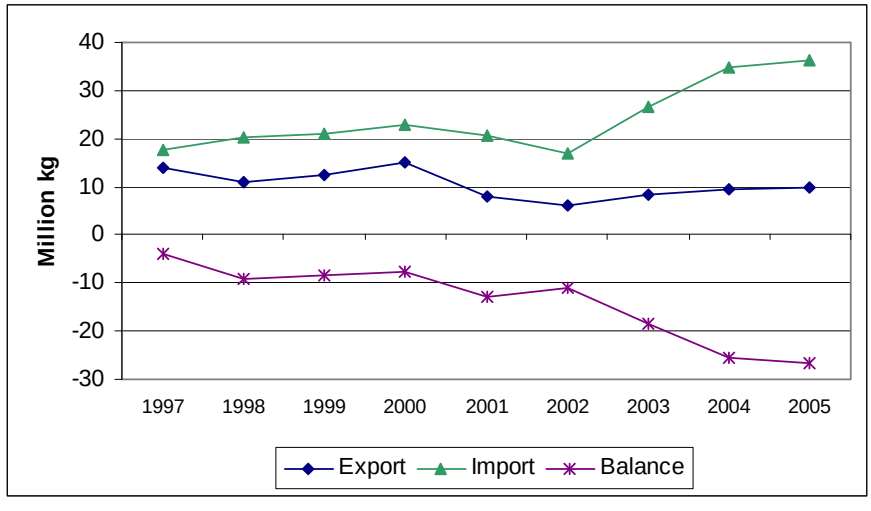
The slight increase in the price of table eggs might indicate increases in real prices or changes in composition of table eggs from battery eggs towards eggs from more animal-friendly production systems. The price of pasteurized eggs[45] has had a more stable development, although there seems to have been a downward shift in the price and the price volatility in the second half of 2001. The average price premium on pasteurized eggs relative to table eggs has thus declined over the period, which all else equal should enhance consumers' economic motives to extend their consumption of pasteurized eggs.

5.2. Foreign Trade

Trade balance

Denmark is a net-importer of eggs as can be seen in Figure 5.5. Between 1997 and 2002, net imports were around 10 million kg. Since 2002, net imports have increased to almost 30 million kg in 2005. The change in net trade is due to increased imports while exports have been rather stable.

Figure 5.5. The import, export and trade balance for eggs



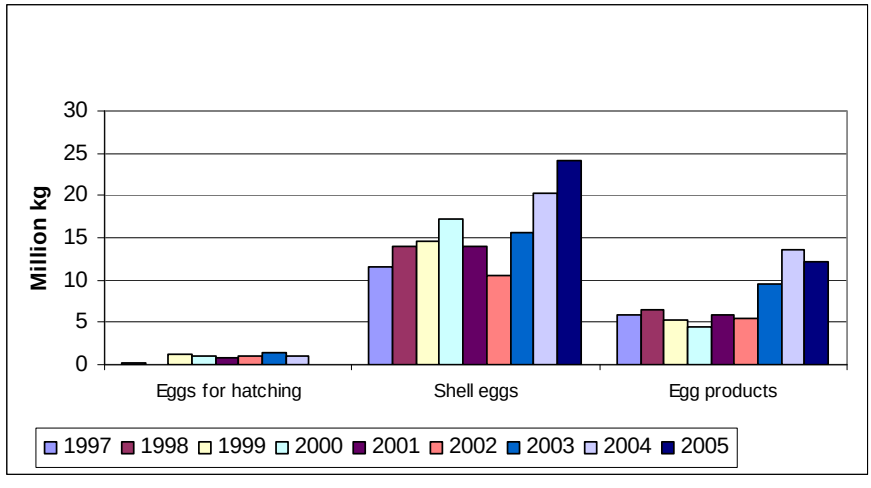
Source: Own aggregations based on DST4.

[45] Pasteurized eggs are sold in small cups usually containing either two egg yolks or one and a half egg white. One cup is here defined as one egg.

Import

Imports of eggs have increased between 1997 and 2005 (Figure 5.5). In Figure 5.6, the composition of Danish egg import according to processing characteristics is shown. As DST4 data are used, it is not possible to identify to what extent imports are re-exported. Imports of table eggs and egg products have increased while the import of eggs for hatching has been relatively stable at a low level. Imported eggs are mainly used by the industry but imported table eggs are also sold in Danish shops. According to DVFA (2006), the import of table eggs constituted 25-30 % of total consumption of table eggs but was hardly expected to contribute to human salmonellosis as the import was mainly for industrial purposes.

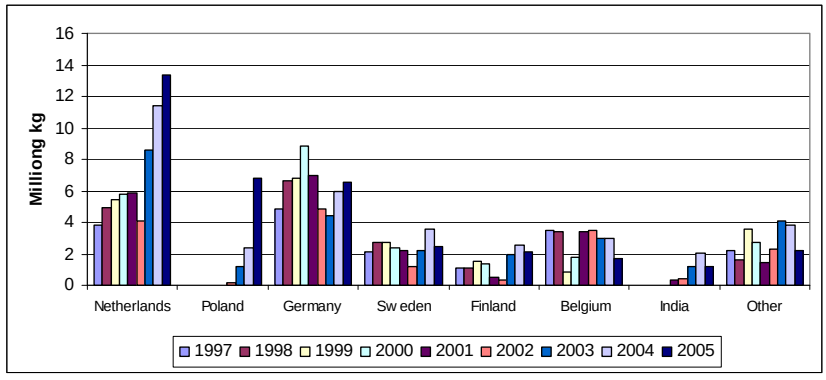
Figure 5.6. The composition of the egg import, 1997 - 2005



Source: Own aggregations based on DST4.

In Figure 5.7, Danish egg import is categorized according to country of origin during the period 1997 to 2005. The Netherlands was the largest exporter of eggs to Denmark in 2005 followed by Germany, Sweden, Belgium, Finland, and India (only dried egg). Based on preliminary data from the first 6 months of 2006, Poland experiences a fast growth on the Danish market.

Figure 5.7. The main exporters of eggs to Denmark ranked according to size of export to Denmark in 2005, 1997-2005

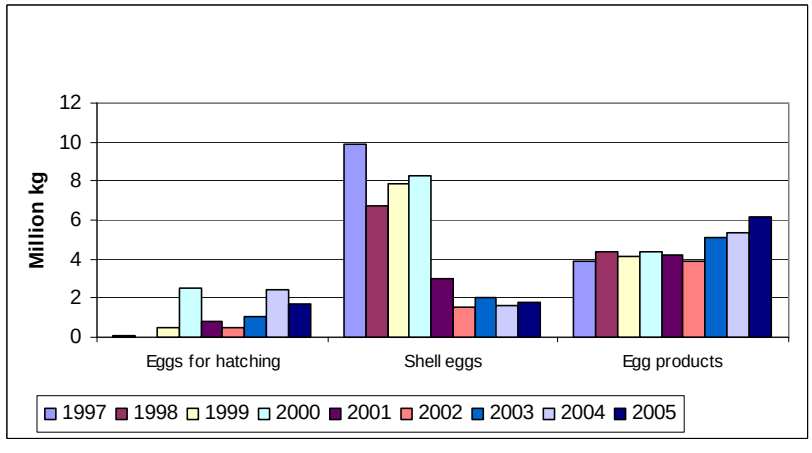


Source: Own calculation based on DST4.

Export

The overall level of export has been rather stable between 1997 and 2005 (Figure 5.5) but the composition has changed (Figure 5.8). From 1997 to 2000, table eggs dominated the Danish egg export. In 2001, there was a dramatic fall in the export of table eggs followed by increasing exports of eggs for hatching and egg products.

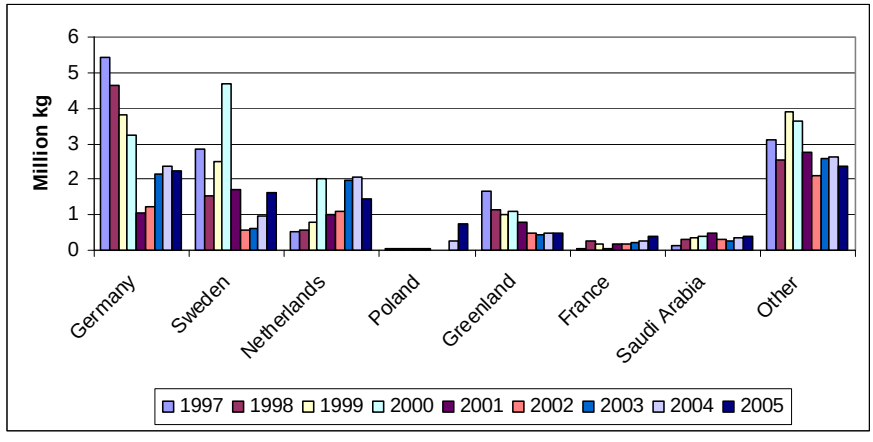
Figure 5.8. Shows the product composition of the Danish egg export, 1997-2005



Source: Own calculations based on DST4.

Even though export to Germany decreased during the period from 1997-2005, Germany was still the largest importer of Danish eggs, closely followed by the Netherlands and Sweden (although the export to Sweden has also fallen), see Figure 5.9. However, it is interesting to note that Poland started to import table eggs in 2006 and in the first 6 months in 2006 they were the largest importer of Danish table eggs (data for 2006 are not shown).

Figure 5.9. The main importers of eggs from Denmark ranked according to size of import in 2005



Source: Own calculations based on DST4.

Foreign trade in organic eggs

The import of organic eggs is very little. In 2004, the import only amounted to a value of 157,000 DKK and it was only from Nordic countries (DST4), which are known to have high food safety standards (Danish Poultry Council, 2005). Barn and free range eggs have almost not been imported by authorised Danish egg packers in the period 2000-2005 (DVFA, 2005). The export of organic eggs directly from authorized egg packers has however increased substantially since 2000. The export of organic eggs has risen from approximately 1 % in 2000 to approximately 9 % of the organic egg production in 2005 (own calculations based on DST2 and the DVFA, 2005). This estimate is probably a lower-end estimate of the total organic egg export, as it only covers export directly from egg packers.

5.3. Summary and discussion on eggs

The market for table eggs distinguishes itself by its large share of eggs from non-standard productions (barn, free range, and organic). In 2004, 40% of the table eggs were produced in non-standard productions. Since 1997, a large increase in the sale of organic eggs has been seen. The large market share for non-standard eggs indicates a large awareness among consumers for welfare among egg laying hens. No significant differences between Salmonella prevalence in flocks from different production systems have been found and there are no known differences in *Campylobacter* risks (these are generally considered to be low in eggs). Hence, there are no documented additional *Salmonella* or *Campylobacter* risks associated with the large market share of non-standard eggs.

Compared with the low Danish consumers' preferences for safer meat products, the consumers tend to have a growing awareness of the potential food hazards related to eggs as indicated by the increasing (but still at a low level) demand for pasteurized eggs (4 % in 2004).

The import of eggs increased from 2002-2004 which could, potentially, pose increased food risk as *Salmonella* prevalence in eggs in other countries are typically significantly larger than in Denmark (eggs from e.g. Sweden constitute an exception). However, as the majority of imported eggs are used for egg products (e.g. cakes), the safety risks related to higher prevalence in imported eggs is substantially reduced (Table 1.2)[46]. Denmark expects to obtain special status in the EU for being able to ban eggs and chicken meat with a non-zero Salmonella risk[47]. In addition, at EU level there are restrictions on trade with eggs from *Salmonella typhimurium* or *Salmonella enteritidis* positive layer flocks – they can not be sold as eggs for private consumption[48].

[46] Information is kindly provided by Peter Bertelsen, Danish Poultry Council, personal communication, 2006.

[47] The application for eggs has been approved in EU and it is expected that it will be approved by WTO in the autumn 2009 (Press release May 19 2009, www.foedevarestyrelsen.dk/Nyheder/Nyheder/2009/saerstatus_salmonella_aeg) while the application concerning chicken meat has not been processed in the EU yet.

[48] See (EF) Nr. 1237/2007. Forordn. om ændring af Europa-Parlamentets og Rådets forordning (EF) nr. 2160/2003 og af Rådets beslutning 2006/696/EF for så vidt angår markedsføring af æg fra salmonellainficerede flokke af æglæggende høner. We want to thank Gudrun Sandøe, Danish Veterinary and Food Administration, for this reference.

The Danish egg market is more domestically oriented than the meat markets. Danish eggs (especially table eggs) hold a very strong market position on the domestic market. Eggs sold to Danish households are predominantly of domestic origin. Hence, in contrast to the situation for the pork and chicken sectors, food safety motivated policy interventions in the egg sector will to a large extent benefit the health of domestic consumers.

6. Conclusion and perspectives

Risk and consumption

Over the recent years, there have been twice as many cases of campylobacteriosis as of salmonellosis per year but at the same time salmonellosis have caused twice as many premature deaths as campylobacteriosis.

In 2007, one out of four cases of salmonellosis could be linked to food purchased in Denmark. Roughly similar shares of salmonellosis were linked to eggs, Danish meat, and imported meat, respectively. Additionally, one out of four cases of salmonellosis was registered as being acquired domestically but of unknown source. For campylobacteriosis, roughly two out of three cases were linked to food purchased in Denmark[49]. The main sources of *Salmonella* infections are pork, poultry, and eggs while *Campylobacter* infections are mainly linked to poultry. Hence, it seems appropriate that policy measures to reduce zoonotic infections are targeted towards these markets.

At the same time, considerable shares of the zoonotic infections are likely to be linked to pork and poultry produced outside Denmark. Firstly, because one out of two cases of salmonellosis and one out of three cases of campylobacteriosis are estimated to be linked to travel. Secondly, import account for 20-25% of pork and 40 % of chicken meat bought in Danish shops. In addition, 25-30 % of eggs are imported – mainly for industrial use and therefore subject to heat treatment. So, even though the Danish pig and poultry sectors may appear to be straightforward objects for intervention, policy measures outside Denmark are also necessary for reducing zoonotic risks to Danish consumers.

Due to the Danish *Salmonella* source account system, it is possible to estimate the source in terms of type of animal product and place of origin for one out of two registered domestically acquired cases of Salmonella. Further improvement of the system as well as implementation of similar systems for *Campylobacter* would certainly increase the precision and validity of data that are used in political decisions. So would an increase in the precision of the registration rate. It is also worth mentioning that the present report has focused on prevalence of pathogenic bacteria. The number of *Campylobacter* and *Salmonella* bacteria in the meat is also extremely important for the risk of human illness. A systematic communication of the number of bacteria in dif-

[49] No detailed source accounts are available for *Campylobacter*. *H*ence, a division of cases from domestic versus imported food is not possible for campylobacteriosis.

ferent types of meat and eggs would therefore shed valuable light on the links between risks in the product and human risks.

The *Salmonella* source account suggests that pork is linked to roughly twice as many human cases of salmonellosis as chicken[50] (2005–2007 data). Can this difference in human incidence be directly linked to differences in the *Salmonella* prevalence between the two meat types? In order to address that question, we tried to address the human exposure by considering the differences in prevalence of *Salmonella* between imported and domestic meat, the proportion of imported meat for consumption, and the relative intake of pork and chicken meat. By adjusting for these factors, we predicted that pork should be responsible for two to five times as many human cases of salmonellosis as chicken meat[51]. Despite a relatively large uncertainty, the result suggests that we should expect even more cases of salmonellosis from pork compared to chicken meat than estimated by the source account. Our calculations indicate the presence of product specific factors, not captured in the calculated exposure estimate, that influence the human incidence. In particular, we suggest that product specific factors such as specific characteristics of the food type[52], differences between handling and preparing chicken vs. pork, differences in the bacterial load in the meat, differences in the subtype distribution of *Salmonella*[53], differences in sampling methods and differences in how easy the bacteria are to sample – all these factors are worth looking into in order to improve our understanding of zoonotic risks related to fresh meat and its impact on human health.

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[50] More precisely 1.7 = 7.8 %/4.5 %

[51] **Using slaughter data for pork prevalens (1.1%):** Average prevalens in pork when adjusting for import: 4.1% = 0.75*1.1%+0.25*13.1% and in chicken meat 6.76% = 0.6*1.6 +0.4*14.5%. Increased risk when adjusting for differences in intake of pork and chicken meat: 1.8=4.1%/6.76%*3. We have said that 1.8 ≈ **2**.
Using case-by-case data for pork prevalens (11.3%): Average prevalens in pork when adjusting for import: 11.75% = 0.75*11.3%+0.25*13.1% and in chicken meat 6.76% = 0.6*1.6 +0.4*14.5%. Increased risk when adjusting for differences in intake of pork and chicken meat: **5.2**=11.75%/6.76%*3.

[52] Pork consumption might to a larger extend than chicken meat consumption be sold as ready-to-eat products with generally a low risk. This could drive some of the difference between the exposure estimate and the prevalence is of raw/fresh meat.

[53] Pires & Hald (forthcoming) found that by comparing Salmonella subtypes from humans with the distribution of the same subtypes in food-animal sources, the proportion of cases that can be attributed to each source can be estimated. In addition, they investigated the ability of different subtypes to result in reported human infections and of food sources to act as a vehicle for disease. They estimated the number of sporadic cases attributable to different *Salmonella* subtypes as a function of the prevalence of these subtypes in the animal-food sources, the amount of food consumed, subtype-related factors, and source-related factors.

Egg contributes to a fair share of the *Salmonella* cases despite the fact that risks from domestic eggs are considered small. This suggests that consumers' handling of eggs and (to the extend, that imported table eggs are sold in Danish shops), a higher *Salmonella* prevalence in imported tale eggs might be risk factors that are worth looking into in relation to reducing the human cases of salmonellosis.

Campylobacteriosis is mainly linked to poultry meat, which covers 20 % of the overall meat consumption. At the same time, the number of cases of campylobacteriosis in recent years has been twice as high as the total number of *Salmonella* infections. Hence, *Campylobacter* in chicken might be considered to be the largest of the zoonotic hazard that we have looked at, that Danish consumers face presently.

A conclusion based on the situation in 2005-2007 suggests that chicken pose the largest bacterial problem, especially with respect to *Campylobacter*. *Salmonella* risks in Danish chicken are small but *Salmonella* risks in imported chicken are rather high. In addition, a large share of chicken has large numbers of *Campylobacter.* It is considered that none or hardly any *Campylobacter* risks are linked to pork and eggs.

The main picture of trade is that Denmark is a net-exporter of chicken and of pork and a net-importer of eggs (mainly for processing).

Trends

The high consumption of pork has a slightly decreasing trend whereas consumptions of eggs and (in particular) chicken meat have been increasing during the last 10-15 years.

The import share of chicken consumption in Denmark has been increasing during the last decade. As the prevalence of *Salmonella* and *Campylobacter* typically appear to be higher in the countries-of-origin of these imports, compared with domestic production, the increased import poses an additional food safety risk. As most of these imports come from EU member states, risks could potentially be reduced through common EU food safety standards.

Large – and increasing – shares of Danish pork and chicken production are exported. Hence, interventions to increase safety in the supply of these products may to a large extent result in improvements that will benefit consumers in export destination countries rather than the domestic consumers. This is a positive development from an

overall global perspective but it may pose a big challenge for the creation of national incentives to intervene. The vast majority of the Danish pork and chicken productions are exported to markets with high degree of price competition. This may make it difficult for producers to pass the increased costs on to consumers by increasing the sales price if consumers in those countries do not consider food safety as a product characteristic they are willing to pay a price premium for.

The average Danish household in 2005 spent 10 % on food out of their total expenditures compared to 13 % in 1990. And, compared with other European countries, the share of total budget allocated to food in Denmark seems to be below average. In addition, evidence from the present overview of Danish markets indicates that Danish consumers do not demonstrate high concern for microbiological food safety and their willingness to pay a higher price for safer products seems to be relatively low, compared to other product characteristics. These trends indicate that an average person in Denmark has a relatively low willingness to pay for safer food and for food in general.

The small market shares of safer food varieties indicate that consumers are not willing to pay for safety. To the extent that this is true, policy intervention leading to increased costs of domestic products might lead to reduced demand for these products and trigger an increase in the consumption of imported products – thereby possibly reducing the average level of food safety rather than increasing it. Such mechanisms should be taken into account in the scoping and design of new policy interventions. Research into these trends and into possibilities for changing perceptions and behaviour towards increased appreciations of safer products might be an instrument to increase market based food safety.

At the same time, Denmark has the world's highest share of organic consumption (Willer & Yussefi 2007)[54] – and recent growth rates in consumption indicate increased importance of the organic markets in the future. It should be kept in mind, though, that the vast majority of consumption still originates from conventional production. For example, 6 % of total food and beverages sold in Denmark in 2006 were organic (Denver et al., 2007). As an interesting annex, recent research indicates that organic consumers do not spend more money on food than non-organic consumers due to changes in the composition of their food consumption (Denver et al., 2007).

[54] Followed by Switzerland, Germany, The US, Great Britain, and France.

The importance of relations between risk and quality characteristics for the overall public health depends on how much consumers eat of the different types of meat and egg. The market shares for organic chicken meat and pork are very small (around 1 % in 2004) whereas the market share for organic eggs was around 15 % in 2004. For all categories, increasing market shares for the organic variety are observed. With respect to reducing *Salmonella* risks, this trend seems to be a good thing because the *Salmonella* prevalens tends to be lower in non-conventional pig herds than in conventional pig herds, no significant differences between Salmonella prevalens in egg layer flocks from different production systems have been found (and the prevalens is generally very low in egg layer flocks), and no differences between chicken meat from different production systems have been documented due to lack of data (but the prevalence is generally very low in conventional flocks) When the aim is to reduce *Campylobacter* risks, increased sales of organic chicken meat is a negative thing, increased sales of pork and eggs do not pose any known risks as there are no known differences in *Campylobacter* risks with respect to different production systems – and generally, the *Campylobacter* risks are considered to be neglectible in pork and eggs.

Policy perspectives

No single policy initiative can possibly incorporate all the above hazards and trends. As a consequence, we might suggest several policy initiatives that might reduce zoonotic risks. First, it could be made more attractive to buy goods with reduced zoonotic risks (stimulate demand). This could be done by making safer food relatively cheaper, through labelling, easier accessibility, etc. Second, consumers' knowledge about zoonotic risks and how to avoid them could be increased (educate consumers). Third, knowledge about the sources of human infections could be increased (stimulate research). Fourth, the supply of safer food could be increased. This could be done by putting increased pressure on the Danish meat producers as well as putting increased pressure on countries that export meat to Denmark and countries that receive Danish travellers. In particular, as the safety level of Danish food production is relatively high by international standards, one appropriate target for policy interventions (which is already pursued) would be to further reduce the inflow foods with high prevalence of zoonoses or microbial resistance, e.g. import restrictions or bans. However, a more long sighted strategy might be to put pressure on other countries to reduce risks (stimulate the international political environment). The expected Danish achievement of an EU special status for eggs (with a zero tolerance) is a very recent example of how to use the international institutions to increase food safety. When considering such types of interventions, account should however be taken of international trade

regulations, within the European Union as well as in the World Trade Organisation, that are formulated to avoid trade barriers.

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Appendix A. Methodology

The methodology of the present report is to use descriptive statistics. Specifically, market sizes and trends are described through various indicators of production, consumption, and international trade that have been selected according to their relevance and availability. Arguments for inclusion of the indicators are shortly presented below.

Production
A description of food production is relevant in order to address the potential domestic sources of zoonoses in foods, as well as for determining an order of magnitude against which the costs of e.g. food safety motivated policy interventions could be assessed. Two types of indicators are used in the description of Danish production, both addressing the output value of the Danish food industry.

- The absolute *output value* of the Danish food and beverage industry, measured in 2000 price level, provides an indication of the absolute magnitude of this industry. In addition, the development in fixed-price output value of the food and beverage industry over time can be interpreted as an aggregate index of produced quantity from this industry.
- Dividing the food and beverage industry output value by the national aggregate output value yields a *relative output value*, which represents the economic significance of the food and beverage industry in a macro-economic context.

Consumption
A description of food consumption patterns is important for identifying the possible sources of zoonotic infections. Furthermore, the efficiency and economic consequences of policy actions to improve microbiological food safety depend consumption patterns and expenditures have roles to play regarding the. Three types of consumption indicators are used in the descriptive analysis.

- The *total food and beverage consumption expenditure* provides an order of magnitude regarding the economic importance of food consumption, and hence an economic reference for measuring consumer-related costs of food safety interventions. In addition, the fixed-price development in food and

beverage consumption expenditure over time can be interpreted as an aggregate quantity index of food and beverage consumption.

- Another quantity indicator is the *consumed physical quantity of selected foods*. This indicator is more suitable when aggregating relatively homogeneous types of foods, e.g. different types of meat. Physical quantities are measured in aggregate figures as well as in per capita figures.
- When addressing the importance of special quality varieties (e.g. organic, free-range) on the market, we use the *market share of specific qualities* (e.g. organic eggs' share of total eggs' sales) measured as expenditure shares as an indicator. This indicator represents the consumers' allocation of the consumption budget towards such quality varieties and hence reflects their priorities. On the other hand, as the prices may differ across quality varieties, such market shares can normally not be interpreted directly as quantity shares of the market.

International trade

International trade plays an important role regarding food safety interventions in domestic supply. On the one hand, the content of pathogens in imported food products is not affected by policy measures addressing domestic production. On the other hand, pathogen reductions in products that are exported do not directly benefit domestic consumers. Three types of indicators are used to describe food trade.

- The *trade balance in selected food categories* measured in monetary terms indicates the extent to which Denmark has a net inflow or net outflow of the respective food types – or of food in general. For specific product categories, the *import quantities* illustrate the extent to which domestic consumers are exposed to imported foods versus domestically produced foods.
- On the other hand, *export quantities* describe the extent to which benefits from safety improvements in domestic food production is exported.
- As the prevalence and types of different zoonoses may vary according to product type and country of origin, the report includes indicators of the *distribution of imports and exports on product type and country of origin/destination*.

Prices and price premiums

Prices reflect information about supply costs as well consumers' demand and hence willingness to pay for commodities. In the present context, this is especially relevant

when comparing different quality varieties of food products, for example the extent to which food products with certain attributes can be marketed and sold a higher price than without these attributes. This aspect is represented by two types of indicators:

- *absolute prices* and their development over time, and
- price premiums for certain quality varieties.

Appendix B. An overview of data sources

The report builds mainly on publicly available data related to the Danish food markets including data from the national statistical bureau (Statistics Denmark, DST), an extensive panel dataset on household consumption from the market analysis company GfK, as well as yearly statistics from Danish Poultry Council, Danish Veterinary and Food Administration, and Eurostat. An overview of the data sources used is given in Table B.1 followed by a description of the individual data sources.

Table B.1. Data sources

Data source		Period	Comments	Used for chapter
DST	National account (DST1)	1990-2004	*Production and consumption data for food and beverages* Measured in values Production data: 1990-2004. Cover production for private consumption Consumption data: 1990-2006. Cover private expenditures only. Detailed consumption data on individual meat categories available for 1990-2004	2
	Agricultural Statistics (DST2)	1990-2007	*Production and consumption data* All measured in quantities[55] Productions of pork and chicken refer to slaughtered weight. Consumption data includes private and industrial consumption.	2, 3, 5
	Foreign trade, main categories (DST3)	1990-2006	Measured in quantities. Includes main categories of foreign trade. Broader categories than DST1 and DST2 Distinguishes between organic/not organic.	2
	Foreign trade detailed categories (DST4)	1997-2006	Only quantity measures are used. Detailed description of foreign trade.	3, 4, 5
GfK		1997-2004	Measured in volume and value Panel data on household consumption. Detailed description.	3, 4, 5
Danish Poultry Council		1999-2005	Measured in quantities Detailed data based on reports from chicken abattoirs Distinguishes between chicken /other poultry and identifies domestic production, domestic stocks, sale for home market and export..	4
The Danish Veterinary and Food Administration		1997-2005	Data on egg turn over based on reports from egg packing companies	5
Eurostat		1990-2005	Pan-European data on food consumption	2

Statistics Denmark (DST)

DST provides several statistics. For the present purpose, data have been drawn from the national account statistics (DST1), the agricultural statistics (DST2), and the foreign trade statistics (DST3 and DST4). National account data (DST1) are used in Chapter 2 to give an overview of the food and beverage market, including data on production, consumption and foreign trade for the period 1990-2005. In addition,

[55] Source: oral communication with Ole Nielsen (2006) and www.statistikbanken.dk.

DST1 provide information about consumption of individual meat categories for the period 1990-2002. Agricultural statistics data (DST2) provide information about consumption and production of various animal products (measured in quantities) for the period 1990-2002. Data on trade with food and beverages in general is provided by (DST3) for the period 1990-2005 while detailed data on trade with different types of pork, chicken and eggs is found in DST4 for the period 1997-2005. Note that the foreign trade statistics has a 2 year lack in the final approval of data. Therefore, data from 2004 and 2005 are preliminary data.

United Nations standard international trade classification (SITC) is used for the description of foreign trade. The definition of *food* in SITC includes both products for human and animal consumption (United Nations Statistics Division's website, 2006)[56].

The GfK Consumer Scan household panel dataset

GfK household consumption data are more detailed than data from Statistics Denmark with respect to the different types of the products pork, chicken and eggs that are purchased. Furthermore, GfK data include only private households' consumption. GfK panel data from the Consumer Scan panel are used in the detailed analyses of pork, chicken, and egg consumption. The GfK data are based on approximately 2000 households. On a weekly basis, all households report their purchases of groceries, including food. The households keep a diary, where they for all grocery groups (among other commodity groups) note:

- Quantity (number or gram)
- Price (DKK)
- Brand
- Type (e.g. frozen or fresh)
- Place of purchase (e.g. Netto)
- Variant size (e.g. 20 piece package)
- On offer/not on offer

The available GfK data are available for 2001-2004, and hence does not include the most recent developments in food consumption at the household level. The likely importance of this will be discussed in relation to the individual results in the following chapters.

[56] For example, the category *food* in the present analysis does not include the category '*group 08: Feeding stuff for animals (less un-milled cereal)*' while beverages oppositely has been added

Danish Poultry Council (Det danske fjerkræråd)
Danish Poultry Council publishes statistics based on reports from the Danish chicken abattoirs, where the total sale of chicken from the abattoirs is registered. Both private and industry consumptions are thus included. The statistic distinguishes itself from Statistics Denmark by registration of chicken separately from other poultry and by registration of sale for the Danish home market. Data for the period 1990-2005 are used.

The Danish Veterinary and Food Administration
The Danish Veterinary and Food Administration provides a number of statistics. In the present analyses, registrations of the turnover of eggs for all egg-packing companies for the period 1990-2005 have been used. These statistics include quality of eggs, whether the eggs are graded or not, place of origin, and to whom they are sold - all of which are registered on a quarterly basis.

Eurostat
The European statistical office (Eurostat) provides comparable statistics for the EU member states. Data for the period 1990-2005 from Eurostat are used for comparing Danish figures with data from similar countries.

Appendix C. Categories in Statistics Denmark

DST1

Description of the categories based on the database that we denote DST1 that are used to describe production and consumption. The figures are drawn from the National Account statistics[57]:

- NAT05[58]: Private consumption (DKK mill.) by classification of individual consumption and price unit
- NAT07[59]: Production etc. (DKK mill.) by kind of activity, variable and price unit

Table C.1. Description of categories based on DST1

Our categories	Classification in DST1	
	Production	**Consumption**
Food and beverage	1509 Mfr. of food, beverages and tobacco (tobacco subtracted)	The sum of this column
Meat	151000 Production etc. of meat and meat products	1120 Meat
Fish	152000 Processing and preserving of fish and fish products	1130 Fish
Fruit and vege-tables	153000 Processing and preserving of fruit and vegetables	1160 Fruit and vegetables except potatoes 1171 Potatoes etc.
Dairy	155000 Mfr. of dairy products	1142 Milk, cream, yoghurt etc. 1143 Cheese 1150 Butter, oils, and fat
Other	158109 Mfr. of bread, cakes and bis-cuits 158120 Bakers shops 158300 Manufactures of sugar 156009 Mfr. of starch, chocolate and sugar products *(incl. mfr. eggs)* 154000 Mfr. of vegetable and animal oils and fats	1110 Bread and cereals 1181 Sugar 1182 Ice cream, chocolate and confection-ery 1190 Food products n.e.c.
Beverage	159000 Manufactures of beverages	120 Non-alcoholic beverages 210 Alcoholic beverages
Eggs		1141 Eggs

[57] "Statistikbanken" under the sub-category "Nationalregnskab, betalings- og kapitalbalance" and "afsluttede serier".
[58] "NAT07X: Produktion mv. (mio.kr) efter branche, anvendelsesident og prisenhed".
[59] "NAT05X: ENS95 – Privatforbrug (mio.kr) efter forbrugergruppe og prisenhed ".

DST2

The list below describes the aggregated categories in the report that are based on the database that we denote DST2. The data are used to describe consumption of meat. The figures are drawn from statistics for Agriculture, consumption of foodstuffs FVF 1 Human consumption of food by type and unit (per year)[60]. The categories cover "meat available for private and industrial consumption" and they are measured in million kilos.

Table C.2. Description of categories based on DST2

Our Categories	Classification in DST2
Meat total	Meat, total
Beef	Beef and veal Edible offals of cattle
Pork	Pig meat Edible offals of pigs
Poultry	Poultry meat
Other	Horse meat Mutton and lamb Game meat
Eggs	Eggs, total

DST3

The table below contains a description of the aggregated categories in the report that are based on the database that we denote DST3. Figures are drawn from the following statistics describing external trade[61]:

- SITC5R3Y: Im- and export (rev.3) according to import and export, SITC-main categories, country and unit'

[60] "Statistikbanken' under 'Landbrug/Fødevareforbrug" and the sub-c ategory "FVF1: Fødevareforbrug efter type og enhed og (år)".

[61] "Statistikbanken' under 'Udenrigshandel" and sub-category "SITC5R3Y: Im- eksport efter im-og eksport, SITC hovedgrupper, land og enhed".

Table C.3. Description of categories based on DST3	
Categories	**Classification in DST3**
Food and beverage	The sum of this column
Meat	00 Live animals (except fish, crustaceans, molluscs and aquatic invertebrates) 01 Meat and meat preparations
Fish	03 Fish (Not marine mammals), crustaceans, molluscs and aquatic invertebrates, and preparations thereof
Fruit and vegetables	05 Vegetables and fruit
Dairy	02 Dairy products and birds eggs
Flour, bread, sugar, and other	09 Miscellaneous edible products and preparations 06 Sugars, sugar preparations and honey 07 Coffee, tea, cocoa, spices and manufactures thereof 04 Cereals and cereal preparations
Beverage	11 Beverages

DST4

The table below contains a description of the aggregated categories in the report that are based on the database that we denote DST4. All figures for pork, poultry, and eggs, respectively are drawn from the statistics describing external trade at a detailed level: KN8A: Imports and exports by imports and exports, commodities, country and unit[62].

[62] Statistikbanken under udenrigshandel/detaljeret udenrigshandel og underkategori KN8Y: Im- og eksport KN (Kombineret nomenklatur) efter im- og eksport, varer, land og enhed

Table C.4. Pork categories based on DST4

Our categories	Classification in EU Combined Nomenclature. DST4
Live	Domestic swine, weighing < 50 kg (excl. pure-bred for breeding) Live domestic sows, having farrowed at least once, weighing >= 160 kg (excl. pure-bred for breeding) Live domestic swine, weighing >= 50 kg (excl. sows having farrowed at least once and weighing >= 160kg)
Chilled Meat	Fresh or chilled domestic swine carcases and half-carcases Fresh or chilled with bone in, domestic swine hams and cuts thereof Fresh or chilled with bone in, domestic swine shoulders and cuts thereof Fresh or chilled fore-ends and cuts thereof of domestic swine Fresh or chilled loins and cuts thereof of domestic swine Fresh or chilled bellies streaky and cuts thereof of domestic swine Fresh or chilled boneless meat of domestic swine (excl. bellies and cuts thereof) Fresh or chilled boneless meat of domestic swine (excl. carcases and half-carcases, hams, shoulders) Fresh or chilled edible swine offal for manufacture of pharmaceutical products Fresh or chilled edible livers of domestic swine Fresh or chilled edible livers of domestic swine (excl. for manufacture of pharmaceutical products) Fresh or chilled edible domestic swine offal (excl. livers) Fresh or chilled edible domestic swine offal (excl. livers and offal for manufacture of pharmaceutics) Frozen edible offal of domestic swine (excl. livers)* Fresh, chilled or frozen subcutaneous pig fat, salted or in brine
Frozen Meat	Frozen domestic swine carcases and half-carcases Frozen boneless hams and cuts thereof of domestic swine Frozen boneless shoulders and cuts thereof of domestic swine Frozen fore-ends and cuts thereof of domestic swine Frozen loins and cuts thereof of domestic swine, with bone in Frozen bellies streaky and cuts thereof of domestic swine Frozen boneless meat of domestic swine (excl. fore-ends, loins, bellies and cuts thereof) Frozen boneless meat of domestic swine, with bone in (excl. carcases and half-carcases, hams, shoulder)
Cured, dried or smoked	Dried or smoked subcutaneous pig fat Domestic swine hams and cuts thereof, salted or in brine, with bone in Domestic swine shoulders and cuts thereof, salted or in brine, with bone in Domestic swine hams and cuts thereof, dried or smoked, with bone in Domestic swine shoulders and cuts thereof, dried or smoked, with bone in Bellies streaky and cuts thereof of domestic swine, salted or in brine Bellies streaky and cuts thereof of domestic swine, dried or smoked Bacon sides or spencers of domestic swine, salted or in brine Three-quarter-sides or middles of domestic swine, salted or in brine Fore-ends and cuts thereof of domestic swine, salted or in brine Loins and cuts thereof of domestic swine, salted or in brine Meat of domestic swine, salted or in brine (excl. hams, shoulders and cuts thereof, bellies and cuts thereof) Boneless meat of domestic swine, salted or in brine (excl. bellies and cuts thereof) Meat of domestic swine, salted or in brine, with bone in (excl. hams, shoulders and cuts thereof, bellies and cuts thereof) Domestic swine fore-ends and cuts thereof, dried or smoked Domestic swine loins and cuts thereof, dried or smoked Dried or smoked boneless domestic swine meat (excl. bellies and cuts thereof) Dried or smoked domestic swine meat, with bone in (excl. hams, shoulders and cuts thereof, bellies and cuts thereof)

Table C.4. Pork categories based on DST4

Our categories	Classification in EU Combined Nomenclature. DST4
Canned food and prepared food	Hams and cuts thereof, of domestic swine, prepared or preserved Prepared or preserved shoulders and cuts thereof, of domestic swine Prepared or preserved domestic swine loins and parts thereof, incl. mixtures of loins or hams (excl collars) Prepared or preserved domestic swine collars and parts thereof, incl. mixtures of collars and shoulders Prepared or preserved mixtures of domestic swine hams, shoulders, loins, collars and parts thereof Meat or offal, incl. mixtures, of domestic swine, prepared or preserved, containing, by weight, >= 80% meat Prepared or preserved meat, offal and mixtures, of domestic swine, containing >= 40% but < 80% meat Prepared or preserved meat, offal and mixtures of domestic swine containing < 40% meat or offal of domestic swine Prepared or preserved meat or meat offal containing meat or offal of domestic swine (excl. of poultry) Pasta, stuffed with meat or other substances, whether or not cooked or otherwise prepared, containing > 20% sausages or the like of meat or offal
Sausages	Uncooked sausages of meat, offal or blood (excl. liver) Sausages and similar products of meat, offal or blood and food preparations based thereon (excl. liver)
Lard	Pig fat, not rendered or otherwise extracted Pig fat, incl. lard, rendered or otherwise extracted (excl. for technical/industrial uses)
By-products	02064100 (sum of the 6 rows below) Frozen edible swine livers for manufacture of pharmaceutical products Frozen edible livers of domestic swine Frozen edible livers of domestic swine (excl. for manufacture of pharmaceutical products) Frozen edible swine offal for manufacture of pharmaceutical products (excl. livers) Frozen edible offal of domestic swine (excl. livers)* Frozen edible offal of domestic swine (excl. livers and offal for manufacture of pharmaceutical products) Edible domestic swine livers, salted, in brine, dried or smoked Edible domestic swine offal, salted, in brine, dried or smoked (excl. livers) Liver sausages and similar products and food preparations based thereon Homogenised prepared meat, offal or blood, put up for retail sale as infant food or for dietetic purposes Preparations of liver (excl. sausages and similar products, finely homogenised preparations put up

***)** 50% of these categories are included here.

Table C.5. Chicken categories based on DST4

Our categories	Classification in EU Combined Nomenclature. DST4
Whole Fresh	Fresh or chilled, plucked and gutted fowls of species Gallus domesticus, with heads and feet, known Fresh or chilled, plucked and drawn fowls of species Gallus domesticus, without heads and feet but with necks, hearts and livers Fresh or chilled, plucked and drawn fowls of species Gallus domesticus, without heads, feet, necks, hearts or livers
Whole Frozen	Frozen fowls of species Gallus domesticus, plucked and drawn, without heads and feet but with necks, hearts and livers Frozen fowls of species Gallus domesticus, plucked and drawn, without heads, feet, necks, hearts, livers
Cut Fresh	Fresh or chilled boneless cuts of fowls of the species Gallus domesticus Fresh or chilled halves or quarters of fowls of the species Gallus domesticus Fresh or chilled breasts and cuts thereof of fowls of the species Gallus domesticus, with bone in Fresh or chilled legs and cuts thereof of fowls of the species Gallus domesticus, with bone in Fresh or chilled cuts of fowls of the species Gallus domesticus, with bone in (excl. halves and quarters)
Cut Frozen	Frozen boneless cuts of fowls of the species Gallus domesticus Frozen halves or quarters of fowls of the species Gallus domesticus Frozen breasts and cuts thereof of fowls of the species Gallus domesticus, with bone in Frozen legs and cuts thereof of fowls of the species Gallus domesticus, with bone in Frozen cuts of fowls of the species Gallus domesticus, with bone in (excl. halves or quarters, whole)
Cooked or conserved	Uncooked, prepared or preserved meat or meat offal of fowls of the species Gallus domesticus containing >= 57% meat or meat offal Cooked, prepared or preserved meat or meat offal of fowls of the species Gallus domesticus containing >= 57% meat or meat offal Prepared or preserved meat or meat offal of fowls of the species Gallus domesticus containing >= 25% and < 57% meat or meat offal Prepared or preserved meat or meat offal of fowls of the species Gallus domesticus (excl. that containing >= 25% meat or meat offal)
Other	Fresh or chilled whole wings, with or without tips, of fowls of the species Gallus domesticus Fresh or chilled backs, necks, backs with necks attached, rumps and wing-tips of fowls of the species Gallus domesticus Fresh or chilled edible livers of fowls of the species Gallus domesticus Fresh or chilled edible offal of fowls of the species Gallus domesticus (excl. livers) Frozen whole wings, with or without tips, of fowls of the species Gallus domesticus Frozen backs, necks, backs with necks attached, rumps and wing-tips of fowls of the species Gallus Frozen edible livers of fowls of the species Gallus domesticus Frozen edible offal of fowls of the species Gallus domesticus (excl. livers) Live fowls of the species Gallus domesticus, weighing > 185 g but <= 2 kg (Live animals) Live fowls of the species Gallus domesticus, weighing > 2 kg

Table C.6. Egg categories based on DST4

Our categories	Classification in EU Combined Nomenclature. DST4
Eggs for hatching	Turkey or goose eggs for hatching Poultry eggs for hatching (excl. turkey or goose)
Shell eggs	Poultry eggs, in shell, fresh, preserved or cooked (excl. for hatching)
Egg products	Egg yolks, dried, for human consumption, whether or not containing added sugar or other sweetening Egg yolks, liquid, suitable for human consumption, whether or not containing added sugar or other sweetening Egg yolks (other than liquid), frozen or otherwise preserved, suitable for human consumption, whether or not containing added sugar or other sweetening Dried birds eggs, not in shell, whether or not containing added sugar or other sweetening matter, suitable for human consumption Birds eggs, not in shell, fresh, cooked by steaming or by boiling in water, moulded, frozen or other except dried, suitable for human consumption Egg albumin, dried e.g. in sheets, scales, flakes, powder, fit for human consumption Egg albumin, fit for human consumption (excl. dried [e.g. in sheets, flakes, crystals, powder])

Appendix D. Description of data used in Chapter 2

Appendix table D provides an overview over the data sources used to describe production, consumption, and foreign trade of food and beverages in Chapter 2.

Table D.1. Overview over data used to describe production, consumption, and foreign trade of food and beverages

Description of	Characteristics	Source	Years
Production	Overall production of food and beverages for private household consumption and for industrial consumption	DST1	1990-2004
	Production of 6 different categories of food and beverages	DST1	1990-2004
Consumption	Private households' expenditures on food and beverages	DST1	1990-2006
	Private households' expenditures on 8 different categories of food and beverages (measured in DDK) Private household and industrial consumption of 4 different meat categories (measured in kg)	DST2	1990-2006 1990-2007
	International comparison of food consumption expenditure	Eurostat	1994-2005
	International comparison of meat consumption per capita	Eurostat	1990-2005
	Aggregate of shell and processed eggs	DST2	1997-2007
Foreign trade	Total import and export of food and beverages	DST3 DST4	1990-2006

In DST, the food industry is defined as 'companies processing products from agriculture and fisheries into food and fodder for respectively human beings and animals'. In particular, to qualify as a 'food industry' firm, it has to engage in a certain degree of processing. For example, values created by bakers are included because material is converted into new products, while butchers and fishmongers are not included as they do not convert material. Similarly, firms that process eggs are categorized as 'food industry' firms while firms selling shell eggs are not included (DST, 2002)[63]. Semi-manufactured articles, which can not be used for food or fodder (for example hides, feathers etc. from abattoirs) are included in DST's definition of food industry. Tobacco is not included as food or beverages. The description of sub-categories of production and consumption is only provided for the period 1990-2004 as detailed data are only released with some delay from DST (oral communication with Bo Siemsen,

[63] This definition is from the Danish industrial classification – DB03, which also is used by DST in the national account (oral communication with Bo Siemsen DST).

DST2006). The overall trend in the food and beverage consumptions and foreign trade are covered for the longer period 1990-2005.

The classifications of food categories vary across data sources. For example, in the description of consumption, *meat* consumption covers meat for private household consumption only but in the description of production, *meat* covers meat produced for private consumption and for industries. Finally, in the description of foreign trade, *meat* consumption includes meat for private consumption as well as meat and live animals consumed by the industry.

Appendix E. Description of data used in Chapter 3 (pork)

Table E.1. Varieties of pork products included in the description

Description of	Characteristics	Categories	Source	Years
Consumption Patterns	Production system	Conventional, free range, organic	GfK	1997-2004
	Brand	Friland, Antonius/Vitalis, Crown of cooking, own brand, no information	GfK Danish Meat Association, Crown of cooking	April 2004-december 2004
	Processing	9 categories: Back, bacon, ham, minced, neck, pork loin, smoked, tenderloin, other	GfK	1997-2004
	fat content in minced pork	<6%, 6-9%, 10-12%, >13%		2001-2004
Foreign trade	Processing	7 categories: Fresh meat; frozen meat; cured, dried or smoked; canned and prepared food; sausages; lard; by-products; live	DST4	1997-2005
	Trading partners, Import	Germany, United Kingdom, Japan, Italy, Russia, Poland Sweden, Netherlands, USA China		
	Trading partners, Export	Germany, Sweden, Netherlands, Poland, Spain, France, Belgium, United Kingdom, Ireland, Italy		

The descriptions of domestic consumption and foreign trade are not easily comparable as they are based on GfK data and DST4 data, respectively. The Gfk data only cover private household consumption, whereas DST4 data covers both private and industrial consumption. This leads to large differences for categories where industrial consumption is large. Also, the categorisation of goods differs between GfK data and DST4 data. For example, live animals are included in DST4 data but not in the GfK

data. Sausages and prepared dishes are included in the analysis of foreign trade but not in the analysis of consumption.

In addition, Danish Meat Association (2008) has been used to describe pork consumption, imports, and exports.

Appendix F. Description of data used in Chapter 4 (chicken)

From a food safety perspective, the following available categories of chicken products are of main interest: Production form, degree of convenience and processing, and import/export characteristics. An overview is provided in Table Appendix table F.

In the GfK data, it is possible to distinguish between chicken products from two different production systems: *Organic* and *conventional*. This categorization of production systems is sasupplemented data from COOP Denmark reported in Baltzer (2002) where also *barn* and *Campylobacter free* chicken products could be identified[64]. *Barn* chicken was marketed by Danpo in 1995 but was withdrawn from the market again in 2001. There is no large scale commercial production of free range chicken in Denmark either, but free range chickens are sold through farm shops (DFR, online 2006). Unfortunately, only COOP data from the period 2000-2002 were available in Baltzer (2002).

From a food safety perspective, production system is important as chicken with outdoor access have significantly higher risks of Campylobacter infections. Salmonella risks are low in all types of production systems and risk assessment analyses have shown that there are no significant differences in Salmonella risks across chicken production systems. Consumer surveys indicate that consumer link production systems to animal welfare – not to food safety issues.

Similarly, many consumers regard the degree of processing as an indicator of convenience but processing might also be relevant in a food safety perspective. We have identified four different categories of convenience in the GfK data: *Breaded, Marinated, precooked/smoked, and raw and other*. Processed as well as raw chicken that are breaded are categorised as *breaded*. *Marinated* include also spiced chicken. Products marinated in a mixture of water and salt (naturally marinated) are included in the category *raw and other*. *Precooked or smoked* includes semi-manufactured chicken. There is no distinction between chilled and frozen in this categorisation. GfK also provides a categorisation of processing characteristics involving the four categories: *Frozen whole, frozen cut, chilled whole* and *chilled cut*. This product categorisation is of major interest from a safety point of view as the freezing process stops bacteria from developing (see Table 1.2).

[64]Barn chicken ('skrabe kyllinger') have more space than conventional chicken.

The relation between convenience/processing, naturalness, and food safety is rather complex. In example, *breaded* products have a high degree of convenience but a low score on naturalness and the effects on safety depend on whether the breaded chicken is raw or cooked. Similarly, marinating chicken increases convenience but decreases naturalness and its effect on safety depends on the type of marinate. Proper pre-cooking a chicken improves food safety and convenience but reduces. A frozen chicken might be considered of lower eating quality than a chilled chicken but has a lower risk of containing bacteria.

There are some important differences in the definitions used in GfK and DST4. DST4 data cover both private and industrial consumption while GfK includes only private consumption. DST4 includes a category *other (*which covers a broad range of processed chicken products e.g. chicken used in other products, chicken sausages etc.) and a category denoted *conserved or cooked* while products belonging to these categories are spread into different categories in the GfK data.

The foreign trade analysis includes categorisation according to processing level and the processing characteristics: *Chilled* or *frozen* (as indicated in Table 5.1). Also the most common foreign trading partners are described. The description of foreign trade is based on data from DST using the EU combined nomenclature. Hence, the commodity group *chicken* includes all commodities where the content of chicken is specified in the EU combined nomenclature, e.g. whole and cut chicken, offal, livers, live, cooked etc (listed in appendix 3). An important omission is chicken fat, which cannot be disaggregated from the group *poultry fat.* The list used is a subgroup of the broader poultry list used by DSTin the agricultural statistic.

The description of foreign trade is based on equating consumption with production plus imports less export plus changes in stock. The approach is similar to the method used by DST. Data on production, export and stock are obtained from Danish Poultrymeat Association while import data are obtained from DST(see the list in appendix 3).

In addition, Danish Meat Association (2008) and Danish Poultry Council (2007) have been used to describe pork consumption, imports, and exports.

Table F.1. Categories of chicken used in the analyses

Description of	Characteristics	Categories	Data	Years
Consumption Patterns	Production system	conventional, organic	GfK	1997-2004
		conventional, organic Campylobacter free, barn	Baltzer (2002), based on COOP	2000-2002
	Convenience/ Processing	breaded, marinated precooked/smoked, raw and other	GfK	2001-2004
	Processing	whole, cut, other	DST4 Danish Poultry Meat Association	1998-2004
	Processing	frozen/whole, frozen/cut chilled/whole, chilled/cut	GfK	1997-2004
foreign trade	Processing	frozen/whole, frozen/cut, chilled/whole, chilled/cut, conserved or cooked, other	DST4 Danish Poultry Meat Association	1997-2005
	trading partners, import	(7 largests) Germany, Netherlands Sweden, France Brazil, Spain United kingdom Other		
	trading partners, export	(7 largest) Sweden, South Korea Germany United Kingdom USA, Malaysia Lithuania Other		

Appendix G. Description of data used in Chapter 5 (eggs)

The categorization of production characteristics of the eggs sold for private consumption includes four different production categories: *Battery*, *barn*, *organic*, and *free range*[65]. The descriptions of consumption patterns are based on data from the Danish Veterinary and Food Administration who keeps records over all sales done through authorized Danish egg packers. The available data covers the period 1997-2005 and includes information on from where egg packers have received eggs (imports, other egg packers or from producers) and who they are selling to (companies producing egg products, export, other egg packers or retail/grocers). Consumption is also categorized according to processing characteristics. Using GfK data, eggs are divided into *shell* and *pasteurized* eggs. The data span the period 1997-mid 2004. Note that pasteurized eggs were not registered separately until in June 1999. The description of foreign trade in eggs is based on data from DST4. The definition of eggs includes the commodity groups listed in appendix 4. The list is similar to the one used by DST in the agricultural statistics (DST2). The categorization of processing characteristics in DST4 and GfK differ: 1) *Eggs for hatching* are included in the foreign trade description based on DST4 but are not included in the GfK data 2) there is a separate category called *pasteurized eggs* in GfK data whereas pasteurized eggs are categorised under *egg products* in the DST data base 3) in DST4, private and industry consumptions are included whereas GfK includes household consumption only. An overview over categorisations and available data is provided in Appendix table G.

[65] In Danish: Battery (bur), barn (skrabe), free range (fritgående), organic (økologisk).

Table G.1. Categories of eggs analysed

Description of	Characteristics	Categories	Data	Years
Consumption patterns	Production system	Battery, barn, organic, free range	Danish Veterinary and Food Administration	1997-2005
	Processing	Shell, pasteurized	GfK	1997-2004
Foreign trade	Processing	Eggs for hatching, shell eggs, egg products	DST4	1997-2006
	Trading partners, import	Holland, Poland Germany, Sweden Finland, Belgium India, Other	DST4	1997-2006
	Trading partners, export	Sweden, South Korea, Germany, United Kingdom, U.A.E., Malaysia Lithuania, Other		1997-2005