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米国産輸入牛肉と我が国の腸管出血性大腸菌による食中毒，および感染症発生に関する研究

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Study on the imported U.S. beef and the occurrence of enterohemorrhagic *Escherichia coli* infection in Japan

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The Japanese government imposed a ban on U.S. beef imports in December 2003 after the first case of bovine spongiform encephalopathy (BSE) in the United States. The ban was lifted in December 2005, but the amount of U.S. beef imported in 2006 was still drastically smaller compared with that before the ban. The aim of this study is to examine whether the amount of imported U.S. beef affects the number of incidents and patients of enterohemorrhagic *Escherichia coli* (EHEC) infection in Japan, by utilizing the statistical and epidemiological data. Since 2004, the amount of imported U.S. beef was drastically decreased but the number of food-borne EHEC cases and the number of all (not only food-borne cases) EHEC patients were relatively constant from 2000 to 2006. On the other hand, the number of food-borne EHEC patients decreased in 2004 and 2005. Considering the individual food-borne EHEC incidents in the Statistics of Food Poisoning presented by the Ministry of Health, Labour and Welfare, there were no large outbreaks (more than 100 patients in one case) occurred in 2004 and 2005, and this might be the reason for the decreased number of EHEC patients in these years. We concluded that U.S. beef did not have a great effect on the situation of EHEC infection in Japan.

Keywords: U.S. beef, enterohemorrhagic *Escherichia coli* (EHEC)

1．はじめに

平成15年12月，米国において牛海綿状脳症（BSE）感染例が報告され，我が国においても速やかに米国産牛肉の輸入停止措置が取られた．平成17年12月，食品安全委員会の答申を経て，輸入停止措置は解除されたが，その後も平成18年１月20日，脊柱混入により再び輸入停止措置が取られ，７月27日に輸入手続きが再開される等，その輸入量は，平成18年には輸入停止措置前の数パーセントという低い水準に留まっている．

腸管出血性大腸菌は，主に牛の腸管内に保菌されていることから，その感染症には，食肉，中でも牛肉の関与が多いことが報告されている[1]．

本研究は，米国でのBSEの発生を契機とする米国産牛肉の輸入量の減少と，同時期の我が国の腸管出血性大腸菌食中毒ならびに感染症発生の推移について関連が認められるかどうか検討し，我が国における腸管出血性大腸菌による健康被害に対する米国産牛肉の影響について考察することを目的とした．

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2．方法

平成15年12月に，米国においてBSE感染牛が発見され，我が国で米国産牛肉の輸入停止措置が取られていることから，調査期間としては，平成12年から平成18年の７年間とした．

牛肉輸入量は財務省の貿易統計[2]から引用した．国産牛肉生産量は本来，農林水産省の食肉流通統計[3]から引用すべきであるが，貿易統計が部分肉ベースであるため（食肉流通統計は枝肉ベース），農林水産省の食肉鶏卵速報[4]の部分肉換算された値を引用した．

腸管出血性大腸菌（VT産生）による食中毒の患者数，件数，および個々の事例の検討については，平成13年以前分は食中毒事件票の原簿から，平成14年以降分は厚生労働省の食中毒発生事例[5]から引用した．腸管出血性大腸菌感染症の報告数については，感染症発生動向調査[6]の集計値を用いた．

3．結果

我が国の国産牛肉生産量，牛肉輸入量等について図1に示した．米国産牛肉の輸入量は平成16年以降著しく減少していた．（米国産牛肉の輸入停止措置は平成15年12月に取られたため，輸入量の減少は平成16年から反映されている．）米国産牛肉の輸入量減少に伴い，豪州産，ニュージーランド産牛肉の輸入量は若干増加しているが，牛肉の輸入量は全体としても減少傾向であった．国産牛肉生産量はほとんど変動していないため，牛肉全体の流通量（国産牛肉生産量＋牛肉輸入量）も輸入量の低下の影響でやはり減少傾向であった．

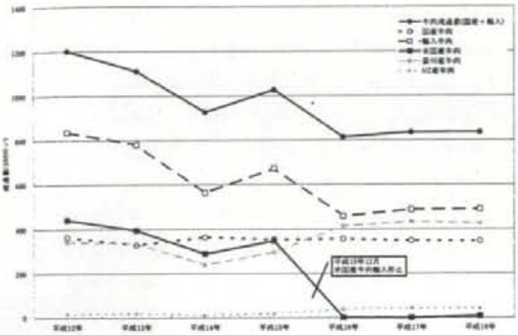

図1　国産牛肉生産量と牛肉輸入量

図2に食中毒発生事例による腸管出血性大腸菌（VT産生）食中毒の患者数と米国産牛肉輸入量について示した．年ごとの患者数は70人から378人と年によるばらつきが大きかったが，平成16年からの米国産牛肉輸入量の減少に一致するように，平成16年，17年の患者数が平成13～15年の患者数に比べて減少していた．

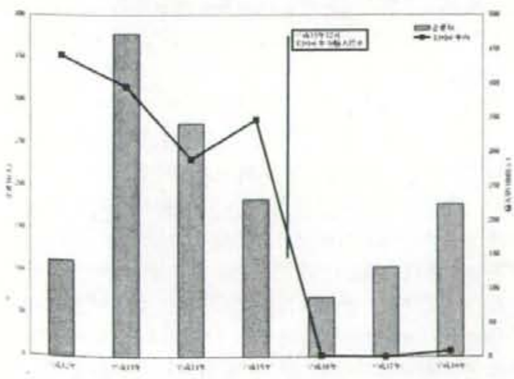

図2　食中毒発生事例 腸管出血性大腸菌（ＶＴ産生）患者数と米国産牛肉輸入量

図3に食中毒発生事例による腸管出血性大腸菌（VT産生）食中毒の件数と米国産牛肉輸入量について示した．食中毒件数は12件から24件の間で推移していたが，平成16年からの米国産牛肉輸入量の減少に一致するような減少は見られなかった．

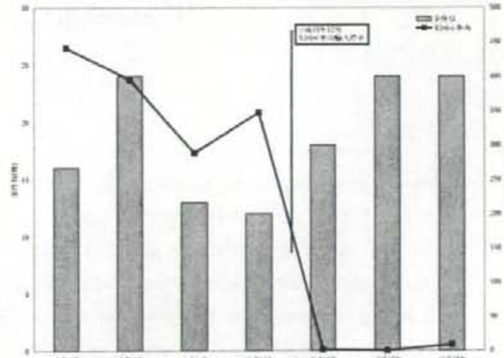

図3　食中毒発生事例 腸管出血性大腸菌（ＶＴ産生）事件数と米国産牛肉輸入量

図4に感染症発生動向調査による腸管出血性大腸菌感染症の報告数と米国産牛肉輸入量について示した．腸管出血性大腸菌感染症の報告数は3000人から4500人の間で推移していたが，平成16年からの米国産牛肉輸入量の減少に一致するような減少は見られなかった．

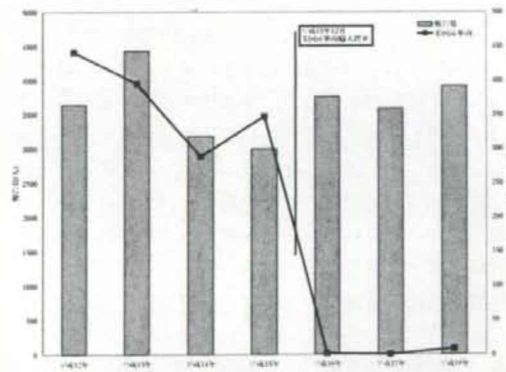

図4　感染症発生動向調査 腸管出血性大腸菌感染症 報告数と米国産牛肉輸入量

4．考察

感染症発生動向調査による腸管出血性大腸菌感染症の報告数は全数把握であり，その数値の信頼性は高いが，反面，すべてが食品を原因とするわけではなく，人－人感染例も多数含まれている．一方，食中毒発生事例によ

る腸管出血性大腸菌（VT産生）食中毒の事件数，患者数は，すべてが食品を原因とする事例であるが，食品が原因であると断定するに足る根拠がない場合には報告されず，その数値は氷山の一角に過ぎないという指摘もある．

図2においては，平成16年度以降の米国産牛肉輸入量の減少と，平成16年，17年における腸管出血性大腸菌（VT産生）食中毒患者数の減少が一致していた．この点について，平成12～18年の食中毒事例（ただし，国内事例のみを対象とし，国外，および国内外不明事例は除外した）を個別に見ていくと（表1～7），平成16年，17年には患者数50人以上，あるいは100人以上の大規模な事例は報告されていないが，平成13年，14年，15年に関しては1件で年間患者数の半数を超えるような100人以上の大規模事例が報告されており，これらが年間患者数を大きく押し上げていると考えられる．食中毒事例による腸管出血性大腸菌（VT産生）食中毒の事件数は年間12～24件と少ないことから，年間患者数は大規模事例に大きく影響される．このことは，表8に示した食中毒事例1件当たりの患者数の中央値と平均値が，大規模事例の起きた平成13年，14年，15年には大きく乖離していることからも推測できる．図3，図4に示した腸管出血性大腸菌（VT産生）食中毒事件数，あるいは腸管出血性大腸菌感染症の報告数には，米国産牛肉輸入量との間に関連が認められなかったことと合わせて考えると，平成16年以降の米国産牛肉輸入量の減少と平成16年，17年の腸管出血性大腸菌（VT産生）食中毒患者数の減少は偶然の一致に過ぎず，米国産牛肉は我が国の腸管出血性大腸菌に関わる健康被害の発生に大きな影響を与えていないと考えられた．

平成13年3月に起きた，千葉県等で発生した（牛タタキ，ローストビーフを原因とする）腸管出血性大腸菌O157食中毒事件（患者数195人）は，米国産牛肉を原因とする大規模食中毒事例であった．そこで，米国産牛肉が大規模な腸管出血性大腸菌食中毒の発生に特に関与しているかについて検討した．

患者数100人を超える腸管出血性大腸菌食中毒事件は，平成13年，14年，15年に1件ずつ報告されている．そのうち，米国産牛肉を原因とする事件は，前述した平成13年の千葉県等で発生した1件のみであり，大規模な

表1　平成18年　腸管出血性大腸菌（VT産生）による食中毒発生事例

都道府県名等	発生月日	発生場所	原因食品	原因施設	摂食者数	患者数	死者数
徳島県	4月1日	徳島県	不明	飲食店	204	4	0
大阪府	4月7日	大阪府	生レバー	家庭	13	6	0
大阪府	4月9日	大阪府	焼肉	家庭	3	1	0
沖縄県	4月18日	国内不明	冷凍ハンバーグ	不明	2	1	0
さいたま市	6月18日	埼玉県	不明（6月17日に提供された食品）	飲食店	55	15	0
福岡市	6月22日	国内不明		不明	不明	6	0
山口県	6月25日	山口県	不明（6月24日～27日に提供した食事）	飲食店	984	55	0
東京都	6月27日	東京都	会食料理（焼肉、牛レバ刺し等）	飲食店	2	2	0
東京都区部	7月16日	東京都	7月11、12日の会食料理	飲食店	9	3	0
大阪府	7月29日	大阪府	生レバー、ユッケを含む焼肉	飲食店	19	8	0
金沢市	7月31日	石川県	不明（7月28日に喫食した焼肉店での食品）	飲食店	25	7	0
東京都	8月11日	東京都	会食料理	飲食店	13	4	0
東京都区部	8月11日	東京都	不明（会食料理）	飲食店	18	8	0
北九州市	8月13日	福岡県	レバー刺し	飲食店	6	3	0
山形県	8月14日	山形県	不明（飲食店の食事）	飲食店	不明	6	0
北九州市	8月15日	福岡県	不明（焼肉料理）	飲食店	4	1	0
北九州市	8月18日	福岡県	不明（焼肉料理）	飲食店	14	6	0
大阪府	8月19日	大阪府	不明（飲食店料理）	飲食店	不明	4	0
北九州市	8月20日	福岡県	不明（焼肉料理）	飲食店	9	1	0
新潟市	8月28日	新潟県	不明（焼肉料理）	飲食店	128	13	0
横浜市	9月1日	神奈川県	不明（8月27日焼肉料理）	飲食店	9	4	0
藤沢市	9月25日	神奈川県	不明（当該施設の食事）	飲食店	1002	16	0
新潟市	10月4日	新潟県	不明（焼肉料理）	飲食店	不明	2	0
静岡市	10月4日	静岡県	牛レバ刺し	販売店	3	3	0
計	24例				2522	179	0

表2　平成17年　腸管出血性大腸菌（ＶＴ産生）による食中毒発生事例

都道府県名等	発生月日	発生場所	原因食品	原因施設	摂食者数	患者数	死者数
熊本市	3月13日	熊本県	牛ホルモン（推定）	飲食店	不明	7	0
富山県	3月26日	富山県	不明	飲食店	不明	9	0
富山県	4月15日	富山県	不明	飲食店	不明	3	0
東京都区部	5月25日	東京都	牛レバ刺し（推定）	飲食店	2	1	0
東京都	5月27日	東京都	不明（会食料理）	飲食店	6	1	0
横浜市	5月27日	神奈川県	牛レバー刺し（加熱用）推定	飲食店	2	2	0
大阪府	6月5日	大阪府	不明（焼肉店で提供された食肉）	飲食店	12	3	0
大阪府	6月5日	大阪府	ユッケ	飲食店	6	4	0
新潟県	6月17日	新潟県	不明（家庭の食事）	家庭	6	4	0
佐賀県	6月28日	佐賀県	不明	飲食店	14	2	0
岐阜県	7月3日	岐阜県	焼肉	飲食店	76	30	0
横浜市	7月13日	神奈川県	不明（平成17年7月10日焼肉料理）	飲食店	3	1	0
東京都区部	7月19日	東京都	不明（焼肉店での会食料理）	飲食店	6	6	0
大阪府	7月21日	大阪府	不明（焼肉店料理）	飲食店	9	2	0
千葉市	7月23日	千葉県	不明（7月20日に原因施設で提供された食事）	飲食店	4	1	0
千葉県	7月24日	千葉県	カルビを含む食事	飲食店	9	3	0
千葉県	7月25日	千葉県	カルビを含む食事	飲食店	3	2	0
東京都区部	8月10日	東京都	焼肉店での食事	飲食店	10	4	0
大阪府	8月10日	大阪府	生レバー及びユッケ	飲食店	8	4	0
愛知県	8月14日	愛知県	ユッケ	飲食店	13	5	0
東京都区部	9月15日	東京都	不明（焼肉店で提供された食事）	飲食店	5	2	0
大阪府	10月11日	大阪府	不明（焼肉店料理）	飲食店	45	4	0
大阪府	10月20日	大阪府	不明（焼肉店料理）	飲食店	21	2	0
横浜市	10月28日	神奈川県	不明（10月22日及び11月3日に提供した食事）	飲食店	6	3	0
計	24例				266	105	0

表3　平成16年　腸管出血性大腸菌（ＶＴ産生）による食中毒発生事例

都道府県名等	発生月日	発生場所	原因食品	原因施設	摂食者数	患者数	死者数
東京都区部	1月27日	東京都	教会のイベントで提供された料理	その他	174	9	0
大阪府	3月24日	大阪府	ホルモン料理	その他	91	11	0
石川県	5月5日	石川県	不明	飲食店	不明	4	0
奈良市	6月2日	奈良県	不明（飲食店で提供された料理）	飲食店	609	2	0
東京都	6月24日	東京都	ユッケ及びユッケ加工品	飲食店	1570	2	0
横浜市	7月13日	神奈川県	不明（7月9日　焼肉料理）	飲食店	4	2	0
栃木県	7月24日	栃木県	不明（岩保食堂で調理された食事）	飲食店	2544	4	0
群馬県	7月25日	群馬県	焼肉料理（7/17～30提供料理）	飲食店	6729	10	0
秋田県	7月28日	秋田県	不明	不明	不明	1	0
横浜市	8月4日	神奈川県	ユッケ（推定）	飲食店	7	4	0
群馬県	8月7日	群馬県	焼肉等（8/4,6に提供されたメニュー）	飲食店	26	4	0
愛知県	8月12日	愛知県	不明(平成16年8月4日の夕食)	飲食店	6	2	0
佐賀県	9月13日	佐賀県	不明	飲食店	5	2	0
東京都区部	9月17日	東京都	不明	飲食店	339	2	0
大阪府	10月14日	大阪府	ユッケ	飲食店	13	4	0
東京都区部	10月20日	東京都	焼肉	家庭	5	1	0
松山市	11月6日	愛媛県	11月2日提供の会食　牛レバー刺し（推定）	飲食店	8	3	0
徳島県	12月14日	徳島県	不明（牛レバ刺し等の宴会料理）	飲食店	498	3	0
計	18例				12628	70	0

表4 平成15年 腸管出血性大腸菌（ＶＴ産生）による食中毒発生事例

都道府県名等	発生月日	発生場所	原因食品	原因施設	摂食者数	患者数	死者数
横浜市	5月14日	神奈川県	不明（5/10会食料理）	飲食店	2	1	0
長野県	5月19日	長野県	5月16日の配食弁当	仕出屋	199	4	1
秋田市	6月16日	秋田県	不明（6/14、飲食店の食事）	飲食店	151	5	0
横浜市	6月20日	神奈川県	不明（6/16の夕、会食）	飲食店	2	2	0
大阪府	6月30日	大阪府	不明（焼肉料理）	飲食店	10	4	0
大分県	7月4日	大分県	井戸水	家庭	4	3	0
東京都区部	7月8日	東京都	不明（飲食店の食事）	飲食店	不明	4	0
福井県	7月9日	福井県	不明	飲食店	477	2	0
仙台市	7月19日	宮城県	不明（配達弁当）	飲食店	125	3	0
福岡市	8月16日	福岡県	不明（鶏刺し、馬ボイルホルモン等の調理済み食肉）	飲食店	54	11	0
茨城県	9月2日	茨城県	飲食店で提供された食事	飲食店	8	4	0
横浜市	9月10日	神奈川県	不明（9/8の幼稚園給食）	仕出屋	3476	141	0
計	12例				4508	184	1

表5 平成14年 腸管出血性大腸菌（ＶＴ産生）による食中毒発生事例

都道府県名等	発生月日	発生場所	原因食品	原因施設	摂食者数	患者数	死者数
堺市	1月17日	大阪府		飲食店	不明	2	0
大阪府	1月18日	大阪府	食肉類（推定）	飲食店	4	1	0
姫路市	4月27日	兵庫県		その他	不明	30	0
富山県	5月7日	富山県	ステーキランチ	飲食店	不明	6	0
福岡市	6月21日	福岡県		事業場	162	74	0
福岡市	6月27日	国内不明		不明	不明	9	0
福岡県	7月10日	福岡県	マサドニアンサラダ、おかか和え	病院	19	7	0
東京都区部	7月28日	東京都	不明（会食料理）	飲食店	10	2	0
宇都宮市	8月2日	栃木県	不明（7月29日提供の昼食）	病院	876	123	9
横浜市	8月5日	神奈川県	レバー刺	飲食店	5	1	0
山梨県	8月10日	山梨県		旅館	29	14	0
横浜市	10月11日	神奈川県	不明	飲食店	11	2	0
沖縄県	10月23日	国内不明		不明	不明	2	0
計	13例				1116	273	9

表6　平成13年　腸管出血性大腸菌（ＶＴ産生）による食中毒発生事例

都道府県名等	発生月日	発生場所	原因食品	原因施設	摂食者数	患者数	死者数
滋賀県	2月28日	滋賀県		飲食店	14	2	0
福井県	3月2日	福井県	不明	不明	1	1	0
富山県	3月7日	富山県	ビーフ角切りステーキ	飲食店	不明	1	0
栃木県	3月12日	栃木県		製造所	454	195	0
富山県	3月13日	富山県	ビーフ角切りステーキ	飲食店	不明	1	0
奈良県	3月13日	奈良県	ビーフ角切りステーキ	飲食店	15	1	0
滋賀県	3月15日	滋賀県		飲食店	11	1	0
青森県	3月30日	青森県	豚生レバー	家庭	4	1	0
奈良県	4月2日	国内不明	不明	不明	不明	3	0
千葉県	4月3日	千葉県	不明（3月30日～4月1日、平城苑の提供食品）	飲食店	8	3	0
沖縄県	4月3日	沖縄県		不明	不明	1	0
栃木県	5月26日	栃木県		旅館	199	86	0
堺市	5月29日	大阪府		飲食店	4	2	0
富山市	6月20日	富山県		飲食店	不明	2	0
大阪府	6月23日	国内不明	不明	不明	不明	3	0
大阪府	6月24日	大阪府	生食用牛肉	飲食店	12	3	0
東京都	6月29日	国内不明	不明	不明	不明	1	0
東京都	7月11日	国内不明	不明	不明	不明	2	0
東京都	7月22日	東京都	不明（飲食店の食事）	飲食店	4	2	0
愛知県	7月24日	愛知県	不明（韓国料理）	飲食店	506	4	0
秋田県	8月5日	秋田県	不明（施設の給食）	事業場	不明	5	0
長野市	8月13日	長野県	不明	飲食店	223	29	0
埼玉県	8月18日	埼玉県		製造所	不明	26	0
大分県	9月25日	大分県	鹿肉の刺身（9/23　家庭の食事）	製造所	5	3	0
計	24例				1460	378	0

表7　平成12年　腸管出血性大腸菌（ＶＴ産生）による食中毒発生事例

都道府県名等	発生月日	発生場所	原因食品	原因施設	摂食者数	患者数	死者数
横浜市	2月10日	神奈川県	オリジナルハンバーグ	飲食店	2821	10	0
愛知県	3月22日	国内不明	不明	不明	1	1	0
沖縄県	4月13日	沖縄県	不明（家庭の食事）	家庭	2	2	0
豊橋市	4月24日	愛知県	仕出し料理のうち、えびフライ、焼き魚（シルバー）	仕出屋	203	24	0
和歌山市	5月4日	国内不明	不明	不明	7	7	0
東京都	5月9日	国内不明	不明	不明	不明	3	0
広島県	5月9日	広島県	不明	家庭	4	3	0
東京都	6月21日	東京都	不明（飲食店の食事）	飲食店	不明	2	0
横浜市	6月22日	神奈川県		飲食店	4	1	0
埼玉県	6月23日	埼玉県		事業場	79	8	1
沖縄県	7月10日	沖縄県		不明	不明	1	0
東京都	7月18日	東京都	不明(飲食店の食事)	飲食店	4	1	0
大阪市	7月24日	大阪府		飲食店	4	2	0
福岡県	8月25日	福岡県		飲食店	不明	2	0
千葉県	10月29日	千葉県	牛の丸焼き	その他	569	41	0
徳島県	11月28日	徳島県	不明（焼肉）	飲食店	7	5	0
計	16例				3705	113	1

表8 食中毒事例 腸管出血性大腸菌食中毒事件1件当たりの患者数の中央値と平均値

	平成12年	平成13年	平成14年	平成15年	平成16年	平成17年	平成18年
中央値	2.50	2.00	6.00	4.00	3.00	3.00	4.00
平均値	7.06	15.75	21.00	15.33	3.89	4.38	7.46

腸管出血性大腸菌食中毒事件のすべてが必ずしも米国産牛肉を原因とするわけではない．一方，米国産牛肉の輸入量が減少した平成16年以降，患者数100人を超える腸管出血性大腸菌食中毒事件は1例も起きていないが，大規模な腸管出血性大腸菌食中毒事件は年に1件あるかどうかの偶発的な事件であるため，これらの関連について評価することは困難であると考えられた．

米国の調査[7]によれば，牛ひき肉の腸管出血性大腸菌汚染率は3.49%（61/1750），うち*E. coli* O157汚染率は1.14%（20/1750）と報告されている．一方，厚生労働省が行っている食品の食中毒菌汚染実態調査[8]によれば，平成13～19年度の我が国の*E. coli* O157汚染率は，牛レバー（生食用）で0.85%（1/117），カットステーキ肉で0.09%（1/1071），牛結着肉で0.31%（1/323）であり，ミンチ肉（牛）（0/1304），牛たたき（0/654），ローストビーフ（0/318）では0%であった．対象や検出方法の違いから単純な比較はできないが，米国の牛ひき肉に比べ，我が国の*E. coli* O157汚染率は低いと考えられた．

本研究では，統計情報，疫学情報を用いて，我が国の腸管出血性大腸菌による健康被害に与える米国産牛肉の影響について考察した．その結果，我が国の腸管出血性大腸菌による健康被害の発生に対する米国産牛肉の影響は小さいと考えられた．

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Review

Campylobacter contamination in retail poultry meats and by-products in Japan: A literature survey

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ABSTRACT

Campylobacter species are common bacterial pathogens that cause gastroenteritis in humans worldw In Japan, campylobacteriosis is the leading food-borne bacterial illness, and the consumption of pou meats and/or by-products is suspected to be the major cause of this illness. In this review, we sumı rized the papers describing *Campylobacter* contamination of retail poultry meats and by-product: Japan, most of which were written in Japanese, for estimating the nationwide situation of Japan. the average, the prevalence of *Campylobacter* contamination in retail poultry meats and by-prodı was approximately 60%; this contamination level is comparable to those observed in North Ameı and Europe. *Campylobacter jejuni* was the dominant species isolated from retail poultry, and Penner se type 2 and 4-complex were the predominant serotypes of *C. jejuni*. A large section of poultry was cont inated with *Campylobacter* spp. at levels that were adequate to induce gastroenteritis if the m consumed was raw or undercooked. Moreover, quinolone resistance was frequently found in poultry i lates. This review provides detailed and referable data on *Campylobacter* contamination of retail pou meats and by-products in Japan, especially for researchers of other countries.

Contents

1. Introduction

Campylobacter species are common bacterial pathogens that cause gastroenteritis in humans, both in industrialized and developing countries (Coker, Isokpehi, Thomas, Amisu, & Obi, 20(Pebody, Ryan, & Wall, 1997; WHO, 2000). Within the ger *Campylobacter*, *Campylobacter jejuni* and *Campylobacter coli* the predominant species isolated from poultry and are the m common species associated with human campylobacteriosis (Co & Atabay, 2001; PHLN, 2000; WHO, 2000). Raw or undercool contaminated poultry meats and/or by-products in particu cause food-borne campylobacteriosis in humans (CDC, 2005).

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ampylobacters are the leading causative agents of food-borne erial illnesses in Japan. In 2006, a total of 2297 patients and cases were officially reported to the Ministry of Health, Labour Welfare (The Ministry of Health, Labour and Welfare, 2007). In than 40% of the cases in which the cause was identified, the umption of poultry meats and/or by-products was suspected e cause, indicating a strong relationship between campylobacsis and the consumption of poultry; the causative foods could ie identified in more than 80% of the total cases (The Ministry ealth, Labour and Welfare, 2007).

lany researchers have reported about *Campylobacter* contamon in retail poultry meats and/or by-products in Japan, but of the research papers were written in Japanese and pubd in Japanese journals or annual reports of the local (prefecor municipal) public health institutes that are controlled by ocal self-governing bodies, making the citation of these padifficult for non-Japanese researchers. Moreover, in most of papers, the number of samples examined was relatively l and the samples were restricted to locally distributed try products. Therefore, in this study, we summarized and yzed these papers in order to estimate the nationwide situ in Japan.

aterials and methods

/e searched for papers that described the contamination of l poultry meats and by-products by *Campylobacter* spp. by a combination of two sets of keywords: "*Campylobacter*" "poultry or chicken". Access to databases such as JSTPlus JMedPlus was provided by the Japan Science and Technology icy, that to PubMed was provided by the United States Nal Library of Medicine, that to ScienceDirect was provided lsevier, and that to Japana Centra Revuo Medicina was prod by the Japan Medical Abstract Society. These databases searched from July to August 2007. The papers, which were ished from 2002 to the time of the searches, describing *pylobacter* contamination of retail poultry in Japan, but not oultry at farms or at processing plants were collected. Finally apers were selected.

/e first classified the poultry into four categories: poultry ts, by-products, frozen poultry, and ground poultry meats, subcategories were formed. In Japan, most of the domestic try are distributed and sold under refrigerated conditions, almost all imported poultry are distributed under frozen conns and sold as either frozen or defrosted poultry and poultry ts and by-products are usually commercially sold as parts not as whole carcasses, i.e., they are sold as breasts, thighs, s, fillets (categorized as poultry meats), gizzards, livers, hearts gorized as poultry by-products), etc. The results of prevalence, ies distribution, number of bacteria contaminated, serotype ibution and antimicrobial resistance were summarized and ilations were performed.

ext, 22 papers met the criteria as below were selected. The crils

combination of Bolton broth or Preston broth for enrichent and charcoal cefaperazone deoxycholate agar (CCDA) lates for isolation was used for detection. Because this comination was used in the majority of papers and reported to e high-performance methods for detecting contamination, ompared to other methods (Ishimura et al., 2006; Kunii t al., 2005).

i total 30 or more samples were examined in the investigation. ecause the results of small-scale studies might be less reliable nd/or skewed.

Subsequently, calculations were performed by the results of these 22 papers.

3. Results and discussion

3.1. Detection methods of *Campylobacter* spp.

Currently, there is no official protocol in Japan for detecting the presence of *Campylobacter* spp. in food stuffs. Hence, the investigations reported by the papers cited in this review employed several different methods for detecting *Campylobacter* spp. For example, the detection methods used were mainly culture methods, such as, the qualitative (enrichment) method, MPN method, and direct plating method; and molecular biological methods in combination with or without enrichment culture. The enrichment media used were mainly Bolton broth or Preston broth, but *Campylobacter* enrichment medium (CEM) broth was also used in some investigations. Moreover, the isolation media used were mainly CCDA plates, but Skirrow plates, Campy food ID agar (CFA) plates, and Butzler plates were used in several investigations. The samples prepared for detection were mainly homogenates of the samples, rinse fluids of the samples, samples immersed in culture media, and drip fluids from the samples. Moreover, the detailed conditions for enrichment and isolation culture, the methods for identification, and the initial sample weights for sample preparation differed among investigations. Detailed lists of all the data, including detailed methods, were presented online.

Table 1
Prevalence of *Campylobacter* in retail poultry in Japan[a]

Samples	No. of references	No. of samples	Prevalence (average) (%)	95% Confidence interval (%)
Poultry meats (total)	29	1551	58.8	56.4–61.2
Breasts	10	190	62.1	55.2–69.0
Thighs	15	358	58.7	53.6–63.8
Wings	10	183	62.3	55.3–69.3
Fillets	3	38	23.7	10.2–37.2
Poultry parts (not specified)	13	782	59.0	55.6–62.4
By-products (total)	9	325	60.3	55.0–65.6
Gizzards	6	74	62.2	51.2–73.2
Livers	7	212	62.3	55.8–68.8
Hearts	2	15	33.3	9.4–57.2
Frozen poultry (total)	7	297	23.6	18.8–28.4
Domestic frozen poultry	2	7	28.6	0.0–62.1
Imported frozen poultry (total)	6	255	22.0	16.9–27.1
From Brazil	3	106	28.3	19.7–36.9
From China	2	21	9.5	0.0–22.0
From Thailand	2	20	55.0	33.2–76.8
From USA	3	19	5.3	0.0–15.4
From Malaysia	1	2	0.0	0.0–0.0
Origin unknown	4	87	13.8	6.6–21.0
Ground poultry meats	3	88	21.6	13.0–30.2

[a] The papers cited in this table were Ando et al. (2003), Fujii et al. (2005), Fujita et al. (2005), Fukushima, Katsube, Hata, Kishi, & Fujiwara (2007), Furuhata et al. (2006), Hamasaki et al. (2006), Hamasaki et al. (2004), Hamasaki, Horikawa, Murakami, Nagano, & Takada (2003), Kai, Yokoyama, Konishi, Yano, & Morozumi (2006), Kawamori et al. (2003), Kunii et al. (2005), Matsuoka, Maruzumi, Morita, & Fujii (2006), Kawamori et al. (2004), Morita et al. (2003), Murakami et al. (2005), Ono, Ando, Ozeki, & Yanagawa (2005), Ono, Ando, Kawamori, Ozeki, & Yanagawa (2005), Ono et al. (2004), Ono et al. (2003), Ono, Ando, Omoe, & Shinagawa (2002), Ono et al. (2002), Saito et al. (2005), Saito et al. (2003), Sakamoto et al. (2006), Sallam (2007), Shimizu et al. (2006), Tada, Sunahara, Tada, & Yamanishi (2004), Tsujisawa et al. (2002), Watanabe et al. (2006) and Watanabe et al. (2005).

3.2. Prevalence of Campylobacter spp. in retail poultry meats and by-products

The prevalence of *Campylobacter* contamination in the poultry meats category was approximately 60% in breasts, thighs, wings, and poultry parts (not specified), while it was relatively low in fillets (Table 1). In the poultry by-products category, the prevalence of *Campylobacter* contamination was approximately 60% in gizzards and livers, while it was relatively low in hearts. Compared to refrigerated poultry, the prevalence of *Campylobacter* contamination was relatively low in frozen poultry, including both domestic and imported products. This can be attributed to the report explaining that frozen conditions damage *Campylobacter* cells and decrease their viability (Bhaduri & Cottrell, 2004). However, frozen poultry imported from Thailand showed a relatively high prevalence of *Campylobacter* contamination. Ground poultry meats showed lower prevalence compared with poultry meats.

As mentioned above, several different methods for detecting *Campylobacter* spp. were employed, but these differences were not considered in Table 1, although it has been reported that there are considerable differences in the performances of the different enrichment and isolation media used to detect *Campylobacter* spp. (Ishimura et al., 2006; Kunii et al., 2005). Then, we selected 22 papers that met the criteria described in Section 2 and were proceeded with the calculations as shown in Table 2. However, the prevalence was not very different from that listed in Table 1. This may be because the combinations of these two media were used in the majority of investigations.

Many papers have reported on the level of contamination with *Campylobacter* spp. in retail poultry meats and/or by-products in North America and Europe. For example, the prevalence of *Campylobacter* spp. was reported to be 79.0% in the USA (Nannapaneni, Story, Wiggins, & Johnson, 2005), 62.4% in Canada (Valdivieso-Garcia et al., 2007), 50.5–73.5% in the UK (Meldrum, Griffiths, Smith, & Evans, 2005; Meldrum, Smith, & Wilson, 2006; Mel Tucker, & Edwards, 2004; Meldrum, Tucker, Smith, & Edv

Table 2
Prevalence of *Campylobacter* in retail poultry in Japan (results from the selected papers only)[a]

Samples	No. of references	No. of samples	Prevalence (average) (%)	95% Confidence interval (%)
Poultry meats (total)	20	1258	61.5	58.8–64.2
Breasts	9	187	59.9	52.9–66.9
Thighs	11	278	56.8	51.0–62.6
Wings	9	167	61.1	53.7–68.5
Fillets	3	38	23.7	10.2–37.2
Poultry parts (not specified)	9	588	66.7	62.9–70.5
By-products (total)	8	322	59.0	53.6–64.4
Gizzards	5	71	60.6	49.2–72.0
Livers	7	212	60.9	54.3–67.5
Hearts	2	15	33.3	9.4–57.2
Frozen poultry (total)	5	221	18.6	13.5–23.7
Imported frozen poultry	4	182	14.8	9.6–20.0
Domestic frozen poultry	1	4	50.0	1.0–99.0
Ground poultry meats	2	72	19.4	10.3–28.5

[a] The papers cited in this table were Ando et al. (2003), Fujita et al. (2005), Furuhata et al. (2006), Igimi, Yamamoto, Okada, Yamasaki, & Ishiwa (2006), Kawamori et al. (2003), Kunii et al. (2005), Morita et al.(2003), Ono, Ando, Ozeki, et al. (2005), Ono, Ando, Kawamori, et al. (2005), Ono et al. (2004), Ono et al. (2003), Ono, Ando, et al. (2002), Ono et al. (2002), Saito et al. (2005), Saito, Yatsuyanagi, Sato, & Ito (2003);Sakamoto et al. (2006), Sallam (2007), Shimizu et al. (2006), Tada

Table 3
Frequency of *Campylobacter* spp. distribution among the isolates from retail pc Japan

References	Samples	No. of samples	*C. jejuni* (%)	*C. coli* (%)
Sallam (2007)[a]	Skin-on breasts	97	82.5	17.5
	Boneless skin-on thighs	85	77.6	22.4
	Skin-on wings	78	84.6	15.4
	Livers	37	81.1	18.9
	Gizzards	29	79.3	20.7
	Hearts	15	86.7	13.3
Sakamoto et al. (2006)[a]	Thighs (domestic and imported)	37	97.3	
Furuhata et al. (2006)[a]	Chicken meats and by-products	30	93.3	6.7
Matsuoka et al. (2006)	Raw thighs	3	66.7	33.3
	Raw breasts	3	100.0	
	Raw gizzards	3	100.0	
Shimizu et al. (2006)[a]	Chicken meats and by-products	5	83.6	16.4
Kai et al. (2006)	Imported chicken (Brazil)	17	67.6	32.4
	Imported chicken (Thailand)	8	31.3	68.8
	Imported chicken (China)	2	75.0	25.0
	Imported chicken (USA)	1	100.0	
Murakami et al. (2005)	Chicken	2	75.0	25.0
Watanabe et al. (2005)[a]	Chicken	6	100.0	
	Livers	10	100.0	
	Breasts	2	100.0	
	Thighs	2	100.0	
	Wings	2	100.0	
	Livers	3	100.0	
Ono, Ando, Kawamori, et al. (2005)[a]	Chicken meats	49	100.0	
Fujii et al. (2005)	Thighs (domestic and imported)	20	100.0	
Tada et al. (2004)[a]	Chicken meats and by-products	38	96.1	3.9
Ono et al. (2004)[a]	Chicken meats	192	94.8	5.2
Kawamori et al. (2003)[a]	Chicken	19	86.8	13.2
	Livers	6	100.0	
	Gizzards	6	91.7	8.3
Morita et al. (2003)[a]	Ground meats	12	100.0	
Ono et al. (2003)[a]	Domestic chicken	48	100.0	
	Imported chicken	16	62.5	37.5
Ono, Ando, et al. (2002)[a]	Livers	50	100.0	
Ono et al. (2002)[a]	Chicken meats	54	98.1	1.9
Tsujisawa et al. (2002)[a]	Chicken	18	83.3	5.6
All papers	Total	1055	89.3	10.4
	Domestic total	954	90.1	9.6
	Imported total	44	60.2	39.8
Selected papers[b]	Total	996	90.0	9.7
	Domestic total	943	90.2	9.6
	Imported total	16	62.5	37.5
	Domestic meats	664	90.3	9.4
	Domestic by-products	143	89.2	10.8

ı5; Wilson, 2002; Wilson, 2003), and 32.0–43.0% in Germany am, Contzen, Horlacher, & Rau, 2006; Hartung, 2006). In this re- w, we calculated that approximately 60% of raw poultry meats l by-products in Japan were contaminated with *Campylobacter* . (Tables 1 and 2); this is almost equivalent to the contamina- ı levels observed in the abovementioned countries.

Frequency of Campylobacter spp. distribution among the isolates n retail poultry

Campylobacter isolates were identified from poultry in 18 out of 32 papers and 14 out of the 22 selected papers, and the fre- ·ncy of *Campylobacter* spp. distribution among the isolates from

e 4a
ıbers of *Campylobacter* spp. contaminated in retail poultry in Japan determined by MPN method[a]

ples	No. of references	No. of samples	Cells/100 g				
			Negative (%)	10 (%)	100 (%)	1000 (%)	>5500 (%)
ıtry meats total)	10	451	28.8	18.4	25.1	21.1	6.7
easts	4	103	27.2	23.3	26.2	20.4	2.9
ıighs	5	102	35.3	8.8	27.5	20.6	7.8
'ings	4	85	42.4	21.2	17.6	15.3	3.5
ıultry parts not pecified)	3	161	18.6	19.9	26.7	24.8	9.9
›roducts total)	3	84	40.5	7.1	16.7	21.4	14.3
zzards	2	15	40.0	20.0	20.0	13.3	6.7
vers	2	69	40.6	4.3	15.9	23.2	15.9
orted frozen oultry	1	100	84.0	14.0	2.0	0.0	0.0
ınd poultry neats	1	16	68.8	0.0	12.5	6.3	12.5

The papers cited in this table were Fukushima et al. (2007), Matsuoka et al.)6), Ishimura et al. (2006), Ono, Ando, Ozeki, et al. (2005), Ono, Ando, Kawamori, l. (2005), Ono et al. (2004), Kawamori et al. (2004), Kawamori et al. (2003), Ono l. (2003), Ono, Ando, et al. (2002) and Ono et al. (2002).

le 4b
ıbers of *Campylobacter* spp. contaminated in retail poultry in Japan determined by MPN method (results from the selected papers only)[a]

ıples	No. of references	No. of samples	Cells/100 g				
			Negative (%)	10 (%)	100 (%)	1000 (%)	>5500 (%)
ltry meats total)	7	409	29.6	17.8	25.7	20.3	6.6
:easts	3	100	28.0	22.0	27.0	20.0	3.0
ıighs	3	89	34.8	10.1	27.0	19.1	9.0
/ings	4	85	42.4	21.2	17.6	15.3	3.5
›ultry parts not pecified)	4	161	18.6	19.9	26.7	24.8	9.9
products total)	2	81	42.0	4.9	16.0	22.2	14.8
izzards	1	12	50.0	8.3	16.7	16.7	8.3
vers	2	69	40.6	4.3	15.9	23.2	15.9
›orted frozen ›oultry	1	100	84.0	14.0	2.0	0.0	0.0
und poultry neats	1	16	68.8	0.0	12.5	6.3	12.5

The papers cited in this table were Fukushima et al. (2007), Ono, Ando, Ozeki, l. (2005), Ono, Ando, Kawamori, et al. (2005), Ono et al. (2004), Kawamori et al.)3), Ono et al. (2003), Ono, Ando, et al. (2002) and Ono et al. (2002).

Table 5
Penner serotype distribution of *C. jejuni* isolated from retail poultry in Japan

References[a]	No. of samples	Penner serotype																					
		1, 44	2	3	4-complex	5	6, 7	8	10	11	12	15	18	19	21	23, 36, 53	31	32	37	38	45	57	UT[b]
Furuhata et al. (2006)	28	2	5		1		1	1								3			5				10
Shimizu et al. (2006)	75	6	20	7	7	1		5	1	3	1			2	1	1			2				18
Fujita et al. (2005)	8		1	1	1					1	1								1				2
Saito et al. (2005)	68		14	3	9	2	1	5	2			3	1	6	2		1		2	2			15
Tada et al. (2004)	40		7	2	1	2		2			3		2		1								21
Ono et al. (2004)	182	12	22	15	12	2	16	11	2	1	4	13	1	8	5	1		4	6	2	2	8	37
Kawamori et al. (2003)	34	2	5	2	1		3	2	2	1	2	3	1	4							2		4
Morita et al. (2003)	12	4	3		1			1															3
Ono et al. (2002)	33		7		4		6	4			2				3	1			1				5
Total	480	5.38%	17.39%	6.21%	7.66%	1.45%	5.59%	6.42%	1.45%	1.24%	2.69%	3.93%	1.04%	4.14%	2.48%	1.24%	0.21%	0.83%	3.52%	0.83%	0.83%	1.66%	23.81%

[a] All papers describing serotype distribution were met the criteria.
[b] UT: untypable.

retail poultry in Japan is listed in Table 3. In domestic poultry, even in both poultry meats and by-products, approximately 90% of the isolates were *C. jejuni*, while approximately only 10% were *C. coli*. On the other hand, it was observed that *C. coli* was isolated more frequently from imported poultry than from domestic poultry; however, this was observed in the investigations reported in only two papers. As shown in Table 3, the number of *C. coli* isolates were higher than that of *C. jejuni* isolates in frozen poultry from Thailand, and *C. coli* was the dominant *Campylobacter* species isolated from poultry in Thailand (Meeyam, Padungtod, & Kaneene, 2004; Padungtod & Kaneene, 2005). It is quite reasonable that the compositions of *Campylobacter* species in imported frozen poultry and in poultry of their original countries are strongly related, but further investigations are needed.

3.4. Numbers of *Campylobacter* spp. contaminated in retail poultry

The most probable number (MPN) method is quantitative and sensitive for detecting microorganisms, although the procedures are somehow complicated. The numbers of *Campylobacter* spp. isolated from retail poultry, as determined by the MPN method, were reported in 11 out of the 32 papers and 10 out of the 22 selected papers. The summarized data are shown in Tables 4a and 4b. Approximately 20–40% of poultry meats and by-products were contaminated with >1000 cells/100 g of *Campylobacter* spp. Livers, in particular, tended to have higher levels of contamination with *Campylobacter* spp. In a volunteer study, *C. jejuni* infection was reported to occur after the ingestion of as few as 500–800 cells (Black, Levine, Clements, Hughes, & Blaser, 1988; Robinson, 1981). This suggests that a large section of retail poultry in Japan was contaminated with *C. jejuni/coli* at levels that were adequate to induce gastroenteritis if the meat consumed was raw or undercooked. Compared to refrigerated poultry, contamination of frozen poultry was less prevalent and frozen poultry had relatively fewer *Campylobacter* cells, although this data is derived from only one paper, mainly because *Campylobacter* cells are damaged under frozen conditions, as mentioned above (Bhaduri & Cottrell, 2004).

3.5. Penner serotype distribution of *C. jejuni* isolated from retail poultry

Penner serotyping is a serological typing method based on soluble heat-stable antigens of *Campylobacter* spp. (Mora Penner, 1999). Penner serotyping is widely used, especiall Japan, because the antisera are commercially available from D Seiken Co., Ltd. (Tokyo, Japan). Penner serotype distributio *C. jejuni* isolates was reported in 9 out of the 32 papers, all of w were selected papers, and is listed in Table 5. In retail poult Japan, serotype 2 was the dominant serotype followed by s types 4-complex, 8, 3, 6 and 7, and 1 and 44. The predominant otypes 2 and 4-complex were reported to be the domi serotypes not only in poultry but also in human and bovine isol in Japan (Fujita, Sakawaki, Morita, Boonmar, & Kimura, 2005; S et al., 2005). Serotype 19, which was reported to be strongly a ciated with Guillain-Barré syndrome in Japan (Fujimoto, 2(was moderately detected (4.14%). Further, approximately a qu of the isolates were untypable.

3.6. Antimicrobial resistance of *Campylobacter* spp. isolated from r poultry

Quinolone resistance and, to a lesser extent, macrolide r tance of *Campylobacter* isolates from production animals now recognized as emerging public health problems (Engl Aarestrup, Taylor, Gerner-Smidt, & Nachamkin, 2001). In par lar, over the past decades, fluoroquinolone resistant *Campylob* species have clearly increased in many parts of the world (Eng et al., 2001). Antimicrobial resistance of *Campylobacter* spp. lated from retail poultry was reported in 8 out of the 32 pa and 7 out of the 22 selected papers and has been summarize Table 6. Resistance to sulfamethoxazole-trimethoprim (10 for *C. jejuni*) was the most frequent, followed by resistanc cephalothin (96.0% for *C. jejuni* and 95.6% for *C. coli*). Resista to quinolones, including nalidixic acid, ciprofloxacin, floxacin, and ofloxacin, was approximately 40% for *C. jejuni*

Table 6
Antimicrobial resistance of *Campylobacter* spp. isolated from retail poultry in Japan

References	Bacteria species	No. of samples	Antibiotics[d]											
			CET	NA	CPFX	TC	ABPC	KM	EM	SM	GM	CP	NFLX	OFLX
Sallam (2007)[a]	*C. jejuni*	150	143	89	71	47	54	51	23	8	5			
	C. coli	45	43	32	30	21	22	24	13	8	0	1		
Shimizu et al. (2006)[a]	*C. jejuni*	75		24	24	27			0				24	24
	C. coli	19		12	12	15			4				12	12
Igimi et al. (2006)[a]	*Campylobacter*	87		39	33	24			2				33	33
Kai et al. (2006)	*C. jejuni* (domestic)	235		74	74	103			0				74	74
	C. coli (domestic)	29		12	12	19			1				12	12
	C. jejuni (imported)	17		8	8	10			0				8	8
	C. coli (imported)	10		10	10	8			1				10	10
Fujita et al. (2005)[a]	*C. jejuni*	23	23	8	7	11	11		0				7	7
Tada et al. (2004)[a]	*C. jejuni*	40		23	22	31			1				22	22
Saito et al. (2003)[a]	*C. jejuni*	91		39	34	38			5				34	34
Tsujisawa et al. (2002)[a]	*C. jejuni/coli/lari*[c]	15		5	6	7			0				6	6
All papers	Total (%)		95.9	44.9	41.0	43.2	39.9	38.5	6.0	8.2	2.6	1.5	37.8	37.8
	C. jejuni (total) (%)		96.0	42.0	38.0	42.3	37.6	34.0	4.6	5.3	3.3	1.3	35.1	35.1
	C. coli (total) (%)		95.6	64.1	62.1	61.2	48.9	53.3	18.4	17.8	0.0	2.2	58.6	58.6
Selected papers[b]	Total (%)		95.9	49.7	43.9	40.6	39.9	38.5	8.8	8.2	2.6	1.5	39.4	39.4
	C. jejuni (total) (%)		96.0	48.3	41.7	40.6	37.6	34.0	7.7	5.3	3.3	1.3	38.0	38.0
	C. coli (total) (%)		95.6	68.8	65.6	56.3	48.9	53.3	26.6	17.8	0.0	2.2	63.2	63.2

[a] These papers were selected by the criteria mentioned in Section 2.
[b] Calculations were performed using the selected papers only.
[c] *C. jejuni* 13, *C. coli* 1, *C. lari* 1.
[d] Not tested

oximately 60% for *C. coli*. On the other hand, *C. jejuni* rarely)ited resistance to erythromycin, streptomycin, gentamicin, chloramphenicol, while *C. coli* rarely exhibited resistance to amicin and chloramphenicol. These trends of antimicrobial tance to fluoroquinolones, such as ciprofloxacin, norfloxacin, ofloxacin, and erythromycin (a macrolide) are almost compa- : to that in other Western countries (Belanger & Shryock, '; Guévremont, Nadeau, Sirois, & Quessy, 2006; Rao et al., ·).

›nclusions

ı conclusion, the prevalence of *Campylobacter* contamination :tail poultry meats and by-products was, on the average, oximately 60% in Japan, although frozen poultry and ground try meats showed lower prevalence. This contamination level ·mparable to those observed in North America and Europe. high prevalence of *Campylobacter* contamination in retail try suggests the necessity of the sanitary handling of poultry ucts.

his review provides detailed and referable data regarding *Cam-)acter* contamination in retail poultry meats and by-products, ıding species distribution, quantitative contamination level, :ype distribution, and antimicrobial resistance of *Campylobac-)p.*, in Japan. It would also be valuable information that can be l by researchers of other countries.

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:ndix A. Supplementary material

ıpplementary data associated with this article can be found, in)nline version, at doi:10.1016/j.foodcont.2008.08.016.

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REVIEW *Public Health*

Campylobacter Contamination in Retail Poultry Meats and By-Products in the World: A Literature Survey

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ABSTRACT. *Campylobacter* species are common bacterial pathogens associated with human gastroenteritis worldwide. In North America, Europe and Japan, campylobacteriosis is one of the leading food-borne bacterial illnesses and the consumption of poultry meats and/or by-products is suspected a major cause of the illness. In this survey, we summarized the research papers describing *Campylobacter* contamination of retail poultry meats and by-products in various countries of the world. In most of the countries, a majority of retail poultry meats and by-products were contaminated with *Campylobacter* spp. *C. jejuni* was usually the dominant *Campylobacter* species isolated from retail poultry and *C. coli* was less frequently isolated, although the ratio of *C. coli* to *C. jejuni* was considerably different among the countries. However, in Thailand and South Africa, *C. coli* was the dominant *Campylobacter* species isolated from retail poultry. A large portion of retail poultry was contaminated with *Campylobacter* spp. in the world; therefore, further trials are required for finding proper countermeasures and attention should be paid for the sanitary handling of poultry products.

KEY WORDS: *Campylobacter*, chicken, food microbiology, food safety.

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Campylobacter species are common bacterial pathogens associated with human gastroenteritis in both developed and developing countries [12, 55, 80]. Contaminated raw or undercooked poultry meats and/or by-products are particularly important to cause food-borne campylobacteriosis in humans [11]. There are many reports describing *Campylobacter* contamination in retail poultry meats and/or by-products in the world. Recently, we summarized the Japanese situation of *Campylobacter* contamination in retail poultry meats and by-products elsewhere [73] and concluded that 58.8% of retail poultry meats and 60.3% of poultry by-products, on the average, were contaminated with *Campylobacter* spp. in Japan. For comparing the contamination levels among the countries or areas, we performed a literature survey of *Campylobacter* contamination in retail poultry worldwide in this article.

METHODS

We searched for the papers which described the retail poultry meats and by-products contaminated with *Campylobacter* spp. by using the combination of two sets of keywords, which were "*Campylobacter*" and "poultry or chicken". The databases, such as JSTPlus and JMedPlus provided by the Japan Science and Technology Agency, PubMed provided by the United States National Library of Medicine, ScienceDirect provided by Elsevier, and Japana Centra Revuo Medicina provided by the Japan Medical Abstract Society, were used. These databases were searched from July to August, 2007. The papers, which were published from 2002 to the time of the searches, describing *Campylobacter* contamination in retail poultry, but not in poultry at farms or at processing plants, were collected. Totally 107 papers were collected but 32 out of 107 papers concerning the Japanese situation were summarized in our previous paper, as mentioned above. Hence, in this article, we summarized other 75 papers, together with the citation of our previous paper for the Japanese situation.

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RESULTS AND DISCUSSION

Detection methods of Campylobacter spp: For detecting *Campylobacter* spp. from food stuffs, several official protocols are presented in the world, such as ISO method (ISO 10272), FDA-CFSAN (BAM) method, UK (PHLS) method, etc. In addition to these official protocols, many other methods were reported in many research papers.

The investigations reported by the papers cited in this article employed several different methods for detecting *Campylobacter* spp. For example, the detection methods used were mainly culture methods, such as, the qualitative (enrichment) method, most probable number (MPN) method, and direct plating method; and molecular biological methods and immunochemical methods in combination with or without enrichment culture. The sample preparation methods used were mainly to homogenize the sample, to rinse the sample, and to immerse the sample directly in the culture media or combinations of the latter two but swabs of the sample or drip fluids from the sample were also used in some investigations. The enrichment media employed were mainly Bolton broth and Preston broth, but Exeter broth, which are included in PHLS method, or Park and Sanders broth, which are included in ISO method, or *Campylobacter* enrichment broth (CEB) were used in several investigations.

The isolation media employed were mainly charcoal cefaperazone deoxycholate agar (CCDA) plates, but Karmali agar plates, which are included in ISO method, or Abeyta-Hunt(-Bark) agar plates, which are included in BAM method, or Preston agar plates were also used in several investigations. Moreover, the detailed conditions for enrichment and isolation culture, the methods for identification, and the initial sample weights for sample preparation differed among investigations. However, these differences in the methods were not considered, although the performance of enrichment and isolation media used to detect *Campylobacter* spp. was considerably different (5).

Prevalence of Campylobacter spp. in retail poultry meats and by-products: We classified into 5 categories; poultry meats, poultry by-products, frozen poultry meats, frozen poultry by-products, and ground poultry meats (Table 1). In several investigations, *Campylobacter* contamination was examined in each part of poultry meats and/or by-products separately, such as breasts, thighs, wings, fillets, gizzards, livers, hearts, etc. However, in a majority of investigations, the portions of poultry meats and by-products examined were not specified or whole poultry carcasses, not poultry portions, were examined. Therefore, we just categorized as poultry meats, including whole poultry carcasses, and by-products instead of each portion. In our previous review describing the Japanese situation, the prevalence of contamination with *Campylobacter* spp. were approximately 60% in any portions of raw poultry meats and by-products except for fillets and hearts [73]. The average prevalence was calculated on the basis of either country or area or total.

In poultry meats, most of the countries showed 50% or more in prevalence of *Campylobacter* contamination, although Estonia and Belgium showed exceedingly lower prevalence (Table 1). However, the methods employed in the papers concerning Estonia and Belgium (2 papers about Estonia [58, 60] and 1 paper about Belgium [18]) were common methods; the samples were prepared by homogenizing or rinsing, then cultured in *Campylobacter* enrichment broth or Preston broth for enrichment, and then subcultured onto CCDA plates for isolation. Hence, at least, the lower prevalence in these countries did not depend on the methods employed. Compared among the areas, Middle and South America and Oceania showed higher prevalence of contamination, although the numbers of the papers were somewhat limited. On the other hand, former Soviet Union & Eastern Europe showed lower prevalence, mainly because exceedingly low prevalence was shown in Estonia. In fact, 74.7% in average prevalence of contamination were shown in this area except Estonia.

Compared to poultry meats, fewer investigations were reported concerning poultry by-products, frozen poultry meats, frozen poultry by-products, and ground poultry meats. Due to less information, these could not be compared on the country- or area-basis. On the average, the prevalence of poultry by-products was relatively higher than poultry meats. Frozen poultry meats and by-products showed lower prevalence compared with poultry meats and by-products, respectively. This can be attributed to the report explaining that frozen conditions damage *Campylobacter* cells and decrease their viability [6, 50]. The prevalence of *Campylobacter* contamination in ground poultry meats was lower than that in poultry meats. *Campylobacter* spp. are microaerobic bacteria and are damaged in the air [22]. Therefore, it is speculated that *Campylobacter* cells contaminated might be exposed to the air and dead during and after the grinding process, although no references could be found describing the effects of grinding on this bacteria.

Frequency of Campylobacter spp. distribution among the isolates from retail poultry: The frequency of *Campylobacter* spp. distribution among the isolates from retail poultry in various countries is listed in Table 2. In most of the countries, *C. jejuni* was the dominant species isolated from poultry and *C. coli* was less frequently isolated, although the ratio of *C. coli* to *C. jejuni* was considerably different among the countries. Traditionally, hippurate hydrolysis test was used for species identification between *C. jejuni* and *C. coli*, but it was reported that this test is not always reliable [63]. In several investigations, molecular biological methods were used for identification instead of the traditional test. For avoiding inaccuracy of hippurate hydrolysis test, only the results of species distribution determined by molecular biological methods are summarized in Table 3. Although some differences were found between Table 2 and Table 3, there were still considerable differences of the *C. coli/C. jejuni* ratio among the countries. Especially in Thailand, *C. coli* was more frequently isolated from retail poultry meats and by-products compared to *C. jejuni*, even determined molecular biologically. Meeyam *et al.* and Padungtod *et al.* reported that *C. coli* and *C. jejuni* were almost comparably prevalent in poultry at farms in Thailand, but via processing plants to markets, the ratio of *C. coli* to *C. jejuni* was drastically increasing [40, 52]. They suggested the possibility of transmission of *Campylobacter* spp. from non-poultry source(s) to poultry, especially at markets. However, it should be noted that *C. coli* was highly colonized even in poultry at farm level in Thailand compared with other countries, where *C. jejuni* was the dominant species colonized [16], although the reasons are not certain.

CONCLUSIONS

In this paper, we surveyed *Campylobacter* contamination in retail poultry meats and by-products in the world. In most of the countries (both developed and developing countries), in spite of their sanitary conditions, a majority of retail poultry meats and by-products were contaminated with *Campylobacter* spp. *C. jejuni* was usually the dominant *Campylobacter* species isolated, but the ratio of *C. coli* to *C. jejuni* varied among the countries. Especially in Thailand and South Africa, *C. coli* was the dominant *Campylobacter* species isolated from retail poultry. In the present situation where a proper countermeasure can not be found, although some trials were made in some countries, attention should be paid for the sanitary handling of poultry products.

Table 1. Prevalence of *Campylobacter* in retail poultry in various countries

Samples	Countries	No. of references	No. of samples	Prevalence (%)	References
Poultry meats	Total average	73	20261	58.0	
	North America	10	2644	63.8	
	USA	7	1167	71.5	13, 14, 17, 47, 48, 51, 59
	Canada	3	1477	57.7	7, 45, 76
	Middle and South America	4	832	82.3	
	Trinidad and Tobago	2	741	84.6	61, 62
	Argentina	1	14	92.9	33
	Barbados	1	77	58.4	84
	Europe	42	12114	53.3	
	Western Europe	37	11229	56.0	
	UK	14	5579	68.7	4, 8, 26, 38, 41, 42, 43, 44, 46, 64, 66, 71, 81, 82
	Germany	8	2462	45.6	2, 3, 21, 31, 34, 35, 68, 69
	Denmark	3	154	64.9	27, 28, 29
	Austria	2	323	51.7	39, 54
	Ireland	2	904	51.1	67, 79
	Italy	2	185	80.0	53, 57
	Spain	2	253	59.3	15, 37
	Belgium	1	917	17.0	18
	France	1	68	58.8	56
	Sweden	1	45	42.2	63
	Switzerland & Liechtenstein	1	339	25.1	32
	Former Soviet Union & Eastern Europe	5	885	19.1	
	Estonia	2	739	8.1	58, 60
	Belarus & Russia	1	10	50.0	70
	Bulgaria	1	135	76.3	72
	Czech	1	1	100.0	23
	Africa	2	316	73.1	
	Senegal	1	250	82.0	9
	South Africa	1	66	39.4	49
	Asia	13	4095	60.3	
	Thailand	4	186	65.1	40, 52, 74, 77
	Korea	3	1458	66.6	20, 24, 30
	Vietnam	2	160	30.0	19, 36
	Japan	1[a)]	1551	58.8	73
	Iran	1	121	62.8	75
	Turkey	1	127	83.5	65
	Pakistan	1	492	48.0	25
	Oceania	2	260	90.4	
	New Zealand	1	230	89.1	83
	Australia	1	30	100.0	1
Poultry by-products	Total average	10	642	69.6	
	Trinidad and Tobago	1	188	90.4	61
	UK	2	17	76.5	8, 64
	Germany	1	13	23.1	3
	Austria	1	44	40.9	54
	Spain	1	2	100.0	37
	Belarus & Russia	1	7	100.0	70
	Thailand	1	16	50.0	74
	Japan	1[b)]	325	60.3	73
	New Zealand	1	30	100.0	78
Frozen poultry meats	Total average	14	2097	47.2	
	UK	7	1299	58.6	4, 26, 41, 42, 44, 46, 81
	Germany	1	49	55.1	31
	Switzerland & Liechtenstein	1	76	7.9	32
	Belarus & Russia	1	28	67.9	70
	Bulgaria	1	105	35.2	72
	South Africa	1	33	18.2	49
	Japan	1[c)]	297	30.5	73
	China	1	210	30.5	85

Table 1. continue

Samples	Countries	No. of references	No. of samples	Prevalence (%)	References
Frozen poultry by-products	Total average	3	108	29.6	
	Austria	1	8	50.0	54
	Belarus & Russia	1	10	0.0	70
	China	1	90	31.1	85
Ground poultry meats	Total average	4	194	17.0	
	Austria	1	66	21.2	54
	Estonia	1	30	0.0	60
	Spain	1	10	0.0	37
	Japan	1[d]	88	21.6	73

a) 1 review originally cited 29 papers. b) 1 review originally cited 9 papers. c) 1 review originally cited 7 papers. d) 1 review originally cited 3 papers.

Table 2. Frequency of *Campylobacter* spp. distribution among the isolates from retail poultry in various countries

Countries	No. of references	No. of samples	Ratio (%)			Cc/Cj	References
			C. jejuni	*C. coli*	others	(Cj as 100)	
Argentina	1	13	100.0	0.0	0.0	0.0	33
Belarus & Russia	1	113	100.0	0.0	0.0	0.0	70
New Zealand	2	376	98.3	1.7	0.0	1.8	78, 83
Denmark	1	220	98.2	1.8	0.0	1.9	29
Estonia	1	48	87.5	8.3	4.2	9.5	58
Canada	3	852	90.3	8.6	0.6	9.6	7, 45, 76
Japan	1[a]	1055	89.3	10.4	0.3	11.6	73
Belgium	1	612	87.1	11.4	1.5	13.1	18
Ireland	2	528	86.6	12.9	0.6	14.9	67, 79
Barbados	1	94	79.8	13.8	6.4	17.3	84
Australia	1	30	83.3	16.7	0.0	20.0	1
UK	6	800	82.4	16.8	0.9	20.3	4, 8, 46, 64, 66, 81
Germany	6	1078	69.1	17.9	13.2	25.9	2, 3, 21, 31, 34, 69
Turkey	1	364	69.2	20.9	9.9	30.2	65
Bulgaria	1	140	73.6	26.4	0.0	35.9	72
Spain	1	51	72.5	27.5	0.0	37.8	37
USA	4	797	64.7	27.2	8.0	42.1	13, 14, 17, 51
Pakistan	1	236	66.1	33.9	0.0	51.3	25
Vietnam	1	31	45.2	25.8	29.0	57.1	36
Senegal	2	373	58.7	34.9	6.4	59.4	9, 10
Italy	2	150	61.7	38.3	0.0	62.2	53, 57
Trinidad and Tobago	1	340	57.1	42.9	0.0	75.3	61
Korea	3	1131	53.1	46.9	0.0	88.5	20, 24, 30
South Africa	1	32	28.1	37.5	34.4	133.3	49
Thailand	3	127	32.3	54.3	14.2	168.3	40, 52, 74

a) 1 review originally cited 18 papers.

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Table 3. Frequency of *Campylobacter* spp. distribution among the isolates from retail poultry in various countries (molecular biologically determined only)

Countries	No. of references	No. of samples	Ratio (%)			Cc/Cj (Cj as 100)	References
			C. jejuni	*C. coli*	others		
New Zealand	1	205	98.3	1.7	0.0	1.8	83
Italy	1	22	93.2	6.8	0.0	7.3	53
Canada	1	749	90.8	8.5	0.7	9.4	76
Belgium	1	612	87.1	11.4	1.5	13.1	18
Barbados	1	94	79.8	13.8	6.4	17.3	84
Japan	1[a]	424	83.5	16.0	0.5	19.2	73
Australia	1	30	83.3	16.7	0.0	20.0	1
Germany	3	221	71.0	18.6	11.3	26.1	2, 3, 31
UK	2	120	73.8	26.2	0.0	35.5	8
Spain	1	51	72.5	27.5	0.0	37.8	37
USA	4	797	64.7	27.2	8.0	42.1	13, 14, 17, 51
Senegal	1	168	58.9	26.8	14.3	45.5	10
Korea	2	552	48.0	52.0	0.0	108.3	20, 24
Thailand	2	87	24.1	65.5	11.5	271.4	40, 52

a) 1 review originally cited 5 papers.

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