

Control of Campylobacter infection in broiler flocks through
two-steps strategy: nutrition and vaccination

-CAMPYBRO-

FP7-SME-2013-605835

**Campylobacter: un reto para la
avicultura de carne europea**



Murcia, 13/12/2013



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Campylobacter vs campylobacteriosis

**¿Cómo puedo reducir el riesgo para los
consumidores?**

**La reducción de la contaminación de la carne
de pollo y el consiguiente riesgo para la salud
humana se puede lograr mediante la
reducción de la concentración de
Campylobacter en los broilers, y otras
medidas en el matadero, sala de despiece y
envasado**

Reduction associated with interventions in primary production is expected to vary considerably between MSs. Reducing the numbers of *Campylobacter* in the intestines at slaughter by 3 log₁₀-units, would reduce the public health risk by at least 90%. Reducing the numbers of *Campylobacter* on the carcasses by 1 log₁₀-unit, would reduce the public health risk by between 50 and 90%. Reducing counts by more than 2 log₁₀ units would reduce the public health risk by more than 90%. The risk

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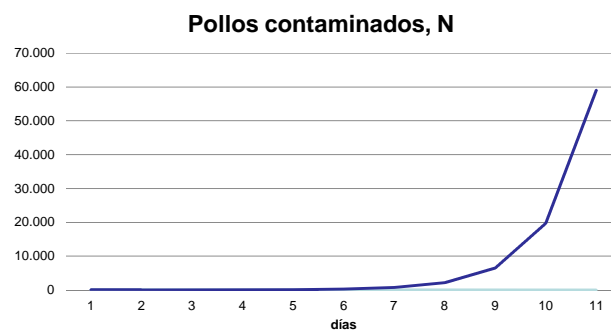
Estrategias de control

- ❑ Estrategias presacrificio
 - ❑ Estrategias post sacrificio
 - ❑ Etiquetado
 - ❑ Información y educación
-
- ❑ **Premisa: sin transmisión vertical**

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Dinámica de infección

- ❑ Baja dosis infectiva (5-50 UFC/pollo)
- ❑ Transmisión eficaz MUY EFECTIVA (100%)
- ❑ 10^8 CFU/g en heces
 - ❑ 10^8 CFU/g*25g*25.000pollos= $6 \cdot 10^{13}$ UFC/d
 - ❑ Supuesto: cada pollo infecta a 3/d



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Estrategias presacrificio



- ❑ Relación entre concentración de *Campylobacter* en los intestinos y en las canales (Reich et al. 2008) .
- ❑ Niveles de *Campylobacter* en ciego son $1\log_{10}$ inferiores que a nivel fecal (Nauta et al., 2007).
- ❑ Reducciones significativas en los ciegos, se traducen en menores contaminaciones de las canales y en las piezas cárnicas

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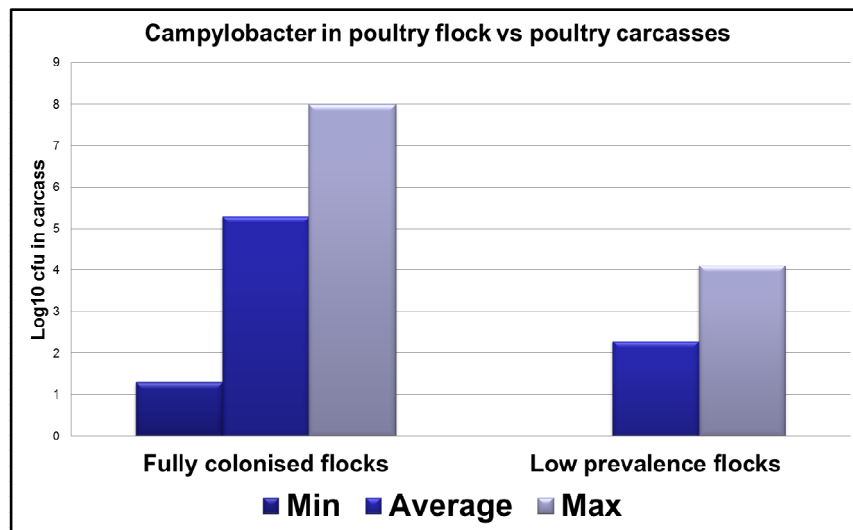
Estrategias presacrificio



- ❑ Los contenidos medios de *Campylobacter*/g en muestras intestinales se sitúan entre $4,74 \log_{10}$ a $8,2 \log_{10}$ cfu/g
- ❑ Los contenidos medios de *Campylobacter*/g en la canal (piel de cuello) se sitúan entre $1,90$ – $3,93 \log_{10}$ cfu/g.
- ❑ ...la concentración en la piel es en torno a $4\log_{10}$ menos que en los intestinos
- ❑ Una reducción de $2 \log_{10}$ puede reducir la incidencia de campilobacteriosis asociada con el consumo de pollo de hasta 30 veces

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Relación contaminación animal-canal



Allet et al., 2007

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Estrategias presacrificio

- ❑ Criterios microbiológicos
 - ❑ Irlanda: $4\log_{10}$ cfu/g
 - ❑ UK (2015): canales $>3\log_{10}$ cfu/g menos 10%
 - ❑ EC?

Broiler (ciego)	Broiler (fecal)	Broiler (canal)
10^n	10^{n-1}	10^{n-3}
10^7	10^6	10^4
10^6	10^5	10^3



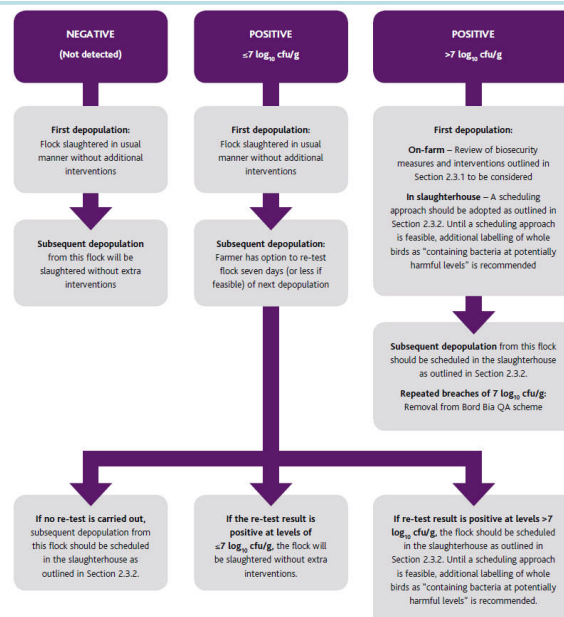
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Criterio microbiológico en granja (Irlanda)

- ❑ Un límite de $<6-7 \log_{10}$ en muestras de ciego es recomendada
- ❑ Muestreo 7d presacrificio, por nave de cebo
- ❑ Selección de 10 pollos al azar en varios puntos, extracción de ciegos, y homogenización en una muestra
- ❑ Análisis de conteos en laboratorio autorizado

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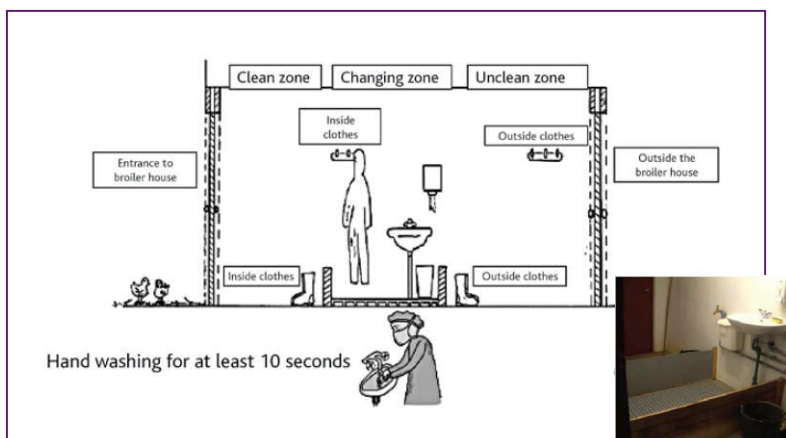
Criterio microbiológico en granja (Irlanda)



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Estrategias presacrificio

- ❑ **Acceso de personal e higiene:**
 - ❑ **Un sistema de cambio de botas y de higiene en la sala de acceso**
 - ❑ **Zona sucia y limpia**



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Estrategias presacrificio

- ❑ **Alrededores de las naves:**
 - ❑ **Limpieza de alrededores, ausencia de vegetación, basuras, aperos, etc**
 - ❑ **Grava para permitir el drenaje**
 - ❑ **Plan de plagas**



Photos: Marta Cerdà and Roser Dolz

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Estrategias presacrificio

- ❑ **Control de moscas**
 - ❑ Cuando sea posible, se deben situar mosquiteras, especialmente en manadas de alta prevalencia
 - ❑ Si no es posible, se deben adoptar otras medidas



Photos: Birthe Hald



Photo: Birthe Hald

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Estrategias presacrificio

- ❑ **Control de moscas**
 - ❑ En discusión (Cancom project under FP7)



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Estrategias presacrificio



- ❑ Reducción de la edad de sacrificio
 - ❑ Una reducción de la edad de sacrificio disminuye significativamente la probabilidad de altos conteos. Posible aplicación en manadas de alta prevalencia, y en meses de verano
- ❑ Programa limpieza y desinfección y vacío sanitario
 - ❑ La transmisión horizontal es muy eficaz, por lo que se debe evitar cualquier fuente de contaminación
- ❑ Cebo de sexos separados
 - ❑ Mayor homogeneidad de canales, mejor ajuste de equipos de sacrificio en matadero.

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Estrategias presacrificio



- ❑ Aclarado (Thining)
 - ❑ Técnica de extracción de parte de la población de una nave, para ajustar la densidad y comercializar pollo asador
- ❑ Ruptura de bioseguridad
- ❑ Claro factor de riesgo para infección de *Campylobacter*
- ❑ Si se hace
 - ❑ Evitar más de una
 - ❑ Lo más cercana al sacrificio
 - ❑ Bioseguridad en el proceso: ropa y botas de operarios específica de cada nave, camiones, desinfección de utensilios entre naves (incluso dentro de misma explotación)
 - ❑ Formación de operarios

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Estrategias nutricionales: bacteriocinas, tamaño partícula

Review

Bacteriocins to control *Campylobacter* spp. in poultry—A review

E. A. Svetoch* and N. J. Stern†

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ABSTRACT The unacceptably high frequency of *Campylobacter jejuni* transmission from poultry to humans encourages scientists to consider and create alternative intervention strategies to control the pathogen in poultry production. Extremely high numbers of *Campylobacter* (often >10⁸ cfu/g of poultry intestinal material) potentiate high numbers of the organism on the processed broiler carcass with increasing consequent human health risk. Many scientists believe interventions during poultry production portend the greatest opportunity for reducing risk of disease. Over the past 10 yr, we have focused our studies on nonantibiotic bacteriocin application to intervene during animal production and this is the subject of the current review. The application of therapeutic bacteriocin treatments to reduce poultry colonization diminishes *Campylobacter* from >10⁸ cfu/g of cecal materials to nondetectable or very low levels in treated birds. Further, the review provides scientists with a useful starting point for the further development of industry-applicable interventions leading to reduced transmission of this agent in human disease.

Key words: *Campylobacter*; bacteriocin; colonization; broiler; intervention

2010 Poultry Science 89:1763–1768
doi:10.3382/ps.2010-00659

Journal of Applied Microbiology

Journal of Applied Microbiology ISSN 1364-5072

ORIGINAL ARTICLE

Reduced spread of *Campylobacter jejuni* in broiler chickens by stimulating the bird's natural barriers

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Estrategias nutricionales: probióticos

Evaluating the efficacy of an avian-specific probiotic to reduce the colonization of *Campylobacter jejuni* in broiler chickens

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ABSTRACT *Campylobacteriosis* is the most frequent zoonotic disease in humans worldwide, and the contaminated poultry meat by *Campylobacter jejuni* can be considered one of the important sources of enteric infections in humans. The use of probiotics, which can help to improve the natural defense of animals against pathogenic bacteria, is an alternative and effective approach to antibiotic administration for livestock to reduce bacterial contamination. In vitro experiments showed that *Enterococcus faecium*, *Palaeococcus acidilactis*, *Lactobacillus salivarius*, and *Lactobacillus reuteri* isolated from healthy chicken gut inhibited the growth of *C. jejuni*. To demonstrate this effect in vivo, 1-d-old broiler chicks received 2 mg/bird per day of a multispecies probiotic product via the drinking water. Controls received no probiotic treatment, and all chicks were infected with *C. jejuni* orally. Results showed that the cecal colonization by *C. jejuni* was significantly reduced by probiotic treatment at both 8 and 15 d postchallenge. To confirm this effect, in a second in vivo experiment, 1-d-old broiler chicks received the same dose of the same probiotic via the drinking water and controls received no probiotic, and all chicks were infected with *C. jejuni* orally. Similarly, probiotic treatment reduced ($P = 0.001$) cecal colonization by *C. jejuni* at both 8 and 15 d postchallenge. **The results of our in vivo experiments conclude that probiotic administration reduced the colonization of *C. jejuni* in broiler chickens.**

Key words: probiotic, *Campylobacter jejuni*, colonization, food-borne illness, broiler

2012 Poultry Science 91:1825–1832
http://dx.doi.org/10.3382/ps.2012-02168

Table 1. The effect of administration of a multispecies probiotic product (PoultryStar sol, BIOMIN GmbH, Herzogenburg, Austria) on the cecal colonization of *Campylobacter jejuni* in broiler chickens in 2 in vivo experiments¹

Item	Treatment			SEM	P-value
	Control (n = 10)	PoultryStar sol (2 mg/bird/day) (n = 10)	PoultryStar sol (20 mg/bird/day) (n = 10)		
First experiment					
<i>C. jejuni</i> (log cfu/g) (8 d postchallenge)	6.77 ^a	3.00 ^b	—	0.51	0.001
<i>C. jejuni</i> (log cfu/g) (15 d postchallenge)	8.00 ^a	2.50 ^b	—	0.23	0.001
Second experiment					
<i>C. jejuni</i> (log cfu/g) (8 d postchallenge)	7.83 ^a	<2.00 ^b	<2.00 ^b	0.52	0.001
<i>C. jejuni</i> (log cfu/g) (15 d postchallenge)	7.80 ^a	<2.00 ^b	<2.00 ^b	0.51	0.001

¹Means within the same row with different superscripts are significantly different (Mann-Whitney test was performed for the first experiment, n = 10/treatment and Kruskal-Wallis test followed by Mann-Whitney test for the second experiment, n = 10/treatment).
²Data presented as means of logarithms of 10 cecal samples per group (log cfu/g).

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Estrategias nutricionales: extractos plantas



Journal of Food Protection, Vol. 65, No. 10, 2002, Pages 1545–1560

Bactericidal Activities of Plant Essential Oils and Some of Their Isolated Constituents against *Campylobacter jejuni*, *Escherichia coli*, *Listeria monocytogenes*, and *Salmonella enterica*

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MS 01-493: Received 31 December 2001/Accepted 24 May 2002

ABSTRACT

An improved method of sample preparation was used in a microplate assay to evaluate the bactericidal activity levels of 96 essential oils and 23 oil compounds against *Campylobacter jejuni*, *Escherichia coli* O157:H7, *Listeria monocytogenes*, and *Salmonella enterica* obtained from food and clinical sources. Bactericidal activity (BA50) was defined as the percentage of the sample in the assay mixture that resulted in a 50% decrease in CFU relative to a buffer control. Twenty-seven oils and 12 compounds were active against all four species of bacteria. The oils that were most active against *C. jejuni* (with BA50 values ranging from 0.003 to 0.009) were marigold, ginger root, jasmine, patchouli, gardenia, cedarwood, carrot seed, celery seed, mugwort, spikenard, and orange bitter oils; those that were most active against *E. coli* (with BA50 values ranging from 0.046 to 0.14) were oregano, thyme, cinnamon, palmarosa, bay leaf, clove bud, lemon grass, and allspice oils; those that were most active against *L. monocytogenes* (with BA50 values ranging from 0.057 to 0.092) were gardenia, cedarwood, bay leaf, clove bud, oregano, cinnamon, allspice, thyme, and patchouli oils; and those that were most active against *S. enterica* (with BA50 values ranging from 0.045 to 0.14) were thyme, oregano, cinnamon, clove bud, allspice, bay leaf, palmarosa, and marjoram oils. The oil compounds that were most active against *C. jejuni* (with BA50 values ranging from 0.003 to 0.034) were cinnamaldehyde, estragole, carvacrol, benzaldehyde, citral, thymol, eugenol, perillaldehyde, carvone R, and geranyl acetate; those that were most active against *E. coli* (with BA50 values ranging from 0.057 to 0.28) were carvacrol, cinnamaldehyde, thymol, eugenol, salicylaldehyde, geraniol, isoeugenol, citral, perillaldehyde, and estragole; those that were most active against *L. monocytogenes* (with BA50 values ranging from 0.019 to 0.43) were cinnamaldehyde, eugenol, thymol, carvacrol, citral, geraniol, perillaldehyde, carvone S, estragole, and salicylaldehyde; and those that were most active against *S. enterica* (with BA50 values ranging from 0.034 to 0.21) were thymol, cinnamaldehyde, carvacrol, eugenol, salicylaldehyde, geraniol, isoeugenol, terpineol, perillaldehyde, and estragole. The possible significance of these results with regard to food microbiology is discussed.

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Estrategias nutricionales: extractos de plantas



Is allicin able to reduce *Campylobacter jejuni* colonization in broilers when added to drinking water?

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ABSTRACT Reducing *Campylobacter* shedding on the farm could result in a reduction of the number of human campylobacteriosis cases. In this study, we first investigated if allicin, allyl disulfide, and garlic oil extract were able to either prevent *C. jejuni* growth or kill *C. jejuni* in vitro. Allyl disulfide and garlic oil extract reduced *C. jejuni* numbers in vitro below a detectable level at a concentration of 50 mg/kg (no lower concentrations were tested), whereas allicin reduced *C. jejuni* numbers below a detectable level at a concentration as low as 7.5 mg/kg. In further experiments we screened for the anti-*C. jejuni* activity of allicin in a fermentation system closely mimicking the broiler cecal environment using cecal microbiota and mucus isolated from *C. jejuni*-free broilers. During these fermentation experiments, allicin reduced *C. jejuni* numbers below a detectable level after 24 h at a concentration of 50 mg/kg. In contrast, 25 mg/kg of allicin killed *C. jejuni* in the first 28

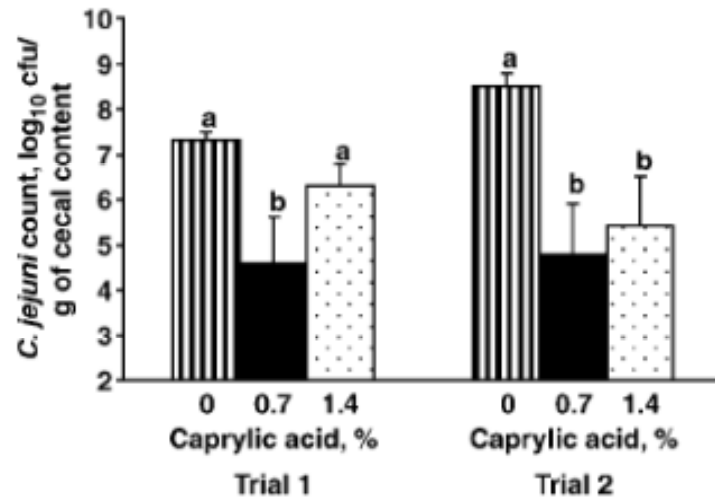
h of incubation, but anti-*C. jejuni* activity was lost after 48 h of incubation, probably due to the presence of mucin in the growth medium. This had been confirmed in fermentation experiments in the presence of broiler cecal mucus. Based on these results, we performed an in vivo experiment to assess the prevention or reduction of cecal *C. jejuni* colonization in broiler chickens when allicin was added to drinking water. We demonstrated that allicin in drinking water did not have a statistically significant effect on cecal *C. jejuni* colonization in broilers. It was assumed, based on in vitro experiments, that the activity of allicin was thwarted by the presence of mucin-containing mucus. **Despite promising in vitro results, allicin was not capable of statistically influencing *C. jejuni* colonization in a broiler flock, although a trend toward lower cecal *C. jejuni* numbers in allicin-treated broilers was observed.**

Key words: *Campylobacter jejuni*, allicin, in vivo, broiler, drinking water

2013 Poultry Science 92:1408–1418
http://dx.doi.org/10.3382/ps.2012-02863

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Estrategias nutricionales: MCFA



De los Santos et al., 2009

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Muestreo post sacrificio

- ❑ Granjas positivas de $\leq 6-7$ log₁₀ cfu/g
 - ❑ Negativas: se da por hecho de que son negativas
 - ❑ Positivas $>6-7$ log₁₀ cfu/g: por hecho contaminación de la canal
- ❑ Tras el enfriado y previo a resto de procesado
- ❑ A mitad de la manada
- ❑ Muestreo de 15 canales: 10g de piel de cuello
 - ❑ 5 grupos de 3 fragmentos (5x25g)
 - ❑ Detección y muestreo de *Campylobacter*

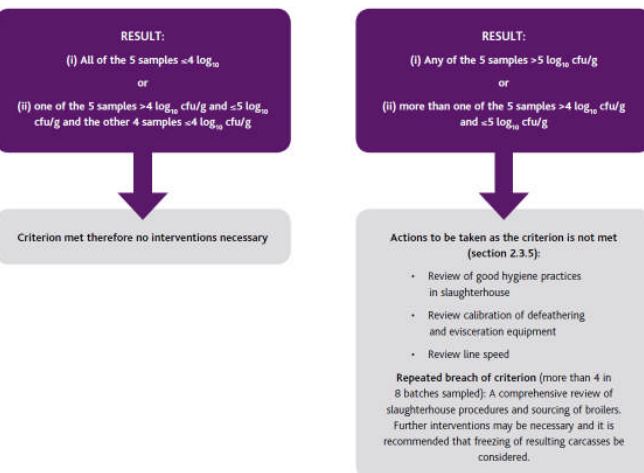


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Post-harvest criteria (Ireland)

Post-harvest sampling should be conducted once a week on a carcass from a flock whose pre-harvest result is positive and $\leq 7 \log_{10}$ cfu/g.

Sampling plan and limits: $n=5$ samples; $c=1$ sample between m and M ; $m=4 \log_{10}$ cfu/g; and $M=5 \log_{10}$ cfu/g (for details see section 2.2.3 and Appendix 2)



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UK

**THE JOINT GOVERNMENT AND INDUSTRY TARGET
TO REDUCE *CAMPYLOBACTER* IN UK PRODUCED CHICKENS BY 2015
DECEMBER 2010**

TARGET TO REDUCE *CAMPYLOBACTER* IN UK PRODUCED CHICKENS

The Target

6. The target will be to reduce *Campylobacter* contamination on whole chickens in UK slaughterhouses and **will be based on *Campylobacter* counts (enumeration)** as this is

The target will be monitored using a banding approach, where samples are grouped into 3 bands according to whether the *Campylobacter* counts in chicken are above or below a set level (i.e. <100 cfu/g, $100-1,000$ cfu/g, and $>1,000$ cfu/g). The target is limited to 3 bands for simplicity and to allow sensible interpretation when monitoring progress against the baseline. The target focuses on decreasing the proportion of birds in the most contaminated group i.e. $>1,000$ cfu/g. A number of factors affect the likelihood of

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UK



**THE JOINT GOVERNMENT AND INDUSTRY TARGET
TO REDUCE CAMPYLOBACTER IN UK PRODUCED CHICKENS BY 2015
DECEMBER 2010**

The UK target for reduction of *Campylobacter* is a reduction in the percentage of chickens produced in UK poultry slaughterhouses that have the highest level of contamination, i.e. those with more than 1,000 cfu per gram, from a baseline of 27% in 2008 to 10% by 2015, measured post-chill. It is expected that the least contaminated chickens i.e. less than 100 cfu per gram, will get no worse or will improve upon the baseline of 42% by 2015. The baseline was determined in 2008 by the EU survey of *Campylobacter* in broiler batches and on *Campylobacter* and *Salmonella* on broiler carcasses⁷.

The target will be set in the slaughterhouse at the end of the slaughter process, post chill. The advantages, and disadvantages, of a slaughterhouse target were compared to

enhanced biosecurity to keep *Campylobacter* out of UK poultry farms. The new on-farm standards will be implemented throughout the UK by the Red Tractor Farm Assurance Poultry Standards – Broiler and Poussin, in April 2011. The new standards will be

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UK



**THE JOINT GOVERNMENT AND INDUSTRY TARGET
TO REDUCE CAMPYLOBACTER IN UK PRODUCED CHICKENS BY 2015
DECEMBER 2010**

Slaughterhouse Interventions

	<i>Campylobacter</i> enumeration		
	<100 cfu/g	100-1,000 cfu/g	>1,000 cfu/g
Baseline	42%	31%	27%
2013 Expected progress	Expected improvement	Expected improvement	19%
Target reviewed 2013 2015 target reset as appropriate			
Model estimates (2015)	68%	22%	10%
Target 2015	Expected improvement	Expected improvement	10% Target

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Medidas post sacrificio

- ❑ **Escaldado**
 - ❑ Suave (50-52°C) a severo (56-68°C)
 - ❑ A 52°C, reducciones notables a partir de 9 min (no comercial) Humphrey et al. (2007)
 - ❑ Tanques de contracorriente: el agua va en sentido contrario a las canales para crear un flujo de sucio a limpio
 - ❑ Tanques de alto fluido de agua
 - ❑ Tanques multi piscina



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Medidas post sacrificio

- ❑ **Desplumado**
 - ❑ Alto riesgo de contaminación cruzada entre canales
 - ❑ Salida de material fecal por la presión ejercida a las canales
 - ❑ Los folículos están abiertos y permiten la entrada y acantonamiento de la bacteria en los mismos
 - ❑ Recomendaciones
 - ❑ Ajuste de la maquinaria al tamaño del lote
 - ❑ Mantenimiento, limpieza y desinfección



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Medidas post sacrificio

- ❑ **Evisceración**
 - ❑ Se debe minimizar la ruptura de los intestino y la diseminación del contenido intestinal
 - ❑ Contaminación de la canal, y contaminación cruzada
 - ❑ Recomendaciones
 - ❑ Alineación de equipos
 - ❑ Inspección visual continua para el máximo ajuste de los equipos
 - ❑ Mantenimiento, limpieza y desinfección



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Medidas post sacrificio

- ❑ **Enfriado**
 - ❑ Enfriado lo más rápidamente posible para evitar la proliferación bacteriana
 - ❑ Junto con la desecación, puede reducir los conteos $1 \log_{10}$
 - ❑ Recomendaciones
 - ❑ Temperaturas y flujos adecuados para secado y enfriado
 - ❑ Retirar de las canales con agua los restos de materia orgánica antes del proceso



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Medidas post sacrificio

- ❑ Congelación
- ❑ Ajuste de maquinaria a tamaño de los pollos, y máxima homogeneidad de las canales
- ❑ Congelación de la parte exterior de la canal mediante CO₂
 - ❑ Reducción de 0,5log₁₀
 - ❑ Se puede vender como carne fresca, siempre que la temperatura no disminuya de -2°C (Reglamento (EC) 543/2008)
- ❑ Retirada de la piel de las piezas, evitando la contaminación cruzada
 - ❑ La piel concentra la mayoría de la contaminación



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Medidas post sacrificio

- ❑ Tratamiento de canales con agua caliente
 - ❑ 1,66 log₁₀ cfu/cm² a 75°C en 30 s (Corry et al. 2007)
 - ❑ Aspecto de cocido
- ❑ Tratamiento térmico con vapor
 - ❑ Más eficaz por penetrar en folículos
 - ❑ 1,3 log₁₀ cfu/g a 90°C con vapor atmosférico en 12 s
 - ❑ Aspecto de cocido
- ❑ Tratamiento con vapor y ultrasonidos
 - ❑ ≥2,52 log₁₀ cfu/canal
 - ❑ Aspecto de cocido
- ❑ Sacrificios logísticos
 - ❑ Sacrificio de manadas positivas al final de la semana
 - ❑ En este momento es imposible por el elevado nivel de contaminación



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Medidas post sacrificio

- ❑ Uso de partidas contaminadas para productos de valor añadido
- ❑ Marinados
- ❑ Asados
 - ❑ D-value (combinación de t y T^a para matar el 90% de a población) (ICMSF, 1996):
 - ❑ 55°C: 2,12-2,25min
 - ❑ 57°C: 0,79-0,98min



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Medidas post sacrificio

- ❑ Atmósfera modificada
 - ❑ Boysen et al. (2007) encontraron reducciones en *Campylobacter* de 2,0-2,6 log₁₀ CFU/g después de 8d en 70%/30% O₂/CO₂ , pero ninguna reducción con 70%N₂/30%CO₂.
 - ❑ Rajkovic et al. (2010) encontraron reducciones en *Campylobacter* de 1,2 log₁₀ CFU/g con 80% O₂/20% N₂



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Control of Campylobacter infection in broiler flocks through
two-steps strategy: nutrition and vaccination

-CAMPYBRO-

FP7-SME-2013-605835



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Consortium



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Imasde Agroalimentaria, S.L.

- ❑ Research center.
- ❑ Coordinator




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ANSES



Paquetes de trabajo



CAMPYBRO		WP	Year 1												Year 2												Year 3											
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30						
WP 1: Efficacy of several compounds against <i>Campylobacter</i> in broilers orally infected looking for synergies		WP1																																				
T1.1. In vivo effectiveness of products based on plant extracts, organic acids, prebiotics, and probiotics against <i>Campylobacter</i> .		T1.1	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*							
T1.2. In vitro effectiveness of mixtures of products: Synergistic effect		T1.2																																				
T1.3. In vivo effectiveness of product mixtures based on plant extracts, organic acids, prebiotics, and probiotics against <i>Campylobacter</i> .		T1.3																																				
WP 2: Feed presentation strategies against <i>Campylobacter</i> .		WP2																																				
T2.1. Effect of feed composition, particle size and feed presentation on the prevalence of <i>Campylobacter</i> in broilers orally infected		T2.1	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*							
T2.2. Effect of whole grain feeding on the prevalence of <i>Campylobacter</i> in broilers orally infected.		T2.2																																				
WP 3: Interactions between products and feed presentation against <i>Campylobacter</i> , Synergies.		WP3																																				
T3.1. Interactions between product mixtures and feeding strategies against <i>Campylobacter</i> looking for synergies		T3.1																	*	*	*	*	*	*	*	*	*	*	*	*	*							
T3.2. Studies in the effect of the duration of treatment on the final infection: design of functional diets		T3.2																	*	*	*	*	*	*	*	*	*	*	*	*	*							
T3.3. Study on the correlation between in vitro and in vivo results. Cost-Benefit analyses.		T3.3																	*	*	*	*	*	*	*	*	*	*	*	*	*							
WP 4: Application of different nutritional strategies against <i>Campylobacter</i> in experimental farm and field trials.		WP4																																				
T4.1. Effect of different strategies against <i>Campylobacter</i> on performance parameters and level of infection of broilers chickens in experimental farms.		T4.1																									*	*	*	*	*							
T4.2. Effect of different strategies against <i>Campylobacter</i> on performance parameters and level of infection of broilers chickens in commercial farms.		T4.2																									*	*	*	*	*							
T4.3. Effect of different strategies against <i>Campylobacter</i> on performance parameters and level of infection of turkeys in commercial farms.		T4.3																									*	*	*	*	*							
WP 5: Development of a novel vaccine against <i>Campylobacter</i> based on reverse vaccinology		WP5																																				
T5.1. Exhaustive identification of new potential vaccine antigens against <i>Campylobacter</i> using the reverse vaccinology strategy.		T5.1	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*							
T5.2. Development of an in vitro test to visualize the recognition of <i>Campylobacter</i> antigens by antibodies.		T5.2																	*	*	*	*	*	*	*	*	*	*	*	*	*							
T5.3. Determination of an efficient sub-unit vaccination protocol		T5.3	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*							
T5.4. Selection of the <i>Campylobacter</i> proteins that will be evaluated for their protective capacity		T5.4																																				
T5.5. Assessment of the protective potentials against <i>Campylobacter</i> induced by the selected vaccine candidates.		T5.5																									*	*	*	*	*							
WP 6: Evaluation of the developed nutritional strategies in different geographical situations.		WP6																																				
T6.1. Evaluation of developed nutritional strategies in South, Central, and East European conditions		T6.1																									*	*	*	*	*							
WP 7: Project Management		WP7																																				
T7.1. Contractual, legal, Administrative and financial management and overseeing of ethical and gender issues		T7.1	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*							
T7.2. Monitoring and coordination of technical activities of the project, and planning, organizing and reporting of Project Coordinating Committee and General Assembly		T7.2	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*							
T7.3. Relationship with the European Commission		T7.3	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*							
WP 8: Dissemination, training and exploitation		WP8																																				
T8.1. Dissemination of project results		T8.1	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*							
T8.2. Training to achieve project results implementation		T8.2																																				
T8.3. Exploitation of project results		T8.3																																				
MILESTONES			MILESTONE 1						MILESTONE 2						MILESTONE 3						MILESTONE 4						MILESTONE 5											

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Work Packages


WP 1. Efficacy of several compounds against *Campylobacter* in broilers orally infected looking for synergies.

☐ T1.1. In vivo effectiveness of products based on plant extracts, organic acids, prebiotics, and probiotics against *Campylobacter*.

☐ T1.2. In vitro effectiveness of mixtures of products: Synergistic effect

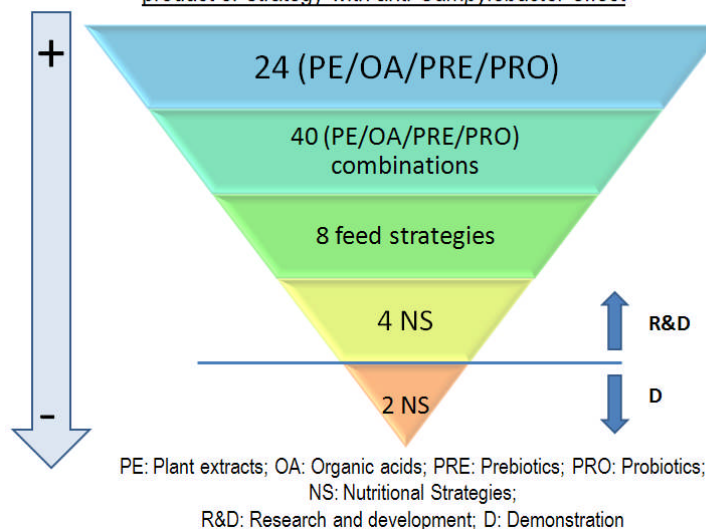
☐ T1.3. In vivo effectiveness of product mixtures based on plant extracts, organic acids, prebiotics, and probiotics against *Campylobacter*.





Work Packages

Figure 1.4.1. Selective pressure procedure to detect to best product or strategy with anti *Campylobacter* effect



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Work Packages

WP2. Feed presentation strategies against *Campylobacter*.

- T2.1. Effect of feed composition, particle size and feed presentation on the prevalence of *Campylobacter* in broilers orally infected
- T2.2 Effect of whole grain feeding on the prevalence of *Campylobacter* in broilers orally infected.

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Work Packages



WP 3. Interactions between products and feed presentation against *Campylobacter*. Synergies.

- ❑ T3.2. Interactions between product mixtures and feeding strategies against *Campylobacter* looking for synergies
- ❑ T3.2 Studies in the effect of the duration of treatment on the final infection: design of functional diets
- ❑ T3.3. Study on the correlation between in vitro and in vivo results. Cost-Benefit analyses.

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Work Packages



WP 4. Application of different nutritional strategies against *Campylobacter* in experimental farm and field trials.

- ❑ T4.1. Effect of different strategies against *Campylobacter* on performance parameters and level of infection of broilers chickens in experimental farm.
- ❑ T4.2. Effect of different strategies against *Campylobacter* on performance parameters and level of infection of broilers chickens in commercial farms.
- ❑ T4.3. Effect of different strategies against *Campylobacter* on performance parameters and level of infection of turkeys in commercial farms.

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Work Packages



WP 5. Development of a novel vaccine against Campylobacter based on reverse vaccinology

- ❑ T5.1. Exhaustive identification of new potential vaccine antigens against Campylobacter using the reverse vaccinology strategy.
- ❑ T5.2. Development of an in vitro test to visualize the recognition of Campylobacter antigens by antibodies.
- ❑ T5.3. Determination of an efficient sub-unit vaccination protocol
- ❑ T5.4. Selection of the Campylobacter proteins that will be evaluated for their protective capacity
- ❑ T5.5. Assessment of the protective potentials against Campylobacter induced by the selected vaccine candidates.

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Work Packages



WP 6. Evaluation of the developed nutritional strategies in different geographical situations.

- ❑ T6.1. Evaluation of developed nutritional strategies in South, Central, and East European conditions

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Work Packages



WP 7. Project Management.



- T7.1. Contractual, legal, Administrative and financial management and overseeing of ethical and gender issues
- T7.2. Monitoring and coordination of technical activities of the project, and planning, organizing and reporting of Project Coordinating Committee and General Assembly
- T7.3. Relationship with the European Commission

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Work Packages



WP 8. Dissemination, training and exploitation.

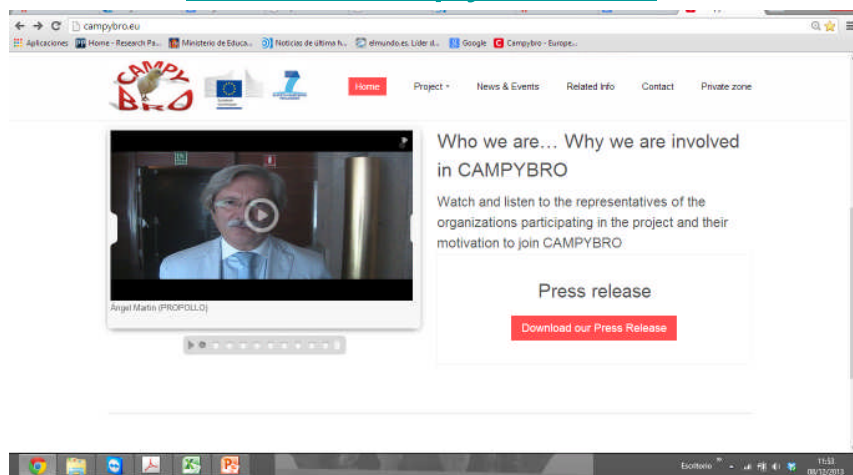


- T8.1. Dissemination of project results
- T8.2. Training to achieve project results implementation
- T8.3. Exploitation of project results

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Consortium

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