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Use of Antimicrobials from Plants in Feed as a Control Measure for Pathogenic Microorganisms

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Abstract

Animal Feed has become an increasing critical component of the integrated food chain, in 2010 about 1000 mt of animal feed was produced globally and 150 mt in the EU27. The animal feed has an important impact in the human health. The farm or feedlot is the origin of microorganisms introduced onto carcasses during slaughter and dressing. It appears that changes in diet and management practices could precipitate increased shedding of pathogens. Additionally, antibiotics are used in animals, not only for treatment or prevent diseases, but also to promote growth. As a result of the use of antibiotics, food can contain antibiotic-resistant bacteria and resistance genes with important public health consequences.

Although antibiotics are banned as growth promoters in the European Union and some other countries, this is not the case throughout the WHO European Region. Travel and the globalization of trade further increase the risk of spreading antibiotic-resistant bacteria.

Keywords: Animal feed; *Campylobacter jejuni*; Salmonella; *Escherichia coli*; Bacteria

Numerous studies carried about for evaluating the antimicrobial activity of plants, vegetables and agro-food by-products have demonstrated their efficiency against different pathogens. The use of these vegetables (plants and by-products) for obtaining natural additives with antimicrobial properties could be used in feed, after the adequate studies, to reduce antibiotics consumption with a natural feeding. Another approach with significant research is feed animals with probiotics ("good bacteria") to competitively exclude the pathogens.

According to EFSA meeting report (2012) related to foodborne pathogens from zoonotic origin, *Campylobacter jejuni*, *Salmonella*, *Escherichia coli*, and *Listeria monocytogenes* have been described with incidence in broiler flocks and raw animal origin products.

Campylobacter jejuni was responsible of the most human zoonotic confirmed cases in 2010. Moreover, it is of concern the human campylobacteriosis significant increase occurred in the last five-year at European Union (2006-2010). The most important reservoir continues to be broiler meat at European Union level, with 30 % of fresh broiler meat units positive for Campylobacter, varying from 3.1 % to 90.0 % (EFSA, 2012).

Regarding Salmonella and although the observed reduction in salmonellosis cases mainly due to successful Salmonella control programmes, salmonellosis still remains as an important disease with economic impact as it may affect animal performance and may result in foodborne disease in humans through the eggs and carcass contamination. The costs associated with non-typhoidal Salmonella infections are estimated at nearly $2.4 billion dollars annually, which includes costs due to loss of productivity and medical treatment costs. A poultry producer suffers losses due to Salmonella infection of the flock including loss of birds and production time [1].

Salmonella is most often detected in fresh broiler at different levels of the production chain, with Salmonella-positive samples proportion varying between 0.2 % and 27.8 % but on average, at European Union level, 1.2 % of the samples were positive. The highest contamination levels (27.8 %, single samples) were reported by Hungary in non-read-to-eat (RTE) meat preparations at retail [2]. It is remarkable the prevalence of the five serovars: *Salmonella enteritidis*, *Salmonella typhimurium*, *Salmonella infantis*, *Salmonella virchow* and *Salmonella hadar*. Among them, *Salmonella enteritidis*, *Salmonella typhimurium* are serovars most frequently associated with human illness [3,4]. Human *Salmonella enteritidis* cases are most commonly associated with the consumption of contaminated eggs and poultry meat, while *Salmonella typhimurium* cases are mostly associated with the consumption of contaminated pig, poultry and bovine meat [2].

Due to the risk for unborn child, infants, and the elderly by means of *Listeria monocytogenes* infection, it will be considered in the present study because of *Listeria* spp. is one of the most relevant zoonotic agents with food safety implications by consumption of ready-to-eat in the last products of animal origin (e.g.. fowl meat) (4.9 % of RTE products of animal origin are non-meeting the criterion of absence of *Listeria monocytogenes* in 25 g of product at processing level) [5].

In Europe 2005, 380,000 European Union citizens were affected by infectious zoonotic diseases, 5311 food-borne outbreaks were reported involving 47,251 people and resulting in 5330 hospitalizations and 24 deaths. Campylobacter and Salmonella reported the highest number of cases, 197,363 and 176,395, mainly related to fresh poultry meat and eggs, poultry and pig meat, respectively [6]. *Yersinia enterocolitica* reported 9630 cases and *Escherichia coli* VTEC caused 3314 cases, which were mainly associated to fresh bovine meat. *Listeria monocytogenes*

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reported 1439 cases, mainly related to RTE products, and *Brucella mellitensis* accounted for 1218 cases [6].

One of the greatest challenges in the meat industry is to keep the product safe and free from pathogen contamination. Several pre-slaughter interventions are used to reduce intestinal carriage of pathogens such as macronutrient diet formulation, antibiotics and growth-enhancing additives, phenolic antimicrobial compounds; organic acids and acidified feed, chlorate and nitro-based compounds and others that have been used in food animals worldwide [7].

Under the principle "from farm to fork", animal feeds are considered to be a sensitive stage at the beginning of the food chain, being the origin of microorganisms present onto carcasses at slaughter and dressing steps. So, animal feed should accomplish the main objective to produce a final meat product with required quality and without health (chemical or microbiological) risk to consumers. It appears that changes in diet and management practices could precipitate increased shedding of pathogens. Feeding cattle barley-based diets [8] or wet distillers grains [9] increased shedding of *E. coli* O157:H7 compared with feeding standard corn diets. There also is significant research on the feeding of probiotics ("good bacteria") to livestock to competitively exclude the pathogens. A *Lactobacillus* based direct-fed microbial has shown promise in decreasing the shedding of *E. coli* O157:H7 [10]. Sodium chlorate treatment has been shown to reduce populations of *Salmonella typhimurium* and *E. coli* O157:H7 in the intestinal content of swine and cattle [11,12] and work is underway to see if this can be used in the field. From the point of view of the manipulation of ecosystem microbial, antimicrobial specificity based on the Gram negative and Gram positive bacteria reaction could be useful. For example, [13] investigated the effect of thymol *in vitro* on the fermentation of glucose by *Streptococcus bovis* and *Selenomonas ruminatium* and verified that thymol inhibited lactate production, glucose uptake and the growth of the *Streptococcus bovis* and *Selenomonas ruminatium*. Furthermore, the thymol has been reported be a strong deaminase inhibitor [14]. Some plants and their extracts have been shown to stimulate the growth of certain bacteria, i.e., prebiotic-type effect [15,16]. This effect was corroborated by [17] that observed the oregano essential oils, like antibiotics, modify the gut microflora and reduce microbial load by suppressing bacteria proliferation. There are some claims that oregano oil can replace anticoccidial compounds, not because they inactivate coccidia, but because they increase the turnover of the gut lining and prevent coccidial attack by maintaining a more healthy population of gut cells. This mode of action would increase the animal's maintenance energy requirement because enterocyte turnover is a major proportion of the basal metabolic rate. In this context, it is very interesting consider the use of natural plant extracts, essential oils or some of its components as one of the tools for animal nutritionist to reduce the excretion of pathogenic bacteria [18,19].

It has been documented that substantial amounts of antibiotics are administered to food animals for growth promotion, feed efficiency, and prophylaxis in the absence of known disease [20-25]. In Europe, the market of antimicrobials was segmented into antibiotics (e.g., oxytetracycline), antibacterial (e.g., carbadox), anticoccidial (e.g., salinomycin), growth promoters (e.g., monensin) and others that included anthelmintic (e.g., ivermectin) [26]. Despite the beneficial effects of antibiotics as additives in feed, their use worldwide has been questioned, regulated and even prohibited. For example, European Union member nations banned all antibiotic growth promoters in 2006 according to European Parliament and Council Regulation EC No. 1831/2003 as a precautionary principle [27]. On the other hand, Russia, Mexico, South Korea, Brazil, USA, Australia, Japan, China, and Canada, allow the use of some antimicrobials as feed additives [28].

In the United States alone, it is estimated that 11.2million kg of antibiotics per year is administered to food animals for nontherapeutic purposes, whereas only 900,000 kg is consumed for therapeutic treatments [29]. An intensive debate, therefore, has raged over past three decades on the impact of the use of antibiotics in food animals on human health [30]. Adverse effects of the extensive use of antibiotics in animal practices include generating antibiotic-resistant organisms and resistance genes [21]. These resistant bacteria can be transferred to humans directly or indirectly via the food chain, which is of special interest and importance to public health in relation to infectious disease [26,31-33]. Antimicrobial resistance is as a result of four strategies namely enzymatic inactivation of the drug [34], modification of target sites [35], reduced cellular uptake [36] and extrusion by efflux [37].

Due to the accumulation of antibiotic-resistant bacteria and genes, leading to the treatment failure or longer convalescence in both humans and animals, research on antibiotic replacement is currently emerging [38-40] under the concept "clean, green, and ethical" (CGE) animal production [41].

Use of natural antimicrobials such as extracts from spices and/or herbs for the purpose of food preservation and/or the substitution of antibiotics have arisen. Before the advent of readily-available antibiotics in the 1950s, antimicrobial plant derivatives were commonly used [42]. These bioactive compounds act as plant survival mechanisms and defense mechanisms in response to environmental stressors, pathogen attack, competing plants and herbivory [43]. Phytocompounds have a large variety of principle actives and their effects expected are several as act on the improvement in the palatability of feed, feed intake, feed digestibility, stimulate the pancreatic secretions to increase endogenous enzyme activity, gut development/health, antimicrobial/antiviral, antioxidative and anti-inflammation effects and immune system that could benefit performance and health of farm animals [17,41,44-54]. Therefore, pthytocompounds could be used to replace some antibiotic growth promoters [55,56]. However, to be most effective as growth promoters, these herbal antimicrobial compounds must be supplemented to the feed in a more concentrated form than found in their natural source [57]. Their application in food animal production has been limited.

According to Liu [58] the phytochemicals can be classified as carotenoids, phenolics, alkaloids, nitrogen-containing compounds or organosulfur compounds. The most studied of the phytochemicals are the phenolics and carotenoids. Among them, the most studied are the phenolics and carotenoids. Phenolic compounds and phenols could be find in a wide range of plant materials (by-products, fruits, leafs, seeds) and plant extracts (essential oils, infusions) [59]. The antimicrobial activity of plant extracts is due to their chemical structure, in particular to the presence of hydrophilic functional groups, such as hydroxyl groups of phenolic components and/or lipophilicity of some essential oil components [56,59-61]. Usually, the phytoconstituents with phenolic groups as oils of clove, oregano, rosemary, thyme, sage and vanillin are the most effective [62-65]. They are more inhibitory against Gram-positive than Gram-negative bacteria [66,67]. Currently, the only way to ensure controlled dosage is to use characterized dried plant material, plant extracts or isolated bioactive secondary metabolites. These sources could be incorporated as natural additives into supplemental concentrate feeds [26]. Besides, the lipophilic nature of these compounds also presents a challenge in effective delivery to the animal gut and this can partially be resolved by microencapsulation and combination with other compounds (synergistic effect) [56].

As with antibiotics, continued use of these plant-based antimicrobials may result in the development of resistance in some pathogenic bacteria [57]. At present there is not sound evidence indicating that the use of natural antimicrobials from plants can induce resistance to those compounds in microorganisms but considering its action mechanism it can be thought that they could behaved as antibiotics. In general, is well documented that the use of inactivation treatments at sub-lethal doses produce cellular damage that after being repaired can give to the cells new abilities or some resistance to the killing agent. Nevertheless, according to several studies, the use of natural antimicrobials can induce resistance or reduce resistance to some antibiotics [57,68-70]. Moreover, the use of carvacrol and citral on *Listeria monocytogenes* produced some changes on virulence of the microorganisms as indicated by Silva [71]. On the other hand, in the literature there are also reports that phytochemicals are capable of inhibiting processes related with quorum sensing (QS), which is responsible for microbial cell genes expression, especially the virulence factors [72,73], without encouraging the appearance of antimicrobial resistance [72]. That way, more research is necessary to evaluate this potential risk for animal production and to human health even though phytogenic compounds are generally recognized safe (GRAS).

In this scenario, there is potential for isolating antimicrobial compounds that exhibit mechanisms unrelated to conventional antimicrobial compounds. Compounds feeding stuffs supplementation with these natural plant materials with possible or tested antimicrobial capability could be an alternative to reduce the final microbial counts at faeces level, with the subsequent impact on food safety not only along the food chain, but also with implications in the international trade [74,75].

However, understanding the potential for novel antimicrobial compounds in foods and feeds will require the physiological examination of foodborne pathogen response under experimental conditions comparable to the environment where the pathogen is most likely to occur.

Research on the foodborne zoonotic agents *Salmonella typhimurium*, *Listeria monocytogenes*, *E.coli* O157:H7 and *Campylobacter jejuni* is extensive and should provide a model for detailed examination of the factors that influence antimicrobial effectiveness. Analysis of pathogen response to antimicrobials could yield clues for optimizing hurdle technologies to more effectively exploit vulnerabilities of Salmonella and other foodborne pathogens when administering antimicrobials during food and feed production.

Although further research must be carried out to understand all the mechanisms and potentials of those active molecules there is little doubt that animal performance can be improved through their use. Feed additives can help in a variety of ways to reduce the risk of Salmonella infections. Essential oil compounds antibacterial properties support good flock health and could contribute to consumer food safety.

References

1. Jarquin R, Hanning I, Ahn S, Ricke SC (2009) Development of rapid detection and genetic characterization of salmonella in poultry breeder feeds. Sensors (Basel) 9: 5308-5323.
2. European Food Safety Authority (EFSA) (2012) The European Union Summary Report on Trends and Sources of Zoonoses, Zoonotic Agents and Food-borne Outbreaks in the European Union in 2010. EFSA Journal 2012 10:2597.
3. Braden CR (2006) *Salmonella enterica* Serotype Enteritidis and Eggs: A National Epidemic in the United States. Clinical Infectious Diseases: an official publication of the Infectious Diseases Society of America 43: 512-517.
4. Fernandes SA, Tavechio AT, Ghilardi AC, Dias AM, Almeida IA, et al. (2006) *Salmonella serovars* isolated from humans in São Paulo State, Brazil, 1996-2003. Rev Inst Med Trop Sao Paulo 48: 179-184.
5. European Food Safety Authority (EFSA) (2013) Analysis of the baseline survey on the prevalence of *Listeria monocytogenes* in certain ready-to-eat foods in the EU, 2010-2011 Part A: *Listeria monocytogenes* prevalence estimates. EFSA J. 11:3241.
6. European Food Safety Authority (EFSA) (2006) Zoonoses in the European Union. ISBN 10-92-9199-044-2.
7. Doyle MP, Erickson MC (2012) Opportunities for mitigating pathogen contamination during on-farm food production. Int J Food Microbiol 152: 54-74.
8. Berg J, McAllister T, Bach S, Stilborn R, Hancock D, et al. (2004) *Escherichia coli* O157:H7 excretion by commercial feedlot cattle fed either barley- or corn-based finishing diets. J Food Prot 67: 666-671.
9. Wells JE, Shackelford SD, Berry ED, Kalchayanand N, Guerini MN, et al. (2009) Prevalence and level of *Escherichia coli* O157:H7 in feces and on hides of feedlot steers fed diets with or without wet distillers' grains with solubles. J Food Prot 72: 1624-1633.
10. Brashears MM, Galyean ML, Loneragan GH, Mann JE, Killinger-Mann K (2003) Prevalence of *Escherichia coli* O157:H7 and performance by beef feedlot cattle given Lactobacillus direct-fed microbials. J Food Prot 66: 748-754.
11. Callaway TR, Anderson RC, Genovese KJ, Poole TL, Anderson TJ, et al. (2002) Sodium chlorate supplementation reduces *E. coli* O157:H7 populations in cattle. J Anim Sci 80: 1683-1689.
12. Anderson RC, Carr MA, Miller RK, King DA, Carstens GE, et al. (2001) Effects of experimental chlorate preparations as feed and water supplements on *Escherichia coli* colonization and contamination of beef cattle and carcasses. Food Microbiol 22: 439-447.
13. Evans JD, Martin SA (2000) Effects of thymol on ruminal microorganisms. Curr Microbiol 41: 336-340.
14. Van Nevel C, Demeyer DI (1988) Manipulation of rumen fermentation. In: HOBSON, HD The rumen microbial ecosystem New York: Elsevier Science 387-443.
15. Zaika LL, Kissinger JC, WassermanAE (1983) Inhibition of lactic acid bacteria by herbs. Journal of Food Science 48: 1455-1459.
16. Nes IF, Skjelkvåle R (1982) Effect of Natural Spices and Oleoresins on *Lactobacillus plantarum* in the Fermentation of Dry Sausage. Journal of Food Science 47: 1618-1621.
17. Bruerton K (2002) Antibiotic growth promoters - are there alternatives. In: Controlling Gut Health without the Use of Antibiotics. Ferket PR Proc.
18. Rebenhors J (1996) Production of methoxyphenol-type natural aroma chemicals by biotransformation of eugenol with *Pseudomonas* sp. Appl Microbiol Biotechnol 46: 470-474.
19. Misra G, Pavlostathis SG (1997) Biodegradation kinetics of monoterpenes in liquid and soil slurry systems. Appl Microbiol Biotechnol 47: 572-577.
20. Khachatourians GG (1998) Agricultural use of antibiotics and the evolution and transfer of antibiotic-resistant bacteria. CMAJ 159: 1129-1136.
21. Wegener HC (2003) Antibiotics in animal feed and their role in resistance development. Curr Opin Microbiol 6: 439-445.
22. Brisse S, Duijkeren Ev (2005) Identification and antimicrobial susceptibility of 100 Klebsiella animal clinical isolates. Vet Microbiol 105: 307-312.
23. Jindal A, Kocherginskaya S, Mehboob A, Robert M, Mackie RI, et al. (2006) Antimicrobial use and resistance in swine waste treatment systems. Appl Environ Microbiol 72: 7813-7820.
24. Gallois M, Rothkötter HJ, Bailey M, Stokes CR, Oswald IP (2009) Natural alternatives to in-feed antibiotics in pig production: Can immunomodulators play a role? Animal 3: 1644-1661.
25. Messaoudi A, Gtari M, Boudabous A, Wagenlehner F (2009) Identification and susceptibility of *Klebsiella* and *Enterobacter* spp. isolated from meat products. Afr J Microbiol Res 3: 362-369.

26. Greathead H (2003) Plants and plant extracts for improving animal productivity. Proc Nutr Soc 62: 279-290.
27. Chattopadhyay MK (2014) Use of antibiotics as feed additives: A burning question. Front Microbiol 5: 334.
28. Maron DF, Smith TJ, Nachman KE (2013) Restrictions on antimicrobial use in food animal production: An international regulatory and economic survey. Global Health 9: 48.
29. Mellon M, Benbrook C, Benbrook KL (2001) Hogging it: Estimates of Antimicrobial Abuse in Livestock. Union of Concerned Scientists, Cambridge, Mass.
30. Marshall BM, Levy SB (2011) Food animals and antimicrobials: impacts on human health. Clin Microbiol Rev 24: 718-733.
31. van den Bogaard AE, Stobberingh EE (2000) Epidemiology of resistance to antibiotics: Links between animals and humans. International Journal of Antimicrobial Agents 14: 327-335.
32. Schwarz S, Chaslus-Dancla E (2001) Use of antimicrobials in veterinary medicine and mechanisms of resistance. Vet Res 32: 201-225.
33. Oyarzabal OA (2008) Multidrug resistance among foodborne pathogens: measures to monitor and control their appearance in poultry meat. 15th Congress of the Federation of Asian Veterinary Associations, FAVA-OIE Joint Symposium on Emerging Diseases Proceedings, Bangkok, Thailand.
34. Davies J (1994) Inactivation of antibiotics and the dissemination of resistance genes. Science 264: 375-382.
35. Spratt BG (1994) Resistance to antibiotics mediated by target alterations. Science 264: 388-393.
36. Smith A (2004) “Bacterial resistance to antibiotics,” in Hugo and Russell’s Pharmaceutical Microbiology 7th Eds Denyer SP Hodges NA, Gorman SP Blackwell Science, Malden.
37. Nikaido H (1994) Prevention of drug access to bacterial targets: permeability barriers and active efflux. Science 264: 382-388.
38. Ultee A, Bennik MH, Moezelaar R (2002) The phenolic hydroxyl group of carvacrol is essential for action against the food-borne pathogen Bacillus cereus. Appl Environ Microbiol 68: 1561-1568.
39. Bagamboula CF, Uyttendaele M, Debevere J (2004) Inhibitory effect of thyme and basil essential oils, carvacrol, thymol, estragol, linalool and p-cymene towards *Shigella sonnei* and *S. flexneri.* Food Microbiol 21: 33-42.
40. Pei RS, Zhou F, Ji BP, Xu J (2009) Evaluation of combined antibacterial effects of eugenol, cinnamaldehyde, thymol, and carvacrol against *E. coli* with an improved method. J Food Sci 74: M379-383.
41. Bickell SL, Durmic Z, Blache D, Vercoe PE, Martin GB (2010) Rethinking the management of health and reproduction in small ruminants. Updates on ruminant production and medicine. 26th World Buiatrics Congress, Chile, 317-325.
42. Cowan MM (1999) Plant products as antimicrobial agents. Clin Microbiol Rev 12: 564-582.
43. Mazid M, Khan TA, Mohammad F (2011) Role of secondary metabolites in defense mechanisms of plants. Biol Med 3: 232-249.
44. Newman K (1997) Herbs and spices: Their role in modern livestock production. 217-224.
45. Gill C (1999) Herbs and plant extracts as growth enhancers. Feed Int 20: 20-23.
46. Langhout P (2000) New additives for broiler chickens. World Poultry-Elsevier 16: 22-27.
47. Schwarz S, Kehrenberg C, Walsh TR (2001) Use of antimicrobial agents in veterinary medicine and food animal production. Int J Antimicrob Agents 17: 431-437.
48. Hertrampf JW (2001) Alternative antibacterial performance promoters. Poult Int 40: 50-52.
49. Tucker LA (2002) Plant extracts to maintain poultry performance. Feed Int. 23: 26-29.
50. Brenes A, Roura E (2010) Essential oils in poultry nutrition: Main effects and modes of action. Anim Feed Sci Tech 158: 1-14.
51. Li SY, Ru YJ, Liu M, Xu B, Peron A (2012) The effect of essential oils on performance, immunity and gut microbial population in weaner pigs. Livest Sci 145: 119-123.
52. Liu Y, Song M, Che TM, Almeida JA, Lee JJ, et al. (2013) Dietary plant extracts alleviate diarrhea and alter immune responses of weaned pigs experimentally infected with a pathogenic *Escherichia coli.* J Anim Sci 91: 5294-5306.
53. Liu Y, Song M, Che TM, Bravo D, Maddox CW, et al. (2014) Effects of capsicum oleoresin, garlic botanical, and turmeric oleoresin on gene expression profile of ileal mucosa in weaned pigs. J Anim Sci 92: 3426-3440.
54. Cerisuelo A, Marín C, Sánchez-Vizcaíno F, Gómez EA, de la Fuente, et al. (2014) The impact of a specific blend of essential oil components and sodium butyrate in feed on growth performance and Salmonella counts in experimentally challenged broilers. Poult. Sci. 93: 599-606.
55. Cheng G, Hao H, Xie S, Wang X, Dai M, et al. (2014) Antibiotic alternatives: the substitution of antibiotics in animal husbandry? Front Microbiol 5: 217.
56. Yang C, Chowdhury MA, Huo Y, Gong J (2015) Phytogenic compounds as alternatives to in-feed antibiotics: Potentials and challenges in application. Pathogens 4: 137-156.
57. Ferket PR (2003) Controlling gut health without the use of antibiotics. In: Proceeding of Thirtieth annual of Carolina Poultry Nutrition Conference.
58. Liu RH (2004) Potential synergy of phytochemicals in cancer prevention: Mechanism of action. J Nutr 134: 3479S-3485S.
59. Burt S (2004) Essential oils: Their antibacterial properties and potential applications in foods--a review. Int J Food Microbiol 94: 223-253.
60. Cosentino S, Tuberoso CI, Pisano B, Satta M, Mascia V, et al. (1999) In-vitro antimicrobial activity and chemical composition of Sardinian Thymus essential oils. Lett Appl Microbiol 29: 130-135.
61. Dorman HJ, Deans SG (2000) Antimicrobial agents from plants: Antibacterial activity of plant volatile oils. J Appl Microbiol 88: 308-316.
62. Akgül A, Kivanç M (1988) Inhibitory effects of selected Turkish spices and oregano components on some foodborne fungi. Int J Food Microbiol 6: 263-268.
63. Skandamis P, Tsigarida E, Nychas GJE (2002) The effect of oregano essential oil on survival/death of *Salmonella typhimurium* in meat stored at 5°C under aerobic, VP/MAP conditions. Food Microbiol 19: 97-103.
64. Pina-Pérez MC, Silva-Angulo AB, Rodrigo D, Martinez A (2012) A preliminary exposure assessment model for *Bacillus cereus* cells in a milk based beverages: evaluating high pressure processing and antimicrobial interventions. Food Control 26: 610-613.
65. Ferrer C, Ramón D, Muguerza B, Marco A, Martínez A (2009) Effect of olive powder on the growth and inhibition of *Bacillus cereus.* Foodborne Pathog Dis 6: 33-37.
66. Mangena T, Muyima NY (1999) Comparative evaluation of the antimicrobial activities of essential oils of *Artemisia afra*, *Pteronia incana* and *Rosmarinus officinalis* on selected bacteria and yeast strains. Lett Appl Microbiol 28: 291-296.
67. Marino M, Bersani C, Comi G (2001) Impedance measurements to study the antimicrobial activity of essential oils from Lamiaceae and Compositae. Int J Food Microbiol 67: 187-195.
68. Wesche AM, Gurtler JB, Marks BP, Ryser ET (2009) Stress, sub lethal injury, resuscitation, and virulence of bacterial foodborne pathogens. J Food Prot 72: 1121-1138.
69. Zanini SF, Silva-Angulo AB, Rosenthal A, Rodrigo D, Martínez A (2014) Effect of citral and carvacrol on the susceptibility of *Listeria monocytogenes* and *Listeria innocua* to antibiotics. Lett Appl Microbiol 58: 486-492.
70. Zanini SF, Silva Angulo AB, Rosenthal A, RodrigoD, Martínez A (2014) Influence of the treatment of *Listeria monocytogenes* and *Salmonella enterica serovar typhimurium* with citral on the efficacy of various antibiotics. Foodborne Pathogens and Disease 11: 265-271.
71. Silva A, Genovés S, Martorell P, Zanini SF, Rodrigo D, et al. (2015) Sub lethal injury and virulence changes in *Listeria monocytogenes* and *Listeria innocua* treated with antimicrobials carvacrol and citral. Food Microbiol 50: 5-11.
72. Hentzer M, Givskov M (2003) Pharmacological inhibition of quorum sensing for the treatment of chronic bacterial infections. J Clin Invest 112: 1300-1307.

Citation: Zanini SF, Dolores R, Pina-Pérez MC, Sanz M, Martinez A (2015) Use of Antimicrobials from Plants in Feed as a Control Measure for Pathogenic Microorganisms. J Microb Biochem Technol 7: 248-252. doi:10.4172/1948-5948.1000218

73. Nazzaro F, Fratianni F, Coppola R (2013) Quorum sensing and phytochemicals. Int J Mol Sci 14: 12607-12619.

74. Rydlo T, Miltz J, Mor A (2006) Eukaryotic antimicrobial peptides: promises and premises in food safety. J Food Sci 7: 125-135.

75. Ricci D, Fraternale D, Giamperi L, Bucchini A, Epifano F, et al. (2005) Chemical composition, antimicrobial and antioxidant activity of the essential oil of *Teucrium marum* (Lamiaceae). J Ethnopharmacol 98: 195-200.

Citation: Zanini SF, Dolores R, Pina-Pérez MC, Sanz M, Martinez A (2015) Use of Antimicrobials from Plants in Feed as a Control Measure for Pathogenic Microorganisms. J Microb Biochem Technol 7: 248-252. doi:10.4172/1948-5948.1000218