A Review of the Use of Plants as Ethno-Veterinary Medical Replacements for Antibiotic Growth Promoters

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Abstract: The European Union ban on dietary inclusions of antibiotic growth promoting substances in the production of livestock has led to an emerging field of research – the use of predominantly plant-based alternatives to said antibiotic products. This review seeks to place this research into context within the South African pork production sector. Findings on both ethnomedicinal remedies and ethnoveterinary remedies are presented, from South African sources, African sources and other global regions. Whilst the main emphasis would be on South African plant species, a gap in the research means that the review has had to incorporate research from other areas.

Keywords: Antibiotic growth promotants; plant products; COX-1 inhibition; anti-inflammatory; anthelmintic; plant extracts; anti-microbial

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INTRODUCTION

According to McCorkle (1995), ethno-veterinary medicine, or the use of local plants as remedies for livestock, is often the only option available to rural and peri-urban populations, particularly in the Third World. Especially in such developing areas, livestock are pivotal for several reasons, the most obvious being for the production of food products. This paper states that as many as 90% of the world's population are predominantly reliant on ethno veterinary remedies for the welfare of their livestock. In light of spiralling costs in the so-called Western health care sector, these ethno veterinary practices are becoming more and more essential, and may play a vital role in the phasing out and eventual eradication of dietary antibiotic inclusions for growth promotant purposes.

The review written by Phillips *et. al.* (2004) defines the impetus behind the search for "alternatives" to antibiotic growth promoters, namely that the utilization of antibiotics in animals destined for the human food sector allows for the survival of and selection for antibiotic resistant micro-organisms. The human public health sector has expressed concerns that these resistant bacteria may spread from the livestock via the food products to humans, and result in increased incidences of human infection.

This is the reason that the human public health sector is seeking to eradicate the use of antibiotic growth promoters in animals intended for human consumption. However, the actual risk of such resistance being transmitted from food animals to humans, is small, and as yet unquantified, especially in light of the small dosages of the drugs which are used for growth promotant purposes (Phillips *et. al.*, 2004).

The potential health hazards associated with banning use of antibiotics might well pose bigger health threats to livestock and humans alike. In addition, despite the overlap of some antibiotic products between the livestock and human health sectors, much of the antibiotic resistance problem currently encountered arises from human misuse (Phillips *et. al.*, 2004).

Resistance may be, as it were, promoted, in food animals, and resistant micro-organisms may well be found in animal-derived food products, but the food will undergo either cooking (meat) or pasteurization (milk), processes during which such organisms should be eradicated, provided the processes are adequately performed (Phillips *et. al.*, 2004).

The paper by Stevens *et. al.* (2007) details the response of a selection of pig producers to a survey about antimicrobials. 1889 pig producers, with 100 plus sows or 1000 plus pigs were surveyed. 25.5% of the producers responded to the survey. 60-75% of the producers reported use of antimicrobial drugs in weaner rations, and 20-62% used antimicrobials in grower rations, with the most common route of administration being via the food. 59% of respondents reported the use of inject able antimicrobials. Antimicrobial injections had been used on 59 per cent of the farms. 49% of respondents used growth promotants for weaner production, but less use was reported for growers (45%) and finishers (34%). 63% of the respondents suggested that continued use of antimicrobials agents for the prevention of disease was justifiable, whereas only 21% were satisfied with the routine use of antimicrobials as growth promotants.

A similar study in the South African context would be useful to establish the prevalence of antibiotic growth promotant use amongst pig producers.

SOUTH AFRICAN PLANTS

Plants traditionally used in South Africa (Luseba *et. al.,* 2007) for the treatment of wounds and retained placenta in livestock were used to derive crude dichloromethane (DCM) and 90% methanolic extracts, which were then screened for antibacterial, anti-inflammatory and mutagenic activity. Three bacterial strains were used in the study - *Staphylococcus aureaus, Esherichia coli* and *Pseudomonas aeruginosa.* The highest level of antibacterial activity was exhibited by DCM extracts of *Dicerocaryum eriocarpum, Pterocarpus angolensis, Ricinus communis* and *Schkuhria pinnata*. DCM stem extracts of *Cissus quadrangular* is and DCM root extracts of *Jatropha zeyheri* showed selective inhibition of COX-2, both above 75%. The shoots of *S. pinnata* yielded selective inhibition against COX-1. The study suggests that the majority of traditional medicinal plants used to treat these two conditions in livestock exhibit efficacy in counteracting infection and alleviating pain. Lack of mutagenicity in all the plants tested suggests that the plants are more than likely safe for use in livestock.

Salvia and *Pelargonium* species have been used by Makunga *et al* (2007) in their laboratory studies as targets for biotechnological research. These species have been used due to their value as medicinal plants. They are popularly used as herbal products in the traditional medicine sector. Any such indigenous plants used and recognised in this sector should be investigated for parallel action in the domestic pig.

The study by Steenkamp *et. al.* (2006) used the familiar screening tests of COX-1 and COX-2 inhibition to test the anti-inflammatory activity of five plant species, as well as investigated their effect against bacteria and hydroxyl molecules. Both water and ethanol extracts were testes for each plant species. *Hypoxis hemerocallidea* and *Equilobium parviflorum* both acted to inhibit Escherichia coli. All ten plant extracts were able to scavenge free hydroxyl radicals, but with varying efficacies (32 - 93%). The most promising result of all the plant species was from *Epilobium parviflorum*, which demonstrated activity against both COX-1 and COX-2, as well as *E. coli* and the hydroxyl molecules.

Buwa & Van Staden's 2007 paper was written regarding the pre-existing knowledge of the anti-microbial (antibacterial and antifungal) activities of the South African indigenous plant *Harpephyllum caffrum*. This plant therefore holds potential for further investigation.

Dichloromethane extraction of *Gethyllis ciliaris* by Elgorashi *et. al.* (2007) resulted in the isolation of isoeugenitol, which has inhibitory activity against COX-1. Inhibition of COX-1 suggests that this plant may be used as an anti-inflammatory agent.

The research of Sparg *et. al. (2002)* showed analysis of screened extracts of *Scilla natalensis* and *Ledebouria ovatifolia* for anti-bacterial, anti-inflammatory, anathematic, anti-schistosomic and anticancer activity. *S. natalensis* proved to have poor anti-bacterial activity against both Gram-positive and Gram-negative organisms. *L. ovatifolia* showed good anti-bacterial activity against Gram-positive bacteria. *S. natalensis* displayed high inhibitory action against both COX-1 and COX-2, suggesting good anti-inflammatory properties. *L. ovatifolia* displayed poor anti-inflammatory and anthelmintic potential. This is yet another paper which reveals the potential of South African plants to be further investigated for their potential as growth promoting species.

The paper by Motsei *et. al.* (2003) shows how the researchers screened 24 South African medicinal plants against Candida albicans to determine anti-fungal properties of the plants. Aqueous bulb extracts from *Allium sativa* and *Tulbaghia violacea* were found to have the highest antifungal efficacy against the fungus, with *Polygala myrtifolia* leaf extracts and *Glycyrrhiza glabra* rhizome extracts also proving to be effective. *Warburgia salutaris* bark and leaves both proved to be effective against the fungus. These five plants thus have anti-fungal properties which could be investigated for similar action against fungal species known to pose a problem to pig producers.

The Taylor & Van Staden (2001) paper investigated the anti-inflammatory activity of the indigenous South African *Eucomis* plant species, which is used traditionally for this purpose. The Cyclooxygenase (COX-1) assay was used as a measure of anti-inflammatory activity. High levels of COX-1 inhibitory activity were displayed by crude extracts produced from the roots, bulbs and leaves of the plant. All eleven species of the plant tested displayed COX-1 inhibitory activity of 70% or more, suggesting that all of these plant species may have potential use in the ethno veterinary field as anti-inflammatory agents.

AFRICAN PLANTS

The paper by Chukwujekwu *et. al.* (2006) examined the antibacterial activity of an extract produced from the roots of *Cassia occidentalis*. Although the plant is not indigenous to Africa, having originated in Brazil, it has become naturalised in Africa. The plant material for this study was obtained from Nigeria. The biologically active component was isolated, and identified as emodin. Emodin proved to be inhibitory against *Bacillus subtilis* and *Staphylococcus aureaus*, but was not active against the two Gram-negative bacteria tested (*Klebsiella pneumoniae* and *Esherichia coli*).

Shale *et. al.* (2004) mention three plants used in Lesotho to treat inflammatory conditions and bacterial infections. The plant species are *Malva parviflora*, *Eriocephalus tenuifolius* and *Asparagus microraphis*. These plant species again show potential for further investigation specifically with regard to application to pig production.

Maytensus senegalensis (Lindsey *et. al.,* 2006) is a widely used and traditionally important medicinal plant in East Africa. Samples of the plant collected from Kenya were used to derive root-bark methanol extracts, which were then examined for antibacterial activity. The plant extracts proved to inhibit *Bacillius subtilis, Esherichia coli, Klebsiella pneumoniae* and *Staphylococcus aureaus*, although inhibitory activity was lower than that reported for the neomycin standard.

The study by Kamatenesi-Mugisha *et. al.* (2006). investigated the effects of two indigenous Central African plants, predominantly on uterine motility. Much of the paper was thus disregarded for the purposes of the review. However, the authors briefly mention other ethno-botanical uses of the plants. The first plant, *Vernonia amygdalina,* is usually used in Western Uganda in the form of a decoction of leaves and roots. The ailments treated with this plant include bacterial and fungal infections, and general pains. This suggests the plant possesses both analgesic as well as anti-microbial properties (Kamatenesi-Mugisha *et. al.*, 2006).

Cleome gynandra roots, leaves and flowers are boiled or cooked as food, and used to treat colic pains. Again, this suggests the potential of this plant to be utilized for further research into analgesic ethnomedicines (Kamatenesi-Mugisha *et. al.*, 2006).

PLANTS FROM OTHER GLOBAL REGIONS

Lans (2001) reports that due to a high incidence of livestock theft, farmers do not find it sound economic practise to invest in veterinary drugs (Lans, 2001).

The abstract names eight plants as being used locally for the treatment of pigs, namely *Erythrina pallida, E. micropteryx, Cecropia peltata, Bambusa vulgaris, Carica papaya, Citrus aurantium, Centropogon cornutus and Coffee arabica robusta* (Lans, 2001).

Indigenous South African plants of similar species/the same family could perhaps in a future project be investigated for similar activity(Lans, 2001).

The abstract gives details of local plants used for the treatment of poultry, ruminants and dogs kept as pets. These are shown in tables 1 - 3 below (Lans, 2001).

The paper by Maegi explored the expanding sector of herbal medicine in Latvia. the research entailed testing the anti-parasitic effectiveness of several herbs. One of the parasites investigated was swine mange mites *(Sarcoptes scabiei var. suis)*. Extracts of sweet flag *(Acorus calamus)*, wormwood *(Artemisia absinthum)* and tansy (Tanacetum vulgare) had the highest efficacy against the parasites, with 100% of tested parasites being eliminated within an hour. The extracts of mugwort (*Artemisia vulgaris)* proved to be less effective (parasite mortality registered up to 80-90%) (Maegi).

The study by Bonet & Valles (2007) details plants used for ethno veterinary medicine in Montseny, located in the Iberian Peninsula. The study revealed 584 plant species used locally, of which 351 are used in the human and veterinary medical fields, 280 in the human and animal food field, and 236 with another use. 16.5% of Montseny's vascular plant population consists of medicinal plants.

A significant proportion of these medicinal plants (6% of the regional flora, comprising 89 species) are used in veterinary medicine. The majority of the ethno veterinary remedies are used for bovines, ovines, swine and equines, with some secondary use in poultry, rabbits and canines. The predominant ailments addressed by these remedies are postnatal maladies, gastrointestinal ills, wounds and dermatological problems. The authors often found the use of these remedies to be fully consistent with their utilization in human remedies (Bonet & Valles, 2007).

Table 1 Medicinal plants used by poultry farmers and poultry keepers (Lans, 2001)

Scientific name	Family	Common name	Plant part used	Use
Allium sativum	Liliaceae	Garlic	Bulb	Reduced appetite
Kalanchoe pinnata	Crassulaceae	Wonder of the world	Leaves	Reduced appetite
Momordica charantia	Cucurbitaceae	Caraaili	Vine	Reduced appetite
Neurolaena lobata	Asteraceae	Z'herbe á pique	Leaves	Reduced appetite
Chrysobalanus icaco	Chrysobalanaceae	Ipecak		Pox
Citrus aurantifolia	Rutaceae	Lime	Juice, pulp	Yaws
Citrus species	Rutaceae	Citrus species	Juice, peel	Respiratory conditions, heat stress
Coffee arabica / robusta	Rutaceae	Coffee	Grounds	Respiratory conditions
Eryngium foetidum	Apiaceae	Chadron bénée	Leaves	Respiratory conditions
Momordica charantia	Cucurbitaceae	Caraaili	Vine	Respiratory
Pimenta racemosa var. *racemosa*	Myrtaceae	West Indian Bay	Leaves	Respiratory
Ricinus communis	Euphorbiaceae	Carapate	Leaves	Respiratory
Aloe vera	Liliaceae	Aloe	Gel	Enhance liveability
Kalanchoe pinnata	Crassulaceae	Wonder of the world	Leaves	Enhance liveability
Ocimum sanctum	Lamiaceae	Tulsi	Leaves	Enhance liveability
Azadirachta indica	Meliaceae	Neem	Leaves	Ectoparasites
Cedrela odorata	Meliaceae	Cedar	Leaves	Ectoparasites
Cordia curassavica	Boraginaceae	Black sage	Leaves	Ectoparasites
Momordica charantia	Cucurbitaceae	Caraaili	Vine	Ectoparasites
Petiveria alliacea	Phytolaccaceae	Kojo root	Leaves	Ectoparasites
Renealmia alpinia	Zingiberaceae	Mardi gras	Leaves	Ectoparasites
Eryngium foetidum	Apiaceae	Chadron bénée	Leaves	Meat quality

Table 2 Medicinal plants used for ruminants (Lans, 2001)

Scientific name	Family	Common name	Plant part used	Use
Bambusa vulgaris	Poaceae	Bamboo	Leafy branches	Retained placenta
Curcuma longa	Zingiberaceae	Turmeric	Rhizome	R/ placenta
Oryza sativa	Poaceae	Rice paddy	Grain	R/ placenta
Senna occidentalis	Caesalpiniaceae	Wild coffee	Leaves, roots	R/placenta
Spondias mombin	Anacardiaceae	Hogplum	Leafy branches	Retained placenta
Achryanthes indica	Amaranthaceae	Man better man	Leaves, roots	Oestrus induction
Aloe vera	Liliaceae	Aloes	Leaves	O/ induction
Mimosa pudica	Fabaceae	Ti marie	Roots	O/ induction
Petiveria alliacea	Phytolaccaceae	Gullyroot	Roots	O/ induction
Ruellia tuberosa	Acanthaceae	Minny root	Roots	O/ induction
Senna occidentalis	Caesalpiniaceae	Wild coffee	Leaves, roots	Oestrus induction
Laportea aestuans	Urticaceae	Stinging nettle	Leaves	Urinary problems
Anacardium occidentale	Anacardiaceae	Cashew	Bark	Diarrhoea
Psidium guajava	Myrtaceae	Guava	Buds	Diarrhoea
Aloe vera	Liliaceae	Aloes	Leaves	Poultice

Asclepias curassavica	Asclepiadaceae	Red head	Flower	Poultice
Curcuma longa	Zingiberaceae	Turmeric	Rhizome	Poultice
Kalanchoe pinnata	Crassulaceae	Wonder of the world	Leaf	Poultice
Musa species	Musaceae	Banana	Stem	Poultice
Nopalea cochenillifera	Cactaceae	Rachette	Joint	Poultice
Theobroma cacao	Sterculiaceae	Cocoa	Pods	Poultice
Aloe vera	Liliaceae	Aloes	Leaf	Wounds
Curcuma longa	Zingiberaceae	Turmeric	Rhizome	Wounds
Azadirachta indica	Meliaceae	Neem	Leaves	Anthelmintic
Petiveria alliacea	Phytolaccaceae	Gullyroot	Roots	Anthelmintic
Ruellia tuberosa	Acanthaceae	Minny root	Roots	Anthelmintic
Stachytarpheta jamaicensis	Verbenaceae	Vervine	Leaves	Anthelmintic, Milk production
Cordia curassavica	Boraginaceae	Black sage	Leaves	Ectoparasites

Table 3 Medicinal plants used for pet dogs (Lans, 2001)

Scientific name	Family	Common name	Plant part used	Use
Anacardium occidentale	Anacardiaceae	Cashew	Bark	Diarrhoea
Psidium guajava	Myrtaceae	Guava	Buds, leaves	Diarrhoea
S. jamaicensis	Verbenaceae	Vervine	Leaves	Milk let down
Bambusa vulgaris	Poaceae	Bamboo	Leaves	Grooming
Cordia curassavica	Boraginaceae	Black sage	Leaves	Grooming
Scoparia dulcis	Scrophulariaceae	Sweet broom	Plant tops	Grooming
Bixa orellana	Bixaceae	Roukou	Inside pods	Mange
Crescentia cujete	Bignoniaceae	Calabash	Pulp	Mange
Eclipta prostrata	Asteraceae	Congo lala	Plant tops	Mange, Fungal skin infections
Musa species	Musaceae	Moko, Banana	Stem	Mange
Manilkara zapota	Sapotaceae	Sapodilla	Seeds	Myiasis
Cajanus cajan	Fabaceae	Pigeon pea	Leaves	Ectoparasite
Cordia curassavica	Boraginaceae	Black sage	Leaves	Ectoparasite
Mammea americana	Guttiferae	Mammee apple	Seeds	Ectoparasite
Nicotiana tabacum	Solanaceae	Tobacco	Leaves	Ectoparasite
Pouteria sapota	Sapotaceae	Mamey sapote	Seeds	Ectoparasite
Areca catechu	Arecaceae	Betel nut	Fruit/nut	Anthelmintic
A. indica	Meliaceae	Neem	Leaves	Anthelmintic
Cajanus cajan	Fabaceae	Pigeon pea	Leaves	Anthelmintic
Carica papaya	Caricaceae	Papaya	Seeds	Anthelmintic
Cassia alata	Caesalpiniaceae	Senna	Leaves	Anthelmintic
C. ambrosioides	Chenopodiaceae	Worm grass	Leaves	Anthelmintic
Cocos nucifera	Arecaceae	Coconut	Jelly	Anthelmintic
Gossypium species	Malvaceae	Cotton bush	Leaves	Anthelmintic

Most of the use reported for these plants was for human medicinary use (93.6%), with proportionally little being for veterinary remedies (6.4%). 1.66% of all reported usage showed an overlap between human and veterinary use, with identical purposes (Bonet & Valles, 2007).

The plants were often found to be administered in combination with each other, based on a local belief that synergistic actions between the plants would increase the benefit to the animal. The variations on these combinations were found to be numerous and highly varied (Bonet & Valles, 2007).

The plants with the widest spectrum of use in the area were found to be as follows: *Sambucus nigra* (51 different uses), *Thymus vulgaris* (36), *Olea europaea* (35), *Malva sylvestris* (29), *Parietaria officinalis* ssp. *judaica* (27) and *Ruta chalepensis* (26) (Bonet & Valles, 2007).

If solely veterinary use is considered, the species with the most numerous uses were: *Olea europaea* (10 different veterinary uses), *Malva sylvestris* (8), *Sambucus nigra* (7), *Vitis vinifera* (7), *Thymus vulgaris* (5), *Ruta chalepensis* (5), *Juniperus communis* (4), *Parietaria officinalis* ssp. *judaica* (4), *Foeniculum vulgare* (3), *Calendula arvensis* (3), *Cistus laurifolius* (3), *Umbilicus rupestris* (3), *Quercus ilex* (3), *Lavandula latifolia* (3), *Mentha suaveolens* (3), *Polypodium vulgare* (3), *Phyllitis scolopendrium* (3) and *Agrimonia eupatoria* (3) (Bonet & Valles, 2007).

There was found to be a high degree of parallel use for the same purposes in both human and livestock populations.

The 351 plant species recorded in this study fall within 89 botanical families. The following ranks the predominant families: Asteraceae (12.2%), Lamiaceae (7.4%), Fabaceae (5%), Rosaceae (5%), Poaceae (4%), Apiaceae (3%), Polypodiaceae (2.5%) and Solanaceae (2.5%). If we take the 89 species used to treat cattle illnesses, the degree of agreement is considerable: these taxa belong to 43 families, the main ones being Lamiaceae (seven species), Asteraceae (6), Fabaceae (6), Poaceae (6), Polygonaceae (3), Polypodiaceae (3), Ranunculaceae (3), Apiaceae (3) Gentianaceae (2), Papaveraceae (2), Rosaceae (2) and Urticaceae (2) (Bonet & Valles, 2007).

The authors drew attention to the fact that although the number of species used in the veterinary remedies was less than 25%, when family numbers are considered, 50% of the families were found to be used for ethno veterinary purposes (Bonet & Valles, 2007).

Morphologically speaking, the aerial regions of the plants were more likely to be used for ethno veterinary purposes (26%), followed by leaves (14%), floral structures (14%), fruits, infructescences and seeds (16%, including olive oil) and roots (5%) (Bonet & Valles, 2007).

The researchers arranged the most widely reported maladies into categories. Only those perceived to be relevant to this review are detailed here (I.e. excluding reproductive maladies, etc.). Gastrointestinal remedies as discussed here are taken to include digestive, anti-diarrhoeal and anti-inflammatory preparations. One gastric anti-inflammatory remedy used is a locally made elderberry wine, produced with the fruit s of *Sambucus nigra*. The essential oil extracted from the inflorescences of this same plant give rise to an intestinal antiseptic and anti-inflammatory remedy, used both for humans and for livestock. The following species were reported as being used for intestinal anti-inflammatory purposes: *Foeniculum vulgare*, *Malva sylvestris*, *Parietaria officinalis* ssp. *judaica* and *Lippia triphylla*. *Mentha suaveolens* and *Mentha pulegium,* sometimes in conjunction with *Oryza saliva,* are used as a treatment for diarrhoea in young calves. Also for the treatment of diarrhoea, a mixture of *Parietaria officinalis* ssp. *judaica*, *Malva sylvestris*, *Cynodon dactylon*, *Rubus ulmifolius* and *Plantago lanceolata* is sometimes prepared (Bonet & Valles, 2007).

Dry distillation of *Juniperus communis* wood was reported to give rise to juniper oil, which was used as both an internal and an external parasitic. This oil is known to have antiseptic and acaricidic properties. The herdsmen in Montseny were found to administer it to livestock in conjunction with the normal dose of feed salt, specifically as prevention or cure for helminthiasis (Bonet & Valles, 2007).

The authors mentioned several so-called salutiferous plant spoecies - plants employed for the general purpose of enhancing livestock health, even though the animals were not suffering from any specific malady. Tender leaves of *Foeniculum vulgare* were used to produce a tisane, administered to young ducks to promote growth. The juice of the *Sambucus nigra* infructescence was similarly given to cows, whilst tisane of *Ruta chalepensis* serves the same purpose in hens. *Vigna unguiculata* was used in cattle as a combatant for anorexia (Bonet & Valles, 2007).

The paper by Molan *et. al.* (2004) investigated the inhibitory effects of tannins, extracted from four forage legumes, on the first and third stages of deer lungworm (*Dictyocaulus viviparus*), and the third stage of deer gastrointestinal nematodes. The tannins used were extracted from *Lotus pedunculatus, Lotus comiculatus,* sulla (*Hedysarum coronarium*) and sainfoin (*Onobrychus viciifolia*). The efficacy of the tannins was measured a as their ability to paralyse the larvae, as well as by analysing the death rate of the larvae. At the highest test concentration (1200 µg/ml), sainfoin tannins had the highest level of inhibitory activity (58%) against the deer lungworm larvae, with *L. pedunculatus* (45 %), sulla (42 %) and *L comiculatus* (35 %) following. The sainfoin tannins likewise displayed the highest level of activity against the gastrointestinal nematodes, with the other three forage tannins following in the same order of efficacy (Molan *et. al.,* 2004).

These results suggest significant potential for tannins to be utilized as anthelmintics. Although this research was conducted on ruminants, such results provide a motivation for similar research to be conducted in monogastrics. Many indigenous South African plants are known to have condensed tannin contents and should be investigated for specific effects in pigs.

The study conducted by Maegi *et. al.* (2006) investigated the efficacy of extracts from four medicinal plant species against sarcoptic mange mites in swine (*Sarcoptes scabiei var. suis*), as well as essential medicinal ethereal oils. The four plant species used were hogweed (*Heracleum sosnowskyi*), Manden, mugwort (*Artemisia vulgaris*), tansy (*Tanacetum vulgare*), and wormwood (*Artemisia absinthium*). The plants were used to make extracts, which were then used in a 10% ethanol solution. The seven essential medicinal ethereal oils used were garlic (*Allium sativum*), black pepper (*Piper nigrum*), juniper (*Juniperus communis*), citronella grass (*Cymbopogon nardus)*, pennyroyal (*Mentha pulegium),* eucalyptus (*Eucalyptus globules)*, and tea tree (*Melaleuca alternifolia*). The oils were tested in emulsions of 1%.

All the preparations tested proved effective by inhibiting the development of the mites, and all were lethal to the mites. Volatile oil preparations of citronella and tea tree had the highest efficacy, reducing the percentage of viable mites to less than five within four weeks of application (Maegi *et. al.*, 2006).

The highest efficacy in a tested ethanol extract was noted in hogweed seeds, which eradicated 57-93% of the mites within 2 – 4 weeks of two applications (Maegi *et. al.*, 2006). Tansy and wormwood both reduced mite counts to 44% of the original count within a week of treatment (Maegi *et. al.*, 2006).

The paper authored by Lans *et. al.* (2007) details the findings of an ethno veterinary medical exploratory study, carried out in Trinidad and Tobago. The study examined backyard remedies used for pigs and chickens. Four remedies are of interest to this review, namely male papaya (*Carica papaya*), which is used to de-worm pigs by dietary administration; coffee grounds, which are used for treatment of scours in pigs; worm grass or (*Chenopodium ambrosioides*) , and cotton bush (*Gossypium* species), both of which are utilized as anthelmintics.

Iqbal *et. al.* (2006) investigated the anathematic activity of *Nicotiana tabacum* leaves, with the purpose being to justify the use of the plant for anti-helmintic properties. *Haemonchus contortus* worms were used to assess the *in vitro* effect of a crude aqueous extract of the plant, as well as a methanol extract. Both extracts paralysed or killed the worm parasites *in vitro*. An *in vivo* study was also done, with the two extracts being administered to sheep naturally infected with a mixed profile of gastrointestinal worm parasite species. The methanol extract resulted in a 73.6% reduction in faecal egg counts after 5 days of treatment with the extract, while the aqueous extract showed a reduction of 49.4%.

Although this level of efficacy is below that of standard anathematic agents such as Levamisole, the study has shown that provided dosage is taken into account, there is justification behind the use of *Nicotiana tabacum* as an anti-helmintic (Iqbal *et. al.,* 2006).

NON-PLANT ANTIBIOTIC ALTERNATIVES

Walsh *et. al.* (2007) detail in their paper research which investigated the potential of two commercial products to enhance growth parameters in weaned pigs. The two products used were LAC, an organic acid blend produced by Kemin Americas Inc., Des Moines, IA, and Kem-Gest, a blend of inorganic and organic acids, produced by Kemin Americas Inc. The products were tested individually, combined with each other, and in sequence. Weaned pigs fed diets containing 0.4% LAC for the first 7 days, followed by 0.2% Kem-Gest for the following 28 days exhibited growth performance not significantly different to that of pigs fed the antibiotic carbadox. The two products, when fed individually, produced results that were not dissimilar from each other. The performance of pigs not fed any growth promoters was significantly lower than those fed on either of the two acid treatments or the antibiotic.

These results show the potential for plants containing high levels of organic acids or inorganic acids to be investigated as possible alternatives to antibiotic growth promoters.

Davis *et. al.* (2004) investigated the effect of phosphorylated mannans on the immune function of weanling pigs. The phosphorylated mannans researched were derived from the cell wall of the yeast organism *Saccharomyces cerevisiae*. The phosphorylated mannans were proposed as possible alternatives to dietary inclusions of antibiotic growth promotants. The study found that performance parameters such as average daily gain increased when phosphorylated mannans were included in the diet.

In those pigs consuming the supplemented diet, lymphocyte count was higher and neutrophiles were less prolific. Lamina propria macrophages isolated from pigs that received the mannan-inclusion diet were discovered to be significantly more phagocytotically active than those from pigs on the basal diet. $CD14^+$ lamina propria leukocyte percentages were lower in pigs fed the basal diet, and $CD14^+MHCII^+$ leukocyte counts were lower in pigs fed on the mannan diet. Mannan-rich diets resulted in lower ratios of $CD3^+CD4^+$:$CD3^+CD8^+$ T lymphocytes than did the basal diet. Therefore this study showed that dietary supplementation with phosphorylated mannans resulted in better rates of gain and efficiency in young pigs, and had an intermittent effect on selected components of the immune systems (Davis *et. al.*, 2004).

Antibiotic growth promoters are banned in Europe, prompting a drive for more research into so-called natural alternatives. Although the practise is permissible in the United States of America, and particularly common in newly weaned pigs, the livestock industry has been put under increasing pressure to find alternatives to such additives, due to the potential development of antibiotic resistant organisms (Davis *et. al.*, 2004).

Mannans are believed to alter gastro-intestinal microbial populations, in a manner similar to that of common dietary antibiotic inclusions (Davis *et. al.*, 2004).

The authors conclude that phosphorylated mannans have the potential to act as non-antibiotic dietary additives with a growth-enhancing capability, particularly in the diets of recently weaned pigs (Davis *et. al.*, 2004).

However, due to the intermittent results obtained in the immunological analysis part of this research, further investigation would be required before any definite effect of phosphorylated mannans on the immune system could be claimed (Davis *et. al.*, 2004).

NON-SPECIFIC PLANTS

The investigation by Jin *et. al.* (2008) studied the effects of different levels of potato proteins included in the diet of pigs. The effects on growth performance, digestibility of nutrients, immune system response, morphology of the small intestine, and microbial populations were studied. The results from dietary inclusions of potato proteins were analysed against a positive control containing apramycin and colistin sulfate.

The dietary inclusion of potato protein was shown to result in linear improvement of average daily gain (ADG) parameters and gain: feed ratios, when included in the diet at increasing amounts. The bacterial populations examined in pigs from both treatment and control were found to be comparable, and feeding potato protein effectively reduced microbial populations in the caecum, colon and rectum, as well as in faeces. The results of this study demonstrate the potential for potato to be included in pig diets as an alternative to antibiotic growth promoters, both because of increasing performance parameters and because of its anti-microbial activity (Jin *et. al.*, 2008).

The potential exists for investigation into indigenous South African plants from the same family for possible similar efficacy.

Prostaglandins are responsible for the sensation of pain perceived by the organism. If biosynthesis of these compounds can be achieved, then the inhibitors can be viewed as potential anti-inflammatory agents. Widely used non-steroidal anti-inflammatory drugs (NSAIDs), e.g. aspirin and ibuprofen, often have negative side effects associated with their use, such as causation of gastric ulcers and renal deterioration. Hence the emphasis has shifted to the discovery of effective natural anti-inflammatory alternatives, without toxic side effects. The anti-inflammatory properties of lectins had not been published in research at the time of this study, leaving a gap which the researchers sought to fill. The main parts of plants predominantly employed in the traditional healing sector are the storage organs, namely bark, bulbs, tubers and rhizomes, which are characterized by high quantities of storage proteins and lectins (Gaidamashvili & Van Staden, 2006).

This study utilized in vitro assay techniques to evaluate the cyclooxygenase (COX) inhibitory potential of lectins extracted from indigenous South African plants used in the traditional healing sector for the treatment of inflammation. The research investigated eight indigenous plant species, detailed in the table below (Gaidamashvili & Van Staden, 2006).

Table 4 Cyclooxygenase Inhibitory Action of Lectin-containing Indigenous Plant Species (Gaidamashvili & Van Staden, 2006).

Plant name	**Family**	**Part used**	**% COX inhibition**
Eucomis autumnalis	Hyancinthaceae	Bulb	88
Combretum mkhuzense	Combretaceae	Bark	82
Merwilla natalensis	Hyancinthaceae	Bulb	47
Bulbine frutescens	Asphodelaceae	Seed	34
Hypoxis hhhhhhhhhhhhhhemerocallideahemerocallideahemerocallidea	Hypoxidaceae	Rhizome	29
Tulbaghia violacea	Alliaceae	Bulb	11
Crinum moorei	Amaryllidaceae	Bulb	0
Drimia robusta	Hyancinthaceae	Bulb	0

CONCLUSION

Therefore, it can be seen from the papers detailed in this review, that there is indeed huge potential for the development of plant products as alternatives to antibiotic growth promotants. However, a definite gap in the research exists – little information is available on indigenous South African plants specifically for such use in pigs. South African plants which have been documented for use in humans would be a logical starting point for such studies. It is well known in scientific circles that humans and pigs share a similar physiology. Plants from other regions which have been used as veterinary remedies can be considered, by using local fauna from the same families as recognised remedial plants. Plant species from other global regions which have been utilised for human ethnomedicinal treatments can also be considered when investigating possible local plant families to target for research.

Another useful set of data pertaining to the topic which has yet to be collected in the South African context is information regarding the prevalence of antibiotic growth promotant use amongst pig producers. Producers might also be approached to determine their willingness to use alternatives, should they become available.

The organisms against which the replacement growth promoters would primarily be required to act should also be determined, to allow for accurate in vitro testing of plant extracts before field trials are pursued.

The economics of such alternative growth promoters would need to be assessed –

there would be little point in commercialising such alternatives befor e a market for the products has arisen. Until such time as South Africa has prohibitive legislation against antibiotic growth promoters, it is unlikely that the majority of commercial pig producers would wish to switch to such altyernatives, unless there is a significant economic or production benefit. However, the development of such plant products, or even simply research into such plant species, would have a large spin-off effect for the rural and peri-urban livestock sector in south Africa. For subsistence and small scale farmers, it would make ecomomic and infrastructural sense to be able to utilise local fauna in order to improve the growth parameters of their livestock.

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