



## Utilisation of Herbal Bullets against Newcastle Disease in Poultry Sector of Asia and Africa (2012-2022)

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### ABSTRACT

Poultry industry is rapidly booming in developing countries with increased demand for consumption. Reportedly, chicken meat is highly expected to be used as a major source of protein. With rising popularity and expansion comes greater risk to health and economic losses due to lethal diseases like New Castle disease. Such diseases not only make flocks vulnerable to morbidity but also increases mortality risks for the whole flock. Thus, controlling, managing, and treating these diseases is direly needed. Developing countries, for example, Asian and African countries, rely on a number of control methods and treatments. One of these is the use of ethnoveterinary medicine. Many researchers have also tested the efficacy of these medicines in various terms. In Pakistan, *Azadirachta indica*, *Nigella sativa*, *Glycyrrhiza glabra*, *Iresine herbstii*, etc. have been found effective against Newcastle Disease. *Phyllanthus embolic*, *Curcuma long* and *Ocimum tenuiflorum*, *Allium cepa*, *Cuminum cyminum*, *Withania somnifera*, *Tinospora cordifolia*, *Allium sativum*, *Azadirachta indica*, *Trigonella foenum-graecum* and *Laurus nobilis* are also found effective against ND in India. China is the largest poultry industry in the world that has also been employing various ethnoveterinary medicines for disease control in farms. Some of the most used ethnoveterinary medicines include *Astragalus membranaceus*, *Angelicae sinensis extract* and *Danggui Buxue San*, *Scutellaria baicalensis*, *Chinese plant*, *ginseng* (Chinese plant) stem-leaf saponins, *Rheum rhabarbarum*, *Glycyrrhiza glabra*, *Sijunzi Decoction*, *Dangguibuxue Tang* and *Morus alba* with vaccine adjuvant. In African countries, Ethnoveterinary botanical medicines are also used. The use of *Allium sativum*, *Azadirachta indica*, *Allium sativum with NDV lasota vaccine*, *Aloe barbadensis miller*, *Moringa oleifera*, *Lagenaria breviflora*, *Cucumis metuliferus*, *Piper guineense*, *Aframomum melegueta*, and *Psidium guajava* are known to be effective. Survey-based studies in Ethiopia have shown that *Acmella caulirhiza*, *Zingibar officinale*, Mixture of Alcohol, Citrus limon and *Allium cepa*, *Capsicum annum*, *Rumex abyssinicus* root and *Brasica compestris* are used as ethnoveterinary. Similarly, In Zimbabwe, *Capsicum annum*, *Sesamum angustifolium fruit*, *Tridactyle bicaudata leaves*, *Strychnos cocculoides*, *Senna singueana leaves*, *Abyssinia bark*, *Aloe greatheadii pods*, and other aloe species are used effectively against NDV. This literature review will highlight some herbs and ethnoveterinary medicines that have been researched to be effective against Newcastle Disease.

**Key words:** Ethnoveterinary Medicine, Botanicals, Asian Herbs, African herbs, Newcastle Disease.

### INTRODUCTION

Poultry is the high demanding agricultural sub-sector, particularly in developing countries, and a crucial key to alleviating poverty and catering income (Mottet & Tempio, 2017). When considering per unit of human intake, poultry meat, and eggs are major protein sources compared to mutton, beef, and milk and, are forecasted to be the highest consumed animal protein items in the next 2-3 years. In the

past decades, a marked increase in poultry consumption has been seen i.e. 16% globally with a projection of a further 5.5% soar in the forthcoming years (Das & Samanta, 2021).

Though, poultry still represents a threat to human health because of infectious diseases (viz. Newcastle disease, Avian Influenza, coccidiosis, etc.) (Mottet & Tempio, 2017). The transmission of these infectious diseases also causes serious impacts on the economic value of the country (Wang et al., 2013). Among these infectious

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diseases, Newcastle disease is a highly contagious and lethal disease even, the birds that suffer from this disease die without exhibiting any signs and symptoms and, infect lots of domestic and wild bird species. It is caused by virulent strains of Newcastle disease virus (NDV) or Avian Paramyxovirus -1, which is a single-strand non-segmented negative sense RNA virus. This NDV virus is prone to high mortality, morbidity, and loss in egg production in poultry flocks that results in economic losses. Epizootics of this disease occurs worldwide including Asia and Africa (Abdisa & Tagesu, 2017; Ansori & Kharisma, 2020). So, there is a dire need to control this disease.

Since Ancient times, use of natural resources like animal products, minerals, and plants have been done to treat many diseases of animals and humans. Millions of people prefer botanical medicines as primary health care (Korkmaz et al., 2016). People believe that these plant-based medicines are safer and cheaper than conventional therapy, therefore, ethno-veterinary botanical medicine use has been increasing for a long time now (McGaw et al., 2020). Another major reason for the increased use of these botanical medicines is the unavailability of modern veterinary medicines (Maphosa & Masika, 2010) and due to antibiotic resistance (Abdisa & Tagesu, 2017; Ansori & Kharisma, 2020). A lot of research data is also available which shows that plant-based home remedies are used to treat livestock diseases in Asian and African countries i.e. Pakistan (Abdisa & Tagesu, 2017; Aziz et al., 2020), India (Sikarwar & Tiwari, 2020), China

(Xiong & Long, 2020), Nigeria (Onwubiko et al., 2020), Ethiopia (Berhanu et al., 2020) and Zimbabwean (Jambwa & Nyahangare, 2020), etc. The literature said, 50-70 thousand plant species are used nowadays for the treatment of different animal diseases (ERARSLAN & Kültür, 2019).

In this review, we will discuss plant-based medicine used against Newcastle disease (cited in table 1) in different countries of Asia and the African continents during 2012-2022 as shown in Figure 1.

**MATERIALS AND METHODS**

In this entire study, Google scholar was used as a main search engine. Moreover, other websites like science direct and research gate were as well used to search papers for the "Control of Newcastle disease by Ethno-veterinary botanical medicine". Furthermore, we took 6 different countries of Asia and Africa (Pakistan, India, China, Nigeria, Ethiopia, and Zimbabwe) and keywords that were used to search papers on this topic are "Newcastle disease", "Ethno-veterinary practice for the Newcastle disease", "Newcastle disease effects on poultry industry", "Ethno-veterinary practice against livestock and poultry diseases", "Evaluation of plant against Newcastle disease" in 6 different countries since 2012 to 2022.

A small number of review papers are used as parent articles. Neither quantification data nor statistical comparison has been done.

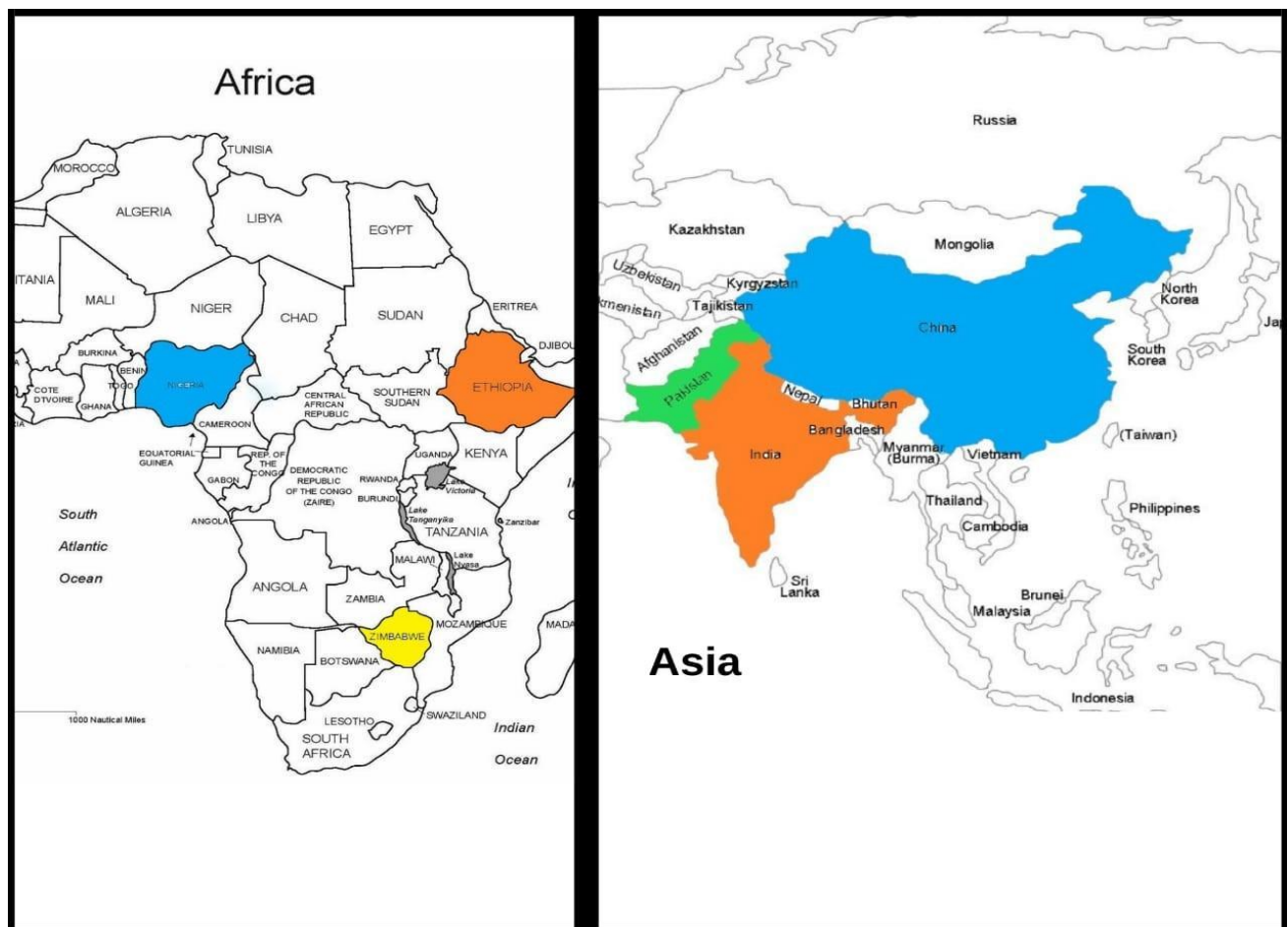


Fig. 1: Study areas to assess the use of ethnoveterinary botanical medicines used against ND.

## Literature Review

### Newcastle Disease and its Ethno-medicinal Treatment in Asian Countries:

#### I. Pakistan:

Pakistan is an agricultural land and integral part of its economy radically based on livestock and poultry. Every fifth family of this country is linked with the poultry industry and emerged as the 2<sup>nd</sup> largest industry of the country with a 4 percent annual increase, supplying eggs and meat. Since the launching of the organized poultry sector in Pakistan, ND caused serious destruction several times to the poultry sector (Shabbir et al., 2013). Most Pakistani farmers are poor and they cannot afford modern allopathic drugs for the control of infectious diseases of livestock, thus ethnoveterinary medicine is used for control and treatment (Murad et al., 2014). The plant products that are naturally produced play a vital role in the control and management of the disease (Mahmood et al., 2018).

*Azadirachta indica* (Neem), commonly found in Pakistan, belongs to the family Meliaceae is used against Newcastle disease. Neem has certain chemical and physical properties to fight against this deadly virus. In 2015, research has been done at Agricultural University, Faisalabad, in which Neem bark extract was used to evaluate its antiviral property. *In-vitro* evaluation was done by spot assay and micro-heamoglotinin test and *in-ovo* by injecting extract in 11-day-old embryonated eggs. The results described that Neem has a direct relation with antiviral activity to control ND (Mahmood et al., 2018).

*Nigella sativa* (Black seed) is an important botanical medicine used to treat different maladies of animals. Another research was conducted at University of Veterinary and Animal Science, Lahore in Pakistan to evaluate its antiviral effect against ND. In this research, ethanol was used to get the extract of black seed which was then inoculated in 14-days-old embryonated chick egg. Gross and histopathological examination revealed that it has a strong immunotherapeutic effect against ND (Khan et al., 2018).

*Glycyrrhiza glabra* (licorice) has been traditionally used for the treatment and control of various infectious diseases. In 2017, research was conducted at GC university, Faisalabad, to evaluate this plant against NDV. Nine-day-old embryonated chick was inoculated with 5 different plant extracts, in which *Glycyrrhiza glabra* had powerful antiviral properties against NDV (Ashraf et al., 2017). In another research, *Glycyrrhiza glabra* (Licorice) was used again NDV with a combination of purified immunoglobulins. In this research, newly hatched broiler chicken was treated with this extract and it was concluded that purified immunoglobulins and Licorice have the potential to fight against ND (Amjad et al., 2022).

*Iresine herbstii* (blood leaf) is used as a food coloring agent. In 2019, this plant was tested against NDV and inoculated in 9-day-old chicken eggs. The results revealed that it has the potential to work against NDV because of its photochemical profile (Andleeb et al., 2020).

Some exclusive plant species found in the Cholistan region of Pakistan near the Cholistan Institute of Desert Studies, Baghdad ul Jadeed Campus, and the Islamia University of Bahawalpur have also been studied. The researcher evaluated 11 different plant species i.e. *Achyranthes aspera*, *Haloxylon recurvum*, *Haloxylon*

*salicornicum*, *Oxystelma esculentum*, *Othocloa compressa*, *Neurada procumbens*, *Panicum antidotale*, *Salsola baryosma*, *Suaeda fruticosa*, *Sporobolus icolados* and *Solanum surattense* against NDV (Shahzad et al., 2019). Their extracts were made and inoculated in 7-11 days old embryonated chicken eggs. The results exhibit that *Achyranthes* was found most effective and *Oxystelma esculentum*, the least effective for the control of ND (Shahzad et al., 2019).

Another study showed a number of plants that can fight against NDV. Among these, the plants which showed *in vitro* antiviral activity are *Momordica balamina*, *Artemisia annua*, *Adansonia digitata*, *Azadirachta indica*, *Moringa oleifera*, and *Psidium guajava*, and, plants that showed *in-ovo* are *Cucumis metuliferus*, *Anthocleista nobilis*, and *Aloe secundiflora*. (Raza et al., 2015) And the plants which have the potential to improve the immune system of animals are *Nigella sativa*, *Mangrove halophytes*, *Melissa officinalis*, *Polysavone*, *Momordica cochinchinensis*, *Withania somnifera*, *Asparagus Racemosus*, and *Echinacea purpurea* (Raza et al., 2015). Hence, the use of ethnoveterinary medicine is common in Pakistan for the control of various diseases including Newcastle disease.

#### II. India:

In India, poultry is one of the swift growing sectors in the agriculture area and contributes about 1 percent of the Indian GDP (Pica-Ciamarra et al., 2011). Backyard poultry plays a significant role to alleviate poverty in the country. Yet, a lot of infectious diseases cause major loss, among these ND is one of the deadliest diseases and endemic in this country. This disease not merely wipe out the entire flock of poultry but is also a major constraining factor in the growth of the poultry industry (Dey et al., 2014).

India is rich in plant biodiversity but a very small amount of systematic studies has been done to evaluate plants against infectious diseases, and few pieces of research have been available for the treatment and control of infectious diseases (Shrivastava & Jain, 2016).

*Phyllanthus embolic* (amla), *Curcuma long* (turmeric), and *Ocimum tenuiflorum* (tulsi) have been used as herbal medicine and have a direct effect on ameliorating the mounting against ND (Reddy et al., 2012). In 2016, a seed mixture of *Phyllanthus amarus* (amla), *Allium cepa* (onion), and *Cuminum cyminum* (Cuminum, jera) was given orally for 3 days and results indicated that ND can be cured by these botanical medicines (Ahamad et al., 2016). Similarly, *Phyllanthus amarus*, *Cuminum cyminum* seeds, and *Allium cepa* pulp along with jaggery was used as an antiviral agent against ND in 2018 (Mekala et al., 2018). The research was conducted at Veterinary University Training and Research Centre, TANUVAS, Tirupur, Tamil Nadu. In this research, a grounded mixture of these plants was used orally at the rate of 10 g per liter for 5 days. The results concluded that these plants have potential activity against NDV (Mekala et al., 2018).

*Withania somnifera* (Ashwagandha), *Tinospora cordifolia* (*Guduchi*), *Allium sativum* (Garlic), and *Azadirachta indica* (Neem) were used against NDV without affecting the egg production and egg qualities. Results concluded with positive results of these plant mixtures (Mohanambal et al., 2018). In another study, *Allium sativum* (Garlic), *Trigonella foenum-graecum*

(fenugreek), and *Laurus nobilis* (bay leaves) herbal feed were used in laying hen to check the immunity status after giving these supplements. The results revealed that the combination of these herbs conferred a high level of immunity as well as a high level of immunoglobulins in eggs (Raj et al., 2013).

Another study aimed to use an herbal mixture of *Curcuma longa*, *Coriander sativum*, *Allium sativum*, *Andrographis paniculata*, and *Trigonella foenum graecum* against NDV. The outcome revealed positive results of this mixture (Priya et al., 2022). Hence, the ethnoveterinary medicines proved to be effective against NDV in India are amla, turmeric, tulsi, neem, onion, garlic, guduchi, bay leaves, and fenugreek.

### III. China:

China has the largest and most rapidly growing poultry industry and this plays a paramount role in the economy of the country (Tarique et al., 2013). Transmission of infectious diseases is a prone serious threat to the poultry sector of China (Wang et al., 2013). Newcastle infectious diseases is endemic in China for decades (Liu et al., 2008). Chinese herbal medicine plays a crucial role to control various infectious diseases not only humans sides but also in veterinary science (Lin & Panzer, 1994). There are a lot of vaccines that have been made in China by Chinese plants against NDV.

*Astragalus membranaceus* (AM) (common name: huáng qí or milkvetch), *Angelicae sinensis* (known as dong quai) extract, and Danggui Buxue San (Chinese herbal mixture) were used for the study of immunity, and hematinic mechanism of chicken against ND by giving these plants orally in the diet. The result revealed improvement in the haemopoietin function and immunity in Chicken (C. Li et al., 2013). Baicalin extract from *Scutellaria baicalensis* (Chinese skullcap) was used to investigate anti-NDV activities. In this study, Chicken Embryo Fibroblasts were infected with NDV and quantitative analysis of apoptotic cells was performed through cell cytometry. Cytotoxicity and antiviral activity of baicalin were found via MTT (3-(4, 5-dimethylthiazolyl)-2, 5-diphenyltetrazolium bromide) assay method. The results revealed a positive impact of baicalin against NDV (Jia et al., 2016).

In 2019, ginseng (Chinese plant) stem-leaf saponins (GSLs) in combination with selenium (Se) were evaluated against NDV and IBV in chicken via an intraocular-and-intranasal route. The results depicted that the GSLs-Se group had the highest antibody response against NDV and IBV virus. Further in 2020, the effect of sunflower oil along with ginseng C.A Meyer plant's extract saponins were used to check the immune response of Chicken against Newcastle diseases. The results showed that it is safer against this deadly virus (Yuan et al., 2020).

Rhein derived from the traditional Chinese plant *Rheum rhabarbarum* (Rhubarb) was evaluated to see its antiviral potential against NDV. The results revealed that they effectively inhibited NDV activity and could be used as a future antiviral drug against NDV (Hu et al., 2022). *Glycyrrhiza glabra* (licorice) is a medicinal plant having antiviral properties because its chemical components include polysaccharides, flavones, and saponins. The polysaccharides extract of this plant was used in one

research that was performed on 14-day-old chick. And the results depicted that polysaccharides extracted from this plant have the ability to enhance the immune activity induced by NDV vaccine (Wu et al., 2022). Sijunzi Decoction is a Chinese herbal mixture and its components were used orally for the control of NDV. The results revealed that this mixture has strong capacity to enhance immunity in chickens and is safe with no adverse effect on the weight and survival of chickens (Zhanga et al., 2012).

Dangguibuxue Tang (DBT) Chinese herbal mixture is also used in one research to enhance immunity against ND virus and IBV virus. The result showed that 0.5% of DBT can ameliorate both cellular and humoral immunity of immunosuppressive chicken (X. T. Li et al., 2013).

Mulberry leaf polysaccharide was used against ND to provide evidence as a potential mucosal vaccine adjuvant (Chen et al., 2021). One study used 25 different medicinal herbs to investigate the cytopathic effect of NDV. Among these, 5 herbs that have the highest inhibitor effect are used including *Herba agastaches*, *Flos chrysanthemi indicis*, *Rhizoma anemarrhenae*, *Astragalus root*, and *Baikal skullcap* root. The results suggested that formulation components have a synergistic effect to improve NDV resistance (Wang et al., 2016). These are some researches on Chinese herbal medicine in recent years for the control and treatment of the New Castle Disease Virus. Hence, Chinese herbal mixture, Chinese skullcap, licorice, DBT, Rhubarb, and Chinese plant are effective against ND in China.

### Newcastle Disease and its Ethno-medicinal Treatment in African Countries:

#### I. Nigeria:

Nigeria is one of the largest countries in Africa and makes one of the fastest growing economies in the world. The poultry industry in Nigeria has an important role in enhancing the economy of the country. This industry is rapidly expanding in recent years (Heise et al., 2015). Poultry infectious diseases are a major threat to the poultry industry and result in severe economic losses (Akintunde & Adeoti, 2014). ND is one of the deadliest infectious diseases in poultry that causes devastating effects on the economy of the country by high mortality and morbidity (Nwanta et al., 2008). In order to control these infectious diseases, ethnoveterinary botanical medicines are used to treat these diseases (Guèye, 1999). Some research has been done in Nigeria to treat NDV via plant-based medicine.

The aqueous extracts of *Allium sativum* (Garlic) and *Azadirachta indica* (Neem) leaf extract are used against NDV. 161-day-old broilers were treated with Garlic and Neem extract individually and their mixture. The research findings suggested that both Garlic and Neem have the capabilities to enhance the immunomodulatory response of the NDV vaccine (Garba et al., 2013).

Another research has been done to check the effect of *Allium sativum* (Garlic) and NDV Lasota vaccine, the birds were administered random treatment in their drinking water. The results revealed that *Allium sativum* (Garlic) and NDV lasota vaccines both have the potential to enhance the immune system of chickens against NDV (Bulus & Zaro, 2019). In 2015, the aloe vera plant was used to test the immune activity against NDV. 140 day old chicks were treated orally with aloe vera extract and results indicated

that this extract is the best immunomodulator against NDV (Ojjezeh & Ophori, 2015).

Moreover, the aqueous seed extract of *Moringa oleifera* (Zogale, horseradish tree) was used against NDV. 9-day-old chick was treated with this plant extract in one research and the results depicted that this plant has antiviral properties. (Chollom, Agada, Gotep, et al., 2012). In another study, *Lagenaria breviflora* (folklore medicine of West Africa) was used in rats. The results concluded that this medicine also has antiviral properties (Adedapo et al., 2013).

*Cucumis metuliferus* is commonly known as African horned cucumber, its alkaloids are administered in embryonated egg, and concluded that this plant pulp has a safer margin and good antiviral (Chollom, Agada, Bot, et al., 2012) activity against NDV (Anyanwu et al., 2016). Moreover, *Piper guineense* extracts also has properties against NDV. In one study, This plant extract was mixed in the drinking water of 48-day-old chick. The result showed that this plant has great potential to control NDV (Osho et al., 2016).

*Aframomum melegueta* (Guinea pepper) leave extract was inoculated in 10-day-old embryonated egg to evaluate the antiviral properties against NDV, fowl-pox virus, and infectious bursal disease. The results concluded with a positive response against these infectious diseases (Dike). One survey revealed that bitter leaf (*Vernonia amygdalina*) and Christmas melon (*Cucumis melo*) serve as a cure to prevent ND (Irivboje et al., 2021). Another botanical plant used to control NDV is *Psidium guajava* (apple guava), their leaf extract has nutritional value and antiviral properties against this deadly NDV. The research was conducted on a hatched chick. The results showed that it is a good immune booster against viruses (Chollom, Agada, Bot, et al., 2012). Hence, in Nigeria, various parts of different plant-based medicines are effective against NDV.

## II. Ethiopia:

More than 70% of Ethiopians are dependent on the livestock industry which showed a major share in the economy of this country. But, livestock diseases are the main constraint in the progress of the country. So, there is a need to control them (Lulekal et al., 2014). For the poultry industry of Ethiopia, ND causes serious destruction in this industry and is endemic in Ethiopic regions (Mazengia, 2012). Ethnoveterinary botanical medicines are used to control diseases in livestock (Lulekal et al., 2014). But the very limited amount of research has been done for the evaluation of veterinary botanical medicine against ND in Ethiopia. Some of the research are mentioned below;

A survey-based study has been conducted to identify ethnoveterinary medicine against poultry diseases. In which, *Acmella caulirhiza* Del. Plant leaves were used against NDV (Moliso et al., 2016). Another study has been

done to identify different plant species used against various infectious diseases of livestock. When we talk only for ND so, *Zingibar officinale* plant rhizome was used to treat NDV (Wodegebriel et al., 2018). Another survey was performed in 2017, in which alcohol, lemon, and white onion mixture was used to treat NDV (Bogale et al., 2017). Another study depicted that *Capsicum annum* (red pepper) seed mixed with oil in feed showed the potential for the treatment of NDV. Moreover, an aqueous extract of *mekmeko* root in drinking water was used against NDV. Furthermore, the aqueous extract of *Brasica compestris* (mustard seed) was also used against NDV and was found effective to combat NDV (Endalew et al., 2018). So, Ethiopia also employs ethnoveterinary medicine to protect poultry from various diseases including ND.

## III. Zimbabwe:

Poultry industry is a crucial sector for the livelihood of Zimbabwean natives. Farmers raise poultry for food and as a source of income. Hence, outbreaks of infectious diseases are prone to a great loss in society (Gobvu et al., 2022). Ethnoveterinary practice is part of the management of various diseases of animals but it is still an emerging field in Zimbabwe. The amount of literature regarding ethnoveterinary practices in Zimbabwe is found to be less in number. (Jambwa & Nyahangare, 2020).

In 2021, a research-based survey was conducted on avian botanical medicine in some selected communal areas of Zimbabwe. The study showed that 36 plant species are useful for the treatment of various poultry diseases. Plants that were used for ND are *Agave sisalana* perrine (mukonji, chickwengu), *Aloe chabaudii* (gavakava), *Aloe greatheadii*, *Bobgunnia madagascariensis* (snake bean pods), *Erythrina Abyssinia* bark, *Tridactyle bicaudata* leaves (paka), *Capsicum frutescens* (Toronga, mumhiripiri, chili pepper) (Jambwa et al., 2021). Hence, any of these ethnoveterinary medicines can be used against ND in one way or the other.

A systematic review has been done in 2022 about ethnoveterinary medicine for the treatment of different poultry diseases. So, the plants that are found in this study to treat NDV are *Capsicum annum* seed (crushed and mixed with sugar in drinking water), *Sesamum angustifolium* fruit (crushed and added to the drinking water), *Tridactyle bicaudata* leaves (pound the plant and suspended them in water), *Strychnos cocculoides* fruit (used in drinking water), *Senna singueana* leaves (used in drinking water), *Erythrina Abyssinia* bark (used in drinking water), *Bobgunnia madagascariensis* snake bean pods (used in drinking water) and aloe species (*Aloe vera*, *Aloe spicata*, *Aloe greatheadii*, *Aloe chabaudii*, *Aloe barbadensis*, and *Aloe arborescens*) (Gobvu et al., 2022).

**Table 1:** Ethno-veterinary medicines used in different countries

Sr. No.	Ethnoveterinary medicines/ Plants used (Scientific Name)	Common Names	Method of usage	Country of Research	Disease(s)	Reference(s)
1	<i>Azadirachta indica</i>	Neem	<i>In-vitro</i>	Pakistan	ND	(Mahmood et al., 2018)
2	<i>Nigella sativa</i>	Black seed	<i>In-ovo</i>			(Khan et al., 2018)
3	<i>Glycyrrhiza glabra</i>	Liquorice	<i>In-ovo</i>			(Amjad et al., 2022)

4	<i>Iresine herbstii</i>	Blood leaf	<i>In-ovo</i>		(Andleeb et al., 2020)
5	<i>Achyranthes aspera</i> , <i>Haloxylon recurvum</i> , <i>Haloxylon salicornicum</i> , <i>Oxystelma esculentum</i> , <i>Ochocloa compressa</i> , <i>Neurada procumbens</i> , <i>Panicum antidotale</i> , <i>Salsola baryosma</i> , <i>Suaeda fruticosa</i> , <i>Sporobolus icolados</i> and <i>Solanum surattense</i>	Various herbs	<i>In-ovo</i>		(Shahzad et al., 2019)
6	<i>Momordica balamina</i> , <i>Artemisia annua</i> , <i>Adansonia digitata</i> , <i>Azadirachta indica</i> , <i>Moringa oleifera</i> and <i>Psidium guajava</i>	Herbal mixture	<i>In-vitro</i>		(Raza et al., 2015)
7	<i>Cucumis metuliferus</i> , <i>Anthocleista nobilis</i> and <i>Aloe secundiflora</i>	African horned cucumber, Cabbage, African aloe vera	<i>In-ovo</i>		(Raza et al., 2015)
8	<i>Nigella sativa</i> , Mangrove halophytes, <i>Melissa officinalis</i> , <i>Polysavone</i> , <i>Momordica cochinchinensis</i> , <i>Withania somnifera</i> , <i>Asparagus Racemosus</i> and <i>Echinacea purpurea</i>	Various herbs	<i>In-ovo</i>		(Raza et al., 2015)
9	<i>Phyllanthus embolic</i> , <i>Curcuma longa</i> and <i>Ocimum tenuiflorum</i>	Amla, Turmeric, Tulsi	Per Oral (mixed with feed)	India	(Reddy et al., 2012)
10	<i>Phyllanthus amarus</i> , <i>Allium cepa</i> and <i>Cuminum cyminum</i>	Amla, Onion, cuminum, Jera	Per Oral (mixed with feed)		(Ahamad et al., 2016)
11	<i>Phyllanthus amarus</i> , <i>Cuminum cyminum</i> seeds and <i>Allium cepa</i> pulp along with jaggery	Carry me seed, Cumin, Onion	Per Oral (mixed with water)		(Mekala et al., 2018)
12	<i>Withania somnifera</i> , <i>Tinospora cordifolia</i> , <i>Allium sativum</i> and <i>Azadirachta indica</i>	Ashwagandha, guduchi, Garlic, Neem	Per Oral		(Mohanambal et al., 2018)
13	<i>Allium sativum</i> , <i>Trigonella foenum-graecum</i> and <i>Laurus nobilis</i>	Garlic, Fenugreek, Bay leaves	Per Oral (mixed with feed)		(Raj et al., 2013)
14	<i>Curcuma longa</i> , <i>Coriander sativum</i> , <i>Allium sativum</i> , <i>Andrographis paniculata</i> , and <i>Trigonella foenum graecum</i>	Various herbs	<i>In-ovo</i>		(Priya et al., 2022)
15	<i>Astragalus membranaceus</i> , <i>Angelicae sinensis</i> extract and Danggui Buxue San	Huáng qí or Milkvetch, Dong quai, and (Chinese herbal mixture)	Per Oral	China	(X. T. Li et al., 2013)
16	<i>Scutellaria baicalensis</i>	Chinese skullcap	<i>In-vivo</i>		(Jia et al., 2016)
17	Ginseng stem-leaf saponins in combination with selenium	Chinese plant	intraocular-and-intranasal route		(Ma et al., 2019)
18	Sunflower seed oil Ginseng C.A. Meyer (E515-D)	Chinese plant	Per-oral		(Yuan et al., 2020)
19	<i>Rheum rhabarbarum</i>	Rhubarb	Per-oral		(Hu et al., 2022)
20	<i>Glycyrrhiza glabra</i>	Licorice	<i>In-ovo</i>		(Wu et al., 2022)
21	<i>Sijunzi Decoction</i>	Chinese herbal mixture	Per-oral		(Zhanga et al., 2012)
22	Danggui buxue Tang	Chinese herbal mixture	<i>In-vitro</i>		(X. T. Li et al., 2013)
23	<i>Morus alba</i>	Mulberry leaf polysaccharide	Vaccine adjuvant		(Chen et al., 2021)
24	<i>Herba agastaches</i> , <i>Flos chrysanthemi indici</i> , <i>Rhizoma</i>		<i>In-vivo</i>		(Wang et al., 2016)

	<i>anemarrhenae</i> , Astragalus root and <i>Baikal skullcap</i> root				
25	<i>Allium sativum</i> and <i>Azadirachta indica</i>	Garlic, Neem	Per-oral	Nigeria	(Garba et al., 2013)
26	<i>Allium sativum</i> and NDV lasota vaccine	Garlic	Per-oral		(Bulus & Zaro, 2019)
27	<i>Aloe barbadensis miller</i>	Aloe Vera plant	Per-oral		(Ojiezeh & Ophori, 2015)
28	<i>Moringa oleifera</i>	Zogale, Horseradish tree	Per-oral		(Chollom, Agada, Gotep, et al., 2012)
29	<i>Lagenaria breviflora</i>	Folklore medicine of West Africa			(Adedapo et al., 2013)
30	<i>Cucumis metuliferus</i>	African horned cucumber	<i>In-ovo</i>		(Chollom, Agada, Bot, et al., 2012) (Anyanwu et al., 2016)
31	<i>Piper guineense</i>	Ashanti pepper	Per-oral(mixed with drinking water)		(Osho et al., 2016)
32	<i>Aframomum melegueta</i>	Guinea pepper	<i>In-ovo</i>		(Dike)
33	<i>Vernonia amygdalina</i> and <i>Cucumis melo</i>	Bitter leaf Christmas melon			(Irivboje et al., 2021)
34	<i>Psidium guajava</i>	Apple guava	Per-oral		(Chollom, Agada, Bot, et al., 2012)
35	<i>Acmella caulirhiza</i>	Toothache plant or paracress	Per-oral	Ethiopia	(Moliso et al., 2016)
36	<i>Zingibar officinale</i>	Ginger	Per-oral		(Wodegebriel et al., 2018)
37	Alcohol, <i>Citrus limon</i> , <i>Allium cepa</i>	Alcohol, lemon, and white onion	Per-oral		(Bogale et al., 2017)
38	<i>Capsicum annum</i>	Red pepper	Per-oral (mixed with feed)		(Endalew et al., 2018)
39	<i>Rumex abyssinicus</i> root	Mekmeko	Per-oral (mixed with drinking water)		(Endalew et al., 2018)
40	<i>Brasica compestris</i>	Mustard seed	Per-oral		(Endalew et al., 2018)
41	<i>Agave sisalana perrine</i> , <i>Aloe chabaudii</i> , <i>Aloe greatheadii</i> , <i>Bobgunnia madagascariensi</i> , <i>Erythrina Abyssinia bark</i> , <i>Tridactyle bicaudata</i> leaves, <i>Capsicum frutescense</i>	Mukonji, Chickwengu, Gavakava, Snake Bean pods, paka, Toronga, mumhiripiri, Chili pepper	Per- oral (mixed with water)	Zimbabwe	(Jambwa et al., 2021)
42	<i>Capsicum annum</i> seed, <i>Sesamum angustifolium</i> fruit, <i>Tridactyle bicaudata</i> leaves, <i>Strychnos cocculoides</i> fruit, <i>Senna singueana</i> leaves, <i>Erythrina Abyssinia</i> bark, <i>Bobgunnia madagascariensis</i> and aloe species ( <i>Aloe vera</i> , <i>Aloe spicata</i> , <i>Aloe greatheadii</i> , <i>Aloe chabaudii</i> , <i>Aloe barbadensis</i> and <i>Aloe arborescens</i> )	Various botanical materials and herbs	Per-oral		(Gobvu et al., 2022)

## Conclusion

Worldwide, Newcastle disease is creating havoc in terms of economic losses. To curb the disease, the use of ethnoveterinary medicine is much more economical and easy to use in all countries, especially developing countries. In this review, 6 different countries are studied that have done research on the use of ethnoveterinary medicine. Out of these countries, the majority are developing countries. In

Asian countries, Pakistan and China have done more research on ethnoveterinary medicines as compared to India. Pakistan has studied Neem, Black seed, Liquorice, Blood leaf, Herbal mixture, African horned cucumber, Cabbage, and African aloe vera as ethnoveterinary medicines and these proved to be effective against Newcastle disease. The use of Huáng qí or milkvetch, Dong quai, Chinese herbal mixture, Chinese skullcap,

Chinese plant, Rhubarb, Licorice, and Mulberry leaf polysaccharide in China against Newcastle disease was found successful. India successfully researched the use of Amla, Turmeric, Tulsi, Onion, Cuminum, Jera, Carry me seed, Ashwagandha, Guduchi, Garlic, Neem, Fenugreek, and Bay leaves for the prevention and control of Newcastle disease. Similarly, the African countries included in the study utilized ethnoveterinary medicine which are; Garlic, Neem, Aloe vera plant, Zogale, horseradish tree, Folklore medicine of West Africa, African horned cucumber, Ashanti pepper, Guinea pepper, Bitter leaf, Christmas melon, Apple guava in Nigeria; Toothache plant or paracress, Ginger, Alcohol, lemon, White onion, Red pepper, Mekmeko, and Mustard seed in Ethiopia; Mukonji, Chickwengu, Gavakava, Snake bean pods, Paka, Toronga, Mumhiripiri, and Chili pepper in Zimbabwe were researched and found to be effective against Newcastle disease. The number of research found in Nigeria was relatively more than the other two African countries and Zimbabwe was found to have the least number of research done. The use of such medicines against Newcastle disease in these countries must be done more thoroughly to have sufficient data for deriving conclusions regarding their uses. Moreover, there is a need of studying various parts of plants in more detail to use the most bioactive part of plants against NDV.

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