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JOURNAL of AGRICULTURE and NATURE

İletişim — **Contact**
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Muş Alparslan University Journal of Agriculture and Nature (MAUJAN) is a scientific journal publishing high-quality papers in all aspects of agriculture and nature.

Muş Alparslan University Journal of Agriculture and Nature (MAUJAN) started its publishing life in January 2021 with the name ***Muş Alparslan University Journal of Agricultural Production and Technologies*** (E-ISSN: 2757-8763), and its name changed in March 2022.

MAUJAN aims to contribute to the scientific literature by publishing recent research on agriculture and nature all around the globe as open-access articles by applying the double-blind peer-review process.

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Agricultural Biotechnology	Environmental Sciences and	Marine Biology
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Hampton, S., Rabagliati, H., Sorace, A., & Fletcher-Watson, S. (2017). *Autism and bilingualism: A qualitative interview study of parents' perspectives and experiences*. PsyArXiv, *Preprint*. https://doi.org/10.31234/osf.io/76xfs

Hetland, B., McAndrew, N., Perazzo, J., & Hickman, R. (2018). *A qualitative study of factors that influence active family involvement with patient care in the ICU: Survey of critical care nurses*. PubMed Central, *Preprint*. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5736422/?report=classic

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Şimşek, E. (2018). Analysis of the factors affecting the discard fate for trawl fishery [Ph. D. Thesis, Iskenderun Technical University] (In Turkish).

Conference Proceedings:

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Original Budapest Open Access Initiative Declaration

An old tradition and a new technology have converged to make possible an unprecedented public good. The old tradition is the willingness of scientists and scholars to publish the fruits of their research in scholarly journals without payment, for the sake of inquiry and knowledge. The new technology is the internet. The public good they make possible is the worldwide electronic distribution of peer-reviewed journal literature and completely free and unrestricted access to it by all scientists, scholars, teachers, students, and other curious minds. Removing access barriers to this literature will accelerate research, enrich education, share the learning of the rich with the poor and the poor with the rich, make this literature as useful as it can be, and lay the foundation for uniting humanity in a common intellectual conversation and the quest for knowledge.

The literature that should be freely accessible online is that which scholars give to the world without expectation of payment. Primarily, this category encompasses their peer-reviewed journal articles, but it also includes any unreviewed preprints that they might wish to put online for comment or to alert colleagues to important research findings. There are many degrees and kinds of wider and easier access to this literature. By "open access" to this literature, we mean its free availability on the public internet, permitting any users to read, download, copy, distribute, print, search, or link to the full texts of these articles, crawl them for indexing, pass them as data to software, or use them for any other lawful purpose, without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. The only constraint on reproduction and distribution, and the only role for copyright in this domain, should be to give authors control over the integrity of their work and the right to be properly acknowledged and cited.

While the peer-reviewed journal literature should be accessible online without cost to readers, it is not costless to produce. However, experiments show that the overall costs of providing open access to this literature are far lower than the costs of traditional forms of dissemination. With such an opportunity to save money and expand the scope of dissemination at the same time, there is today a strong incentive for professional associations, universities, libraries, foundations, and others to embrace open access as a means of advancing their missions. Achieving open access will require new cost recovery models and financing mechanisms, but the significantly lower overall cost of dissemination is a reason to be confident that the goal is attainable and not merely preferable or utopian.

To achieve open access to scholarly journal literature, we recommend two complementary strategies.

I. Self-Archiving: First, scholars need the tools and assistance to deposit their refereed journal articles in open electronic archives, a practice commonly called, self-archiving. When these archives conform to standards created by the Open Archives Initiative, then search engines and other tools can treat the separate archives as one. Users then need not know which archives exist or where they are located in order to find and make use of their contents.

II. Open-access Journals: Second, scholars need the means to launch a new generation of journals committed to open access, and to help existing journals that elect to make the transition to open access. Because journal articles should be disseminated as widely as possible, these new journals will no longer invoke copyright to restrict access to and use of the material they publish. Instead, they will use copyright and other tools to ensure permanent open access to all the articles they publish. Because the price is a barrier to access, these new journals will not charge subscription or access fees and will turn to other methods for covering their expenses. There are many alternative sources of funds for this purpose, including the foundations and governments that fund research, the universities and laboratories that employ researchers, endowments set up by discipline or institution, friends of the cause of open access, profits from the sale of add-ons to the basic texts, funds freed up by the demise or cancellation of journals charging traditional subscription or access fees, or even contributions from the researchers themselves. There is no need to favor one of these solutions over the others for all disciplines or nations, and no need to stop looking for other, creative alternatives.

Open access to peer-reviewed journal literature is the goal. Self-archiving (I.) and a new generation of open-access journals (II.) are the ways to attain this goal. They are not only direct and effective means to this end, but they are also within the reach of scholars themselves, immediately, and need not wait on changes brought about by markets or legislation. While we endorse the two strategies just outlined, we also encourage experimentation with further ways to make the transition from the present methods of dissemination to open access. Flexibility, experimentation, and adaptation to local circumstances are the best ways to assure that progress in diverse settings will be rapid, secure, and long-lived.

The Open Society Institute, the foundation network founded by philanthropist George Soros, is committed to providing initial help and funding to realize this goal. It will use its resources and influence to extend and promote institutional self-archiving, to launch new open-access journals, and to help an open-access journal system become economically self-sustaining. While the Open Society Institute's commitment and resources are substantial, this initiative is very much in need of other organizations to lend their effort and resources.

We invite governments, universities, libraries, journal editors, publishers, foundations, learned societies, professional associations, and individual scholars who share our vision to join us in the task of removing the barriers to open access and building a future in which research and education in every part of the world are that much more free to flourish.

For various reasons, this kind of free and unrestricted online availability, which we will call open access, has so far been limited to small portions of the journal literature. But even in these limited collections, many different initiatives have shown that open access is economically feasible, that it gives readers extraordinary power to find and make use of relevant literature, and that it gives authors and their works vast and measurable new visibility, readership, and impact. To secure these benefits for all, we call on all interested institutions and individuals to help open up access to the rest of this literature and remove the barriers, especially the price barriers, that stand in the way. The more who join the effort to advance this cause, the sooner we will all enjoy the benefits of open access.

More detail can be found at https://dergipark.org.tr/en/pub/maujan/page/14761

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The views of referees have a decisive place in the publication quality of *Muş Alparslan University Journal of Agriculture and Nature*.

Muş Alparslan University Journal of Agriculture and Nature uses the double-blind review method, which means that both the reviewer and author identities are concealed from the reviewers, and vice versa, throughout the review process, in the evaluation process of all studies. For this reason, the authors are asked to erase their names while uploading the articles to the system.

All the studies submitted to *Muş Alparslan University Journal of Agriculture and Nature* are evaluated by double-blind review method according to the following steps.

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The studies submitted to *Muş Alparslan University Journal of Agriculture and Nature* are first evaluated by the editor. At this stage, studies that are not in line with the aim and scope of the journal, are weak in terms of language and narrative rules in English contain scientifically critical mistakes, are not original worthy and cannot meet publication policies are rejected. Authors of rejected studies will be notified within one month at the latest from the date of submission. Eligible studies are sent to the field editor to which the study is relevant for pre-evaluation.

2. Pre-Evaluation Process

In the pre-evaluation process, the field editors examine the studies, introduction and literature, methods, findings, results, evaluation and discussion sections in detail in terms of journal publication policies, scope and authenticity of study. Study which is not suitable as a result of this examination is returned to the author with the field editor's evaluation report within four weeks at the latest. The studies which are suitable for the journal are passed to the referee process.

3. Referee Process

The studies are sent to the referees according to their content and the expertise of the referees. The field editor examining the study may propose at least two referees from the pool of *Muş Alparslan University Journal of Agriculture and Nature* Advisory Board or referee pool according to their field of expertise or may propose a new referee appropriate to the field of study.

The editors evaluate the referee's suggestions coming from the field editor and the studies are submitted to the referees. Referees are obliged to guarantee that they will not share any process or document about the study they are evaluating.

4. Referee Evaluation Process

The period given to the referee for the evaluation process is 15 days. Proposals for corrections from referees or editors must be completed by the authors within 1 month according to the "correction instruction".

Referees can decide on the suitability of the study by reviewing the corrections and may also request multiple corrections if necessary.

Referee Reports

Referee evaluations are based in general on the originality of the studies, the method used, and the conformity with the ethical rules, the consistent presentation of the findings and results, and the examination of the literature.

This review is based on the following elements:

1. Introduction and Literature: The evaluation report contains the presentation and purpose of the problem addressed in the study, the importance of the topic, the scope of the relevant literature, the timeliness and the originality of the study.

2. Methodology: The evaluation report includes information on the suitability of the method used, the choice and characteristics of the research group, validity and reliability, as well as on the data collection and analysis process.

3. Findings: The evaluation report includes opinions on the presentation of the findings obtained in the frame of the method, the correctness of the analysis methods, the aims of the research and the consistency of the findings, the presentation of the required tables, figures and images and the conceptual evaluation of the tests used.

4. Evaluation and discussion: The evaluation report includes the opinion on the subject based on findings, relevance to research questions and hypotheses, generalizability and applicability.

5. Conclusion and suggestions: The evaluation report contains the opinion on the contributions to the literature, future studies and recommendations for the applications in the area.

6. Style and narration: The evaluation report includes compatibility of the headline with the content, appropriate use of English in the study, and references in accordance with the language of the study and APA (7th) rules.

7. Overall evaluation: The evaluation report contains opinion on the authenticity of the study as a whole, its contribution to the educational literature and the applications in the area.

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MUŞ ALPARSLAN UNIVERSITY
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Utilization of The Saga Plant *Abrus Precatorius* L. in Indonesian Folk Medicine

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Review

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A B S T R A C T

Saga or known by the Latin name *Abrus precatorius* L. belongs to the Fabaceae family and is a leguminosae plant that grows in tropical and subtropical regions and has also been widely used for traditional medicinal practices. Saga is believed to be a plant that has natural properties and is important as a source of ingredients for making medicines to treat various diseases. Many pharmacological studies have been carried out which state that saga has various biological activities that can be act as anti-diabetic, anti-fertility, anti-germ, anti-cancer, and so on. Parts of the saga plant in the form of leaves, roots and seeds can be used for natural medicine which has been carried out by many traditional people for generations. Part of the leaf blade contains triterpene compounds, alkaloids, glycosides, and glycyrrhizin. It is known that the saga plant also has an abrin compound which has a very dangerous toxic effect when consumed by humans. The review of this article aims to gather useful information regarding the saga plant so that it can be better utilized and empowered for the benefit of human beings.

1. INTRODUCTION

Indonesia is a rich in number of plants used as spice and medicinal plants. The expertise of our ancestors in concocting medicinal plants and discovering the properties of plants is a legacy that should be preserved. Knowledge of the efficacy of medicinal plants by their ancestors is known as "Jamu" or herbal medicine (Widiyanti, 2005) and has been found in many traditional community medicinal practices across generations.

The glycyrrhizin contained in saga part of the roots and leaves of this plant is used to treat thrush, cough, and sore throat (Depkes RI, 1979), also as a flavoring agent (Rosrta et al., 1991). This plant is easily propagated by seed (Heyne, 1987). According to research by Juniarti et al., (2010) saga leaves contain flavonoids and steroids in their leaves; which can be act as antioxidants. Antioxidants play an important role in counteracting the effects of free radicals associated with degenerative diseases such as coronary heart disease, cancer and diabetes or diabetes mellitus which are caused by several degenerative biochemical pathways in the human body (Juniarti et al., 2010).

Flavonoids in plants also activate as natural killer (NK) cells to stimulate production of interferon-γ (IFN-γ) production in several cells of the immune system, which is the main cytokine of Macrophage Activating Cytokine (MAC) and plays a role in cellular non-specific immunity (Eriani et al., 2018).

Saga seeds also have a potential to act as an immunomodulator. Its seeds have secondary metabolites gallic acid, trigonelline, squalene, 5-beta cholanic acid, glycyrrhizin, abrusic acid, abrine, precabrine, abraline and also hypaphorine (Akram et al., 2014). Furthermore Bhatia et al., (2013) also reports abrus agglutinin activity in native (NA) and heat denatured (HDA) states for the proliferation of secreting cytokines, murine splenocytes, activating NK cells, and for lymphocyte proliferation.

HDA-induced native agglutinins and conditioning media from adhering splenocytes can stimulate non-adherent splenocytes and vice versa. Agglutinins that are denatured by heat activate NK cells to a lower extent than the amount of NA, but at a much higher activation rate for NK cells for NA. Thymocyte proliferation by NA and HDA was also further observed. This illustrates that Abrus agglutinin is capable of being a potential immunomodulator both in the native state (NA) and in heat denatured (HDA) conditions (Bhatia et al., 2013).

The toxicity test was carried out by the Bhatia et al., (2013) to find safe dose of abrin; which was 1.25 mg/KgBW for five days in normal mice, and could stimulate a specific humoral response. Increases in numbers were observed in the distribution of total leukocyte counts, antibody-forming cells, thymus, bone marrow cellular, spleen weight, positive bone marrow cells as well as circulating antibody, alpha-esterase. Observations suggest that abrin can potentially respond to host humoral immunity (Bhatia et al., 2013). The dose of Saga leaves is safe to use is 3 × 5 g of leaves per day (Menkes, 2017).

More than 166 chemical compounds have been identified from A. precatorius, which primarily cover flavonoids, phenolics, terpenoids, steroids, alkaloids, organic acids, esters, proteins, polysaccharides, etc. A wide range of in vitro and in vivo pharmacological functions of A. precatorius have been reported, such as antitumor, antimicrobial, insecticidal, antiprotozoal, antiparasitic, anti-inflammatory, antioxidant, immunomodulatory, antifertility, antidiabetic, other pharmacological activities (Qian et al. 2022).

Further studies are needed to increase the value of the saga plant by utilizing it to become a product that is known and liked by the community. This paper aims to enrich information about the saga plant which has the potential to be developed as a medicinal plant which has bright prospects in the future.

According to Backer et al, (1965) saga plants are classified as follows:

Kingdom: Plantae

Division: *Magnoliophyta*

Class: *Magnoliopsida*

Order: *Fabales*

Family: *Papilionaceae*

Genus: *Abrus*

Species: *Abrus precatorius* L.

2. SAGA PLANT MORPHOLOGY

The leaves are compound, oval in shape and small in size. Saga leaves have odd fins and have a slightly sweet taste. Saga has pods filled with red seeds having shiny and smooth black dots. The flowers are light purple in shape (resembling a butterfly), in clusters of flowers.

Shrubs, vines and twisting, branched woody stems, young stems are green and are green-brown at old age. They have compound leaves, alternate, pinnate odd, leaflets oval, green color. Inflorescence is bunch shaped. Seeds are contained in pods, which are ovoid, red with black spots.

In general, the height of old saga trees can reach 20-30 m. Saga trees are deciduous or change leaves every year (Diningrat, 1987). The leaves are even pinnate compound, grow alternately, the number of leaflets is 2-6 pairs, the leaf blade is 6-12 pairs, the stem length reaches 25 cm, the leaves are light green. Small yellowish flowers are produced with 4-5 strands of Corolla and 8-10 stamens.

Fig. 1. *Abrus precatorius* L.Plant (Source: https://www.cabidigitallibrary.org/doi/10.1079/cabicompendium.1965#image-27530)

3. DESCRIPTION OF SAGA PLANT

Saga plant shrubs, grow as vines, growing wild in forests, fields or yards in dry areas with altitudes up to 1,000 meters above sea level requiring a partial or full shade. The plant height reach 2-5 meters length and have small stems.The saga plant family fabaaceae has small green leaves oval shaped pinnate compound leaves resembling tamarind leaves, (Abrupte pinnatus) with a length of 6.025 mm and a width of 3-8 mm, occuring in pairs of 8-18 leaflets.

Saga flowers are compound in the form of bunches, small with a white and light purple butterfly-shaped crown, the lower part is androgynous, the upper part consists only of male flowers, the petals are serrated, short hairy, and the stamens are fused on the tube, the stamens are approximately 1 cm, yellow anthers pistil, winged flower crown. The fruit includes pods with a length of 2-5 cm, green when dark brown. Inside the fruit are red seeds with black dots, shiny and smooth, oval in shape, small and hard.

In Indonesia the saga plant has several regional names including: Thaga (in Aceh), Saga (in Batak Makasar and Sampit), Parusa (in Mentawai), Kundi (in Minangkabau), Kandari (in Lampung), Kendari (in Malay), Taning Bajang (in Dayak), Walipopo (in Gorontalo), Kaca (in Bugis), Ailalu Picar (in Ambon), Pikal (in Haruku), Pikolo (in Saparua), Seklawan (in Buru), Idisi Ma Lako (in Loda Halmahera), Idihi Ma Lako (in Pagu Halmahera), Idi-idi Ma Lako (in Ternate Tidore), Punoi (in Arafuru), Kalepip (in Irian/Papua) (Depkes RI, 1979).

4. CULTIVATION OF SAGA PLANTS

The plants can grow well at an altitude of 1-1.000 m above sea level, on a variety of soils, with rainfall of 1.500-4.500 mm/year in Indonesia. The anti-nutritional compounds analyzed in saga seed coat were anti-trypsin (Rosrta et al., 1991), anti-chymotrypsin (Kardianan, 2005), and saponins by spectrophotometric method (Gatler, 1991). The leaves are compound, oval in shape and small in size. Saga leaves are oddly finned. Saga has pods filled with seeds that are red and smooth. Saga seed coat which is on the outside is very hard so that the seed is resistant to environmental conditions during its period as a plant seed (regeneration).

Vines grow well on the fences, generally in the yard. Plant propagation is done by seeds. The seeds are soaked overnight in water and only viable seeds are selected to raise the nurseries. Thereafter, 3-4 months old plantlets are transplanted to the gardens.

Seeds can also be sown at depths of 3-5 cm directly in the garden after preparation of land and levelling for 1-2 times and leveling it using plant to plant distance of 25-60 cm. Each drill hole is filled with 3-5 grains. The need for seeds for 1 hectare of land is approximately 25-40 kg of seeds (an average of 1 kg contains 7.500 seeds).

How to plant directly in the garden is done in the rainy season or in the dry season when water is available. The plants can be hoed to improve the ground cover that serve as fertilizer and improve organic matter in the soil classified as a green manure.

This plant does not require much maintenance, which, consists of replanting, fertilizing, controlling pests and diseases. Control of plant lice using systemic insecticides, and extermination of plants attacked by Meloidogyne sp, Heterodera sp, and devil's broom disease caused by marioni virus.

Slightly weak soils are fertilized with fertilizers containing 25-50 kg of nitrogen, 45 kg of phosphorus and 50 kg of potassium per hectare. The first harvest is done after the plants are 6-8 months old. Harvest the leaves by cutting the plant 25-30 cm from the ground. Harvest the roots after the plants are 2.5-3 years old with a production of 2.500-3.500 kg of wet roots per hectare.

5. SUBSTANCE CONTENT

Saga plants have several chemical constituents in the leaves, stems, seeds and roots. The chemical content contained in the saga plant can be seen in table 1 below.

Saga seeds contain flavonol glucoside, proximate and protein which are rich in essential amino acids. Saga seeds are also rich in abrin compounds which can cause apoptosis in leukaemic cell cultures. Saga seed coat pigment dissolves in fat solvents and produces a light yellow color. The solubility properties of saga seed coat pigments in fat solvents show similarities to the solubility properties of chlorophyll and carotenoid pigments, while the solubility in water solvents show similarities to the solubility properties of anthocyanin and anthoxanthin pigments (Barrows, 1968).

Saga seeds also contain saponins in the red skin of the seeds. Saponins are a type of glycosides that are found in plants. The main source of saponins is grains, apart from saga seeds, they are also found in soybeans. Saponins have the characteristic of foaming. So if it is reacted with water and shaken, a number of foam will appear which can last longer. Saponin compounds are very easily dissolved in water and not easily soluble in ether. These saponins have a distinctive taste that is bitter, stinging and can cause sneezing and irritation of the mucous membranes. Saponin is also a poison that can destroy blood clots or hemolysis. In addition, saponin compounds are toxic to cold-blooded animals and

are widely used as fish poison. Saponins that have a strong or toxic effect are known as sapotoxins (Dwijoseputro, 1989).

Saponin is a glycoside that may be present in many plants. Saponins are present throughout the plant with high concentrations in certain parts and are influenced by plant varieties and growth stages. Its function in plants is unknown, possibly as a storage form of carbohydrates or as a waste product of plant metabolism. Another possibility is as a protection against insect attacks.

Table 1. Substance Content of Saga Plants (Ministry of Health RI, 1979).

Plant Parts	Chemical Contents
Leaf	saponins and flavonoids, glycyrhizin
Stem	polyphenols, saponins and flavonoids
Seed	tannins, saponins and flavonoids
Root	glycyrizin, alkaloids, saponins, polyphenols

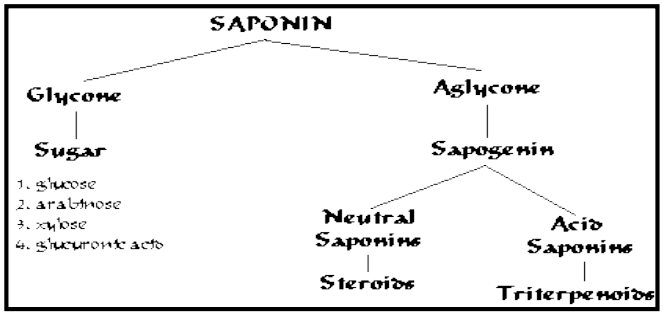

Fig. 2 Derivatives of saponin

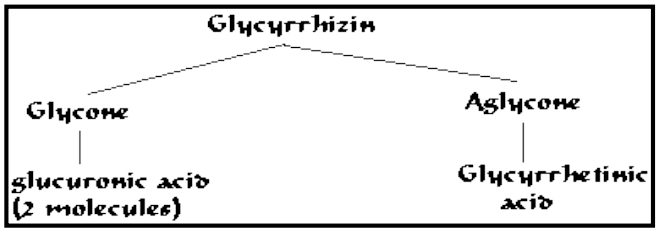

Fig. 3 Glycyrhizin

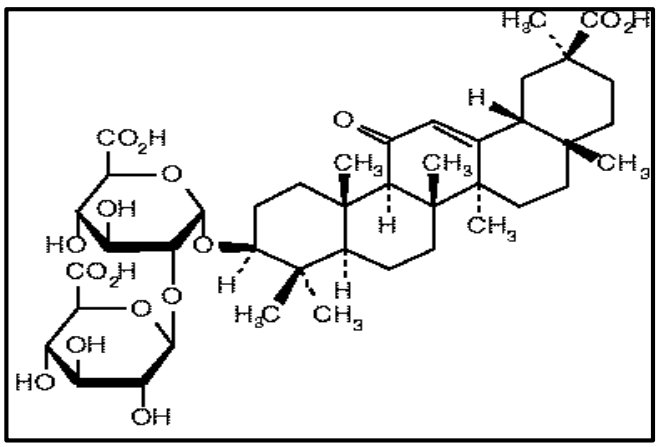

Fig. 4 Chemical structure of glycyrrhizin

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Saponin is a glycoside that may be present in many plants. Saponins are present throughout the plant with high concentrations in certain parts and are influenced by plant varieties and growth stages. Its function in plants is unknown, possibly as a storage form of carbohydrates or as a waste product of plant metabolism. Another possibility is as a protection against insect attacks.

Two types of saponins are known, namely alcohol triterpenoid glycosides and structural steroid glycosides (Hadioetomo, 1985). Saponins are surface active compounds and are shaped like soap, and can be detected based on their ability to form foam and hemolyze blood cells. Saponins contained in simplicia contain terpene derivatives and a small portion of steroids. Some saponins are acidic, due to the presence of a carboxyl group on the aglycone and/or sugar group (Raddish, 1961). Hemagglutinin is mainly present in beans and peas of the Leguminose and Euphorbiaceae families. This active substance is a protein that will clot and hemolyze blood grains. Its toxic form is also in the form of inhibition of various protease enzymes (Raddish, 1961). Seeds are composed of the skin, cotyledons, and hypocotyl. The skin is the larger part, which is 52.13% with a range of 51.8-52.5%, while the cotyledons and hypocotyl are 47.87% with a range of 46.2-48.91%. The signs of old saga seeds are the pods broken and split and the cupped pod shells forming a spiral arrangement, the seeds are very hard, the seed coat is

bright red, and the seeds are brownish yellow in color (Emmyzar et al., 1990).

In the structure of wood or extractives it occupies a certain morphological place. That is, fats and waxes are found in the parenchyma cells of the fingers whereas resinous acids can be found in the resin ducts. Extractive – Phenol extractives are mainly found in heartwood and in the bark. The results showed that between water, methanol, ethanol, and propanol which was able to dissolve the most dyes was methanol. The dissolving ability of each solvent sequentially is methanol > water > ethanol > propanol (Raddish, 1961).

6. BENEFITS OF SAGA PLANTS

The saga plant is used as a traditional medicine and can be used as a remedy for canker sores, tonsillitis and eye inflammation. Saga plants also contain vitamins A, B1, B6, C, protein, calcium oxalate and many other minerals needed by the body. In various tips for processing saga leaves, it is stated that it is not recommended to treat with the seeds because saga seeds contain a toxic substance called abrin.

Antioxidants play a major role in reducing the effects of free radicals which can trigger degenerative diseases such as coronary heart disease, cancer, high blood pressure and diabetes which are based on the biochemical processes that occur in the body. Free radicals that are produced continuously during normal metabolic processes are believed to be one of the causes of damage to the function of body cells which results in degenerative diseases (Helliwel, 1999). Generally, the effects of free radicals can be minimized by certain antioxidants, namely natural antioxidants or synthetic antioxidants. Most natural antioxidants come from plants, including tocopherols, carotenoids, ascorbic acid, phenols, and flavonoids (Wang. et al, 1989).

At high doses of compounds, bioactive compounds can have toxic effects, so that the in vivo killing power of these compounds against certain organisms such as animals can be used for bioactivity and also for observing bioactive fractions during fractionation and purification. Brine shrimp is an example of an organism suitable for animal testing (Meyer et al., 1982).

7. PHYTOCHEMICAL COMPOUNDS OF SAGA PLANT

Parts of the Leaves: the leaves contain glycyrrhizin compounds up to 10%, triterpenes, glycosides, pinitol and also alkaloids namely abrine, hepaphotine, choline then precatorine (Garaniya and Bapodra 2014). Tree glycoside compounds based on aglycones as well as abrutigenins, while for the cycloartane type, namely triterpene glycoside compounds include abusosides A, B, and C (Bahrami and Franco 2016). There are other active compounds that can be found in saga leaves, namely methyl abrusgenate, tritepenes abrusgenic acid, abruslactone A, liquirtiginin-7-diglycoside, toxifolin-3-glucoside, flavonoid vitexin and liquirtiginin-7-monoglycoside.

Part of the seed: the seeds of the saga plant contain ash (5.38%), fat (3.92%), carbohydrates (42.42%), crude protein (39.20%), crude fiber (9.08%) and high water (5.06%) (Das et al., 2016). Other active compounds can be found in saga seeds, namely alkaloids, flavonoids, anthocyanins, steroids, fixed oils and lectins (Pal et al., 2009). Alkaloid compounds found in saga seeds contain precatorine, choline, abrine and hepaphotine (Garaniya and Bapodra 2014). Meanwhile, the oil contained in sage seeds is oleic acid and linoleic acid

Steroids were found in saga seeds containing cholesterol, abricin, stigmasterol, linoleic, 5β-cholanic acid and also-sitosterol (Yonemoto et al., 2014). The red color seen in saga seeds is the presence of delphinidin, pelargonidin, cyanide, abranin and glycosides (Bhakta and Das 2020). Other compounds that can be found are hederagenin methyl ether, sapogenol, kaikasaponin III methyl ester, abrisapogenol J, sophoradiol, flavones including abrectorin and saknone which are other main supports of saga seeds (Verma, 2016). The main supports of saga seeds are abrin and lectin. The toxic (abrin) and non-toxic lectin constituents are (abrus agglutinin). Abrin is known as abrin a, b, c, and d which are short polypeptide chains and also large β-polypeptide chains which are then connected by disulfide bonds (Herrmann and Behnke, 1981). Root components: the root part of the saga plant contains alkaloid compounds and also glycyrrhizin such as abrasives and precasine in addition to related bases and also abrine (Verma et al., 2011).

8. CHEMICAL COMPOUND CONTENTS OF SAGA LEAF EXTRACT

Juniarti et al., (2009) mentions chemical content of saga leaf extracts as shown in Table 3. It can be seen that after the phytochemical tests were carried out on the three extracts, it was found that the n-hexane extract of saga leaves contained steroid compounds, and the ethyl acetate extracts contained flavonoids and steroids, while the methanol extract contained steroid compounds. Phenolic compounds and saponins were not found in the three extracts of the saga (*Abrus precatorius*, L) leaves. This can be seen from the absence of foam in the saponin test and the absence of green, blue, or purple colors in the phenolic compound tests.

Table 2. Phytochemical Test of Saga Leaf Extract

No	Chemical Compounds	Extract results			Notes
		n-hexane	ethyl acetate	methanol	
1	Flavonoids	Yellow (-)	Orange (+)	Green (-)	(+) If red, yellow or orange is formed
2	Phenolic	Yellow (-)	Brown (-)	Brown (-)	(+) If a green, blue or purple color is formed
3	Saponins	No foam (-)	No foam (-)	No foam (-)	(+) if permanent foam is formed ± 15 minutes
4	Steroids/terpenoids	Dark green (+)	Green (+)	Green (+)	Steroids (+) if a blue or green color is formed, triterpenoids (+) if a red/violet color is formed

9. TOXIC EFFECT

An unfortunate incident has been discovered after ingesting the chewed saga seeds. Because the seed coat is hard, it can then pass through the digestive tract without being properly processed and then shows a harmless state. Raw seeds have a soft skin and break easily so it is more dangerous. Symptoms of poisoning have been found through finger pricks while stringing seeds. These symptoms then develop after a few hours to several days after consumption.

Toxicity can be identified including severe nausea and vomiting or gastroenteritis. Mydriasis may occur, followed by cold sweats, muscle weakness, tremors and tachycardia. There is no physiological drug that can be found (Ross, 2003). However, even though the saga plant has many therapeutic benefits, it should be a concern if an inappropriate or excessive dose or intake will result in poisoning which is very dangerous and can cause death (Nenov et al., 2003). Saga seeds can cause toxic effects in the dose range of 90 to 120 mg Tam et al., 2017. Apart from that, saga seeds contain the compound abrin, if consumed in the dose range of 0.0001 to 0.0002 mg/kg it will become a natural poison Wooten et al., (2014). The effects of accidentally ingesting saga seed poisoning can affect the performance of the digestive tract, kidneys, lymphatics, liver and spleen systems (Patil et al., 2016). When exposed to saga seed extract, it can cause eye damage, blindness and conjunctivitis (Karpurashetti, 2014). Acute gastroenteritis with vomiting is another symptom of poisoning from saga seeds.

10. USE OF SAGA PLANTS IN ETHNOMEDICINAL SYSTEM OF INDONESIA

Saga plants as medicine can treat several diseases, namely:

10.1. Thrush

The patients take enough saga leaves and dry them until they wilt. These leaves are chewed until smooth while using them to rinse mouth.

10.2. Tonsils

The patients take enough saga root, one piece of cinnamon, and rock sugar to taste after washing the roots with cinnamon and boiling in 5 cups of water. There after, the patients strain the water and drink twice a day in the morning and evening.

10.3. Eye Inflammation

The patients take enough sage leaves, crush them until they are smooth. Next, the paste is boiled in 2 cups of water to take hot steam. The patients also use water vapors of saga leaves as eye drops.

10.4. Relieves heart pounding and cold sweat

The patients take 8 grams of sweet saga leaves and 10 grams of sembung (Blumea balsamifera; DC). They add 5 grams of aromatic ginger and boil it with 2 cups of water followed by drinking the the boiled water.

10.5. Treat high blood pressure

The patients take sweet saga leaves, horse-foot leaves, duringgi leaves, white pumpkin leaves, and kejibeling leaves (Strobilanthes crispa). They boil them in 4 cups of water and reduce it to 2 cups. The mixture is strain before drinking the compound.

10.6. Treat dry cough

The patients take sweet saga leaves, ripe pace fruit, and po'o leaves (Mentha × piperita L). These are ground finely before boiling with 4 cups of water. It is strained before drinking.

11. CONCLUSION

From the discussion about the saga plant, it turns out that it is used to maintain health, and treat several diseases. These can be used by pounding, boiling, chewing as per prescription. Saga plants also contain vitamins A, B1, B6, C, protein, calcium oxalate and many other minerals needed by the body. It is not recommended to use seeds because they contain toxins the saga plant seeds has an abrin compound which has a very dangerous toxic effect when consumed by humans that can injurious to intestines.

COMPLIANCE WITH ETHICAL STANDARDS

Author Contributions

All authors contributed to the study conception and design. The first draft of the manuscript was written by J.K and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Conflict of Interest

The authors do not have any conflicts of interest to declare.

Ethical Approval

For this type of study, formal consent is not required.

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Usage Shrub and Tree-Form Plants in Traditional Folk Medicine

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A B S T R A C T

The study purpose at the fourteen villages is to compile traditional knowledge and shrubs and trees used to improve human and animal health. In the study, traditional information about the medicinal uses of some wild plants in the form of trees, shrubs and heather, which the people continue to use primarily for food have been recorded and, 34 taxa used in folk remedies (human and animal health) have been determined. These plants belong to 11 families and most of the taxa used belong to the Rosaceae family. The families that these plants belong to are respectively; Rosaceae (15), Lamiaceae (5), Berberidaceae (2), Cupressaceae (2), Elaeagnaceae (2), Grossulariaceae (2), Salicaceae (2), Asteraceae (1), Adoxaceae (1), Ericaceae (1), Hypericaceae (1). These taxa consist of 59% shrub, 9% semi-shrub, 6% shrubby and 26% tree or small tree. These taxa's leaves, flowers, shoots and roots are used primarily in the fruit parts. These natural plants are used in respiratory system (18%), digestive system (9%), urinary system (14%), appetite and hematic purposes (11%), hemorrhoid (23%), rheumatism (7%), diabetes (11%) and other (9%) ailments. In the study, it was also determined that four taxa were used in animal diseases. It is imperative to record, protect and transfer the traditional knowledge and cultural richness that are fighting for survival in the study area, which has a rich flora. For this reason, it is necessary to identify, record and present to serve ethnomedicinal wealth.

1. INTRODUCTION

Traditional uses of medicinal plants are a part of human life in our country as well as all over the world. There are many studies on medicinal plants and raw pharmaceutical materials obtained from these plants, but it is more important to use traditional knowledge in this study. For this reason, studies based on recording traditional information have been given more attention, especially in recent years. According to the World Health Organization, at least 80% of developing countries have been used traditional methods in treating human and animal diseases (WHO, 2023). Herbal medicinal methods are advanced in many countries, such as Romania, Bulgaria, Hungary, India, China, and Japan. Even in Germany, with marginal plant diversity, more than 500 plants have been used for medicinal purposes. The World Health Organization (WHO) reports that in many developed countries, society still clings to traditional medicine and primary health care has been fueled by the workforce provided by those who use traditional practices. According to the World Health Organization, at least 80% of developing countries are used traditional methods in treating human and animal diseases (WHO, 2023). Herbal medicinal methods are advanced in many countries, such as Romania, Bulgaria, Hungary, India, China, and Japan. Even in Germany, with marginal plant diversity, more than 500 plants are used for medicinal purposes. The World Health Organization (WHO) reports that in many developed countries, society still clings to traditional medicine and primary health care is fueled by the workforce provided by those who use traditional

practices. Approximately 80% of the population of North India (Jaiswal, 2010) and Southeastern Ethiopia (Wabe et al., 2011) primarily prefer to use medicinal plants for human healthcare (Mesfin et al., 2013). Other studies in Jordan and Madagascar (Nawash, 2013) have indicated that these countries continue to benefit from high levels of bio-diversity, despite the threat of increasing population and climate change (Rabearivony et al., 2015). Anatolia has approximately 12.000 plant species, 30% of which are endemic, due to its rich geography that allows for rich plant diversity (Güner et al., 2012). The number of plant species added to literature is increasing daily. The natural flora has various trees, shrubs, and shrub-like plants, whose fruits or different parts are used or consumed. These plants are very advantageous as they are located in certain ecological, topographic, and geographic areas. They are also important genetic resources for breeding studies. Alongside the increase in technology and industrialization, it has become inevitable to conclude that the prospect of a healthy life a faces wide variety of threats. For this reason, alternatives for returning to rural or natural life have become an important area of research. Medicinal plant treatments, which are alternative medicine method, have gained popularity. Non-wood forest products are very important for the development of local people in the world and in our country. In our country, there are many traditional medical applications However, tradition and traditional knowledge are rapidly disappearing for many years. It is imperative to record, protect and transfer the traditional knowledge and cultural richness fighting for survival in the study area, which has a rich flora. For this reason, it is necessary to identify, record and present to serve ethnomedicinal wealth.

On the other hand, genetic erosion has increased due to overuse of natural resources, degradation of plant habitats, climate changes and environmental destruction. Protecting or preserving these plants for current or future research is extremely important. Therefore, such studies will also contribute to conserving genetic resources. For these reasons, with an ethnomedical approach, this study has examined the medicinal uses (in treating of animals and humans) of trees, shrubs or shrub-like plants in fourteen villages. The study aims to record the traditional usage information of shrubs and trees used for treatment, contribute to the literature and transfer them to future generations. In addition, it is also thought that the findings will be a source for studies in different disciplines.

2. MATERIALS AND METHOD

The study was carried out in fourteen (14) villages of Aşkale (Erzurum) and Center (Bayburt) districts (Figure 1).The targeted villages have been visited between March and November each year from 2012 to 2015. Information has been obtained from people living in the region for a long time. In the research; general information about the plant and information about its medical use have been recorded. Wild-growing shrubs and trees, used by the local people have been identified and recorded (Ekim and Kart Gür, 2019). Herbarium specimens have been collected, pressed, and stored (Tan et al., 2013). Suitable for techniques herbariums were prepared, and plant seed samples were taken (Tan and Taşkın, 2013). In plant identifications, mainly Flora of Turkey (Davis, 1965-88) was used. Plant identifications; Turkey's Trees and Shrubs (Yücel, 2005; Mamıkoğlu, 2007) were also controlled. In addition, technical support was received from the Botanical Department of Karabuk University-Faculty of Forestry to identify some species. Moreover some seeds and information forms have been sent to gene banks.

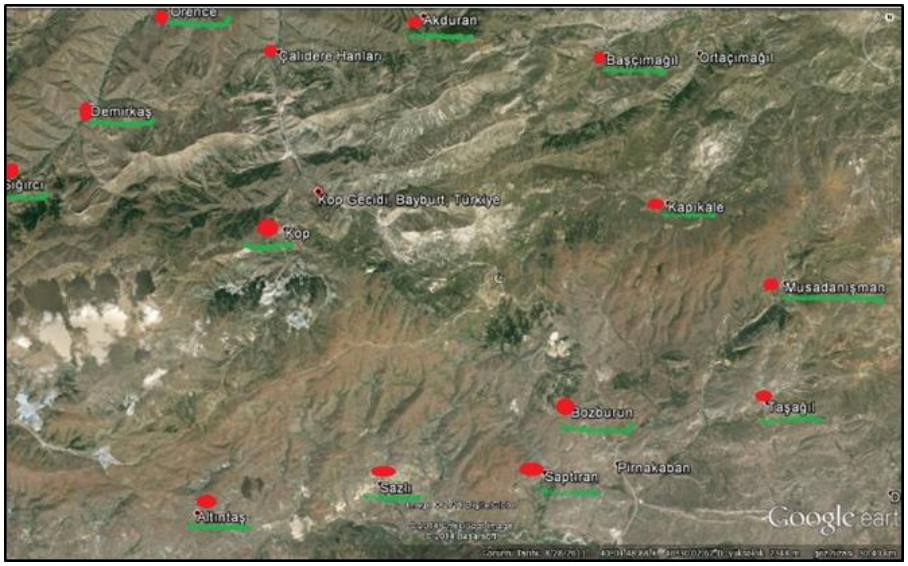

Figure 1. Geographical location of the research area

3. RESULTS AND DISCUSSION

The ethnomedicinal information was obtained through structured interviews with the local people. Although plants in question are generally considered as nutritional sources, they are also used for medicinal purposes. In the study; by learning the local names of the plants collected, the location of the place, habitat, used parts of the plant, and their usage has been recorded. 34 trees or shrubs belonging to 11 families, which are still used in the treatment of human and animal diseases, have been recorded. 15 taxons from Rosaceae family, 5 taxa from Lamiaceae family, 2 taxa from Grossulariaceae family, 2 taxa from Elaeagnaceae, 2 taxa from Berberidaceae family, 2 taxa from Cupressaceae family, 2 taxa from Salicaceae family, 1 taxa from Adoxaceae family, 1 taxa from Asteraceae family, 1 taxa from Ericaceae family and 1 taxa from Hypericaceae were found.

Grapefruits, raspberry and blackberry (*Rubus*), blackcurrant and gooseberry (*Ribes*), blueberry (*Vaccinium*), rosehip (*Rosa*), sea buckthorn (*Elaeagnus*), jackal prune (*Prunus*) and their related species are plants known and used by the public. Five species of blackcurrant are known to grow in natural areas. These species are red currant (*Ribes rubrum* L., black currant (*Ribes nigrum* L.), eastern black currant (*Ribes orientale* Desf.), alpine currant (*Ribes alpinum* L.) and caucasian currant (*Ribes biebersteinii* Berl. Ex.Dc.) species. Türkiye is the natural distribution area of these species; different forms of these species are encountered in all regions (Ağaoğlu, 2006). These plants were categorized according to their forms and habitus: 2 of them were classified as shrub-like plants, 3 as semi-shrubs, 20 as shrubs, and 9 as trees or treelets. Rosaceae family has the highest amount of taxons, and these taxons are consumed as fruit, fruit products and medicine. The Lamiaceae family plants are considered aroma plants and are also used for medicinal purposes. According to the recorded information, out of 34 taxons, fruits of the 13, leaves of 11, roots of 5, flowers of 4, stems of 2, shoots of 1, barks of 1, and branches of 1 are used for medicinal purposes.

Apple, pear, plum, cherry, rosehip, raspberry and blackberry etc. in the working area. It is collected from nature and evaluated. People are trying to continue this tradition. In addition, its fruits are used by the local people as jam, marmalade, fruit juice and dessert. The fact that most of the natural plants used are for food and treatment purposes, shows that the natural flora has been continued use in nutrition and health. Information regarding the plants used for medicinal purposes by the local population is parallel to information obtained via other ethnobotanical studies carried out in the region (Baytop, 1999; Özgökçe and Özçelik, 2004; Özgen *et al*., 2004; Bulut, 2005; Aksakal and Kaya, 2008; Özgen et al., 2012; Kadıoğlu and Kadıoğlu, 2014). Thirteen (13) of the taxa are used for hemorrhoids or other intestinal disorders, 10 are used for general respiratory ailments, 5 are used digestive system related disorders, 8 are used for urinary system disorders, 6 are used for diabetes, 4 are used for rheumatism, 6 are used for building appetite and for hematinic purposes, and 5 are used for other disorders. Hemorrhoids and respiratory ailments are the most common complaints in the findings (Figure 2a). It has been recorded that four taxa are used in some animal diseases. These taxa are; *Juniperus excelsa* M. Bieb. (foot-mouth- disease), *Juniperus communis* var. *saxatilis* Pall. (skin disease), *Pyrus elaeagnifolia* Pall. (diarrhea) and *Pyrus syriaca* var. *syriaca* Boiss. (diarrhea) (Figure 2b).

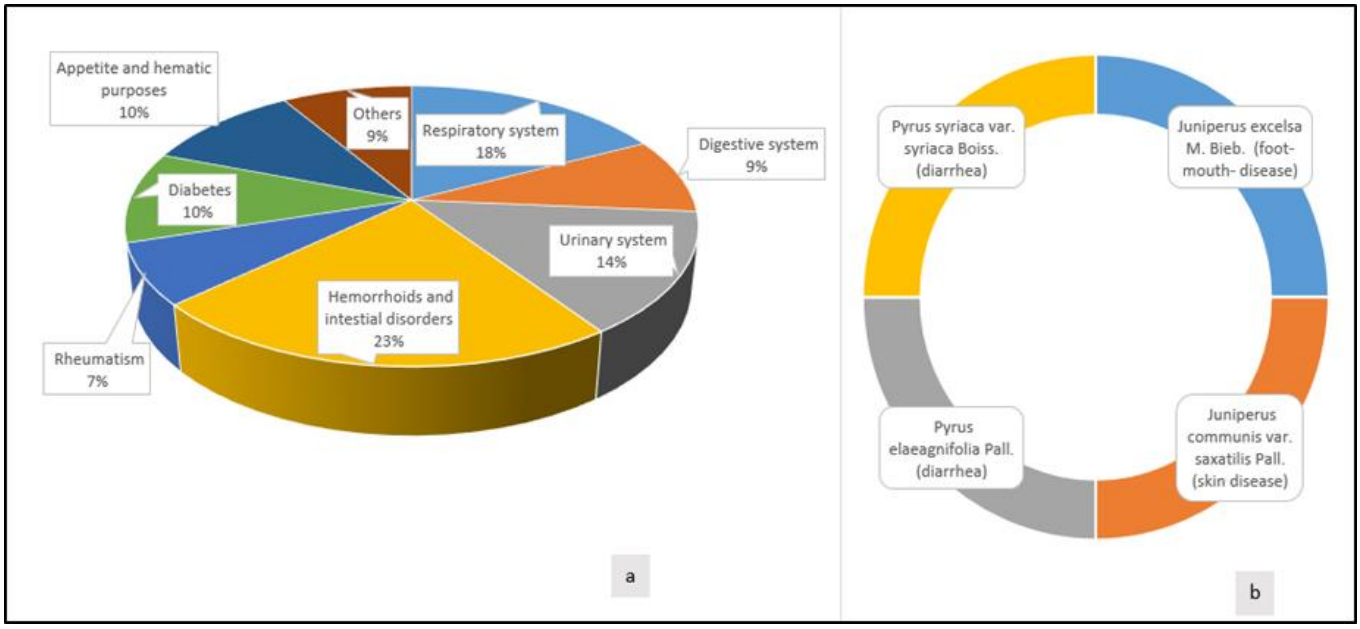

Figure 2. Human and animal diseases and ailments in which shrubs and trees are used

It has been determined that many plants (Berberis, Rubus, Ziziphora, Malus, Pyrus) are used to treat diabetes in the study. These plants are used for the treatment of disorders that are common in Türkiye. The plants determined to be used in the treatment of some ailments in the study are also included in similar studies conducted throughout Türkiye (Gürhan and Ezer, 2004; Tuzlacı et al., 2010; Sarıkaya et al., 2010; Altay and Çelik, 2011; Arıtuluk and Ezer, 2012; Polat et al., 2012). The plants used by the local people in folk medicine for both human and animal health are given in Table 1 in alphabetical order. Their families, scientific, Turkish, English and local names, intended use, parts used, usage patterns and references are given in Table 1.

Table 1. The plants used by the local people for both human and animal health in folk medicine

Family: Asteraceae **Taxa:** *Artemisia absinthium* L. **English name:** Wormwood **Turkish Name:** Acı pelin **Local Name:** Boz ot, pire out **Plant form:** Shrubby **Location:** Taşağıl-Çığırtka **Habitats:** Stream,riverside, sloping areas **Used parts:** Herba **Recipe for use:** The research revealed that this plant had been used as herbal tea (decoction) for relieving pain, stomach-ache, and for expelling kidney stones. Additionally, for women, who are unable to have children, a cup of tea made with a pinch of this plant is given every morning for a month. **Similar uses:** Dülger et al., 1999; Bağcı et al., 2006; Yaldız and Kılınç, 2010	**Family:** Adoxaceae **Taxa:** *Viburnum lantana* L. **English name:** Wayfarer **Turkish Name:** Germeşe **Local Name:** Germişo, germişek **Plant form:** Shrub or Small Shrub Tree **Location:** Bozburun, Demirkaş **Habitats:** Rocky stony areas **Used parts:** Fruit **Recipe for use:** Riped fruits is crushed in a certain amount of water and consumed as a laxative to relieve constipation. This mixture for kidney stones is drunk every morning, one glass a day. **Similar uses:** Altun et al., 2010; Şimşek et al., 2004
Family: Berberidaceae **Taxa:** *Berberis integerrima* Bunge **English name:** Barberry **Turkish Name:** Sarıçalı **Local name:** Kızamık, kızambuk **Plant form:** Shrub **Location**: Sazlı **Habitats:** Calcareous slopes **Used parts:** Leaf /Fruit **Recipe for use:** The fruits are used in the production of syrup. The fruits together with the leaves are also made into brines and pickles. Tea (infusion or decoction) made from its leaves is consumed to reduce blood sugar (diabetes).	**Family:** Berberidaceae **Taxa:** *Berberis vulgaris* L. **English name:** Common barberry **Turkish name:** Kızılkaramuk **Local name:** Kızamık, kızambuk **Plant form:** Shrub **Location:** Bozburun **Habitats**: Stony slopes **Used parts:** Roots **Recipe for use:** The tea (tea-decoction) obtained by boiling the roots is drunk in a tea glass on an empty stomach in diabetes.
Similar uses: Altundağ and Öztürk, 2011; Arıtuluk and Ezer, 2012, Arslanoğlu and Ayna, 2019	

Table 1. The plants used by the local people for both human and animal health in folk medicine (continuance)

Family: Cupressaceae **Taxa:** *Juniperus excelsa* M. Bieb. **English name:** Greek juniper **Turkish Name:** Boz ardıç **Local Name:** Çekem, kekem **Plant form:** Shrub **Location:** Bozburun, Akduran **Habitats:** Rocky slopes **Used parts:** Fruit /Root **Recipe for use:** Fruits and roots are used. Tea (decoction) made from the plant is used for shortness of breath, common cold and bronchitis. Its roots are chopped, boiled with water, and placed in an earthen pot with holes at the bottom. A container is placed under this earthen pot to hold the filtered liquid. This liquid obtained is used against hemorrhoids and eczema (external application) **Similar uses:** Baytop, 1999; Fujita et al., 1995 **Animal health:** Foot-and-mouth disease (FMD) **Application:** This liquid was used (externally) in FMD.	**Family:** Cupressaceae **Taxa:** *Juniperus communis* var. *saxatilis* Pall. **English name:** Common juniper **Turkish Name:** Bodur ardıç **Local Name:** Çekem, kekem **Plant form:** Shrub **Location:** Saptıran-Göltarla **Habitats:** Mountain bush **Used parts:** Fruit/Root **Recipe for use:** Fruits and roots are used. Tea (decoction) made from the plant is used for shortness of breath. **Similar uses:** Cansaran et al., 2007; Güneş and Özhatay, 2011. **Animal health:** Skin diseases **Application:** Tar obtained from wood is used externally in the treatment of skin diseases of animals.
Family: Elaeagnaceae **Taxa:** *Elaeagnus rhamnoides* (L.) A.Nelson **English name:** Sea-buckthorn **Turkish Name:** Çıçırgan **Local Name:** Sincan, tikanucu **Plant form:** Shrub **Location:** Kapıkale- Kom, Demirkaş **Habitats:** Rocky slopes **Used parts: Fruit, flower, branch,** Leaf **Recipe for use:** The leaves are consumed as tea (decoction) for stomach pain, mouth sores, flu, common cold **Similar uses:** Duke, 2004; Zeynalov, 2008; Khan et al., 2010	**Family:** Elaeagnaceae **Taxa:** *Elaeagnus angustifolia* L. **English name:** Russian olive, Silver berry **Turkish Name:** İğde **Local Name:** İğde **Plant form:** Shrub-Tree or Shrub **Location:** Kopköy- Karasu Çayı **Habitats:** Stream sides **Used parts:** Fruit **Recipe for use:** The fruits are boiled with milk and turned into porridge. It is eaten to relieve respiratory problems associated with bronchitis. Tea (decoction) prepared by boiling the flowering branches is used against diabetes. **Similar uses:** Sarıkaya et al., 2010; Özgen et al., 2012)

Table 1. The plants used by the local people for both human and animal health in folk medicine (continuance)

<table>
<tr><td colspan="2">Family: Ericaceae
Taxa: Vaccinium uliginosum L.
English name: Bog bilberry, Bog blueberry
Turkish Name: Avcı üzümü
Local Name: Yemişen, ayı üzümü
Plant form: Shrub
Location: Taşağıl-Ağbaba, Akduran-Yıkıkhanlar
Habitats: Bushes
Used parts: Leaf/Fruit
Recipe for use: The fruits and leaves are used to make tea (decoction). Fruit or leave tea is used for anti-inflammatory purposes and to expel kidney stones.
Similar uses: Karık, 2017</td></tr>
<tr><td>Family: Grossulariaceae
Taxa: Ribes orientale Desf.
English name: Currants, Gooseberries
Turkish Name: Çeçem
Local Name: Horhoç, İt üzümü, Çeçem
Plant form: Shrub
Location: Sığırcı, Akduran
Habitats: Bushes
Used parts: Leaf/ Fruit</td><td>Family: Grossulariaceae
Taxa: Ribes petraeum Wulfen
English name: Currants, Gooseberries
Turkish Name: Kaya çeçemi
Local Name: Bük üzümü, Horhoç
Plant form: Shrub
Location: Taşağıl, Sığırcı, Akduran
Habitats: Road sides
Used parts: Leaf/ Fruit</td></tr>
<tr><td colspan="2">Recipe for use: Their fruits can be consumed without any processing. The fruits are also made into syrups and marmalades. Tea (decoction) made from its leaves has diuretic, diaphoretic and laxative purposes. The fruits are eaten raw for their appetite-increasing and hematinic characteristics.
Similar uses: Baytop, 1999; Özgen et al., 2012</td></tr>
<tr><td colspan="2">Family: Hypericaceae
Taxa: Hypericum scabrum L.
English name: St. John's wort, goatweed.
Turkish Name: Karahasançayı
Local Name: Mayasıl otu, Kantaron
Plant form: Shrubby
Location: Yukarı Kopköy
Habitats: Mountainous, Steppe
Used parts: Leaf/Flower
Recipe for use: Hypericum species have been popular among the people for centuries. As a healing herb, rheumatoid arthritis and stomach pain in relieving pain caused by ailments used (Kaçar and Azkan, 2010). The oil extracted from its flowers is used for joint and lower back pain. The plant is crushed along with its flowers and placed in olive oil for 40 days. The resulting oil is applied to the painful area and wrapped.
Similar uses: Cırak and Kurt, 2014</td></tr>
</table>

Table 1. The plants used by the local people for both human and animal health in folk medicine (continuance)

Family: Lamiaceae **Taxa:** *Origanum acutidens* (Hand.-Mazz.) Ietsw. **English name:** Oregano **Turkish Name:** Zemul **Local Name:** Koç anığı **Plant form:** Half Shrubby **Location:** Taşağıl-Tatlıbahar, Yukarı Kopköy **Habitats:** Cliff, Water edge, Slope **Used parts:** Leaf/ Flower **Recipe for use:** Its leaves and flowers are used as a spice. Tea prepared by boiling (decoction) the plant is used to relieve abdominal pain. **Similar uses:** Baytop, 1999	**Family:** Lamiaceae **Taxa:** *Teucrium polium* L. **English name:** Felty germander **Turkish Name:** Acı yavşan **Local Name:** Mayasıl otu **Plant form:** Half Shrubby **Location:** Başçimagil- Karasu **Habitats:** Field edge **Used parts:** Leaf/Flower **Recipe for use:** Leaves and flowers of plants are used. It is used to flavor soups. It is used externally for hemorrhoids (plant leaves and flowers are boiled with water). **Similar uses:** Özgen et al., 2012; OGM, 2023
Family: Lamiaceae **Taxa:** *Thymbra sintenisii* subsp. *sintenisii* Bornm. & Azn. **English name:** Thyme **Turkish Name:** Akzahter **Local Name:** Karaanıh **Plant form:** Shrub **Location:** Musadanışman-Karaçamur **Habitats:** Cliff, Slope, Bushes **Used parts:** Leaf/Flower **Recipe for use:** Leaves and flowers of plants are used. It is used to flavor soups. It is used externally for hemorrhoids (plant leaves and flowers are boiled with water). **Similar uses:** OGM, 2023	**Family:** Lamiaceae **Taxa:** *Thymus fallax* Fisch. & C.A.Mey. **English name:** Thymes **Turkish Name:** Catri **Local Name:** Anuh, karaanıh **Plant form:** Shrub **Location:** Taşağıl-Kom, Yukarı Kopköy **Habitats:** Cliff, Slope **Used parts:** Leaf/ Flower **Recipe for use:** It is used as a spice also ıt is prepared as a tea (infusion) and for asthma, one glass is consumed each morning. **Similar uses:** Melikoğlu et al., 2015
Family: Lamiaceae **Taxa:** *Ziziphora clinopodioides* Lam. **English name:** Mediterranean thyme **Turkish Name:** Dağ reyhanı **Local Name:** Anuh, reyhan **Plant form:** Half Shrubby **Location:** Örence-Yayla **Habitats:** Steppe **Used parts:** Leaf/ Flower **Recipe for use:** Its leaves and flowers are used. It is used in soups and making herbed cheese. It is used externally for hemorrhoids (plant leaves and flowers are boiled with water) (decoction) **Similar uses:** Baytop, 1999; Özgen et al., 2012; Maral et al., 2015	

Table 1. The plants used by the local people for both human and animal health in folk medicine (continuance)

<table>
<tr><td colspan="2">Family: Rosaceae
Taxa: Cerasus angustifolia var. sintenisii (C.K.Schneid.) Browicz
English name: Cerasus (cherries)
Turkish Name: Kiraz
Local Name: Yabani kiraz
Plant form: Small Tree
Location: Kopköy-Ahpunların üstü
Habitats: Bushes
Used parts: Fruit / Fruit stems
Recipe for use: Wild cherries have a small tree structure. Its fruits and fruit stems are boiled with water. Tea (decoction) are used for diuretic (urine enhancer) and diaphoretic purposes.
Similar uses: Kültür, 2007</td></tr>
<tr><td>Family: Rosaceae
Taxa: Crataegus monogyna var. monogyna
English name: Common hawthorn
Turkish Name: Yemişen
Local Name: Yemiş
Plant form: Small Tree
Location: Taşağıl-Tatlıbahar
Habitats: Bushes, hill edge
Used parts: Flowering branches
Recipe for use:
For shortness of breath, flowering branches are boiled and drunk.
Similar uses: Elçi and Erik, 2006</td><td>Family: Rosaceae
Taxa: Crataegus orientalis var. orientalis Pallas ex Bieb.
English name: Silver thorn tree
Turkish Name: Alıç
Local Name: Aloş, aloç
Plant form: Small Tree
Location: Bozburun, Örence
Habitats: Cliff
Used parts: Fruit /Root
Recipe for use: The fruits are eaten raw. Tea (decoction) made from its fruits or roots is used for hemorrhoids and shortness of breath. Branch pieces gathered in the flowering period are boiled before drinking to clear the veins. Tea made using the leaves and fruits are drunk or applied externally to the area (as a pulp) to relieve joint pain.
Similar uses: Baytop, 1999; Behçet and Arık, 2013; Korkmaz and Alpaslan 2014; Melikoğlu et al., 2015</td></tr>
<tr><td>Family: Rosaceae
Taxa: Cotoneaster integerrimus Medik.
English name: Common cotoneaster
Turkish Name: Garagat
Local Name: Mecuk, Koyungözü
Plant form: Shrub
Location: Bozburun, Saptıran- Yıkıkhanlar, Çalıderehanları
Habitats: Stony slope
Used parts: Fruit/ Root/ Bark
Recipe for use: Roots or barks peeled from the trunk are boiled in cold water for a while and drunk as tea (decoction) against hemorrhoids. The fruits are eaten raw to relieve inflammation.</td><td>Family: Rosaceae
Taxa: Cotoneaster nummularius Fisch. & C.A.Mey.
English name: Coinwort cotoneaster
Turkish Name: Dağ muşmulası
Local Name: Mecuk
Plant form: Shrub
Location: Taşağıl- Kom
Habitats: Bushes, calcareous slope
Used parts: Fruit/ Shoots
Recipe for use: Shoots are boiled in cold water and drunk as tea (decoction) against hemorrhoids.</td></tr>
<tr><td colspan="2">Similar uses: Kadıoğlu and Kadıoğlu, 2014; Korkmaz and Alpaslan, 2014</td></tr>
</table>

Table 1. The plants used by the local people for both human and animal health in folk medicine (continuance)

<table>
<tr><td colspan="2">Family: Rosaceae
Taxa: Malus sylvestris (L.) Mill.
English name: European crab apple
Turkish Name: Yabani elma
Local Name: Eşki elma
Plant form: Tree
Location: Demirkaş-Kom
Habitats: Forest edge
Used parts: Fruit
Recipe for use: Its fruits are used in making syrups and marmalades. Its fruits are eaten due to their appetite-increasing and hematinic characteristics. It lowers the blood sugar. For diabetes, these apples are steeped in water for a period of 7 to 10 days. Obtained apple juice is drunk twice a day (morning a glass and evening a glass).
Similar uses: Arıtuluk and Ezer, 2012; Karakurt, 2014; Kadıoğlu and Kadıoğlu, 2014; Korkmaz and Alpaslan, 2014</td></tr>
<tr><td>Family: Rosaceae
Taxa: Pyrus elaeagnifolia Pall.
English name: Oleaster-leaf pear
Turkish Name: Ahlat
Local Name: Yabanarmudu, ahlat
Plant form: Small Tree
Location: Musadanışman
Habitats: Coniferous and deciduous fields
Used parts: Fruit</td><td>Family: Rosaceae
Taxa: Pyrus syriaca var. syriaca Boiss.
English name: Syrian pear
Turkish Name: Çakalarmudu
Local Name: Yaban armudu
Plant form: Tree
Location: Yukarı Kopköy
Habitats: Dry stony slopes, forest remains, field edges
Used parts: Fruit
Recipe for use: They have white-colored flowers and fleshy fruits. Its fruits are used in making syrups, marmalades, and similar spreads. The fruit is eaten boiled to prevent abdominal pain and diarrhea and to eliminate intestinal worms.</td></tr>
<tr><td colspan="2">Similar uses: Çakılcıoğlu et al., 2011
Animal diseases: Diarrhea
Application: Fruits are boiled with water and fed to animals with diarrhea after waiting for a while.</td></tr>
</table>

Table 1. The plants used by the local people for both human and animal health in folk medicine (continuance)

Family: Rosaceae **Taxa:** *Prunus divaricate* Ledeb. **English name:** **Turkish Name:** Dağ eriği **Local Name:** Yabani erik **Plant form:** Shrub or Small Tree **Location:** Taşağıl- Kom **Habitats:** Steep slope **Used parts:** Fruit **Recipe for use:** In addition to being consumed as regular fruits, the fruits are used in making syrups and marmalades. The fruits are eaten for their appetite increasing and hematinic characteristics. Unripe, sour raw fruits are boiled and drunk to lower blood sugar (diabetes). **Similar uses:** Arıtuluk and Ezer, 2012	
Family: Rosaceae **Taxa:** *Rosa spinosissima* L. **English name:** Burnet rose **Turkish Name:** Karakuşburnu **Local Name:** Garaguşburni **Plant form:** Shrub **Location:** Çalıderehanları **Habitats:** Cliff slope **Used parts:** Leaf/Fruit/Root **Recipe for use:** They have white coloured flowers and fleshy fruits. Its fruits are used in making syrups and marmalades. The fruit is eaten boiled to prevent abdominal pain and iarrhoea and to eliminate intestinal worms. Used for hemorrhoids (tea-decoction). **Similar uses:** Baytop, 1999; Tanker et al., 2007; Çakılcıoğlu et al., 2011	**Family:** Rosaceae **Taxa:** *Rosa villosa* L. **English name:** Downy rose, Apple rose **Turkish Name:** Sakız gülü **Local Name:** Kuşburnu **Plant form:** Shrub **Location:** Sazlı, Küçükahbun **Habitats:** Bushes, meadow **Used parts:** Leaf/Fruit/Root **Recipe for use:** Fruit and root parts of the plant are used. Similar to the general uses of the plant around Türkiye, its fruits are used in making syrups, juices, and marmalades, and its roots are used in making tea. The tea (decoction) made by boiling the fruits is drunk while hot for common cold and flu. The tea (decoction) prepared with its roots is drunk daily, preferable while hot or lukewarm, for hemorrhoids. This is continued until the complaints decrease or cease to exist. **Similar uses:** Kadıoğlu et al., 2010, Arık and Behcet, 2013; Kadıoğlu ve Kadıoğlu, 2014

Table 1. The plants used by the local people for both human and animal health in folk medicine (continuance)

Family: Rosaceae **Taxa:** *Rosa canina* L. **English name:** Dog rose, Wild rose **Turkish Name:** Yaban gülü **Local Name:** İtburnu, öküzgötü **Plant form:** Shrub **Location:** Saptıran, Kapıkale **Habitats:** Coasts, rocky slopes, scrub, hedges, forests and clearings, mainly limestones **Used parts:** Fruit/Root **Recipe for use:** Fruit of the plant are used. Its fruits are used in making syrups, juices, and marmalades. Plant tea (decoction) is drunk while hot for cold, bronchitis and flu. **Similar uses:** Bağcı et al., 2006; Sarper et al., 2009; Yapıcı et al., 2009; Akçiçek, 2010	**Family:** Rosaceae **Taxa:** *Rosa foetida* J.Herrm. **English name:** Austrian briar, Persian yellow rose **Turkish name:** Kuşburnu **Local name:** Kuşburni **Plant form:** Shrub **Location:** Akduran **Habitats:** Road side, slope **Used parts:** Fruit **Recipe for use:** Used for colds, hemorrhoids (tea-decoction). **Similar uses:** Doğan et al., 2016
Family: Rosaceae **Taxa:** *Rubus caesius* L. **English name:** Dewberry **Turkish name:** Böğürtlen **Local name:** Mormor, gözemor **Plant form.** Shrub **Location:** Akduran, Taşağıl-Tatlısuderesi **Habitats:** Stream edge **Used parts:** Fruit/Leaf/Root **Recipe for me:** Fruits, leaves, and roots of plant are used. Rubus is rich in fiber, vitamin C, and vitamin K. Rubus fruits are consumed raw and are widely used in making desserts, jams, and marmelade. Tea (decoction) made by boiling the plant's root and leaf parts is drunk to reduce blood sugar (diabetes). **Similar uses:** Bozkurt, 2019; Harris, 2012	**Family:** Rosaceae **Taxa:** *Rubus idaeus* L. **English name:** Raspberry **Turkish Name:** Ahududu **Local Name:** Yabani çilek **Plant form:** Shrub **Location:** Musadanışman- Karaçamur **Habitats:** Stoy slope **Used parts:** Fruit/Leaf **Recipe for use:** Rubus fruits are consumed raw and are widely used in making desserts, jams, and marmalade. The leaves are boiled (tea-decoction) and a glass is drunk in the morning and evening (for hepatit). **Similar uses:** Giano et al., 2010

Table 1. The plants used by the local people for both human and animal health in folk medicine (continuance)

Family: Salicaceae **Taxa:** *Salix fragilis* L. **English name:** Crack willow, Brittle willow **Turkish name:** Gevrek söğüt **Local name:** Gevrek, düllük **Plant form:** Big Shrub or Small Tree **Location:** Çalıdere hanları **Habitats:** Field edge **Used parts:** Shoot/ Bark **Recipe for use:** It is used to relieve rheumatic pain. Young shoots are tied to the sore parts of the body while raw or cooked. **Similar uses:** Özgen et al., 2012; Torlak, 2020	***Family:*** *Salicaceae* **Taxa:** S*alix alba* L. **English name:** White willow **Turkish Name:** Söğüt **Local Name:** Söğüt **Plant form:** Tree **Location:** Sazlı **Habitats:** Riverside **Used parts:** Shoot **Recipe for use:** It is rheomatic pain. Young shoots are tied to the sore parts of the body while raw or cooked. **Similar uses:** Kerr, 2009

4. CONCLUSION

The study examined ethnomedicinal uses of plants in tree, shrub or shrubby forms. These plants, rich in vitamins and minerals are consumed as fruits. In addition, products such as sweets, syrups, compotes, canned food, jams, and marmalades are produced in the season. It has been noted that these plants roots, leaves, and fruits which have many health benefits are also used. The recorded data revealed that the fruits and other parts of these 34 taxa are used for medicinal purposes and in treating many ailments such as intestinal problems, diabetes, eczema, asthma, and rheumatism. Biodiversity is the interaction of living things with the environment in the different environments in which they live. The study area; it has a rich biodiversity including a flora of plants used for health, aroma and other purposes. Plants with wild ancestors in nature need to be cultivated to obtain new varieties or to improve existing uses or to develop them as needed. New research supporting the results of the study; argues that the cultivation and expansion of these plants can prevent the extinction of plants for different reasons (especially urbanization, construction). Taxa with medicinal uses can be evaluated in other studies and supported by pharmacological studies to achieve better results. It is thought that plant genetic resources that continue to be used for medicinal purposes will be recorded and protected by similar studies.

COMPLIANCE WITH ETHICAL STANDARDS

Author Contributions

Concept, design, supervision, resources, data collection and/or processing, analysis and/or interpretation, literature search, writing manuscript, critical review – S.K.

Resources, data collection, literature search, writing manuscript – B.K.

Data collection, literature search – K. K. S

Conflict of Interest

The authors do not have any conflicts of interest to declare.

Ethical Approval

For this type of study, formal consent is not required

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Nanotechnology and The Use Of Nanoparticles and Its Effect On Wheat Growing

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A B S T R A C T

It is expected that the rapid increase in the human population will cause the increasing demand for agricultural land to be unmet in the near future. Therefore, soil fertility is gaining importance day by day and soil texture is becoming a strategic element. With the development of nanotechnology, the usability of nanoparticles in many fields has started to be investigated and discussed. In recent years, the application of nanotechnology-based applications in agriculture has been one of the topics of interest to researchers. Studies in agricultural nanotechnology have generally focused on using less pesticides, increasing yields or developing stress-resistant crops. Some studies in this field have started to yield positive results. However, more studies are needed for nanotechnology to be used in agriculture. Because deciding on the use of nanoparticles is an issue that can be reached in the long term. In line with these needs, it has become inevitable to use nanotechnology to increase plant resistance in wheat, one of our main food sources, and to control the effectiveness and safety of pesticides and fertilizers. In this study, the strengths, weaknesses, opportunities and targets of the use of nanotechnology and nanoparticles in wheat agriculture are presented.

1. INTRODUCTION

Wheat is one of the most widely grown and consumed cool climate cereals in the world. People do not consume wheat directly. It is known that almost half of people's daily energy needs are met from wheat-origin products such as flour, bulgur and bread. The sentence needs to be revised in this regard. Intense population growth and malnourished societies require a significant increase in wheat production. However, in developed countries, which produce most of the world's wheat, there has been little or no increase in wheat yields in the last 20 years. In this situation, most of the deficit has been met by developing countries with yields far below their wheat production potential. The most important obstacles to production growth and sustainability are limited land and water resources and global climate change. Conflicts over the use and sharing of these resources will be inevitable in the coming years. One of the possible scenarios is that food will be the only thing that money cannot buy in times of severe famine.

Regardless of the level of development of a country, it is important that its productivity is absolutely self-sufficient. It has been shown how indispensable the product is for countries where wars and famines in the past were essential foods. No matter how strong a country is economically, if it cannot produce the wheat for which its product is sold, it would otherwise always work to survive (Akay, 2005).

Wheat constitutes the main food source of the majority of people in the world, especially in Europe, North America and the Near East. Cereals are one of the most studied plants due to their high economic importance. As a result, varieties and genotypes that can adapt to many different environmental conditions have been developed. Cereals are the most widespread plant group in the world due to their richness of varieties and forms (Sepetoğlu, 2006).

Wheat ranks first among the cultivated plants used in human nutrition in terms of cultivation and production in the world. This is because the wheat plant has a wide range of adaptability. Wheat provides about % 20 of the total calories provided to the world population from plant-based foods. In Turkey, this rate is % 53. Wheat, the main raw material of the grain-based industry, is of critical importance for our country's agriculture. Wheat is used in many food and industrial sectors, especially bakery products (Anonymous, 2022). It is also seen that the sector operates in many different areas (such as biscuits, bread, chocolate).

Wheat production has economic and strategic importance in the world. Wheat; It has been the basis of nutrition for thousands of years and constitutes the basis of self-confidence and stability in society. It is the product with the largest share and importance among the herbal products produced in Turkey. Wheat is a food product that meets the needs of humans and animals. Although the consumption of wheat varies depending on the population of the countries, it is of great importance in terms of constituting the raw material of bread, which is the basic nutrient in developing and underdeveloped countries (Oğuz and Arisoy, 2005).

According to the United Nations (UN) report titled "World Population Prospects", the world population, which is currently around 7.7 billion, is projected to increase by two billion to 9.7 billion by 2050 (U.N., 2019). In addition, preferences for meat-based diets and growing demands for bioenergy crops are triggering an ever-increasing demand for agricultural production globally. In this context, FAO has projected that global cereal production will need to increase by %70 by 2050 to meet these demands. Given the limited arable land and scarcity of water resources in the world, a significant increase in the application of agricultural fertilizers is seen as an approach to reach the production potential required for global food production. However, high rates and long-term applications of various conventional fertilizers in the agricultural sector to maintain current levels of grain production have caused serious environmental problems globally. For example, the intensive use of nitrogen (N) and phosphorus (P) fertilizers have become major anthropogenic factors exacerbating and even influencing worldwide eutrophication problems in surface freshwater bodies and coastal ecosystems (Conley et al, 2009).

There is a need to develop innovative, effective fertilizers using new technologies for sustainable agriculture and the environment. Nanotechnology is used in food and agriculture as in many other fields. Today, nanotechnology is recognized as a solution to improve nutrient utilization efficiency (Gunaratne et al., 2016). Nanofertilizers, which increase plant growth and development by providing one or more nutrients to the plant, have an important potential in increasing agricultural production (Daghan, 2017).

There is an imperative research need to develop innovative fertilizers to increase wheat yields, improve the efficiency of plant-nutrient uses and minimize environmental degradation for global sustainable development. In the context of sustainable agriculture, the application of innovative nanotechnology in agriculture (including fertilizer development applications) is considered as one of the promising approaches to significantly increase crop production and feed the world's rapidly growing population (Lal, 2008). For this purpose, studies are being carried out for fertilizer R&D studies of nanotechnology in order to increase the effect of fertilizers used in conventional agriculture on yield factors (Uzal and Yaşar, 2023).

Although many researchers are interested in the development and application of nanomaterial-related fertilizers, research directly related to the effect of nanotechnology on wheat yield is not sufficient. However, some recent research in nanotechnology has shown a promising perspective in terms of nanofertilizer development and application. For example, observations that C nanotubes (CNTs) and zinc oxide nanoparticles (NPs) can penetrate tomato (Lycopersicon esculentum) plant roots or seed tissues suggest that a new nutrient delivery system can be developed through the use of nanoscale porous areas on plant surfaces (De Rosa et al., 2010). Therefore, the main objective of this research is to analyze the strengths and weaknesses of nanotechnology and nanoparticles that can improve wheat plant growth, yield and reduce environmental risks.

2. DEFINITION AND APPROACH OF NANOTECHNOLOGY IN AGRICULTURE

Cereals are an important food source in the basic and healthy nutrition of people. In this context, it is of great importance that they are grown in a healthy manner and delivered to consumers with the same care. FAO estimates that global production needs to be increased by 70% by 2050 to cope with a rapidly growing global population and meet demand by 2050. But with arable land and water resources limited, other strategies are needed to increase global food production. In recent years, the application of nanotechnology-based applications in agricultural fields is one of the strategies that have attracted the attention of researchers (Ergül and Çakır, 2023).

Nanotechnology has the potential to revolutionise the agriculture and food industry with new approaches such as molecular treatment of diseases, rapid disease diagnosis, enhancing the ability of plants to absorb nutrients. Smart biosensors and controlled release systems will help the agricultural industry fight viruses and other pathogens. In the near future, nanostructured catalysts will make pesticides

and herbicides more effective with lower doses. Nanotechnology will also reduce pollution through the use of alternative (renewable) energy compounds and filter/catalysts and indirectly protect the environment by cleaning existing pollutants (Scott and Chen, 2002).

Nanotechnology is the science that investigates the development of nanoscale materials, systems and devices. It has a wide range of applications in medicine, cosmetics, textiles, pharmaceuticals, electronics and food industries. In recent years, nanotechnology has enabled the development of healthy and innovative foods in the food industry. In line with the demands of consumers, studies are carried out especially in areas such as food processing, storage, packaging, development of nanoadditives (additives) and nanosensors for high quality, fresh, long-lasting and high quality foods (Saka & Gülel, 2015; Ameta, 2020). Nanotechnology explores a wide range of areas and creates a wide spectrum for various applications in the fields of biotechnology and agriculture. Nanotechnology has become a new technology that can be used in various industries; industry, pharmaceuticals, food science and safety, smart packaging and agriculture.

Especially in recent years, the use of nanotechnology in many stages of agriculture has increased, and it is widely applied in agricultural product production, development, processing, packaging, storage and transportation, making major changes in food and agricultural systems. It has also been used to increase plant resistance and to control the efficacy and safety of pesticides and fertilizers (Torney et al., 2007; Perez and Rubials, 2009; Sekhon, 2014; Salama D.M. et al., 2018; El Mohamedy et al., 2019). Thus, it is predicted that the application of nanostructured materials designed for sustainable crop production reduces nutrient losses and plant diseases and increases yields (Dura and Tang, 2022).

Agriculture is the backbone of developed countries and the livelihood of more than 60% of the population depends on it. Nanotechnology is being used to develop systems for monitoring the release of pesticides/herbicides. In this way, the biology of different crops can be understood, potentially improving crop productivity and nutritional quality (Kumari and Yadav, 2014).

Attempts to apply nanotechnology in agriculture began with the growing realization that conventional agricultural technologies can neither further increase productivity nor restore ecosystems damaged by existing technologies to their pristine state. Together with the need to phase out irrigation, fertilizers and pesticides, the long-term effects of farming with "miracle seeds" are being questioned at both scientific and political levels.

Nanotechnology in agriculture has gained momentum in the last decade with ample public funding, but the pace of development has not been as fast as desired, even though many disciplines fall under the agricultural umbrella. Because of the unique nature of farm production, functioning as an open system in which energy and matter are freely exchanged; because the scale of demand for input materials, unlike industrial nanoproducts, is always gigantic; because, unlike industrial nanoproducts (e.g. cell phones), there is no control over input nanomaterials and their fate must be considered on the geosphere (pedosphere)-biosphere-hydrosphere-atmosphere continuum; the delay in emerging technologies reaching the farmers' field, especially given the unwillingness of many developing economies to spend on innovation; and the lack of foresight resulting from the fact that agricultural education has not attracted sufficient numbers of bright minds worldwide have affected the pace of development of nanotechnology in agriculture.

Agricultural production and yields are affected by a number of factors, including climatic conditions, crop and land management practices, pathogens, diseases and pests, and increases in weather events. According to studies, for each degree of global temperature increase, the yield of cereals such as wheat and maize, which have an important place in the nutrition of the world and our country's population, is expected to decrease by 4-6%, increases in temperature are expected to affect plant productivity similarly, and it is predicted that by the end of the century, there will be a decrease in the yield of producing areas worldwide (Leimu et al., 2010; Greaver et al., 2016; Pugh et al., 2016). Plant pathogens and pests have shown latitudinal distribution shifts as a product of climate change, and changes in regional climatic conditions are expected to exacerbate yield losses by altering plant pathogen virulence and infection rates (Velasquez et al., 2018). Adaptation to changes in climatic conditions, such as the number of extremely hot or cold days, changes in the optimal locations for planting different crops, crop management and production of cultivated plants are likely to adapt to these changes (Fini et al., 2017). That is, this includes crop changes such as the expansion of cultivation areas for drought-resistant crops in drought-prone areas and the cultivation of new crop varieties that are better adapted to the changing environment. For this purpose, it has become inevitable to expand the use of nanotechnology.

3. DEFINITION AND APPROACH OF NANOPARTICLES IN AGRICULTURE

Improving the long-term sustainability of food production is key to ensuring future food and nutrition security. Increasing world food production is possible by reducing production costs through better crop management, increasing yields and developing new technologies. In this

context, innovations in fertilizer technology and use play an important role in increasing productivity.

At the nanoscale, matter shows extraordinary properties that bulk materials do not. For example, the surface area, cation exchange capacity, ion adsorption, complex formation and many other functions of clays are multiplied when brought to the nanoscale. One of the main ways in which a nanoparticle differs from a bulk material is that a high proportion of atoms in a nanoparticle are located on the surface (Maurice and Hochella 2008). Compared to macro-sized particles, nanoparticles can have different surface compositions, different type and site densities, and different reactivity according to processes such as adsorption and redox reactions, which can be profitably used in synthesizing nanomaterials for use in agriculture (Hochella et al., 2008; Waychunas et al., 2005).

Nutrients encapsulated in nanoparticles are released according to environmental conditions and plant demand, leading to increased yields. In addition, slow and controlled release fertilizers also improve the soil and reduce the negative effects of excessive fertilizer application (Gunaratne et al., 2016). Encapsulation is defined as coating the target object with a homogeneous or heterogeneous matrix. Encapsulation method has many benefits such as protection of the coated object from adverse conditions, controlled release and precise targeting (Ezhilarasi et al., 2012; Gunaratne et al., 2016; Özdemir and Kemerli, 2016). Different encapsulation technologies are mentioned depending on the size and shape of the capsules. Macro encapsulation/coating creates macro-scale capsules, while micro and nano encapsulation creates micro and nano-scale particles (Özdemir and Kemerli, 2016).

In a study in the USA, nanoparticles made of iron were used to clean contaminated land and groundwater. Iron nanoparticles, trichloroethene, carbon tetrachloride, dioxin and many toxic It catalyzed the degradation and oxidation of organic contaminants such as non-simple carbon compounds (Anonymous, 2024). In another study, iron oxide nanoparticles, underground It was extremely effective in removing arsenic from water by binding (Wong et al., 2002).

Some laboratory studies have shown that a number of NPs (silica, Fe oxides, C-coated Fe and polymers) can enter plant tissues/cells and transport DNA and chemicals within tissues/cells (Ambrogio et al., 2013, Ghafari et al., 2013, Gonzalez-Melendi et al., 2008, Torney et al., 2007). Such studies have supported the hypothesis that zinc oxide nanoparticles (NPs) can provide nutrients to plants as a new fertilization or feeding technique. However, there is as yet no concrete evidence demonstrating the advantages of this approach over conventional methods in increasing fertilizer use efficiency or reducing risks of environmental degradation. For example, since crops are naturally able to absorb soluble nutrients (e.g. N, P and K) from soil solutions through their root systems, stronger and more specific justifications are needed to support the research and implementation of such novel approach of delivering nutrients to plants through these inert zinc oxide nanoparticles (NPs), as to the necessity of injecting nutrient-laden zinc oxide nanoparticles (NPs) into plant tissues to enhance their growth.

In wheat cultivation, nanofabricated materials containing plant nutrients can be used in aqueous suspension and hydrogel forms to provide non-hazardous application, easy storage and a convenient delivery system. Similarly, the application of zero-valent iron nanoparticles or even nanoparticles derived from iron rust can be used to remediate soils contaminated with pesticides, heavy metals, and radionuclides, given the high adsorption affinity that these nanomaterials have for organic compounds and heavy metals (Liu and Lal, 2012).

4. THE IMPACT OF NANOTECHNOLOGY AND NANOPARTICLES ON WHEAT AGRONOMICS

Recent studies have shown that wheat is directly sensitive to environmental factors. Wheat is extremely adversely affected by pests and diseases due to direct effects of climate change, such as changes in temperature, precipitation and carbon dioxide concentrations, and indirect effects such as changes in the distribution and frequency of soil moisture (Abeysingha et al., 2016; Ludwig et al., 2009). In a study conducted in India, wheat yields are estimated to decrease by about 6-23% and 15-25% in the 2050s and 2080s, respectively (Kumar et al., 2014). This decrease, which corresponds to a significant potential in wheat agriculture due to climate change, has increased the importance of nanotechnology. Many researchers have shown that nanotechnology plays a vital role in mitigating stress-induced changes in plants. The use of nanotechnology in wheat agriculture will enable the deployment of pesticides, encapsulated nanocides, controlled and targeted release of nanomaterials as well as pesticides containing stabilization nanomaterials (Kashyap et al, 2015).

4.1. Nanoparticle-Wheat Interaction

Of the nanoparticle (NPs) formulations, those containing essential metals are being considered. Fertilization to enhance plant nutrition in soils has the property of low metal bioavailability, low uptake efficiency of water and essential Ca and Fe nutrients for seed germination and plant growth and development that can enhance seed germination and plant growth (Villagarcia et al., 2012). In a study conducted under laboratory conditions, germination and root

elongation of wheat improved with industrial grade MWCNTs (2,560 mg kg^{-1}) without significant uptake or translocation were found to be significant, as CNTs adsorbed to the root surfaces of wheat (Miralles et al. 2012). In another study, soluble CNTs in water wheat plants affected root and shoot growth under light and dark conditions (Tripathi and Sarkar 2015).

4.2. Uptake, Transport and Accumulation of Some Nanoparticles by Wheat

Noteworthy studies have examined the uptake, transport and accumulation of some nanoparticles by wheat. In these studies, it was determined that the wet and dry weights of some wheat cultivars and a significant part of the root were affected by nTiO2 and wheat plants with increased NPs regulated the activity of enzymes related to growth and product components under water deficit stress (Ceberzade et al. 2013). NPs (TiO2) also help nitrogen metabolism such as nitrate reductase, glutamate dehydrogenase, glutamine synthase and glutamic-pyruvic plants to absorb nitrate. It also promoted the conversion of inorganic nitrogen to organic nitrogen. Nitrogen in the form of protein and chlorophyll increased the fresh weight and dry weight of the plant (Mishra et al., 2014).

In another study conducted in wheat plants, it was reported that foliar application of NP decreased nAl2 O3 (<50nm) of wheat seedlings, increased root length and increased superoxide dismutase and catalase enzymes as a result of oxidative stress (Riahi-Madvar et al. 2012).

4.3. Reactions Of Wheat To Nanoparticles

In a published biocompatible report, hydrated graphene ribbon (HGR) was observed to enhance germination and resistance of aged wheat seed to oxidative stress, and analysis of HGR's metabolism of carbohydrate, amino acid, and secondary determinant fatty acids, nitrogen sequestration, cell membrane integrity, permeability, and oxidation resistance metabonomics showed (Hu and Zhou 2014).

4.4.Effects Of Nanoparticles On Oxidative Stress And Antioxidant Defense System

Titanium dioxide nanoparticles (nTiO2), an efficient and beneficial nutrient source for plants, have improved biomass production due to enhanced assimilation, photoreduction activities of photosystem and electron transport chain, scavenging of reactive oxygen species and nitrogen (Raliya et al., 2015; Morteza et al., 2013). It has been reported that nanoparticles (TiO2) do not have different effects on plants, but on seed germination in wheat, NPs can translocate through the roots to the leaves (Larue et al., 2012). During the accumulation of titanium dioxide nanoparticles (nTiO2), it was reported that NPs could only form in wheat roots when the diameter of the NPs was <140 nm, with higher accumulation occurring when the NPs were much smaller (14-22 nm) (Larue et al., 2012). It was also reported that titanium dioxide at the optimum concentration of nano (1200 ppm) has a stimulating effect on root and shoot growth Mahmoodzadeh and Aghili, 2014).

4.5. Effects of Nanoparticles on Wheat Abiotic Stress Response

Drought and heat stress often occur together in many crops, such as maize and wheat, and the combination of these stress types causes more significant yield reductions than each stress alone (Muller and Martre, 2019). Drought and heat stress reduce nutrient uptake and photosynthetic efficiency in plants, and stress responses include a wide range of physiological and biochemical responses. The difficulty in producing stress-tolerant plants is the large number of genes involved in stress responses. Transcription factors, which control genes activated by stress in plants, are an important component in plant signaling and studies in various plants have reported that overexpression of transcription factors increases drought, cold and salt tolerance (Chowdhury et al., 2017; Zampieri et al., 2017; Reside et al., 2018). Modulation of transcription factors could be an effective way to increase the environmental stress tolerance of many agricultural crops, and targeting them within traditional and novel cultivation technologies could be an effective strategy to produce better crops.

5. CONCLUSIONS AND RECOMMENDATIONS

Tackling global food challenges is possible by integrating nanotechnology into wheat agriculture. Considering agricultural sustainability and climate change, so far the level of interest of nanotechnology in wheat breeding has not reached field conditions. Therefore, extensive studies are needed.

The development and application of new types of fertilizers using innovative nanotechnology is one of the effective options to significantly increase agricultural production on a global scale, which is necessary to meet the future demands of a growing population. A review of the existing literature shows that some engineered nanomaterials can enhance plant growth at certain concentration ranges and can be used as nanofertilizers in agriculture to increase agricultural yields of crops and minimize environmental pollution.

Macronutrient nanosolvents, Micronutrient nanosolvents, nutrient-laden nanosolvents and plant growth

enhancing nanomaterials should be studied with reference to the chemical composition, particle size, applied concentrations, plant species utilized, plant nutrition methods and plant growth enhancement aspects and rates of nanomaterials according to cereal and legume categories. The importance, research directions and research needs of each nanosubstance category should also be specifically studied to achieve sustainable agriculture.

Nanotechnology can have both positive and negative impacts on the agroecosystem. Therefore, it is necessary to carefully study the relationship between NPs and wheat. Nanotechnology can be used as an important tool to develop new methods to improve plant traits, yield and tolerances to biotic and abiotic stresses in wheat agriculture. Therefore, genetic and molecular modification mechanisms for the interaction of different nanomaterials with wheat crops need to be explored.

Experimental verification of the permissible limit of use requires that the nanoparticle dosage is within safety limits. The interaction of nanomaterials with plants varies according to the concentration applied, type and number of NPs, treatment duration, plant genotype and developmental stage. When conducting nanotoxicity studies, the study should be kept in mind and the selection of the permissible level along with the study, intergenerational and food (trophic) chain transfer effects should be considered.

Nanosensor research is of high value for rapid technology in diagnostics and effective pest management. Therefore, it is extremely important to explore the application of nanosensors, i.e. the detection of wheat pests in fields and grain storage structures.

Despite these potential benefits, nanotechnology in applied wheat breeding may be negatively affected if nanomaterials are misused in plants that do not pose risks to the environment, as well as soil microbes and other life forms that may be beneficial. Therefore, the achievement of better agro-ecological results in nanotechnology is particularly related to the dose response, the release of ions and nutrients with effects specific to the nanoparticles of the mineral, it is important to exploit the expected benefits in terms of nano-formulation applications.

The effect of nanotechnology on the germination of wheat seeds, its use as a fertilizer, the use of nanoparticles in seed development, the use of nanotechnology as plant protection products in wheat, the use of nanotechnology against abiotic stress in wheat agriculture are among the researches that should be focused on first.

Recent research shows that nanotechnology is underutilized in wheat agriculture, although it meets expectations. So far, no knowledge base on the transformations and bioavailability of nanoparticles is available. There is a need to create an up-to-date and accessible database. Bioavailability is the basis for the increase in wheat yield and plant quality. With this understanding, it is necessary to utilize the advantages of nanotechnology. Within nanotechnology, it is of great importance today to develop precision toolkits such as nanosorbents, nanopesticides, nanoherbicides, nanosensors and smart delivery systems.

Compliance with Ethical Standards

Author Contributions

Authors contributed equally to this paper.

Conflict of Interest

The authors do not have any conflicts of interest to declare.

Ethical Approval

For this type of study, formal consent is not required.

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The impact of Credit Policy Environment on Poultry Production in Nigeria

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A B S T R A C T

The research provided empirical data on the correlation between poultry production index and the credit policy environment in Nigeria. An autoregressive distributed lag (ARDL) bound test approach was employed to establish co-integration between series. The estimated long and short-run models parameters demonstrated stability, best quality, efficiency, and unbiased results. The findings revealed that, in the long run, commercial bank loan to the agricultural sector and domestic credit to the private sector had a significant positive influence on poultry production index. On the other hand, agricultural credit guarantee scheme loans to poultry subunit and lending interest rates exhibited negative relationships. In the short run, the current year coefficient of lending interest rates, the agricultural credit guarantee scheme loans to poultry subunit and domestic credit to the private sector showed significant negative correlation with the poultry production index. However, commercial bank credit to the agricultural sector had a positive effect on poultry production in the short run. The implications of the findings justify the need to increase the commercial bank credit to the agricultural sector and domestic credit to private sector as a strategy to boost poultry production. Additionally, the agricultural credit guarantee scheme fund should be reassessed and modified to align its initial objectives. The lending rate should be deliberately lowered to increase credit access for poultry farmers.

1. INTRODUCTION

The bulk of rural farmers in Nigeria are resource-poor, with low income and savings capacity (Akpan et al., 2011; Akpan et al., 2013, Anderson et al., 2017, Isiorhovoja et al., 2020, Ahamefule et al., 2023). This makes it challenging for most farmers to adopt new technologies that would increase their agricultural efficiency and profitability. Agricultural credit is widely considered to be one of the mediating factors between the adoption of agricultural innovations and the increase in agricultural income among rural farmers in Nigeria (Oladeebo and Oladeebo 2008; Omonona et al., 2008). Farm credit is one of the fundamental components needed for sustainable agricultural production in a less developed economy like Nigeria (Imran et al., 2023). Therefore, the supply and demand for farm credit has become one of the prerequisites required for reducing rural poverty, guaranteeing food self-sufficiency and addressing the Sustainable Development Goals (SDGs) No. 2 in Nigeria (Adedokun 2021, Imran et al., 2023 and Egberi, 2023). Farm

credit is considered an important tool needed to promote rural agricultural production (Mejeha and Ifenkwe, 2007; Nwaru, 2011 and Bolarinwa and Fakoya, 2011). According to several studies, a significant proportion of farmers in developing countries are faced with credit constraints and production inefficiencies (Dorfman and Koop 2005; Hussein and Ohlmer, 2008 and Omonona et al., 2010). Due to the decades-long slow growth rate of the country's economy, there are frequent defaults among farmers and the corresponding reluctance of financial institutions (both formal and informal) to prioritize financing agricultural activities (Umoren et al., 2016; Umoren and Akpan 2021). The central government has recognized the importance of credit in agricultural production, and has responded by initiating agricultural credit policies and creating programs and institutions to enhance credit disbursement to famers. The manifestation of the Agricultural Credit Guarantee Scheme Fund (ACGSF) in 1977 is undeniably one of the successful agricultural credit finance intervention in country (Akpan et al. 2012). The intervention was seen as a palliative measure since official financial institutions paid little attention to agricultural credit financing. Other sources of credit financing introduced by the central government include the Nigerian Agricultural Cooperative and Rural Development Bank (NACRDB) in 1972; the Nigerian Agricultural and Cooperative Bank (NACB) established in 1973 to provide medium and long-term loan to farmers. In 1980s, a rural banking policy was introduced that required Commercial Banks to set branches in the rural communities in order to push banking services closer to the farmers. In 1990, Community Banks were introduced in the country to further advance rural banking services. In addition, the Nigerian Agricultural Insurance Corporation (NAIC) was established in 1987 to insure farm produces against risks (Manyong et al., 2003; Eze et al., 2010; Anetor et al., 2016; Bako 2020).

Poultry businesses/enterprises are one of the sub-sectors of the agricultural economy that require additional financing in addition to the investment funds held by farmers (Akpan et al., 2013 and Akpan et al., 2020). Modern poultry farming requires producers to use modern technology and other resources in managing poultry operations (Udoh et al., 2017). For most Nigerians, it is one of the cheapest or most affordable sources of white meat. The poultry industry is undoubtedly among the most attractive investment opportunities in the agribusiness industry in Nigeria today. The subunit demand resources and necessitates the producer to have control over the environment, nutritional and health needs of the birds to ensure optimal production (Mottet and Tempio, 2017; Attia et al., 2022; Castro et al., 2023). The Nigerian government had previously promoted the development of modern poultry farms by setting up research institutes, hatcheries, and training programs in modern poultry management. In addition, collaboration in poultry production has been promoted through strategic measures such as public-private partnership (PPP), privatization, multilateral cooperation, and commercialization measures. These incentives have led to a sudden influx of people from diverse backgrounds into the poultry industry (Ajala et al., 2021).

Despite the numerous incentives for the country's poultry industry, the majority of Nigerians are experiencing a decline in animal protein intake (Akpan and Udo, 2021; Akpan and Nkanta, 2022; Akpan, 2022). Due to the advantages of poultry farming over other areas of livestock farming, the sub-sector can provide reliable cheap meat sources if resources are utilized appropriately. Therefore, providing cheap and sustainable animal protein to many poor households is the key to promoting poultry production in the country. Due to the capital intensive nature of a modern poultry enterprise and high poverty rate among farmers in Nigeria, it implies that increasing poultry production and its value chain would require exogenous stimulant such as credit. Given the multitude of interventions already implemented in the country, there is an overwhelming need to evaluate the performance of these tools. Again, a lot has happened over the last two decades in the Nigerian macroeconomic environment in which some of these interventions are anchored (Umoren et al., 2016; Umoren et al., 2018; Udoh and Akpan 2019). Therefore, the available information on the relationship between poultry production and credit policy needs to be updated for efficient production. Furthermore, identifying and understanding the relationship between poultry production and credit policy variables would provide policymakers with insights into solving the problem of credit shortage in this subsector.

However, the significance of this relationship has been examined by several authors using different study approaches. For example, Abedullah et al. (2009) and Khan et al., (2018) found a direct correlation between agricultural credit and livestock production in Pakistan. In Nigeria, Olagunju and Babatunde (2011) found a significant positive relationship between poultry farmers' productivity and credit acquisition, while Carrer et al. (2020) pointed out the importance of rural credit policies for the implementation of integrated crop-livestock systems in Brazil. Rahman et al., (2011) established a positive relationship between agricultural credit and livestock production derivatives (milk, meat and eggs) in Bangladesh. Similarly, Shiferaw et al. (2015) identified the positive effect of credit on livestock production in Ethiopia. Similarly, Kuye (2013) pointed out the positive contribution of microcredit to livestock production in the southern region of Nigeria. Furthermore, Orok and Ayim (2017) claimed that ACGSF had a greater

influence on the cereals subsector than the livestock subsector. Still in Nigeria, Abu (2017) and Reuben et al. (2020) found that ACGSF increased the productivity of the livestock subsector from 1981 to 2014. Udoka et al. (2016) and Asekome and Ikojie, (2018); Iliyasu, (2019), in Nigeria, found that lending interest rate influence agricultural investment negatively. Imran et al., (2023) in Pakistan opined that increase access to microcredit has a positive impact on sustainable rural development; social, economic, and environmental development of rural areas. They asserted that increase access to microcredit helps to alleviates rural poverty, reduce unemployment and promote higher productivity among farmers. Salisu and Alamu (2023) asserted that commercial bank loan to agricultural sector and lending interest rate have a positive effect on agricultural output in Nigeria.

From the literature reviewed, most researchers have found a significant relationship between livestock and credit variables. Poultry production as an important component of livestock production is not given due priority in terms of production and credit policy relations in Nigeria. Currently, poultry production enjoys greater acceptance than other components of the livestock subsector among Nigerian youths in all agriculture-based entrepreneurial skills acquisition programs (Akpan et al., 2017). In addition, poultry farming is productive, has a short gestation period, and its by-products are very useful raw materials for the country's agricultural-based industry. Furthermore, Nigeria has a greater comparative advantage in poultry production and consumption than any other component of the livestock sub-sector. Therefore, there is a need to provide useful empirical information on poultry production and its relationship with credit policy variables in order to improve poultry production and invariably animal protein consumption in Nigeria. Therefore, the study specifically sought to establish the empirical relationship between poultry production index and credit policy variables in Nigeria.

2. MATERIAL AND METHODS

Study Area: The study was conducted in Nigeria, located in the tropical zone of West Africa in the gulf of guinea. The country spans between latitudes 4° and 14° north of the equator and longitudes 3° and 15° east. Nigeria is endowed with rich agricultural resources, and the majority of its population is engaged in various forms of agricultural activities. Notable crops produced in Nigeria include; rice,yam, cassava, cowpea, wheat, maize, sorghum, onions, tomatoes, melons and vegetables among others. Aditionally, the country is rich in animal husbandry such as poultry, ruminants; monogastric animals, snail production among others (Federal Ministry of Environment, 2021).

Source of Data: The study used time series data obtained from the Central Bank of Nigeria, World Bank, and Food and Agriculture Organization (FAO), covering the period from from 1991 to 2022.

Theoretical Framework adopted

The study adopted a production theory framework. A production theory focuses on the combination of production inputs to generate the desired quantity of output. Assuming the production variables are time series, a typical long-run production function is represented as in equation one.

$$Y_t = \int (X_{1t}, X_{2t}, X_{3t}) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

The relationship signifies that the output (Y_t) depends on the combination levels of the variable inputs X_{1t}, X_{2t} and X_{3t}. According to several authors (Adjognon et al., 2017; Ullah et al., 2020; Adewale et al., 2022), agricultural credit facilitate the acquisition of agricultural inputs such as land, labour, capital and management. Therefore, the availability of agricultural inputs at any given time depends on the amount of agricultural credit accessible to the farm. This relationship can be expressed mathematically as follows:

$$X_t = \int (M_{1t}, M_{2t}, M_{3t}) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (2)$$

Where M_t represents the sources of credit available to agricultural enterprises in period t. By combining equations (1) and (2), the relationship between production (Y_t) and the variables representing sources of credit for agricultural enterprises is given by:

$$Y_t = \int (X_{1t}, X_{2t}, X_{3t}, M_{1t}, M_{2t}, M_{3t}) \dots\dots\dots\dots\dots\dots\dots\dots (3)$$

Equation (3) illustrates that output at period "t" can be expressed as a function of credit variables.

Specification/Analytical Technique

The study employed the Cobb Douglas functional form to examine the contribution of the agricultural credit policy environment to the growth of poultry subunits (proxied by poultry production index) in Nigeria. The specification is implicitly shown in equation (4).

$$\mathrm{POU_t} = \mathrm{f(POG_t, CAG_t, LEN_t, DCP_t)} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (4)$$

Where,

POU_t = Poultry gross production index (2014-2016 = 100) (%)

POG_t = Guarantee loan for poultry unit/total fund guarantee by Agricultural Credit Guarantee Fund Scheme (%)

CAG_t = Commercial bank credit to agricultural sector/economy GDP (%)

LENt = National lending interest rate (%).

DCP_t= Domestic credit to private sector (% of GDP)

The independent variables were selected from the literature base on the various credit policies implemented by the Nigerian government. For example, the federal government introduced the Agricultural Credit Guarantee Scheme Fund (ACGSF) in 1977. This scheme was specially enunciated to guarantee funds/credit to farmers using the Central Bank of Nigeria (CBN) as the sole guarantor (POG_t). Over the years, the federal government mandated commercial banks to allocate a certain proportion of their total credit and advances to agricultural production (CAG_t). In addition, the CBN has maintained regulated lending rates to moderate the volume of credit in the economy (LENt). Furthermore, the central government has implemented credit policies to incentivize the financial sector to boost private investment in critical sectors (DCP_t).

Relationship between the Credit policies and Poultry Production

The study utilized the Autoregressive Distributed Lag (ARDL) model to analyze the link between the poultry production index and agricultural credit environment policy variables. The ARDL model was chosen to confirm cointegration among specified series (Pesaran and Shin 1999 and Pesaran et al., 2001). Both short- and long-run models of poultry production index were estimated. The ARDL model offers several advantages over other techniques (Engle and Granger (1987) two-stage technique and Johansen and Juselius (1990) cointegration method), including handling series with mixed unit root problems, applicability to stationary series at levels or first differences, efficient for small and finite sample data, and provision of unbiased long run estimates (Harris and Sollis, 2003).

The ARDL model for poultry production index in logarithm form is expressed as follows:

$$\Delta POU_t = \eta_0 + \Phi_1 \sum_{i=1}^{n_1} \Delta POU_{t-i} + \Phi_2 \sum_{i=1}^{n_2} \Delta POG_{t-i} + \Phi_3 \sum_{i=1}^{n_3} \Delta CAG_{t-i} + \Phi_4 \sum_{i=1}^{n_4} \Delta LEN_{t-i} + \Phi_5 \sum_{i=1}^{n_5} \Delta DCP_{t-i} + \Psi_1 POU_{t-i} + \Psi_2 POG_{t-i} + \Psi_3 CAG_{t-i} + \Psi_4 LEN_{t-i} + \Psi_5 DCP_{t-i} + U_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

When using ARDL, the dependent variable forms a vector, implying that equation (5) is equally applied to the remaining independent variables in the model. The coefficients Φ_1 to Φ_5 represent short-run estimates of ARDL while Ψ_1 to Ψ_5 are the long-run coefficients. η_0 represent the drift or constant element and "n" denotes the maximum lag length. U_t is stochastic error term. The ARDL bound test is employed to verify the presence of co-integration among series. If the ARDL bound F-statistic exceeds the upper critical limit at the conventional probability levels (1%, 5%, or 10%) it indicates cointegration, rejecting the null hypothesis of no cointegration. The tested hypothesis is examplified as follows:

$H_0: \delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$ (There is no cointegration)

$H_a: \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq 0$

If the ARDL bound F-statistic falls below the lower critical limits, the null hypothesis cannot be rejected, suggesting the absence of co-integration among series. When the ARDL bound F-statistic falls between the lower and upper critical limits, the test is interpreted as inconclusive (Pesaran et al., 2001). Upon confirming the presence of co-integration, then the long and short-run (ECM) models are specified.

The long run model is given as:

$$POU_t = \Psi_0 + \Psi_1 POG_t + \Psi_2 CAG_t + \Psi_3 LEN_t + \Psi_4 DCP_t + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

The short run model (ECM model) specification is:

$$\Delta POU_t = \Phi_0 + \Phi_1 \sum_{i=1}^{q_1} \Delta POU_{t-i} + \Phi_2 \sum_{i=1}^{q_2} \Delta CAG_{t-i} + \Phi_3 \sum_{i=1}^{q_3} \Delta LEN_{t-i} + \Phi_4 \sum_{i=1}^{q_4} \Delta DCP_{t-i} + \Phi_5 \sum_{i=1}^{n_5} \Delta POG_{t-i} + \forall ECM_{t-1} + U_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Where $\forall$ represents the error coefficient or the ECM. The estimates capture the short run adjustment speed towards the long-run stability while the rest of the coefficients measure the short-run elasticity or impacts. The stability and reliability of the ECM were tested using RESET, serial correlation, normality, and heteroscedasticity tests. Additionally, cumulative sum (CUSUM) and CUSUMSQ tests were conducted to confirm the reliability of the ECM.

3. RESULTS AND DISCUSSION

The summary of descriptive tests of variables are shown in Table 1. The variability coefficients of variables were all less than 50.00%. The poultry production index exhibited the lowest volatility index of 16.03%, indicating minimal

fluctuations during the study period. The exponential growth rate of variables showed an average annual growth rate. Notably, all variables recorded a single-digit growth rate within in the study time frame. However, the guarantee loan for the poultry sub sector from the Agricultural Credit Guarantee Scheme Fund (POGt) demonstrated an annual exponential growth rate of 4.80%, while the lending interest rate (LENt) recorded a negative annual exponential growth rate of -1.59% per annum.

Table 1. Descriptive tests

Variable	Min	Max	Mean	Std. deviation	CV	Skewness	Exponential growth rate (%)
POU	75.033	127.47	97.135	15.572	0.16031	0.34219	1.40
POG	1.9716	15.004	8.5700	3.7469	0.43721	0.13733	4.80
CAG	15.824	76.661	43.488	19.647	0.45178	0.19264	4.71
LEN	11.483	31.650	18.739	3.7735	0.20137	1.2941	-1.59
DCP	5.2411	19.626	10.446	3.4607	0.33129	0.88032	2.69

Source: Prepared by author

Stationarity test

The ADF and ADF-GLS techniques (Dickey and Fuller, 1979; Elliott et al., 1996) were used to verify the stationarity of series, and the results are presented in Table 2. The results showed that the lending interest rate (LENRt) was stationary at the level, while others series were stationary at the first difference for ADF equation, including constant and trend. However, for the ADF-GLS equation including constant and trend, all specified series were stationary at their first difference. Hence, the result gave a mix of stationarity of the specified variables. The unit root test results justified the use of ARDL model on the specified series.

Table 2. Stationarity tests (ADF and ADF-GLS unit root tests)

Variable	ADF-GLS (with constant and trend)				ADF(with constant and Trend)			
	Lag	Level	1st Diff.	Decision	Lag	Level	1st Diff.	Decision
POU_t	0	-2.3458	-5.8094***	1(1)	0	-2.2570	-5.5997***	1(1)
POG_t	0	-1.2245	-6.1004***	1(1)	0	-1.04384	-5.8848***	1(1)
CAG_t	0	-2.9062	-6.1434***	1(1)	0	-2.9158	-5.9859***	1(1)
LEN_t	0	-3.2602**	-	1(0)	0	-3.1941	-5.7211***	1(1)
DCP_t	0	-2.7776	-4.7252***	1(1)	0	-2.8146	-5.2125***	1(1)
Critical values								
1%		-3.7700	-3.7700			-4.2967	-4.3098	
5%		-3.1900	-3.1900			-3.5684	-3.5742	
10%		-2.8900	-2.8900			-3.2184	-3.2217	

Note: Asterisks ***, ** and * indicate 1%, 5%and 1% level of significant. Variables in log.

The optimum lag length for series

The optimum lag length for series in ARDL model, was determined using information criteria (Akaike information criterion (AIC), Schwarz-Bayes criterion (SBC), and Hannan-Quinn criterion.). The corresponding optimum lag length needed for the estimation of ARDL is shown in Table 3. The result showed that lag 3 is the best lag for the ARDL model. Figure 3 displays 20 computed ARDL models based on AIC criterion.

Table 3. Optimal lag length of series

Lags	Loglik	P(LR)	AIC	BIC	HQC
1	30.40851		-1.950709	-1.607110	-1.859552
2	30.41780	0.89156	-1.868150	-1.475465	-1.763971
3	35.56204	0.00134	-2.213503*	-1.771733*	-2.096301*
4	37.63517	0.04173	-2.302931	-1.8122075	-2.172707
5	38.04123	0.36750	-2.253436	-1.713494	-2.110189

Asterisk level shows optimal lag length.

The ARDL bound test

The ARDL bound test was used to authenticate the presence of cointegration in series. The F-statistic for the selected equation (8.057) is shown in the upper part of Table 4. The result implies that the calculated F-test at the 1% probability level exceed the tabulated or crıtıcal upper bound value of 4.37.

Table 4. ARDL Bound Test (Restricted Constant and No Trend)

Equations	**Lag**	**F-Statistic**	**Decision**
F_{POUt}(POUt | CAGt, DCPt, POGt, LENt)	(3, 1, 3, 0, 3)	8.057329	Co-integration
Critical Values at Bound (at K = 4 and Asymptotic: n = 1000)			
Significant level	Lower (1(0)	Upper 1(0)	
10%	2.20	3.09	
5%	2.56	3.49	
2.5%	2.88	3.87	
1%	3.29	4.37	
Critical Values at Bound (at K = 4 and Finite sample: n = 35)			
10%	2.46	3.46	
5%	2.947	4.088	
1%	4.093	5.532	

Source: Extracted from analysis. Actual sample size (n) =27. Null hypothesis: No level relationship.

The findings imply that a long run equilibrium or stable equation exists for poultry production index. This indicates cointegration between the poultry production index and the specified macroeconomic variables, hence rejecting the null hypothesis. The bound test results infer stability or equilibrium of the long run poultry production index. Furthermore, the short-run or ECM model was generated to capture the short-run dynamics and identify the speed of adjustment in response to the deviation from the long-run equilibrium. After establishing the cointegration of series, the results in Table 5 show the estimates or parameters of the long-run of the ARDL model.

The long run model

The parameters of the long-run model showed that the commercial bank total credit to the agricultural sector (CAGt) has a positive significant association with poultry production (with a significant probability level of 10%). The finding denotes that a unit increase in the commercial bank total credit to the agricultural sector would lead to 0.55% increase in the poultry production index. This means that with every increase in the commercial bank credit to the agricultural sector, poultry production will be increased accordingly. The result reveals the importance of commercial bank credit in poultry production in Nigeria. The finding also implies inelastic relationship between commercial bank credit to agriculture and poultry production. This means that the change in commercial bank credit to the agricultural sector is larger than the change in the gross poultry production index. A similar relationship has been established by Abedullah et al. (2009); Rahman et al. (2011); Olagunju and Babatunde (2011); Kuye (2013); Shiferaw et al. (2015) and Khan et al., (2018).

The result found a positive significant relationship between the domestic credit to the private sector variable and the index of gross poultry production in Nigeria. The finding revealed that, a one percent increase in the domestic credit to the private sector variable would result in a 0.43% increase in poultry production index. Alternatively, the production of poultry in Nigeria could be increased if the private sector received more domestic credit. The finding result is in line with a priori expectation. The country has recently witnessed massive investments in agro-industrial units, particularly poultry feed, agrochemicals and hatchery production, driven mainly by the private sector. The country currently is the largest egg producer and second largest chicken producer in Africa, hence offering enormous potential for private investment. Again, the provision of incentives and the protection of the domestic poultry market (through poultry importation ban) have attracted private investment resulting in a corresponding increase in the subsector's output.

Table 5. The Long- run estimates

Variable	**Coefficient**	**Standard error**	**t-value**	**Prob.**
Constant	7.50557	1.99736	3.75775***	0.0024
CAG_t	0.54794	0.28637	1.91343*	0.0780
DCP_t	0.42752	0.12224	3.49723***	0.0075
POG_t	-0.38968	0.12422	-3.13691***	0.0090
LEN_t	-0.74404	0.28750	-2.58799**	0.0209

Asterisks ***, and ** indicate 1% and 5% level of significance respectively. Variables in log.

The results also showed that the agricultural credit guarantee scheme loan to poultry enterprises/farmers (ACGt) has a negative significant correlation with poultry production index at 1% probability level. This suggests that a unit surge in the guaranteed loan to poultry farmers would reduce the gross poultry production index by 0.39%. The finding contradicts a priori expectation. Several factors could be responsible for this result. Firstly, it could be the timely provision of credit facilities. Since agricultural activities are largely regulated by natural phenomena like rainfall, seasons, etc., timely disbursement of loan is of utmost importance for increasing poultry production. Secondly, the widespread corruption among loan administrators also contributed to this result. For instance, if poultry loan are diverted to unintended beneficiaries, the amount of loans disbursed will be accounted for by the poultry unit. The third factor could be attributed to poor monitoring and evaluation of the agricultural credit guarantee loan process and high default rate, which prevented efficient recycling of the credit process. The finding contradict the empirical reports of Orok and Ayim (2017) and Abu (2017).

The result establishes a negative significant relationship between the poultry production index and the lending interest rate in the long run. Further exposition of the finding revealed that a one percent increase in the lending interest rate would result in 0.74% decline in the gross poultry production index. This means that as lending interest rates rise, poultry production will decrease significantly in the long run. The result align with a priori expectations. For instance, poultry production is known to be very prolific, resource oriented and has a short gestation period. Therefore, poultry farmers/enterprises would swiftly react to an increase in the lending interest rate by reducing production as it will affect resource availability and efficiency. The finding agrees with the reports of Udoka et al. (2016); Asekome and Ikojie, (2018); Iliyasu, (2019), but contradict the submission of Salisu and Alamu (2023).

The short run ARDL model

The estimated parameters of ARDL short run model are presented in Table 6. The parameter or coefficinet of the error correction variable is negative and statistically significant at 1% probability level. This finding affirms the existence of cointegration between the poultry production index and the specified macroeconomic variables. The coefficient of tthe residuals variable (ECM) represents the adjustment speed in the long-run equilibrium following a short-run disturbance or shocks. This shows that annually about 77.69% of the disequilibrium in the short-run model is adjusted towards its long-run equilibrium. The ECM diagnostic tests produced an R2 of 0.976, indicating that the agricultural credit policy variables explained about 97.60% of the total variations in poultry production index in the country.

The empirical result showed that the commercial bank credit disbursed to the agricultural sector at level has a direct short-run influence on poultry production index. The result suggests that a unit increment in commercial bank credit to the agricultural sector will shift the index of gross poultry production by 0.335% in the short run period. The finding means that an increase in the current year commercial bank credit to the agricultural sector would boost current year poultry production. For the current year relationship, increase in efficiency in the financial system and prioritizing agricultural financing could be responsible for the results. However, for the previous 3-year value of commercial bank credit to the agricultural sector, the relationship was reversed. This means that the lag 3 of the commercial bank credit to the agricultural sector is negatively related to the country's current poultry production index. The result could be attributed to the instability in the macroeconomic variables in the last decade and the issue of disease outbreak that rampage the poultry subsector in the previous years. A similar relationship has been established by Abedullah et al. (2009); Rahman et al. (2011); Olagunju and Babatunde (2011); Kuye (2013); Shiferaw et al. (2015) and Khan et al. (2018).

The agricultural credit guarantee loan provided to poultry farmers/enterprises by ACGS had a negative significant correlation with poultry production. This means that if the value of the loan guarantee for poultry beneficiaries in the short run is increased by one percent, the index of poultry production will decrease by 0.054%. The outcome is comparable to that of a long-run relationship. However, the current poultry production index is positively correlated with the agricultural credit guarantee loan to poultry beneficiaries for the previous one and two year's variables. The finding revealed that the slope coefficient of the previous one and two years agricultural credit guarantee loan to poultry beneficiaries has a stimulating impact on the gross poultry production index whereas the current year slope coefficient of agricultural credit guarantee loan had opposite relationship. Orok and Ayim (2017); Abu (2017) have reported similar result.

The previous year 1 and year 2 values of the poultry production indices correlate positively with the current year production index. These results imply that the poultry farmers' current year production index is the response of the previous year's production indices. The finding implies that the current year output of the subsector depends on the performance of the previous year outputs. Hence, stimulating outputs in the subsector through prudent financial system will produce sustainable growth in output in the subsector.

Table 6. The Short - run model (Restricted constant, no trend)

Variable	Coefficient	Standard error	t-value	Probability
D(POU)(-1)	0.78259	0.10908	7.17457***	0.0008
D(POU)(-2)	0.97956	0.08056	12.15940***	0.0001
D(DCP)	-0.01942	0.04448	-0.43674	0.6805
D(DCP)(-1)	-0.02275	0.05094	-0.44658	0.6739
D(DCP)(-2)	-0.21070	0.05335	-3.94958***	0.0109
D(LEN)	-0.34439	0.06641	-5.18571***	0.0035
D(LEN)(-1)	0.40250	0.05228	7.69869***	0.0006
D(LEN)(-2)	0.22898	0.04672	4.90157***	0.0045
D(LEN)(-3)	0.69875	0.06543	10.67960***	0.0001
D(POG)	-0.05444	0.01407	-3.87067**	0.0118
D(POG)(-1)	0.09894	0.01294	7.64814***	0.0006
D(POG)(-2)	0.09958	0.01121	8.88508***	0.0003
D(CAG)	0.33513	0.04632	7.23539***	0.0008
D(CAG)(-1)	0.05651	0.04527	1.24824	0.2672
D(CAG)(-2)	0.05636	0.04101	1.37423	0.2278
D(CAG)(-3)	-0.05452	0.02712	-2.01025*	0.1006
ECM (-1)	**-0.77693**	**0.09585**	-8.10560***	**0.0005**
R-Squared	0.975716	Adjusted R-Squared		0.936862

Source: Obtained from Eview results. Asterisk ***, and ** indicate 1% and 5% probability respectively. Variables in log., difference. ARDL lag length (3, 3, 4, 3, 4) from Akaike info criterion.

The lending interest rate at level is found to have a significant negative correlation with the index of poultry production. For instance, a 10% increase in size of the lending interest rate would leads to a 3.44% decline in the gross poultry production index. The result suggests that in the short run, as lending interest rates rise, poultry production index will decline accordingly. The finding is consistent with the study's expectation, as an increment in the lending interest rate is known to upsurge agricultural risk and limit farmers' capacity to expand production and agricultural investment. However, the coefficients of the previous one, two- and three-year lending interest rate are positively correlated with poultry production index in the country. The results can largely be explained by the misalignment of the national credit policy with agricultural development policy. Other conditions that likely contributed to the results include: high level of inflation, deteriorating value of domestic currency, and the nature of market supply and demand for credit in the economy among others. The negative relationship between the poultry production index and lending interest rate corroborates Udoka et al. (2016); Asekome and Ikojie, (2018) and Iliyasu, (2019).

Furthermore, the finding revealed a negative significant relationship between the value of domestic credit to the private sector in the last two years and poultry production in Nigeria. According to the outcome, there will be a 0.211% drop in the poultry production index, with a 1% rise in domestic credit granted to the private sector. The risky nature of agribusiness, the low returns of the agricultural sector and the reluctance of the private sector as well as banks to invest in agribusinesses in the short run period could help to explain the results.

Diagnostic test of the ECM

From the result presented ın table 7, there is no significant autocorrelation of residuals as shown by the value of Breusch-Godfrey serial correlation (LM test) (3.345). According to Laurenceson and Chai, (2003), the presence of autocorrelation does not affect the short-run parameters. In addition, the null hypothesis was not rejected for RESET test, the Breusch-Pagan test of heteroscadasticity, normality test and the CUSUM tests. This implies that short run model or ECM has structural rigidity, no heteroscedasticity, normally distributed error terms, and is stable within the specified time frame.

Table 7: Diagnostic Statistics

Test	Value	Probability
Ramsey RESET Test	1.136139	0.3193
Normality test (Jarque-Bera)	1.355929	0.5076
Heteroscedasticity (Breusch-Pagan-Godfrey)	1.021700	0.4873
Breusch-Godfry Serial Correlation LM Test	3.345467	0.1722

Note: prepared by authors

Test of the Stability of the ARDL ECM

The plots of the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMQ) obtained from the ARDL-ECM model are shown in Figures 1 and 2, respectively. The results indicate stability of the model estimates. The plots lie within the critical bands of the 5% confidence interval (or 95% probability levels) of parameter stability.

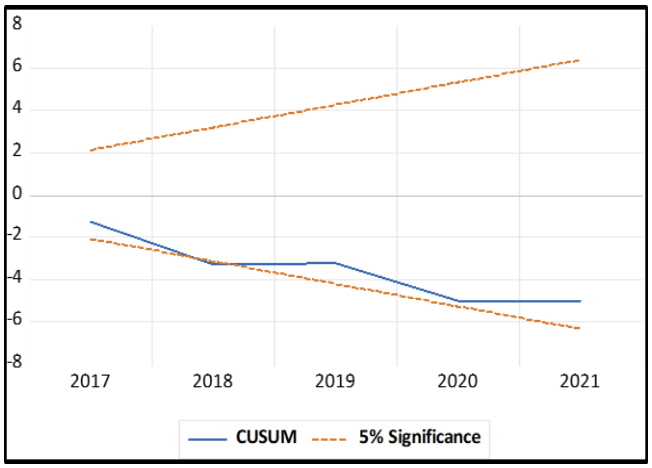

Figure 1. Plot of CUSUM for parameters' stability of ARDL model.

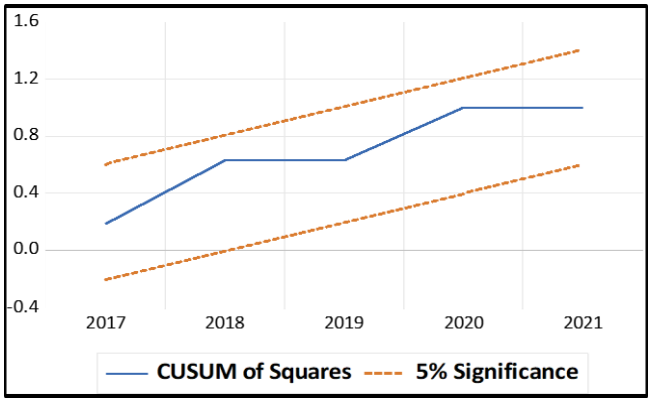

Figure 2. Plot of CUSUMSQ for parameters' stability of ARDL model.

4. CONCLUSION

The analysis identified an empirical correlation between certain agricultural credit policy variables and the poultry production index in Nigeria. The study used secondary information obtained from the World Bank (WB), Food and Agriculture Organization (FAO) and Central Bank of Nigeria (CBN). The unit root of series were determined by ADF and ADF-GLS methods. The results of the unit root showed that one variable was non-stationary at level I(0), but became stationary at the first difference 1(1). The other variables were non-stationary at level, nonetheless they were stationary at their first difference. The cointegration of series was tested by the ARDL bound test, confirming the evidence of the long run equilibrium. After confirming the evidence of cointegration of variables, the parameters of the long run model and ECM or short-run model of the poultry production index were estimated. The parameter of the error correction term was statistically significant at 1% significant level and exhibited appropriate sign. The finding showed that the commercial bank loans to the agricultural sector are positively linked to the poultry production index in the long and short run periods. However, in the short run, the lag 3 of the commercial bank loans to the agricultural sector showed a negative influence on the poultry production index. On the contrary, the agricultural credit guarantee scheme loans allocated to the poultry subunit were negatively correlated with poultry production index in the short and long run periods. In the short-run model, the result was mixed as lags 1 and 2 of the loan guarantee for the poultry unit showed a positive association with poultry production index. The lending interest rate and poultry production index are negatively correlated in both short and long run periods. Again, the results were mixed in the short run model as lags 1, 2 and 3 of the lending rate were found to have a positive association with poultry production index. The relationship between the total domestic credit to the private sector and the poultry production index in the long run was positive, but it was negative in the short run. The summary of findings revealed that the credit policy environment played a significant role in poultry production in Nigeria. Conversely, the results demonstrated the importance of a sound credit policy environment in stimulating growth in the poultry subsector of Nigeria. The findings showed the significant of sustainable credit policy in achieving the Sustainable Development Goal (SDGs) of zero hunger in the nearest future in Nigeria.

Based on these empirical facts and the need to boost poultry production in a sustainable way in Nigeria, it is recommended that the commercial bank credit to the agricultural sector be increased to provide more incentives to poultry farmers/enterprises to increase poultry production. Additionally, the domestic lending to the private sector should be strengthened or increased as a means to surge poultry production in the country. Moreover, the current lending rate in the country should be reduced to improve poultry farmers/enterprises access to farm credit. The Agricultural Credit Guarantee Scheme loans for the poultry sub-sector should be reassessed and monitored to achieve the desired objectives.

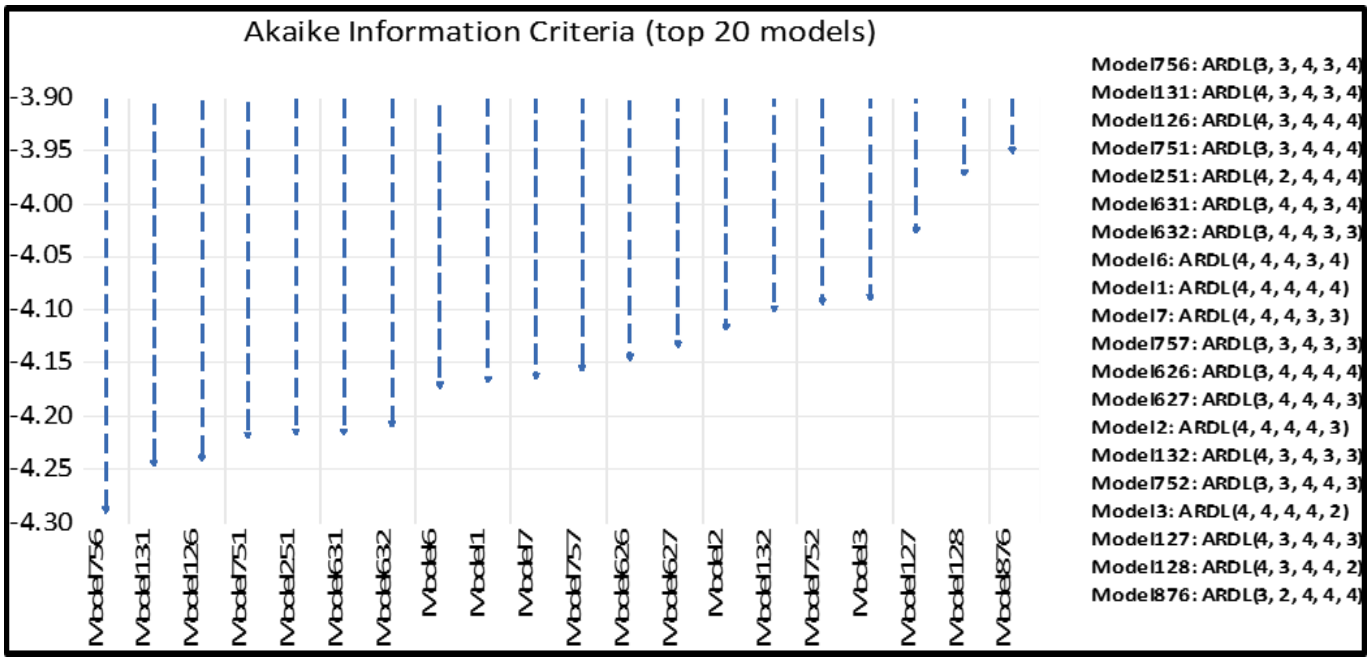

Figure 3. Akaike information criteria graph.

COMPLIANCE WITH ETHICAL STANDARDS

Author Contributions

Authors contributed equally to this paper.

Conflict of Interest

The authors do not have any conflicts of interest to declare.

Ethical Approval

For this type of study, formal consent is not required.

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