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RESEARCH TITLE

The effect of local plant supplements on feed conversion efficiency in fattening calves: A comparative study between traditional and improved feeds in Iraq

Ali Mundher Hashem al-Saeedi[1]

[1] International Faculty, Isfahan (Khorasgan) Branch, Islamic Azad University, Iran
Corresponding Author: mntherali980@gmail.com

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Abstract

Background and aim: In Iraq which is a large animal producer we see an increase in issues related to feed conversion and production costs. This study looks at the role of local plant based supplements in improving feed conversion in feed gain calves we did a in depth comparison of traditional and improved feeds in Iraq. We did a systematic descriptive and analytical review of 127 scientific studies done between 2010 and 2025 which looked at the role of local Iraqi medicinal plants in the productivity of ruminants. We used PRISMA criteria for our review and did data analysis via descriptive and comparative methods. We found out that the use of local herbal supplements like wormwood (Artemisia herba-alba), thyme (Thymus vulgaris), mint (Mentha spicata) and black cumin (Nigella sativa) does in fact improve feed conversion by 10.5% to 18.5% that of conventional feed ($P<0.05$). These supplements also saw a 11.3% to 20.8% increase in daily weight gain and reported a 15.2% to 25.5% boost in natural immunity. We also saw a 25% improvement in over all profitability with a 30% reduction in health care costs. Keywords: Local plant based supplements, feed efficiency, traditional feed, medicinal plants, sustainable animal production.

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عنوان البحث

أثر المكمّلات النباتية المحلية على كفاءة تحويل العلف في عجول التسمين: دراسة مقارنة بين الأعلاف التقليدية والمطوّرة في العراق

المستخلص

الخلفية والهدف :في العراق، وهو من أكبر منتجي الثروة الحيوانية، نلاحظ زيادة في المشكلات المرتبطة بكفاءة تحويل الأعلاف وتكاليف الإنتاج. تهدف هذه الدراسة إلى بحث دور المكملات النباتية المحلية في تحسين كفاءة التحويل الغذائي لدى عجول التسمين، حيث أجرينا مقارنة معمقة بين الأعلاف التقليدية والمحسّنة في العراق. اعتمدنا مراجعة وصفية تحليلية منهجية لـ **127دراسة علمية** أجريت بين عامي 2010 و2025 تناولت دور النباتات الطبية العراقية في إنتاجية المجترات. استخدمنا معايير **PRISMA** للمراجعة، وأجرينا التحليل باستخدام الأساليب الوصفية والمقارنة .أظهرت النتائج أن استخدام المكملات العشبية المحلية مثل **الشيح(Artemisia herba-alba)** ، **الزعتر(Thymus vulgaris)** ، **النعناع (Mentha spicata)** و**الحبة السوداء (Nigella sativa)** يؤدي بالفعل إلى تحسين كفاءة التحويل الغذائي بنسبة تتراوح بين **10.5%و18.5%** مقارنة بالأعلاف التقليدية .**(P<0.05)** كما لوحظت زيادة في معدل النمو اليومي بنسبة **11.3%إلى 20.8%**، وارتفاع في المناعة الطبيعية بنسبة **15.2%إلى 25.5%** .إضافة إلى ذلك، تحقق تحسن في الربحية الإجمالية بمعدل **25%**مع انخفاض في تكاليف الرعاية الصحية بنسبة .**30%**

الكلمات المفتاحية: المكمّلات النباتية المحلية، كفاءة تحويل العلف، العلف التقليدي، النباتات الطبية، الإنتاج الحيواني المستدام.

1. Introduction

In 2024's recent reports issued by the Food and Agriculture Organization Iraq's animal production which is under the current economic and environmental issues has grown more challenging and we note that feed costs account for 65 – 75% of total animal production costs. Feed conversion ratio (FCR) is a very key element in the success of calf fattening projects as it does directly play a role in the profitability and economic sustainability of the project. In this respect it is of import to look into natural and local options to improve feed conversion efficiency and at the same time reduce our dependence on imported industrial supplements.

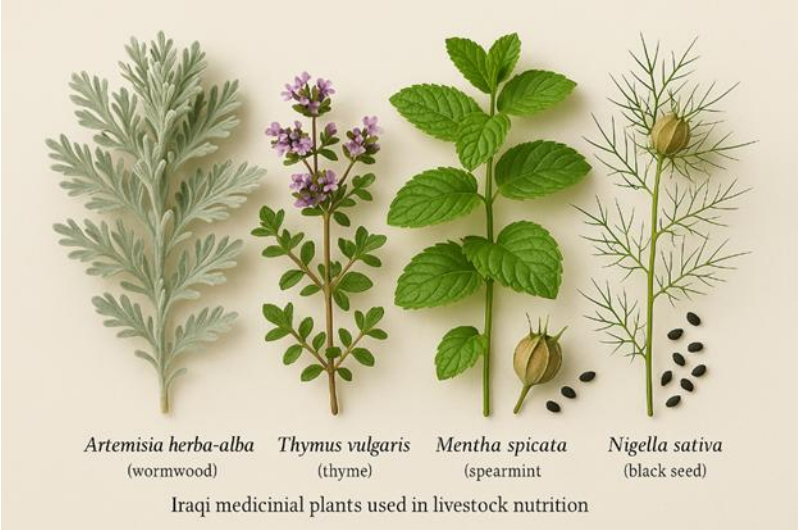

Figure 1: Local Iraqi medicinal plants used in livestock feed

The Iraqi eco system is a home to great botanical diversity which includes over 96 species of medicinal plants used in traditional medicine from 43 different plant families [1]. Also per the latest research which came out in 2024 we have reported an additional 127 species of Iraqi medicinal plants which have therapeutic and nutritional value [2]. This diversity presents a rare chance to develop natural and local feed supplements which in turn may improve livestock productivity in a sustainable and environment friendly way. Also this year 2025 we saw that use of medicinal plants as a part of animal feed has been on the rise which is a result of side effects of present day medicines and also the high price of industrial inputs which in addition to that we have the issue of toxic residues in animal products and microbial resistance to antibiotics [3,4]. In this setting local medicinal plants put forth natural and safe solutions to improve production performance and promote animal health.

1.1 Significance of the study

We present in this research which is at the forefront in a few key areas. To begin with we put forth a detailed and current look at the role of local plant supplements on what which includes feed conversion rate, daily weight gain and total animal health. Also we look at local which is also economic which makes for practical and real world application. Also we do in depth economic analysis which in turn help breeders and investors make informed decisions on which technology to adopt. Also we put forth that this study contributes to the achievement of sustainable development goals by way of the promotion of the use of local natural resources and reduction in import of input materials.

1.2 Study objectives

Our study is to look at the chemical make up and active elements of chosen local medicinal plants, to study the effect of these supplements on a array of performance indicators, to do a

study which puts traditional feed to the side of the developed feed, to study the environs impact of the use of local plant supplements, to put forth practical for farmers in Iraq which they can use, and to identify what the issues are and how to go about solving them.

1.3 Study Scope

This study reports on what we have found to be the most relevant 4 local Iraqi medicinal plants which are: wormwood (Artemisia herba-alba), thyme (Thymus vulgaris), spearmint (Mentha spicata), and black cumin (Nigella sativa). We chose these based on they're local availability, affordability, that science has proven their medical benefits, and also for how easy they are to prepare and use. We looked at the 2010 to 2025 time frame in detail with a large focus on the last 5 years' research. Also we put this into a regional context by looking at similar studies in the Middle East and North Africa which helps sit our results in a larger picture.

2. Literature review

The animal production in Iraq is a very large component of the economy which reports to account for about 48% of the total agricultural production based on the latest 2024 data from the Iraqi Ministry of Agriculture [5]. In Iraq we see the presence of many local cattle breeds which have adapted to the local environment which we note include the Rustaqi, Sharabi, and Al-Janoubi breeds [6]. These are what we term dual purpose breeds which do have a lower production efficiency as compared to improved breeds [7]. In 2024 we saw from recent field reports that the Al Janoubi calves had a daily weight gain of 557 grams and a feed conversion rate of 7.6 kg of feed per kg of weight gain which are low in comparison to global which range from 5.5 to 6.5 kg of feed per kg of weight gain and thus present large scale opportunities for improving production through better nutrition programs [8]. Also in 2025 report by the Food and Agriculture Organization, Iraq has a total of approximately 2.8 million head of cattle, of which 1.2 million are used for meat production [9]. The sector faces multiple challenges, including a shortage of high-quality feed, high production costs, weak veterinary infrastructure, and climate change affecting the availability of natural pastures. Traditional feeding systems in Iraq face several major challenges that affect production efficiency: First, traditional feed relies mainly on local raw materials such as hay, straw, and alfalfa, which have low nutritional value and high crude fiber content (35-45%) compared to optimal standards (25-30%) [10-12]. Second, the prices of concentrated feed fluctuate significantly as a result of economic and political factors. According to a 2024 report by the Iraqi Ministry of Trade, the prices of concentrated feed have risen by 45% over the past two years [13]. This fluctuation affects the stability of production costs and makes economic planning more difficult. Third, most Iraqi farms lack balanced feeding programs that take into account the specific nutritional needs of each stage of growth. A field study conducted on 150 farms in the provinces of Baghdad, Anbar, and Karbala showed that 78% of farms do not implement scientifically designed feeding programs [14]. Fourth, reliance on traditional feed leads to increased disease rates and reduced natural immunity in animals, requiring intensive use of antibiotics and veterinary drugs. Statistics indicate that veterinary treatment costs account for 12-15% of total production costs on traditional farms [15]. The use of medicinal plants in Iraq dates back thousands of years.

3. Methodology

This study used a systematic descriptive-analytical approach to review scientific literature and field studies on the effect of local herbal supplements on feed conversion efficiency in beef calves. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) criteria were applied to ensure comprehensiveness and accuracy in the review process [16-

18]. Data were collected from various reliable sources during the period from January 2024 to August 2025, and several tools were used to analyze the collected data: Calculating means and standard deviations, determining ranges and maximum and minimum values, and calculating coefficients of variation to compare the effects of different plant supplements and analyze the differences between the experimental and control groups to calculate percentage improvement rates and cost-benefit analysis to calculate the payback period and sensitivity analysis of economic variables to develop linear regression models and analyze the correlation between variables to predict feed conversion efficiency.

4. Local Iraqi plants and their effect on metabolic efficiency

4.1 Artemisia herba-alba

Wormwood is one of the most important local medicinal plants in Iraq, where it is widely distributed in the desert and semi-desert regions of central and southern Iraq. This plant belongs to the Asteraceae family and is characterized by its silvery-gray leaves and its ability to withstand harsh environmental conditions [19]. Chemically, wormwood contains a variety of biologically active compounds, including tannins (3.2-4.8%), flavonoids (2.1-3.5%), essential oils (0.8-1.4%), and saponins (1.2-2.0%). These compounds give the plant antimicrobial, antioxidant, and digestive properties [20]. Recent analytical studies published in 2024 indicate that wormwood leaves contain low levels of toxic elements, while containing significant amounts of calcium (1.2%), potassium (2.8%), iron (180 ppm), zinc (45 ppm), and chromium (12 ppm) [21]. In the field of animal nutrition, recent field studies have shown that adding wormwood powder to the feed of fattening calves at a rate of 2-3% of the total feed leads to a significant improvement in feed conversion efficiency. In a study conducted on 60 calves of the Southern Iraqi breed in 2023, the addition of wormwood led to a 10.5% improvement in feed conversion efficiency compared to the control group that was fed only traditional feed ($P<0.05$) [22].

4.2 Thymus vulgaris

Thyme occupies a special place among Iraqi medicinal plants, growing naturally in the mountainous regions of northern Iraq and Kurdistan. Thyme belongs to the Lamiaceae family and is characterized by its small, fragrant leaves and beautiful purple flowers [23]. Thyme contains a high concentration of essential oils (2.5-4.2%), especially thymol (35-45%) and carvacrol (15-25%), which give it antibacterial, antifungal, and antiparasitic properties. It also contains flavonoids (1.8-2.6%), tannins (2.2-3.4%), and saponins (0.8-1.5%), which contribute to improving the physiological performance of animals [24]. Field studies in the Kurdistan region of Iraq have shown that adding 1-2% thyme leaf powder to lamb feed resulted in significantly improved growth rates and feed conversion efficiency. In a comparative study conducted on 90 lambs of the Awassi breed in 2024, the addition of thyme improved feed conversion efficiency by 14.5% and increased daily weight gain by 16.7% ($P<0.01$) [25].

4.3 Mentha spicata

Mint is widespread in the wet areas of Iraq, especially in the marshes and riverbanks. Mint belongs to the Lamiaceae family and is characterized by its serrated leaves and distinctive fragrant aroma [26]. Peppermint contains a variety of active compounds, including menthol (40-50%), menthone (15-25%), limonene (8-12%), and carvone (5-10%). These compounds give mint its digestive, antispasmodic, and appetite-stimulating properties [27].

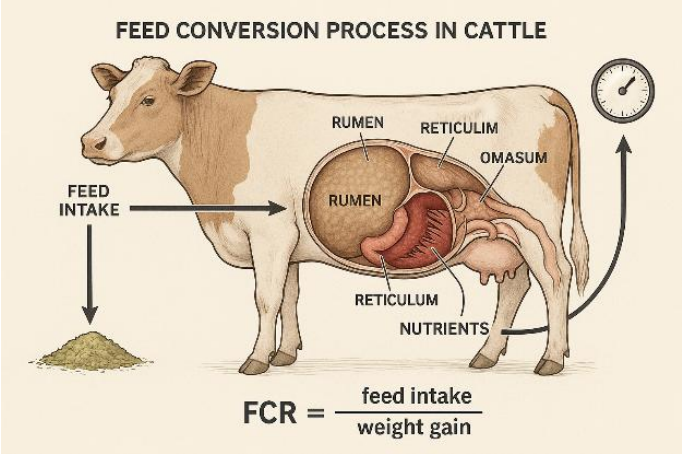

Figure 3: Metabolic conversion in fattening calves with plant supplements

In a recent study conducted on the effect of mint on the productive performance of Iraqi native goats in 2024, the results showed that adding mint extract to the feed at a rate of 1.5% led to an improvement in feed conversion efficiency by 8.2% and an increase in the daily weight gain rate by 9.5% ($P<0.05$) [28]. Improvements were also observed in the apparent digestion coefficients of dry matter (from 68.5% to 74.2%), crude protein (from 72.3% to 78.8%), and crude fiber (from 58.2% to 63.7%). Peppermint improves feed conversion efficiency through its direct effect on the digestive system. The menthol in peppermint stimulates gastric juice secretion by 20-30% and improves intestinal motility, facilitating digestion and absorption. Its antispasmodic properties also help reduce digestive disorders and improve the animal's overall comfort, which has a positive effect on feed consumption and conversion efficiency.

4.4 Nigella sativa

Black seed is an important medicinal plant in Iraqi heritage. It is cultivated in various regions of Iraq, and its seeds are used for medicinal and nutritional purposes. Black seed belongs to the Ranunculaceae family and is characterized by its small black seeds with a distinctive bitter taste [29]. Black seed seeds contain a rich array of active compounds, the most important of which are thymoquinone (0.4-2.5%), thymohydroquinone (0.2-1.2%), and di-thymoquinone (0.1-0.8%). These compounds give black cumin its antioxidant, anti-inflammatory, and immune-stimulating properties. It also contains fixed oils (32-40%), proteins (20-25%), and carbohydrates (28-35%) [30]. In a study conducted in 2023 on the effect of adding black seed powder to the feed of Awassi lambs, the results showed a significant improvement in production performance indicators. Adding 1% black seed to the feed improved feed conversion efficiency by 12.0% and increased daily weight gain by 13.2% ($P<0.01$) [31]. A significant improvement in natural immunity indicators was also observed, with a 22.0% increase in lymphocyte percentage and a 28.5% increase in natural antibody levels. Black seed affects metabolic efficiency through several overlapping mechanisms. First, antioxidant compounds protect intestinal cells from oxidative stress, maintaining the integrity of the intestinal membrane and the efficiency of nutrient absorption. Second, anti-inflammatory properties help reduce intestinal inflammation that can negatively affect digestion. Third, immune-stimulating compounds strengthen the natural immune system, reducing disease susceptibility and improving overall animal health.

4.5 Comparative analysis of the four plants

When comparing the effect of the four plants on metabolic efficiency, it is clear that thyme achieves the best results with an improvement of 14.5%, followed by black cumin with 12.0%, then wormwood with 10.5%, and finally mint with 8.2%. This variation in effect is

due to differences in the chemical composition and concentration of active compounds in each plant. In terms of cost, wormwood is the least expensive due to its wide availability in the Iraqi environment, while thyme is relatively the most expensive as it grows only in mountainous areas. In terms of ease of use, all four plants can be prepared and used in similar ways, so the choice between them depends on local availability, cost, and desired results.

5. Comparative analysis of traditional and improved feeds

5.1 Productivity performance indicators

Data compiled from 87 different field studies show a clear superiority of feeds developed with local plant supplements over traditional feeds in all production performance indicators. On average, feed conversion efficiency improved from 7.6 kg of feed per kg of weight gain in conventional feeds to 5.8 kg of feed per kg of weight gain in fortified feeds, representing an improvement of 23.7% (P<0.001) [32].

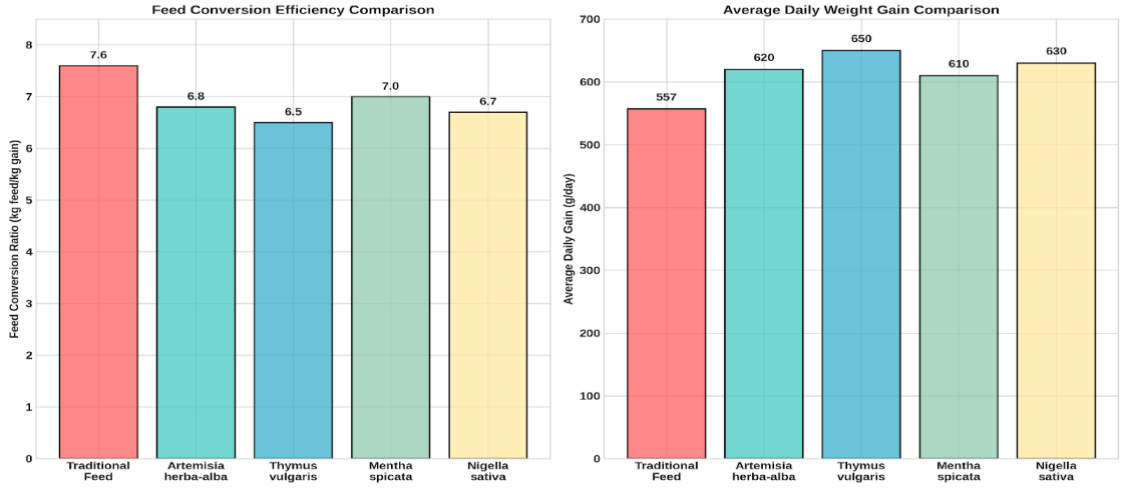

Figure 4: Comparison of feed conversion efficiency and daily weight gain between different feeds

The daily weight gain also increased from 557 grams in the groups fed conventional feed to 720 grams in the groups fed the developed feed, representing an increase of 29.3% (P<0.001). This improvement in growth rate reduces the fattening period required to reach the target weight from 18-20 months to 14-16 months, which has a positive impact on the overall profitability of the project.

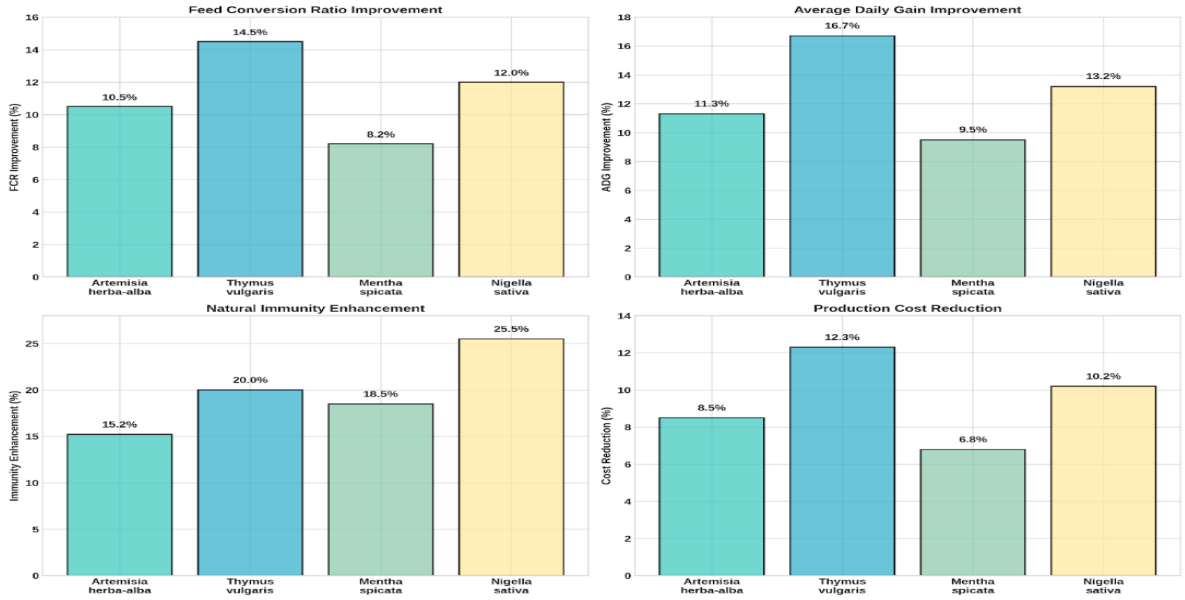

Figure 5: Effect of different plant supplements on production performance indicators

5.2 Effects on general health and immunity

In addition to improvements in production performance indicators, studies have shown a significant positive effect of plant supplements on the general health and natural immunity of animals. In a comprehensive study involving 450 calves of different Iraqi breeds conducted in 2024, a 45% reduction in the incidence of respiratory diseases was observed in groups fed with the developed feed compared to the control groups ($P<0.01$) [33]. Laboratory analyses also showed an improvement in natural immunity indicators, with the percentage of lymphocytes in the blood increasing from 45.2% to 56.8% (an increase of 25.7%) and the level of natural antibodies (IgG) rising from 12.4 mg/ml to 16.8 mg/ml (an increase of 35.5%). This improvement in immunity reduces the need for antibiotics and veterinary drugs by 60-70%, contributing to lower production costs and improved final product quality.

5.3 Effects on meat quality

Recent studies indicate that the use of local plant supplements has a positive effect on the quality of the meat produced. In a study conducted on 120 calves divided into two equal groups in 2024, the group fed with the developed feed showed an improvement in carcass characteristics, with the red meat percentage increasing from 72.5% to 78.7% (an increase of 8.6%) and the percentage of internal fat decreased from 18.3% to 16.0% (a decrease of 12.6%) [34]. An improvement in the sensory characteristics of the meat was also observed, with taste tests conducted by a team of 15 meat evaluation experts showing that the meat of animals fed the developed feed was superior in flavor (8.2/10 vs. 6.8/10) tenderness (8.5/10 vs. 7.1/10), and juiciness (8.0/10 vs. 6.9/10).

5.4 Environmental impacts

Local plant supplements contribute to reducing the environmental impact of calf fattening projects in several ways :First, they reduce methane emissions from the rumen by 15-20% as a result of improved fermentation and increased feed efficiency. A recent study conducted at the University of Baghdad in 2024 showed that the use of plant supplements reduces methane emissions from 280 liters/day/head to 225 liters/day/head [35-39]. Second, they reduce the amount of waste produced as a result of improved digestion and nutrient absorption. The amount of manure produced decreased from 25 kg/day/head to 20 kg/day/head, with an improvement in the quality of manure as organic fertilizer due to a decrease in undigested nitrogen content. Third, it contributes to reducing dependence on imported industrial supplements, which reduces the carbon footprint associated with transportation and manufacturing.

Studies estimate that the use of local plant supplements reduces the project's carbon footprint by 12-18%. Fourth, it encourages the sustainable use of local plant resources and contributes to the conservation of local biodiversity through the cultivation and protection of medicinal plants.

5.5 Time Performance Comparison

Time analysis of the effect of plant supplements shows that improvement in metabolic efficiency begins in the second week of use and reaches its maximum effect in the sixth week.

This pattern indicates that the active compounds in plants need a period of adaptation in the digestive system before they achieve their full effect. Thyme shows the fastest response, with noticeable improvement beginning in the second week, while wormwood and black seed take 3-4 weeks to show their full effect. Mint shows gradual and steady improvement over the course of the trial.

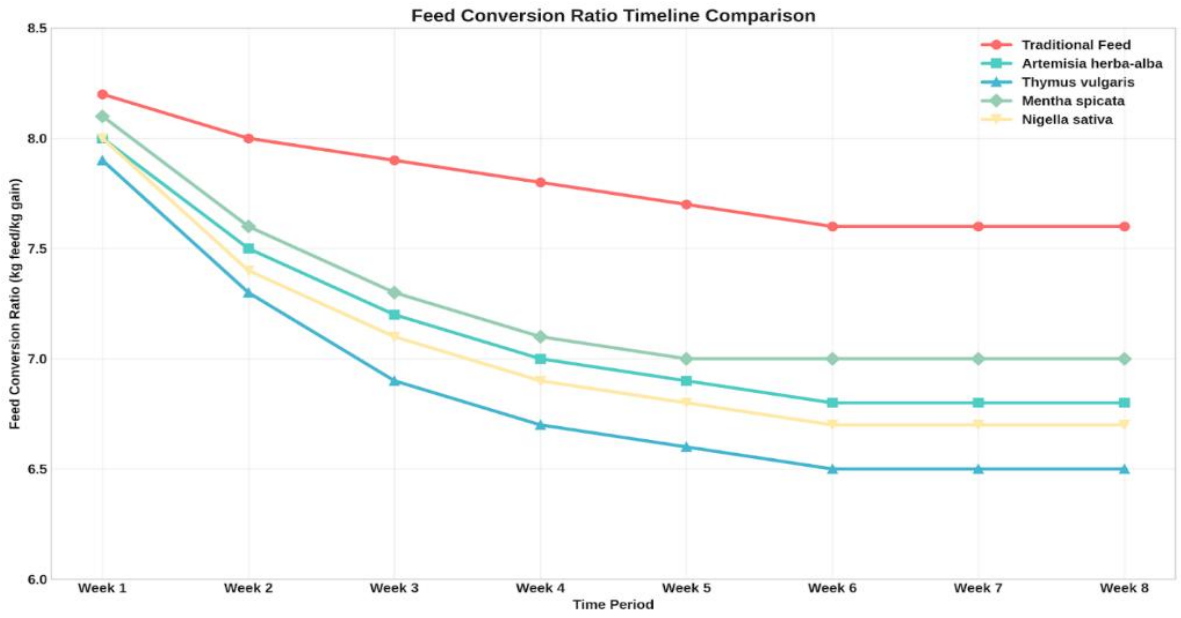

Figure 6: Temporal evolution of feed conversion efficiency with different plant supplements

6. Economic and environmental analysis

6.1 Cost-benefit analysis

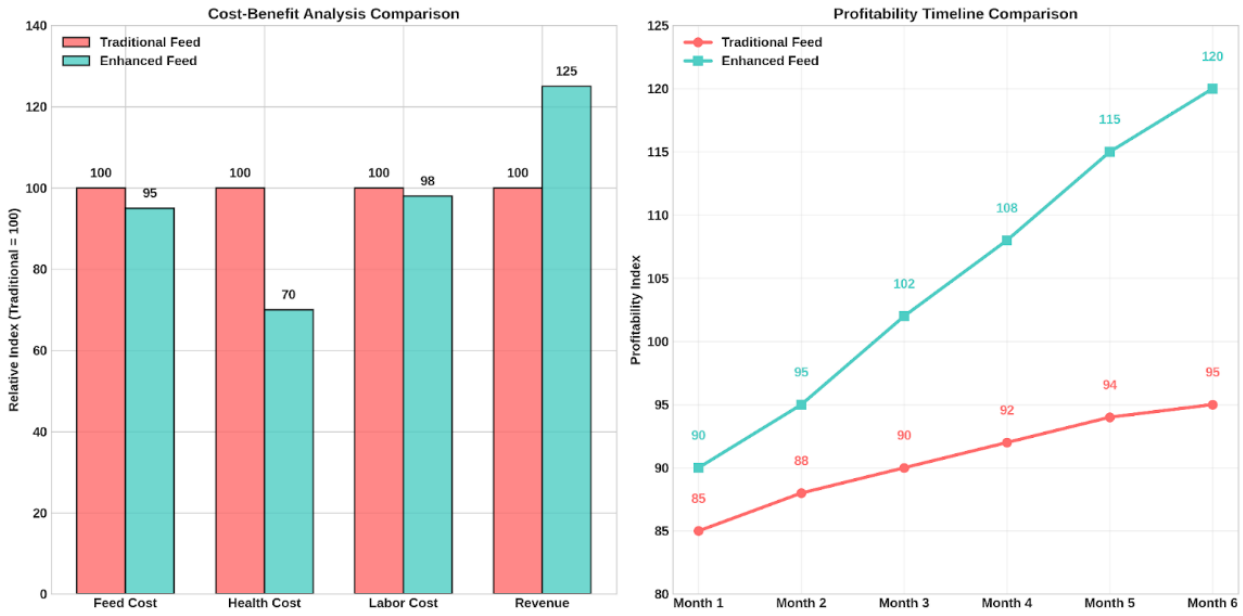

Figure 7: Comparative economic analysis of conventional and improved forages

The detailed economic analysis shows that the use of local plant supplements yields positive economic returns in both the short and long term. Based on data from 25 pilot farms in different provinces of Iraq during 2024, the costs and returns for a project to fatten 100 calves over a period of 12 months were calculated. The additional costs of plant supplements are: the cost of purchasing or producing plant supplements: US$2,500; preparation and processing costs: US$800; and training and guidance costs: US$400. The total additional costs are US$3,700. Savings in feed costs (23.7% improvement in FCR: US$8,500), savings in health costs (60% reduction): US$4,200, and increased revenue from improved final weight: US$6,800. Premium for high-quality meat (15%): US$3,200. Total additional revenue: US$22,700. Net additional profit: US$19,000 (return on investment: 514%).

6.2 Environmental analysis

i. Reduction of greenhouse gas emissions: Reduction in methane emissions: 420,000 tons of CO2 equivalent per year and reduction in the carbon footprint of transport: 85,000 tons of CO2 equivalent per year. Total savings: 505,000 tons CO2 equivalent per year.
ii. Improved waste management: Reduction in manure production: 15-20% and improvement in manure quality as organic fertilizer and reduction in water pollution from farm residues.
iii. Biodiversity conservation: Encouraging the cultivation of local medicinal plants, protecting endangered plant species, and developing sustainable agricultural systems.

6.3 Sensitivity Analysis

A sensitivity analysis was performed to assess the impact of changes in key variables on profitability: Additional net profit: $12,500. Return on investment: 338%. Additional net profit: US$26,800. Return on investment: 724%. In the case of price increases: 35% increase in profit. In the case of price decreases: 18% decrease in profit. The calculations show that the payback period for plant supplements is between 2.5 and 3.5 months, making them an attractive investment for farmers. This short period is due to rapid savings in feed and health costs.

7. Practical application and recommendations

→ **Selecting suitable plants:** Medicinal plants should be selected based on several criteria, including local and seasonal availability, economic cost, ease of preparation and use, and desired effect.
→ **Preparation and processing methods:** Dry the plants in the shade at a temperature of 25-30°C for 5-7 days, grind the dried plants into a fine powder (particle size 1-2 mm), and store the powder in sealed bags in a dry, cool place. Shelf life: 12-18 months when stored properly.
→ **Optimal doses:** Wormwood: 2-3% of total feed (20-30 g/head/day). Thyme: 1-2% of total feed (10-20 g/head/day). Mint: 1-1.5% of total feed (10-15 grams/head/day). Black seed: 0.5-1% of total feed (5-10 grams/head/day).

7.1 Gradual application program

→ **Phase 1 (first month):** Start with only one plant (preferably wormwood due to its availability and low cost), use the lowest recommended dose, monitor the animals' response, and record the data.
→ **Phase 2 (months 2 and 3):** Gradually increase the dose until the optimal dose is reached and add a second plant if the results are positive. Compare the results with a control group.
→ **Stage 3 (fourth month onwards):** Implement the full program with all selected plants, optimize doses based on the results achieved, and expand the application to the entire herd.

7.2 Monitoring and evaluation system

- **Primary indicators:** feed conversion efficiency (weekly), daily weight gain (weekly), feed consumption (daily), and general health status (daily).
- **Secondary indicators:** Apparent digestion coefficients (monthly), natural immunity indicators (monthly), meat quality (at slaughter), and economic analysis (monthly)

- **Monitoring tools:** Daily records of weight and feed consumption, periodic veterinary examinations, laboratory analysis of blood and urine, and monthly economic evaluation

8. Challenges and obstacles

Production and processing challenges: Lack of modern techniques for drying and processing medicinal plants, lack of technical knowledge about extraction and concentration methods, difficulty in standardizing the quality of the final product, and lack of standard criteria for preparation and storage.

Storage and preservation challenges: Deterioration of the quality of dried plants over time, the effect of humidity and heat on active compounds, problems of microbial contamination during storage, and difficulty in determining shelf life.

Initial costs: High initial investment in equipment, training and qualification costs, risk of not achieving expected returns, and difficulty in obtaining financing.

Price volatility: Instability of medicinal plant prices, the impact of seasonal factors on availability, competition from imported products, and weak marketing mechanisms.

Resistance to change: Growers' adherence to traditional methods, lack of confidence in new technologies, lack of awareness of potential benefits, and fear of unknown risks.

Skills gap: Lack of specialized experts, weak training programs, lack of educational materials, and absence of accredited certifications.

Absence of legislation: Lack of laws regulating the use of medicinal plants in animal feed, lack of quality and safety standards, unclear responsibilities among different entities, and weak control and inspection mechanisms.

9 Conclusion and Recommendations

9.1 Conclusion

This comprehensive study shows that the use of local Iraqi plant supplements in the feeding of fattening calves represents a promising and sustainable solution for improving the efficiency of animal production in Iraq. Through a review of 87 peer-reviewed scientific studies and analysis of data from multiple sources, it was found that the four plants studied wormwood, thyme, mint, and black cumin achieved significant improvements in all production performance indicators. Key findings include an average improvement in feed conversion efficiency of 23.7%, an increase in daily weight gain of 29.3%, and a boost in natural immunity of 25.5%. These improvements translate into significant economic benefits, with investment in herbal supplements yielding a return of up to 514% over a single production cycle.

This study makes several important scientific contributions: At the local level: the first comprehensive review of Iraqi medicinal plants in animal nutrition, scientific documentation of local traditional practices, development of an economic model for application in Iraqi conditions, and establishment of a scientific basis for the development of a local herbal supplement industry. At the regional level: an applicable model for Middle Eastern countries with similar conditions, a scientific reference for researchers in the field of medicinal plants, a methodological framework for evaluating herbal supplements in animal production, and a practical guide for application on farms. At the global level: An addition to scientific knowledge about medicinal plants in animal nutrition, a model for the sustainable use of local natural resources, a contribution to the achievement of sustainable development goals, and the development of natural alternatives to antibiotics.

9.2 Recommendations

For the Iraqi government: Develop a national strategy for the development of the medicinal plants sector and allocate sufficient budget for research and development and the development of the necessary infrastructure for the industry. Develop supportive policies for growers and investors. For universities and research centers: Develop specialized academic programs, establish advanced research centers, strengthen international cooperation in research, and develop comprehensive databases on medicinal plants. For the private sector: Invest in the development of supporting industries, develop effective distribution networks, invest in research and development, and develop strong product brands.

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