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Article Id
AL04327

ADAPTIVE ENERGY ALLOCATION DURING INSECT DIAPAUSE: INSIGHTS AND IMPLICATIONS

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Diapause, a crucial behavioral adaptation in insects, entails metabolic challenges due to limited food resources, necessitating energy reserves buildup, particularly in the fat body and a reduction in body water content before entering diapause. Survival hinges on adequate energy reserves, prompting insects to curtail energetically costly functions like metamorphosis, long-distance flight, and reproduction. In diapause, insects dynamically manage energy utilization, possibly sensing metabolic reserves to determine diapause initiation and duration. Climate change impacts diapause, as rising temperatures escalate metabolic rates, tightening energy budgets. While the molecular mechanisms of nutrient regulation in diapause remain unclear, insulin signaling is pivotal. Photophase and scotophase durations influence diapause onset. Certain metabolites, such as TCA cycle intermediates, can deter diapause, hinting at potential pest management strategies. Further research into these mechanisms promises insights into insect survival strategies and improved pest control methodologies.

Diapause is a state of arrested development in insects, enforced by physiological mechanisms rather than concurrent unfavorable environmental conditions. It is characterized by low metabolic rates, oxygen consumption, body weight, water content, and vitamin deficiency. Coined by William Wheeler in 1893, the term "diapause" originates from the Greek "diapausis," meaning "pause". Historically, diapause's various phases have been studied since the early 20th century. Terms related to diapause include dormancy, quiescence, and diapause itself, the latter being a highly evolved form of dormancy to overcome cyclic and extreme environmental conditions. Thus, it is a vital survival strategy for insects,

allowing them to withstand adverse environmental conditions and ensuring their species' continuation through generations.

Basic Classification of Diapause

- Diapause is classified based on seasonal variation and the influence of environmental factors. Aestivation occurs in response to higher temperatures (summer diapause), while hibernation occurs due to lower temperatures (winter diapause). For example, the spotted stem borer undergoes hibernation in North India and aestivation in South India.
- Based on environmental influence, diapause is classified into facultative and obligatory types. Facultative diapause occurs due to unfavorable environmental conditions and ends when conditions become favorable. Obligatory diapause is hereditary and species-specific, controlled by genes.
- Diapause also varies according to the life stage of the insect. Egg diapause is found in species like the mulberry silkworm, grasshoppers, and locusts, while larval diapause occurs in insects like the pink bollworm and maize stem borer. Pre-pupal diapause is observed in the Indian meal moth, pupal diapause in the cabbage butterfly and red hairy caterpillar, and adult diapause in species such as the white grub and mango nut weevil. Imaginal diapause is seen in mosquitoes.

Phases of Diapause

Insect diapause encompasses three phases, as outlined by Kostal *et al.* (2004):

1. **Prediapause:** Consisting of two sub-phases: a) **Induction Phase:** Genotype-specific ontogenetic stages trigger cues from the environment to switch from direct development to diapause. b) **Preparation Phase:** Occurs after induction, involving covert programming for diapause expression, including behavioral and physiological changes.
2. **Diapause Phase:** Further divided into three sub-phases: a) **Initiation Phase:** Direct development ceases, followed by metabolic suppression, while diapausing stages may continue feeding and preparing for adversity. b) **Maintenance Phase:** Endogenous arrest persists under favorable conditions, with specific stimuli helping to maintain diapause intensity. c) **Termination Phase:** Environmental changes trigger a decrease

in diapause intensity, synchronizing populations for overt or covert resumption of development.

3. **Post-diapause Phase:** Follows diapause termination, characterized by exogenously imposed inhibition of development and metabolism, allowing for reorganization before full activity resumes.

Endocrine System Involved in Insect Diapause

The insect endocrine system plays a crucial role in regulating diapause. Key hormones include juvenile hormone (JH), diapause hormone (DH), and prothoracicotropic hormone (PTTH). DH, primarily in *Bombyx mori*, induces diapause, while PTTH stimulates prothoracic glands to produce ecdysteroids for development. The corpora allata produces JH, critical for development. In *Riptortus pedestris*, pars lateralis neurons inhibit JH production, maintaining reproductive diapause. Absence of JH in adults leads to muscle degeneration and reproductive tissue atrophy, halting mating. JH presence in larvae prevents molting, and in *Diatraea gradiosella*, it facilitates fat body protein accumulation for diapause. DH regulates embryonic diapause in *Bombyx mori* by triggering glycogen conversion into sorbitol and glycerol, inhibiting embryo development. Glycerol and sorbitol revert to glycogen at diapause termination.

Consequences of Energy Shortfalls and Abundance

The energy reserves an insect can affect the decision to enter diapause, the decision to terminate diapause, and fitness during the postdiapause period. If insects that have not sequestered sufficient reserves to survive a lengthy diapause have four options: firstly they will die during diapause or post diapause development when all reserves have been depleted; secondly they have choice to avert diapause, an attempt to produce one more generation is a better option than dying; thirdly they terminate diapause prematurely when energy reserves become dangerously low; or lastly compensate for this deficiency by feeding during diapause.

Mechanisms Related to Diapause in Insect

In diapausing insects, energy sensing and insulin sensing mechanisms are crucial for assessing nutrient levels and regulating metabolic processes. Al-Anzi *et al.* (2009) found that fat bodies play a critical role in nutrient sensing and homeostasis. They identified specific neurons in *Drosophila melanogaster* that regulate feeding and nutrient balance. Baker and

Thummel (2007) studied the insulin-like peptide (ILP) pathway, which affects growth, reproduction, and metabolism. Disruption of insulin signaling in *D. melanogaster* inhibits reproduction and increases energy stores. The fork-head transcription factor (FOXO) is involved; in the presence of insulin, FOXO is suppressed, while its absence leads to fat accumulation.

Factors Affecting Insect Diapause

Environmental cues such as photoperiod, temperature, food availability and quality, host plant condition and parental rearing conditions collectively influence the induction or termination of diapause in insects. Photoperiod, the alternating light-dark phases in a day, is a primary cue, with changes triggering diapause onset or cessation. Temperature fluctuations, including thermoperiods, also impact diapause phases; for instance, chilling periods may signal the end of diapause in certain species like the woolly bear caterpillar. Food scarcity can induce diapause, as seen in the green lacewing and stem-boring moths. Additionally, host plant conditions can influence diapause induction. Parental rearing conditions, exemplified by the brown locust, may also play a role in diapause regulation, affecting the proportion of diapaused eggs laid. Overall, these factors, along with genetic predispositions, collectively control insect diapause.

Intensity of Diapause

Insect diapause exhibits significant variability in intensity, often measured by the duration of the diapause period. Typically lasting 9-10 months in temperate zones, diapause can extend for over a year in some cases, termed prolonged or extended diapause. Remarkable instances include the yucca moth with adults emerging after 19 years of diapause and wheat-blossom midges larvae overwintering for up to 12 years before adult emergence. Some sawflies show diapause stages lasting 3-4 years.

Use for Pest Control

Research indicates that diapause in insects involves a decrease in the release of certain intermediates from the fat body, leading to reduced activity in the tricarboxylic acid (TCA) cycle in the brain. Injecting diapause-programmed pupae with a mixture of four metabolites, including two TCA cycle intermediates, can prevent diapause and promote normal development. Glucose alone does not have this effect; the entire mixture is necessary. These findings suggest that metabolic intermediates play a crucial role in determining

developmental outcomes. In simpler terms, disrupting the TCA cycle intermediates can abort diapause. Since diapause serves as a protective mechanism against environmental changes for many insect pests, interrupting it could lead to their demise, making it a potential method for pest control.

Conclusion

Insects predominantly store energy in the form of triacylglycerides, supplemented by glycogen reserves and hexameric storage proteins. Metabolic depression, induced by varying temperature conditions, is crucial for conserving these energy stores. The energy sensing mechanism plays a significant role in regulating the storage of diapause energy reserves. However, diapause negatively impacts key biological parameters including developmental duration, fecundity, progeny survivorship, egg viability, adult longevity, and reproductive behavior. Nonetheless, exclusion of diapause using specific metabolites presents a potential avenue for intervention and pest control strategies.

References

- Al-Anzi, B., Sapin, V., Waters, C., Zinn, K., Wyman, R. J., & Benzer, S. (2009). Obesity-blocking neurons in *Drosophila*. *Neuron*, 63(3), 329-341.
- Baker, K. D., & Thummel, C. S. (2007). Diabetic larvae and obese flies—emerging studies of metabolism in *Drosophila*. *Cell metabolism*, 6(4), 257-266.
- Koštál, V., Tamura, M., Tollarová, M., & Zahradníčková, H. (2004). Enzymatic capacity for accumulation of polyol cryoprotectants changes during diapause development in the adult red firebug, *Pyrrhocoris apterus*. *Physiological Entomology*, 29(4), 344-355.

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BLACK RICE (*CHAK-HAO*) AND ITS AMPLE BENEFITS

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C*hak-hao* has an interesting history of its own. In China, it was only grown and reserved for the consumption of the Emperor for both its unique colour and properties thus giving it the moniker of Forbidden Rice, as commoners were not allowed to eat it. *Chak-hao*, an indigenous black rice has been cultivated in the plains and hills of Manipur and Nagaland for centuries. This scented glutinous rice has an intense dark purple-hued outer bran layer which almost looks black, a distinctive fragrance and taste. The two varieties of *Chak-hao* namely *Chak-hao Poireiton* and *Chak-hao Ambui* are used largely for community feasts and ceremonial purposes. It has a rich cultural history, called "Forbidden" or "Emperor's" rice; it was reserved for the 'Emperor' in ancient China and considered as a tribute food. In the time since it remained popular in certain regions of China and recently has become prized worldwide for its high levels of antioxidants. Despite its long history, the actual origin of black rice is still obscure. Black rice cultivars are found in several locations scattered throughout Asia (Banerjee *et al.*, 2019; Oikawa *et al.*, 2015).

Socio-Economic Value

Chak-hao is highly associated with socio-cultural value of people of Manipur. It plays a unique role in festival and cultural ceremonies of the state as it uses for namesake on the occasion like birth and death ceremonies of domicile of Manipur (Borah, 2018). During death ceremony, it uses as to make cuisine serve to their ancestor. *Chak-hao* has a deep black color and it usually turns purple after cooked. Its dark purple color is mainly due to the presence of anthocyanin content, which is higher by weight than that of other colored grains. It is very

useful and peasant taste when making porridge, dessert, traditional Chinese black rice cake, bread, and noodles.

Table1: Nutritional value of black rice per 100 gram

Content	Percentage
Total crude protein	12.15
Total carbohydrate	72.43
Amylose	8.27
Total fat	4.8
Ash	1.57
Curde fibre	0.71

(Source: MOMA, 2023)

Table 2: Minerals component of black rice

Mineral	Quantity
Calcium	24.06 mg
Magnesium	58.46 mg
Manganese	1.03 mg
Copper	4.30 mg
Cobalt	0.43 mg
Iron	23.34 mg
Total anthocyanin	69.2-74.0 mg (cyanidin 3-glucoside)
Total phenolic	500 and 577 mg (Gallic acid equivalent)

(Source: MOMA, 2023)

Health Benefits

Chak-hao possessed with antioxidant quotient which helps in boosting immunity levels and help your body stave off various ailments and infections better. The antioxidants also help discard toxic elements from human body. The Anthocyanins is helps in reducing heart attack prospects. It is also helps in preventing plaque buildup in artery walls and lowering cholesterol levels in human body. It is recommended to serve to pregnant women to provide nourishment to developing baby and to fulfil the nutritional requirement of pregnant women. It helps to reducing the sugar level of diabetic patient.

Use and Processing Opportunities of Black Rice

Most often, *Chakh-hao* is eaten as kheer or rice after cooking. Powder, *suji* (flour), syrup, chocolate, beer, wine, cake, bread, flattened rice, paratha, *ladoo*, and other sweetened foods are a few examples of value-added products that can be made. Manipur is the largest

producer of Black rice (Chak-hao) has huge value addition property various cuisine are cooked at home kitchen like *Kheer*, *Laddu*, *halawa* and other sweetened items. On the other side, processing firms also prepares value added products like biscuits, *bhujia*, cake, *gulab jamum*, *laddu* etc. *Chak-hao* extracts are a plentiful source of anti-oxidative phytochemicals that can be used as nutraceuticals, functional food products and natural colorants rather than toxic synthetics. Black rice, possessed with various nutraceutical compounds like tocotrienols, gamma-aminobutyric acid, oryzanol, rice bran saccharine, lutein, zeaxanthin, butylate hydroanisole and phytosterol, can be economically extracted.

Processed Products of Black Rice



Biscuits

Bhujia

Gulab Jamun



Cake

Laddu

Black rice

Home Made Products of Black Rice

**Kheer****Laddu****Flour**

Future Scope

Black rice is a popular food in Manipur due to its high nutritional and economic value. The majority of farmers grow it to fulfill homestead consumption, but those who produce it for sale secure a high profit. Therefore, it can be suggested that if farmers are cultivating black rice as a business motive, the value addition of the same would be helpful to reduce unemployment and boost the economy of the state.

Conclusion

Black rice is an aromatic variety of rice and the state of Manipur covers the largest area of the nation. It is the richest source of vitamins and anthocyanin, due to which its purple colour attracts consumers. Moreover, the pleasant taste of black rice attracts people to consume it at cultural festivals of the state and in the form of various value-added products after processing. Its market price is very high to ensure a high profit for the farmers as well as value chain actors. Therefore, ultimately, it might be helpful to reduce unemployment if it commercializes in the state.

References

Banerjee, R., Chakraborty, A., Chowdhury, S., & Ganguly, S. (2019). Mediconutritional value and profitability of black rice-the new black gold of Indian agriculture. *Science for Agriculture and Allied Sector*, 3(6), 11-16.

Nepolion Borah, Florida Devi Athokpam, RL Semwal and SC Garkoti (2018). Chakhao (Black Rice; *Oryza sativa* L.): A culturally important and stress tolerant traditional rice variety of Manipur. *Indian Journal of Traditional Knowledge*, 17(4): 789-794.

Oikawa, T.; Maeda, H.; Oguchi, T.; Yamaguchi, T.; Tanabe, N.; Ebana, K. Yano; M., Ebitani; T., Izawa, T. (2015). "The birth of a black rice gene and its local spread by introgression". *Plant Cell*. 27 (9): 2401–2414.

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ATMANIRBHAR CLEAN PLANT PROGRAM: REVOLUTIONIZING INDIA'S HORTICULTURAL SECTOR

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The agricultural sector plays a significant role in India's economy, contributing approximately 18.3% to the country's gross value added (GVA)¹, and engaging over half of the working-age population. With a focus on doubling farmers' income, India places particular emphasis on horticulture, which accounts for 33% of the agricultural GVA². Recent years have witnessed a surge in horticultural production, attributed to factors such as population growth, evolving consumer preferences, and government-led initiatives. India has emerged as the world's second-largest producer of fruits and vegetables, notably mangoes, bananas, and guavas. However, amidst challenges, efficient utilization of land and water resources remains paramount to meet domestic demand and enhance horticultural productivity.

Certifying planting materials as disease-free is crucial as viral infections are not visibly detectable by farmers and require laboratory testing. Farmers often obtain planting materials from nurseries, and if infected, this can result in reduced yields and lower product quality. Certification ensures healthy planting materials, preventing losses, and nurseries' propagation methods should undergo inspection under certification schemes.

In a determined stride towards self-reliance, India unveils the Atmanirbhar Clean Plant Program, a transformative initiative poised to reshape the nation's horticultural landscape. With a strategic focus on disease-free planting material and enhanced yield, this program holds the potential to bolster India's horticultural sector and amplify its global competitiveness.

Unveiling the Atmanirbhar Clean Plant Program:

Program Objectives: The Atmanirbhar Clean Plant Program is set to be launched with a substantial budget of Rs. 2,200 crores over the next 7 years, until 2030 (PIB Delhi). This ambitious initiative aims to achieve several key objectives:

- Elevate the yield of horticultural crops.
- Promote the dissemination and adoption of climate-resilient varieties.
- Safeguard the ecosystem through proactive measures against viruses and diseases.

Program Implementation: Spearheaded by the National Horticulture Board (NHB), the program will establish Clean Plant Centers across the nation. These centers will serve as vital hubs for producing high-quality planting material free from diseases. Success hinges on collaborative efforts with stakeholders to ensure widespread adoption of clean plant seeds and nurseries.

Asian Development Bank (ADB): ABD has approved a \$98 million loan to improve horticulture crop farmers' access to certified disease-free planting materials, which will boost their crops' yield, quality, and resilience to climate impacts.

Nurturing the Need for the Clean Plant Program

Global Best Practices: Drawing inspiration from leading nations such as the United States, Netherlands, and Israel, which have pioneered clean plant programs, India aims to tap into similar success stories. These initiatives have significantly enhanced crop yield, quality, and agricultural sustainability.

Quality Concerns: Despite India's significant production of fruits like banana, mango, pomegranate, and papaya, its share in global exports remains limited due to quality issues. For instance, while India contributes to 27% of global banana production, its export share is only around 1%. The Clean Plant Program seeks to address these concerns, catapulting India's exports to new heights.

Horticultural Growth and Exports: Over the past 7 years, India has witnessed substantial growth in horticulture, with the area expanding from 23.4 to 27.5 million hectares and production increasing from 280.9 to 333.25 million tonnes. The Clean Plant Program is poised to further accelerate this growth trajectory.

Summary: Establishing "Clean Plant Centers"

Pioneering Approach: The introduction of Clean Plant Centers marks a groundbreaking endeavor in India's horticultural sector. These centers are poised to revolutionize practices and play a pivotal role in reshaping the industry. Mainly government is planning to develop at least six public clean plant centers (CPC) across India that will comprise: quarantine blocks for all the domestic and imported materials that are intended for commercial propagation, laboratories for diagnostic testing and tissue culture; and foundation blocks to maintain and distribute clean planting materials from climate resilient varieties to certified nurseries.

Targeted Crops: Clean Plant Centers will focus on various fruit crops, including apple, walnut, almond, grapes, mango, and pomegranate. Fully funded by the central government and implemented in a Public-Private Partnership (PPP) mode, these centers will collaborate with research organizations, agricultural universities, and private sector partners.

Services Provided: These centers will offer a comprehensive range of services, including disease diagnostics, therapeutic interventions, multiplication of plants, and generation of mother plants. These critical services aim to ensure the propagation of high-quality planting material free from diseases.

Streamlining Imports: With the demand for imported planting material rising, Clean Plant Centers will significantly streamline the process. Currently, imported plants undergo a two-year quarantine period, hampering efficiency. Establishing these centres will reduce this period to just six months, facilitating smoother and faster imports.

Conclusion

The Atmanirbhar Clean Plant Program promises a paradigm shift in India's horticultural sector. By prioritizing disease-free planting material, enhancing yield, and embracing global best practices, the program aims to bolster India's position as a major player in the global horticultural market. As the program unfolds over the next decade, India's journey towards self-reliance and growth takes a significant leap forward.

Reference

Ministry of Agriculture and Farmers Welfare. 2023. Annual Report 2022-23. New Delhi, Government of India.

Ministry of Agriculture and Farmers Welfare, Government of India. 2018. Horticultural Statistics at a Glance 2018. New Delhi.

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ENHANCING FARM ANIMAL WELFARE OPERATIONS

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The welfare of farm animals is a topic of increasing concern in modern agriculture. As society becomes more conscious of animal rights and ethical treatment, the practices surrounding the raising, handling, and slaughtering of farm animals have come under scrutiny. With the growing demand for animal products, it's imperative to reassess and improve welfare practices to ensure the well-being of these sentient beings. This article delves into the importance of welfare practices for farm animals and explores strategies to enhance their quality of life.

Animal Welfare

Animal welfare encompasses the physical, mental, and emotional well-being of animals. In the context of farm animals, welfare includes access to adequate food, water, shelter, space, and the ability to express natural behaviors. It also involves minimizing stress, pain, and suffering throughout the animal's life, including during transportation and slaughter.

Challenges of Welfare Practices

Traditional farming methods often prioritize efficiency and profitability over animal welfare, leading to crowded and unsanitary living conditions, routine use of antibiotics, and limited access to outdoor spaces. Confinement systems, such as battery cages for hens and gestation crates for pigs, severely restrict movement and social interaction, resulting in significant distress and discomfort for the animals.

Furthermore, long-distance transportation and inadequate handling during loading and unloading processes contribute to the stress and injuries experienced by farm animals. Additionally, the methods used for slaughter, such as stunning and bleeding, if not executed properly, can cause unnecessary pain and suffering.

Improvement in Welfare Practices

Fortunately, there is growing awareness and momentum towards implementing more humane and sustainable practices in animal agriculture. Here are some strategies to improve welfare practices for farm animals:

Transition to Free-Range and Pasture-Based Systems:

Allowing farm animals to roam freely outdoors, graze on pasture, and engage in natural behaviors is essential for their well-being. Free-range and pasture-based systems provide animals with ample space, fresh air, and opportunities for social interaction, promoting physical and psychological health.

1. Implement Animal Welfare Standards and Certification Programs:

Governments, industry organizations, and consumer groups can establish and enforce animal welfare standards to ensure that farms adhere to humane practices. Certification programs, such as Animal Welfare Approved and Certified Humane, help consumers make informed choices by labeling products from farms that meet specific welfare criteria.

2. Invest in Animal Welfare Research and Education:

Continued research into animal behavior, welfare science, and sustainable farming practices is crucial for identifying best practices and implementing evidence-based solutions. Educational programs and training initiatives can help farmers and industry professionals adopt humane handling techniques and improve overall animal care.

3. Enhance Transportation and Slaughter Practices:

Efforts should be made to minimize the duration and stress of transportation by using well-designed vehicles and implementing protocols for proper handling and loading. Slaughter facilities must prioritize humane methods, such as stunning and euthanasia, to ensure that animals are rendered unconscious and insensitive to pain before the slaughter process begins.

4. Promote Consumer Awareness and Demand for Ethical Products:

Consumers play a vital role in driving change within the agricultural industry by supporting companies and producers that prioritize animal welfare. By choosing products from farms that demonstrate ethical and transparent practices, consumers can incentivize the adoption of humane standards throughout the supply chain.

Conclusion

Improving welfare practices for farm animals is not only a moral imperative but also essential for building a more sustainable and ethical food system. By prioritizing the well-being of animals, we can create environments where they can thrive and live fulfilling lives. Through collaboration among farmers, policymakers, consumers, and advocacy groups, we can work towards a future where compassion and respect for all living beings are central to agricultural practices.

References

- Grandin, T. (2010). Auditing animal welfare at slaughter plants. *Meat Science*, 86(1), 56-65.
- Farm Animal Welfare Council. (2009). Five Freedoms. Retrieved from <https://webarchive.nationalarchives.gov.uk/20121010012427/http://www.fawc.org.uk/freedoms.htm>
- Duncan, I. J. H., & Fraser, D. (1997). Understanding animal welfare. In *Animal Welfare* (pp. 19-31). Springer, Dordrecht.
- Appleby, M. C., Mench, J. A., Olsson, I. A. S., & Hughes, B. O. (2011). *Animal welfare*. CABI.
- European Food Safety Authority. (2012). Scientific Opinion on the welfare of animals during transport. *EFSA Journal*, 10(1), 2538.

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FISH ALSO HAVE TONSILS

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Protection mechanisms against pathogens at barrier tissues, which serve as the boundary between the environment and the host, are crucial for the survival of pluricellular organisms. The advent of adaptive immunity, which occurred some 500 million years ago, was a significant milestone in the field of pathogen defence. Adaptive immunity relies on the process of clonal selection, where cells that express genes generating antigen (Ag) receptors are chosen. Naïve B or T cells are generated and undergo differentiation in primary lymphoid organs. Subsequently, these naïve lymphocytes migrate to secondary lymphoid organs, where they begin adaptive immune responses. Both main and secondary lymphoid organs are in a state of constant development and form at specific places (Hofmann et al., 2010).

Secondary lymphoid organs have played a crucial role in promoting adaptive immune responses throughout evolution. They provide an organisational structure that promotes the colocalization of antigens (Ags) and Ag-specific cells, which are necessary for efficiently inducing antibody-mediated responses. Extensive research has been conducted on the evolutionary development of lymphoid tissues and adaptive immunity in vertebrates (Zapata and Amemiya, 2000; Boehm et al., 2012; Neely and Flajnik, 2016; Flajnik, 2018; Zapata, 2020). There are several parallels between the key elements of the immune system in teleost fish and humans (Renshaw and Trede, 2012; Carmona et al., 2017). Teleost fish possess a majority of the cells found in the innate and adaptive immune systems of mammals, including granulocytes, innate lymphoid cells, T cells, B cells, and Ag-presenting cells like macrophages. Jawed vertebrates also possess common molecular processes that are involved in the detection of infections and the modulation of immune responses (van der Vaart et al., 2012). Teleost fish possess two types of major lymphoid organs: (i) the thymus, which serves

as the location for the development and maturation of T lymphocytes, and (ii) the kidney, which is responsible for haematopoiesis and the development of B cell precursors. The pronephros, often known as the "head-kidney," is a significant location of immunological activity in teleost fish. It is closely linked to the functioning of secondary lymphoid organs (Bjørngen and Koppang, 2022). Nevertheless, within the fish species, the spleen is often recognised as the primary systemic secondary lymphoid organ. Teleost fish have not been found to possess lymph nodes or tonsil counterparts.

Mucosal tissues in both fish and humans serve as a large surface that links the organism to the external environment. This connection enables important processes like food absorption and gas exchange. However, it also increases the organism's vulnerability to diseases. Fish mucosae, like those in humans, have protection by many "mucosa-associated lymphoid tissues" (MALTs) that play a role in the immunological monitoring of the mucosal barrier. Fish MALTs are mostly found in the gastrointestinal tract (GALT), the integumentary system (SALT), the nasal cavity (NALT), and the gills (GIALT). Recent research has also shown the presence of a malignant adenocarcinoma (MALT) linked to the oral cavity and the pharynx. Mammalian MALTs are organised into distinct zones where immune cells are dispersed, resulting in a diffuse mucosal immune system. Additionally, they create organised lymphoid aggregates, such as Peyer's patches in the gut and Waldeyer's ring of tonsils in the nasal area. On the other hand, the fish mucosal immune system is normally viewed as a collection of dispersed immune cells distributed over mucosal regions (Salinas et al., 2011; Salinas, 2015).

Recent Findings

The fish MALTs exhibit a greater level of organisation. This phenomenon is indeed applicable to the branchial cavity, which is referred as gill chambers or pharyngeal cavities. The branchial cavity is comprised of two chambers, flanking the head, which are connected by the pharynx in the centre and may be accessed externally by the operculum slits. The sub-pharyngeal isthmus refers to the area located underneath the pharynx that serves as a barrier between the gill chambers. The entire branchial cavity is covered with a nonkeratinized squamous epithelium known as the "cavo-branchial epithelium," which is derived from the pharyngeal tissue. The gill chamber of zebrafish exhibits a series of four gill arches, with each arch consisting of two ALTs and one ILT. Finally, a thymus lobe is situated on the upper surface of each gill chamber.

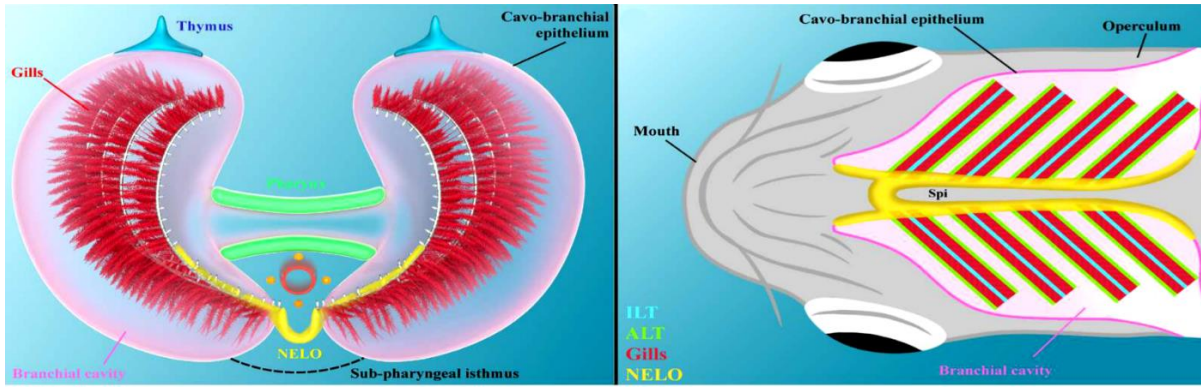


Figure 1 Diagrams of NELO's localization. Image is taken from Resseguier et al., 2023.

Nemausean lymphoid organ (NELO)

The Nemausean lymphoid organ (NELO) is derived from the Gallic-Roman mythology of "Nemausus - Nemausicae" and is linked to the concepts of protection, water, and healing. The recent studies differentiate it from the histologically unique epithelium that envelops the pharynx. In the sub-pharyngeal area of the branchial cavity, there is a conspicuous lymphoid organ that has not been previously characterised; it is called the "Nemausean lymphoid organ" (NELO).

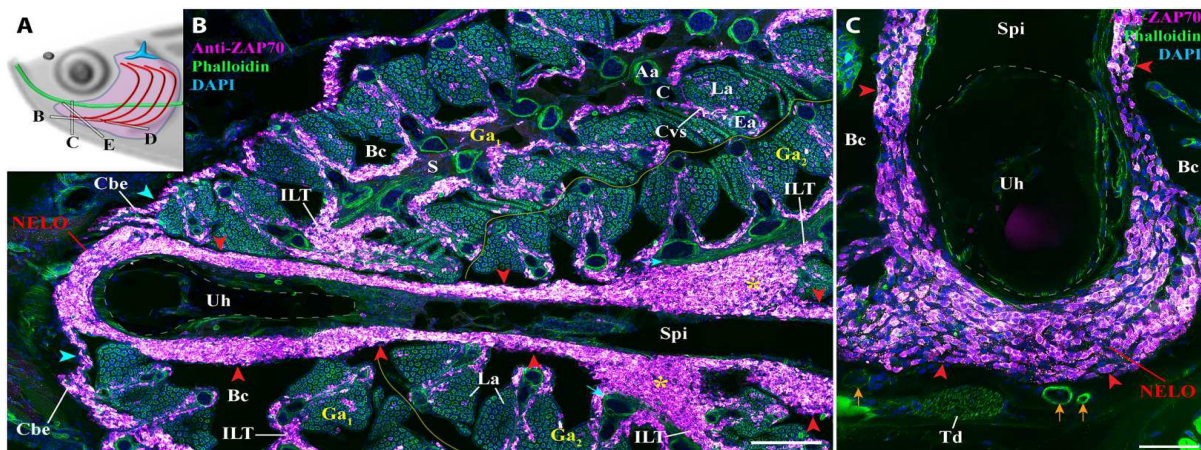


Figure 2 General organization and localization of NELO in zebrafish (A) The different orientations of the NELO images and the position of the thymus (blue), pharynx (green), and gills (red). (B and C) NELO (red arrowheads) wraps around the urohyal bone. Image is taken from Resseguier et al., 2023.

NELO is a substantial anatomical assemblage characterised by a high concentration of ZAP70-positive cells situated in the squamous mucosal epithelium that lines the sub-pharyngeal isthmus, a region situated under the pharynx and serving as a partition between

the two gill chambers. NELO encircles the urohyal bone at the front of the branchial cavity and then extends along both sides of the sub-pharyngeal isthmus until it reaches the back of the branchial cavity. NELO is linked to all 24 gill lymphoid aggregates, namely the 8 ILTs and the 16 ALTs, over its whole length. There is a lack of distinct demarcation between ILT/ALT and NELO at these linkage points, indicating that the lymphoid tissues inside the branchial cavity may operate as an integrated unit (Resseguier et al., 2023).

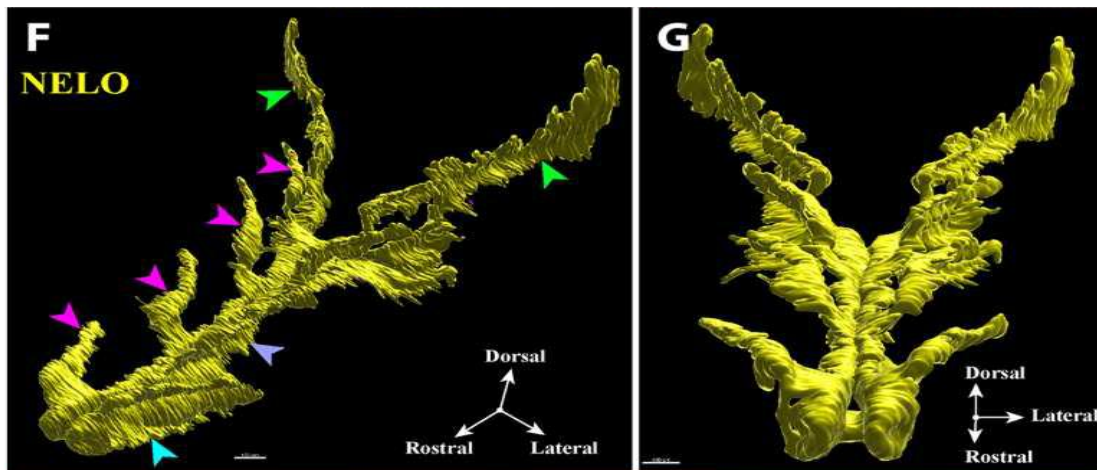


Figure 3 (F and G) NELO 3D reconstruction and its segmentation into four anatomic regions: the anterior area wrapped around the urohyal bone (cyan arrowhead), antler-like protrusions (magenta arrowheads), the core (blue arrow), and the posterior end (green arrowheads). Image is taken from Resseguier et al., 2023.

Conclusion

The NELO is a mucosal secondary lymphoid organ found in fish, which has several characteristics that bear resemblance to the tonsils seen in mammals. NELO, which is closely linked to gill lymphoid aggregates, emerges as a promising lymphoid centre that plays a crucial role in coordinating lymphocyte movement and defence mechanisms inside the respiratory mucosa of fish. This enhances comprehension of the evolutionary development of the immune system in vertebrates and provide novel perspectives on fish immunology. The concept of graft immunity is becoming significant in the context of future aquaculture vaccines and the advancement of zebrafish disease models.

References

- Bjørngen, H. and Koppang, E.O., 2022. Anatomy of teleost fish immune structures and organs. *Principles of Fish Immunology: From Cells and Molecules to Host Protection*, pp.1-30.
- Boehm, T., Hess, I. and Swann, J.B., 2012. Evolution of lymphoid tissues. *Trends in immunology*, 33(6), pp.315-321.
- Carmona, S.J., Teichmann, S.A., Ferreira, L., Macaulay, I.C., Stubbington, M.J., Cvejic, A. and Gfeller, D., 2017. Single-cell transcriptome analysis of fish immune cells provides insight into the evolution of vertebrate immune cell types. *Genome research*, 27(3), pp.451-461.
- Flajnik, M.F., 2018. A cold-blooded view of adaptive immunity. *Nature Reviews Immunology*, 18(7), pp.438-453.
- Hofmann, J., Greter, M., Du Pasquier, L. and Becher, B., 2010. B-cells need a proper house, whereas T-cells are happy in a cave: the dependence of lymphocytes on secondary lymphoid tissues during evolution. *Trends in immunology*, 31(4), pp.144-153.
- Neely, H.R. and Flajnik, M.F., 2016. Emergence and evolution of secondary lymphoid organs. *Annual review of cell and developmental biology*, 32, pp.693-711.
- Renshaw, S.A. and Trede, N.S., 2012. A model 450 million years in the making: zebrafish and vertebrate immunity. *Disease models & mechanisms*, 5(1), pp.38-47.
- Resseguier, J., Nguyen-Chi, M., Wohlmann, J., Rigaudeau, D., Salinas, I., Oehlers, S.H., Wiegertjes, G.F., Johansen, F.E., Qiao, S.W., Koppang, E.O. and Verrier, B., 2023. Identification of a pharyngeal mucosal lymphoid organ in zebrafish and other teleosts: Tonsils in fish?. *Science Advances*, 9(44), p.eadj0101.
- Salinas, I., 2015. The mucosal immune system of teleost fish. *Biology*, 4(3), pp.525-539.
- Salinas, I., Zhang, Y.A. and Sunyer, J.O., 2011. Mucosal immunoglobulins and B cells of teleost fish. *Developmental & Comparative Immunology*, 35(12), pp.1346-1365.
- van der Vaart, M., Spaink, H.P. and Meijer, A.H., 2012. Pathogen recognition and activation of the innate immune response in zebrafish. *Advances in hematology*, 2012.

Zapata, A. and Amemiya, C.T., 2000. Phylogeny of lower vertebrates and their immunological structures. *Origin and evolution of the vertebrate immune system*, pp.67-107.

Zapata, A.G., 2022. Lympho-hematopoietic microenvironments and fish immune system. *Biology*, 11(5), p.747.

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BIOSPECKLE LASER TECHNIQUE: A NOVEL NON-DESTRUCTIVE APPROACH FOR ENHANCING FOOD QUALITY AND SAFETY

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The biospeckle laser technique is a cutting-edge, non-destructive method for evaluating the quality of biological samples, especially in the food industry. It offers rapid assessment, user-friendly operation, and cost-effectiveness while ensuring product freshness and safety. By utilizing numerical processing techniques, it enables the analysis of biological activity influenced by contamination, damage, and maturation. Applications include detecting bruises, monitoring fruit ripening, assessing meat quality, analyzing seed viability, and identifying fungal infections. Challenges such as external noise and interference require standardized procedures for accurate analysis. Overall, the biospeckle laser technique holds immense potential for diverse applications in agriculture and quality control.

In recent years, the quest for innovative non-destructive techniques to assess food quality and safety has intensified, spurred by the growing demands for reliable methods that minimize product loss while ensuring consumer health. Amidst this pursuit, biospeckle laser technique has emerged as a promising frontier, offering a novel approach to scrutinize the biological activity within food samples without compromising their integrity.

Traditional methods for evaluating food quality often involve invasive procedures, such as physical or chemical analyses, which can alter the food's composition or structure, rendering it unsuitable for consumption or further processing. Furthermore, these methods may lack the sensitivity required to detect subtle changes indicative of spoilage or contamination. Recognizing these limitations, researchers have turned their attention to biospeckle laser technique, drawn by its ability to provide real-time, non-invasive insights into the dynamic processes occurring within food matrices. At its core, biospeckle laser technique harnesses the principles of laser speckle phenomena, wherein coherent light

interacts with moving particles within a sample, generating interference patterns that encode valuable information about the sample's biological activity. By analyzing changes in these speckle patterns over time, researchers can infer various attributes of the sample, including microbial activity, enzymatic reactions, and structural integrity, among others. One of the most significant advantages of biospeckle laser technique lies in its versatility and adaptability across diverse food types, ranging from fruits and vegetables to meat and dairy products. Its non-destructive nature allows for repeated measurements over time, enabling continuous monitoring of food quality throughout the production, storage, and distribution processes. Moreover, its potential for automation and integration with other analytical tools holds promise for streamlining quality control procedures in food industries, thereby enhancing efficiency and reducing costs.

Biospeckle Laser Technique

The biospeckle laser technique operates on the principle of laser speckle phenomenon, which arises when coherent light, such as that emitted by a laser, interacts with a rough or dynamic surface. When a laser beam illuminates a biological sample, such as fruits, vegetables, or other food products, it encounters various structural and biological elements within the material. These elements can include cells, membranes, fluids, and other microstructures.

As the laser light (of wavelength above 600 nm) interacts with these biological components, it undergoes multiple scattering events, leading to the formation of a random interference pattern known as speckle. This speckle pattern appears as a collection of bright and dark spots, which arise due to constructive and destructive interference of the scattered light waves. Importantly, the intensity and distribution of these speckle patterns are not static but instead fluctuate over time due to the dynamic nature of biological materials. The dynamic fluctuations in the speckle patterns are primarily caused by several biological processes occurring within the sample. These processes can include metabolic activity, respiration, water movement, mechanical vibrations, and other physiological changes. As a result, the speckle patterns captured by a camera or photodetector (**CMOS** = Complementary metal oxide semiconductors, and **CCD** = Charge Coupled Device) exhibit temporal variations, reflecting the underlying biological activity and structural dynamics of the sample. To analyze these speckle patterns, specialized image processing algorithms are employed. These algorithms quantify the temporal changes in the speckle patterns by calculating

parameters such as speckle contrast, speckle intensity, or correlation coefficients over time. By tracking these parameters, researchers can derive valuable information about the biological activity, quality attributes, and structural integrity of the food sample.

Importantly, the biospeckle laser technique offers several advantages over traditional methods for assessing food quality and safety. Firstly, it is non-destructive, allowing for repeated measurements without altering or damaging the sample. Secondly, it provides real-time monitoring capabilities, enabling early detection of quality defects or microbial contamination. Additionally, it is economical, rapid and straightforward, and also offers high sensitivity, allowing for the detection of subtle changes in biological samples that may not be visible to the naked eye.

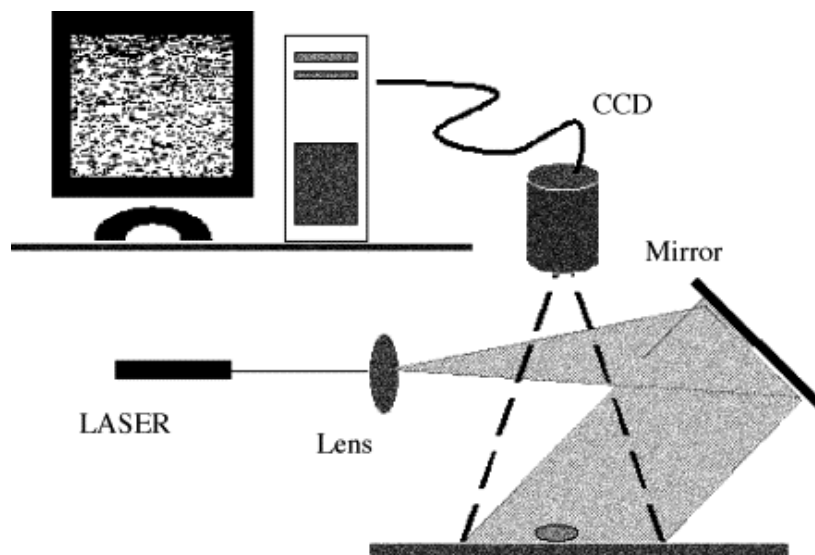


Figure 1: Illumination and image capture set-up.

Application of Biospeckle Laser Technique in Agro-Products

The biospeckle laser technique finds diverse applications in the assessment and monitoring of agro-products, including:

- **Detection of Mechanical Damage:** Biospeckle laser techniques are employed for detecting mechanical damage in horticultural produce such as fruits and vegetables during harvesting, transportation, and storage. This includes identifying bruises, tissue breakage, and other forms of damage that compromise the quality and safety of the produce. By analyzing speckle patterns, alterations in biological activity associated with damaged areas can be detected.
- **Detection of Microbial Contamination:** Biospeckle techniques are used for detecting

microbial contamination in agro-products. This includes identifying pathogenic microorganisms in fruits, vegetables, and seeds. By analyzing biospeckle patterns, changes associated with microbial growth can be quantified, aiding in early detection and quality control measures.

- **Quality Monitoring and Assessment of Storage Conditions:** It can be used to monitor the ripening process of fruits and vegetables by detecting changes in biological activity, helping to determine the optimal harvest time and post-harvest handling procedures. And also helps to predict ripening stages, shelf life, and quality parameters such as firmness and sugar content. And it also assesses the aging process in meat, particularly beef. By correlating enzyme activity with parameters like tenderness and color, the technique helps in quantifying biological changes during meat aging. The technique can evaluate the effects of storage conditions (e.g., temperature, humidity) on the quality and shelf life of agro-products, facilitating optimal storage management practices.
- **Evaluation of Processing Techniques:** It can assess the impact of different processing techniques (e.g., drying, freezing) on the quality attributes of agro-products, aiding in the optimization of processing parameters to maintain product quality.
- **Quality Assurance in Food Packaging:** Biospeckle analysis can be employed to evaluate the integrity of food packaging materials and the efficacy of packaging systems in preserving the quality and freshness of agro-products during storage and transportation.
- **Assessment of Seed Viability:** In agriculture, the technique can be used to assess seed viability by monitoring metabolic activity and physiological changes in seeds, aiding in seed quality testing and selection for optimal crop production.

Challenges in Biospeckle Laser Technique

While the biospeckle laser technique offers numerous advantages for evaluating food quality and safety, it also has certain limitations:

- **Lack of Standardization and Specialized Equipment:** Standard methods and dedicated equipment for agricultural use are lacking. Additionally, the penetration depth of laser light into biological samples is limited, typically ranging from a few micrometers to a few millimeters depending on the wavelength (632.8 nm wavelength) used. This restricts the technique's applicability to surface or thin samples, making it less suitable for assessing the quality of thicker or opaque food products.
- **Sensitivity to Environmental Conditions:** Biospeckle measurements can be influenced

by environmental factors such as temperature, light, humidity, and vibrations. Variations in these conditions may introduce noise into the speckle patterns, affecting the accuracy of the analysis.

- **Hardware and Software Challenges:** Maintaining laser stability is crucial for accurate measurements. He-Ne (Helium-neon) lasers are common but face transportation difficulties, while diode lasers require stable power sources. Camera adjustments can affect speckle formation, emphasizing the need to disable automated functions. Portability is vital for outdoor use, and standardization efforts aim to categorize analysis methods.
- **Interpretation Challenges:** Analyzing biospeckle patterns requires expertise in image processing and interpretation. Differentiating between biological activity and noise within the speckle patterns can be challenging, potentially leading to misinterpretation of results.

Despite these limitations, ongoing research and advancements in technology hold promise for addressing some of these challenges and expanding the applicability of biospeckle laser technique in food quality and safety assessment.

Conclusion

The biospeckle laser technique stands as a revolutionary method for enhancing the assessment of food quality and safety within agriculture. This non-destructive approach offers a plethora of benefits, including swift evaluation, user-friendly operation, and cost-effectiveness, all while upholding the freshness and safety standards of agricultural products. Nevertheless, challenges such as the need for standardization, technological limitations, and hardware/software complexities must be overcome to fully exploit the potential of this technique. Ongoing research and innovation in biospeckle laser techniques hold tremendous promise for revolutionizing the assessment of food quality and safety in agriculture. With continued advancements and standardization efforts, biospeckle laser techniques are poised to become indispensable instruments in ensuring the quality, safety, and sustainability of agricultural products in the years ahead.

References

- Amaral, I.C., Braga Jr, R.A., Ramos, E.M., Ramos, A.L.S. and Roxael, E.A.R. (2013). Application of biospeckle laser technique for determining biological phenomena related to beef aging. *Journal of Food Engineering*, 119(1), 135-139.

- Kaur, R., Nikhanj, P. and Kapoor, S., Biospeckle Laser Technique - A Novel Non-Destructive Approach for Quality Detection. *In Emerging Techniques for Food Processing and Preservation*, 143-163, CRC Press.
- Mulone, C., Budini, N., Vincitorio, F.M., Freyre, C.E., López, A.J. and Ramil, A. (2014). Biospeckle activity evolution of strawberries.
- Pandiselvam, R., Mayookha, V.P., Kothakota, A., Ramesh, S.V., Thirumdas, R. and Juvvi, P. (2020). Biospeckle laser technique—A novel non-destructive approach for food quality and safety detection. *Trends in Food Science & Technology*, 97, 1-13.
- Zdunek, A., Adamiak, A., Pieczywek, P.M. and Kurenda, A. (2014). The biospeckle method for the investigation of agricultural crops: A review. *Optics and Lasers in Engineering*, 52, 276-285.

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CRISPR/CAS MEDIATED ADVANCES IN GENE EDITING TOOLS IN BIOFUEL PRODUCTION

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One of the main causes of greenhouse gas (GHG) emissions is the consumption of fossil fuels. A potential substitute for fossil fuels in the transportation, power generating and heating sectors is biofuel. Fossil fuels can be combined with biofuel or utilized as a substitute for them. When biofuels are burned, substantially less greenhouse gas is released into the atmosphere than when traditional fuels are used (Lapuerta *et al.*, 2017). Therefore, the use of biofuel can aid in the prevention of environmental degradation.

Biofuels can be divided into four categories based on the feedstock: first, second, third, and fourth generation biofuels (FGBs). The biofuels of the first generation, and second generation which are derived from sugar, starch and biofuel crops have the fears about competition for arable land and raw minerals Algal-based third-generation biofuels have garnered significant interest because of their high yield, ability to assimilate carbon dioxide (CO₂) and ease of processing. For improved biofuel production, fourth generation biofuel is derived from genetically modified algal biomasses and other microorganisms.

Among gene editing, tools the clustered regularly interspaced short palindromic repeats-CRISPR-associated proteins (CRISPR-Cas) system, an RNA-guided immune system in bacteria and archaea, is the most modern weapon in the genetic engineering armory. The manipulation of several aspects of the production of biofuels is made easier by this straightforward but accurate tool.

Basic Components of CRISPR/Cas and Their Function

A single-guide RNA (sgRNA) and an RNA-guided Cas9 endonuclease are the two primary parts of the CRISPR-Cas9 system. Each of the two nuclease domains that the Cas9 protein comprises, HNH and RuvC, cleaves one strand of the target double-stranded DNA.

The combination of tracrRNA and crRNA is simplified in to single-guide RNAs (sgRNAs). Together, the sgRNA and Cas9 nuclease generate the Cas9 ribonucleoprotein (RNP), which can attach to and break the targeted DNA. Moreover, the binding of the Cas9 protein to the target DNA requires the presence of a protospacer adjacent motif (PAM) sequence (Ran *et al.*,2013).

Limitations in Biofuel Production

- a) Feedback inhibition
- b) Affects the survivability of microorganisms.
- c) Temperature fluctuations
- d) Selection of a single microbe for targeted co-fermentation
- e) less capacity to use substrates.
- f) Availability of less feed stock

CRISPR/CAS Mediated Engineering Strategies in Biofuel Production

1. Strain Improvement: CRISPR/Cas9-mediated site-directed mutagenesis is required to achieve high level of biofuel production by enhancing the metabolic performance of the microbial cells.
2. Metabolic Engineering: Using genome editing technologies, targeted changes to certain amino acids can modify the specificities of cellulases.
3. Gene Knockouts and Knock-ins: CRISPRi-based knockdown is inducible and reversible, which enables the temporal and dynamic regulation of interested genes.
4. Gene silencing: Tuning gene repression is helpful because some genes are extremely sensitive to knockdown and many genes of interest are expected to be expressed under tight control.
5. Gene regulation: Mechanistically, dCas enzymes repress transcription by preventing the binding of RNA polymerase or, if targeted to open reading frames, by interfering with transcription elongation.

Advances in CRISPR/CAS Tools to Address the Challenges

1. a. Cas9n-mediated single-nick generation and HR:

Homology-directed repair is another way to fix DNA lesions when a homologous template is present. In the study performed by Xu *et al.* (2015) to mutate the *pyrF* gene by small

DNA deletion, a homologous donor template with a length of 2 kb carrying a 23-bp deletion in the middle was designed and cloned it into pCas9-pyrF and pCas9n-pyrF, generating all-in-one pCas9-pyrF donor and pCas9n-pyrF-donor plasmids.

b. CRISPR-Cas12

A compact enzyme called C2c1 facilitates packing into vectors, which may contribute to the simpler and quicker transfection process. Cpf1(Cas12) just needs crRNA, but C2c1 also needs a tracrRNA, in contrast to Cas9. The Cpf1 system's growing number of guide-RNAs and small size contribute to improved flexibility and expand its use in multiplex genome editing. Here is an example where the Cas 12a enzyme is used to cut/delete the highly expressed gene that is *pyrF* responsible for orotate phosphoribosyl transferase in *Clostridium ljungdahlii*. Ran *et al.*, (2019) have succeeded in deletion of that gene and conclude that CRISPR/Cas12 can be used as a novel tool in modifying *Clostridium ljungdahlii*, which is a good producer of biofuel.

2. **Base Editing:** Base editing is a precise gene-editing technique that allows the direct conversion of one DNA base pair into another without inducing double-strand breaks. This method can reduce off-target effects and has the potential to be more accurate than traditional CRISPR-Cas methods.
3. **Prime Editing:** Prime editing is a relatively new technique that allows for the precise editing of specific DNA sequences without causing double-strand breaks. It uses a catalytically impaired Cas9 protein and a specially engineered reverse transcriptase to introduce changes at the target site.
4. **CRISPR Interference (CRISPRi) and CRISPR Activation (CRISPRa):** enable the regulation of gene expression without making permanent changes to the DNA sequence. These tools can be used to fine-tune the expression of genes involved in biofuel production pathways. The RuvC and HNH nuclease domains are present in the Cas9 protein. Double-stranded DNA is cleaved by these two regions. The Cas9 protein loses its endonuclease activity when the H840A and D10A mutations are incorporated; this is known as deactivated Cas9 (dCas9). While it is not able to cut DNA, the dCas9 protein is a great RNA-guided DNA binding protein. After being tested in *E. coli* for its capacity to selectively suppress gene expression, the CRISPR/dCas9 system gave rise to the CRISPR interference (CRISPRi) method.

- 5. Multiplexed CRISPR Systems:** simultaneous editing of multiple genes, which is crucial for optimizing biofuel production pathways. Researchers are developing CRISPR tools that allow the editing of multiple genes in a coordinated manner.
- 6. Synthetic Biology Approaches:** CRISPR technologies are often combined with synthetic biology approaches to design and engineer microorganisms for enhanced biofuel production. This includes the construction of synthetic gene circuits and the optimization of metabolic pathways.
- 7. High-Throughput Screening:** used to identify genes and pathways that can be targeted to improve biofuel production efficiency. This involves systematically editing genes in a high-throughput manner to assess their impact on the desired traits.

How Advanced Tools Increase Precision and Efficiency

- Enables targeted editing without generating double-stranded DNA breaks.
- Avoids undesirable indels.
- Helps to overcome Cas9 toxicity.
- Truncation of metabolic pathways
- Precise insertions of nucleotides
- Gene inactivation without knocking out.

Conclusion

- To deal with the current problem of global energy demand, effective measures are required.
- The CRISPR-Cas gene editing technique can boost non model organism's biofuel output.
- Gene suppression or inactivation using CRISPRi redirects metabolic flow to biofuel production pathways.
- CRISPR-Cas genome editing may improve substrate utilization, fermentation inhibitor tolerance and biomass breakdown cellulases and hemicellulases.

References

- Alok, A., Sandhya, D., Jogam, P., Rodrigues, V., Bhati, K. K., Sharma, H. AND Kumar, J. (2020). The rise of the CRISPR/Cpf1 system for efficient genome editing in plants. *Frontiers of plant science*, 11,264-268.

- Lapuerta, M., Barba, J., Sediako, A.D., Kholghy, M.R. AND Thomson, M. J., 2017, Morphological analysis of soot agglomerates from biodiesel surrogates in a coflow burner. *Journal of aerosol science*, 111:65–74.
- Ran, F. A., Hsu, P. D., Wright, J., Agarwala, V. AND Scott, D. A., 2013, Genome engineering using the CRISPR-Cas9 system. *Nat. Protoc.*, 8: 2281–2308.
- Ran, Z., Yanqiang, L., Huan, Z., Changsheng, C., Jin, W., Weihong, J. AND Yang, G., 2019, CRISPR-Cas12a-mediated gene deletion and regulation in *Clostridium ljungdahlii* and its application in carbon flux redirection in synthesis gas fermentation. *ACS Synthetic Biology*, 8(10): 2270–2279
- Xu, T., Li, Y., Shi, Z., Hemme, C. L., Li, Y, Zhu, Y., Van Nostrand, J. D., He, Z., Zhou, J. 2015. Efficient genome editing in *Clostridium cellulolyticum* via CRISPR-Cas9 nickase. *Applied and Environmental Microbiology*, 81:4423–4431.

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MEDICINAL PROPERTIES OF *Salvia hispanica* SEEDS

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The plant known as chia (*Salvia hispanica* L.), which belongs to the Lamiaceae or Labiatae family, can thrive in arid, tropical, and moderate temperatures. It is indigenous to Mesoamerica and was grown alongside maize, beans and amaranth as one of the primary crops by pre-Columbian people. This seed, which is actually a fruit, was utilised as a food supplement and medicinal by the Mayans and Aztecs. But because of its deep ties to native religious rituals, chia cultivation was forgotten following the Spanish conquest. A number of studies showing the high nutritional and nutraceutical benefits of chia have recently rekindled interest in the crop.

In addition to containing significant quantities of dietary fibre (18–30%), proteins (15–25%), vitamins, minerals, and antioxidants like kaempferol, quercetin, rosmarinic, and caffeic acids, chia seeds are also a major plant source of a-linolenic fatty acid (around 60% of the oil) (Ayerza and Coates, 2006; Police et al., 2020). Chia, on the other hand, has less than 2 mg of ascorbic acid per 100 g, making it a poor source of vitamin C. On the other hand, new research has rekindled interest in chia seeds by revealing its remarkable nutritional and nutraceutical benefits (Baginsky et al., 2016).

The Nutritional Powerhouse

Salvia seeds are a nutritional treasure trove, not just a garnish. Packed with vital nutrients, such as fibre, protein, antioxidants, omega-3 fatty acids, vitamins, and minerals, each small seed provides a concentrated dose of goodness.

- **Gut Health and Digestive Bliss**

Rich in nutritional fibre, salvia seeds aid in digestion and support intestinal health. When combined with liquids, the soluble fibre in them creates a gel-like substance that assists with digestion, constipation prevention, and bowel regularity maintenance.

- **Heart Health Warriors**

Salvia seeds are a powerful ally against cardiovascular disorders because of their high content of omega-3 fatty acids. These heart-healthy fats help lower blood pressure, cholesterol, and improve heart health overall, which lowers the risk of heart disease and stroke.

- **Blood Sugar Regulation**

For those who struggle with blood sugar control, salvia seeds provide a natural remedy. Chia seeds are a useful supplement for diabetics and others trying to maintain healthy glucose levels because studies suggest that including them in the diet may help stabilize blood sugar levels.

- **Weight Management Support**

Having trouble controlling your weight? You only need to look at salvia seeds. These small seeds, which are high in protein and fiber, help you feel full and satisfied, which reduces cravings and helps you lose weight.

- **Antioxidant Arsenal**

Salvia seeds are a great source of antioxidants, including as flavonoids, quercetin, and chlorogenic acid, which help the body fight oxidative stress and eliminate dangerous free radicals. This antioxidant power helps prevent chronic illnesses and early aging in addition to promoting general health.

- **Bone Health Boosters**

Salvia seeds are a great source of calcium, magnesium, and phosphorus, three elements that are vital for strong bones and the prevention of osteoporosis. Including these seeds in your diet can help you have strong, healthy bones for the rest of your life.

- **Hydration Heroes**

Salvia seeds produce a gel-like material that helps with hydration and extends fluid retention when they are soaked in water or other liquids. They are the perfect option for athletes and energetic people looking for prolonged energy and endurance because of their special hydration feature.

Conclusion

With an abundance of health advantages crammed into their small size, salvia seeds shine out amid the vast array of superfoods. From heart health to blood sugar control, weight control to digestive health, these little powerhouses provide an abundance of nutrition and energy. Accept the benefits of salvia seeds and discover the keys to a happy, healthier self.

References

- Ayerza, R., Coates, W. (2011) Protein content, oil content and fatty acid profiles as potential criteria to determine the origin of commercially grown chia (*Salvia hispanica* L.). *Ind Crop Prod* 34:1366–1371.
- Baginsky C, Arenas J, Escobar H, Garrido M, Valero N, Tello D, Pizarro L, Valenzuela A, Morale L, Silva H (2016) Growth and yield of chia (*Salvia hispanica* L.) in the Mediterranean and desert climates of Chile. *Chil J Agric Res* 76:255–264.
- Police Patil, A. S., Ambrish, G., Reddy, S. B. and Reddy, B. S. (2020) Importance of Chia (*Salvia hispanica*) Cultivation in Indian Agriculture. *Vigyan Varta* 1 (6): 17-19

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EMPOWERING SMALLHOLDER DAIRY FARMERS THROUGH TOURISM INITIATIVES: A SUSTAINABLE PATH TO ECONOMIC GROWTH

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India currently became the milk hub of whole world. Being the largest producer of milk and dairy products it contributes significantly in global supply chain of milk and dairy product. This rise of milk production throughout the nation has mainly started in 1970s with the strong visionary of Dr. Verghese Kurien. This Indian White revolution is generally the byproduct of continuous cumulative growth of small dairy farmers under the umbrella of the dairy Cooperatives. Those farmers who has at least small herd of 2-3 milking cows or buffalos are known as the small holder dairy farmers. They generally recognized as the backbone of Indian dairy sector.

After the green revolution Indian Agriculture and allied sector came across numerous achievements by adopting paradigm shift as well as changes along with the time. From traditional subsistence oriented, supply driven (seed to seed) farming approach to demand driven, market oriented participatory approach by farmers themselves, we came a long way. With technological innovation and farmers friendly govt policy delivery through strong extension network the agriculture and allied sector, especially dairy is moving slowly towards the motto of sustainability by promoting self-employment in dairy sector. In this way to make farming as well as dairy more profitable a new emerging concept called 'Dairy Tourism' evolved among the policy makers.

If we look at the overall tourism industry in India, mostly it has worth of 15.7 Rs 15.7 trillion in 2022 and the future predicted value will be Rs.16.5 trillion in 2023 as per the data released by World Travel & Tourism Council (WTTC). Dairy tourism aims to match this huge amount of potential by integrating and modernising dairy industry, dairy farms with tourism industry. Govt of India has taken innovative steps through the schemes like 'Dekho Apna Desh', 'Swadesh Darshan Scheme' and 'Vibrant Villages Programme' to promote the tourism sector and rural tourism.

The Significance of Smallholder Dairy Farmers

Dairy products currently leading among the top ranked commodity in India. The contribution of small-scale dairy farmers is 62% of total milk produced in the country. There is an expectation that dairy industry of India will exhibit a CAGR of 13% during 2023-2028. The small holder farmers in dairy play the major key role in this growth. In the total supply chain of daily milk production by all the dairy cooperatives of different states and UTs small holder farmers act as the basic unit. India's small dairy farmers actively support the sector, which contributes significantly to the country's rural economy. It significantly affects the nation's economic progress. Due to the fact that small dairy farmers are essential to providing food security and the importance of dairying in India, it helps the rural population preserve their way of life and serves as a source of income.

Challenges Faced by Smallholder Dairy Farmers

Challenges are the causes against the course of action and make the path harder for any individuals. As per the Indian dairy scenario some of the most acknowledged challenges faced by Indian small holder dairy farmers are listed below –

- Depends more upon traditional dairy farming practices.
- Lack of availability of doorstep A.I facilities and PD (Pregnancy diagnostic) kit.
- Lower ratio of VEO (Veterinary Extension Officer) and Dairy Farmer.
- Improper supply chain management of milk and milk processed foods.
- Limited access to commercial markets by the individual farmers.
- Farmer exploitation by the middle man and commission agents.
- Farmers attitude towards practicing dairy farming as a stand-alone enterprise by ignoring the emerging other sector which can be integrated with it.
- Young farmers` non participation in dairy as they feel dairy as a loss-making enterprise.
- Lack of credit as well as insurance accessibility by small holder dairy farmers.
- Besides non availability of year-round feed and fodder, improper health and hygiene, disease outbreak like lumpy skin disease, mastitis, repeat breeding etc.

Need for Innovative Approaches to Support and Empower Smallholder Dairy Farmers

The popularity of an innovation systems approach to development is founded on its inclusivity and the interactions of actors to co-influence one another, learn from one another, invent new things, and provide real advantages. Innovative approaches are crucial to support and empower smallholder dairy farmers due to their unique challenges. By harnessing technology and modern agricultural practices, these farmers can increase productivity, access to markets, and financial services. Novel solutions can provide training and knowledge-sharing platforms, enabling them to adapt to changing climates and sustainability practices. Additionally, innovative financing models can enhance their access to credit and resources, fostering investment in infrastructure and equipment. Empowering smallholder dairy farmers through innovation strengthens rural economies, ensures food security, and contributes to sustainable development, creating a more resilient and inclusive agricultural and dairy sector.

The Emergence of Dairy Tourism

The term 'Dairy Tourism' is new one which is designed by integrating the dairy farming along with the highly demanding tourism industry, if we look into the origin of dairy tourism, it generally comes as well as evolved from the concept of Rural Tourism as well as Agro-Tourism. Rural tourism, according to the World Tourism Organization (WTO), is defined as travel that allows tourists to interact personally with locals, experience the physical and social environment of the countryside, and, to the extent possible, engage in their customs, traditions, and way of life. The Organization for Economic Co-Operation and Development (OECD) claims that tourism is what occurs in rural areas (Reichel et al., 2000). The concept of dairy tourism gets popularity in twenty first century .it is also called as `Cow Tourism`.

Why Dairy Tourism?

Agriculture and animal husbandry practice is getting more and more costlier day by day. And due to various unfortunate reason like climate change, flood, heat wave, market failure, distress sale of agricultural and milk or milk-based product induces the farmers to quit their job of farming and migrate towards urban salary-based work. Besides 60-70% people who are in the corporate work culture and those who mostly belong to the congested city or town in most of their life already started feeling losing connection with the rural India. Being surrounded by closed work culture in cities full of concrete and artificial things the

stress and anxiety level of most of the urban people are increasing and they feel the urge to be enjoy with the nature apart from the urban hectic life. The concept of Cow therapy also get popularity in this context. Dairy tourism acts as a common platform to address and mitigate these two burning problems of both urban people and rural frustrated farmers. In one side it helps the dairy farmers to adopt the commercial dairy farming with the philosophy of tourism so that it helps them to get extra complementary income by selling the dairy products like packaged milk, flavoured milk, various types of sweets. Beside the locally famous dishes can also be presented to the visitors. For making the dairy business profitable as well as sustainable in long run Dairy tourism is the easiest alternative.

Principle of Dairy Tourism

Some of the basic principles are

Provide something to see for visitors

In the Dairy Tourism Park visitors can enjoy the natural scenic beauty of nature along with different dairy breeds like – Sahiwal, Gir, Karan Fries etc, buffalo breeds, goat breeds etc. the visitor also can enjoy the cow milking, the processing of milk and milk products. Dairy farmers can arrange live demonstration of calf rearing, animal feeding practices which will definitely pleasure for the visitors. The well managed, clean cattle shade, the bathing practices of cow, wallowing of buffalo shall provide close connection with the outsiders. Even the visitors can go to the nearby fodder field to enjoy natural beauty of farm. The nearby water pump in fodder field and the adjacent bio gas plant helps the visitor to grow interest. Apart from these the rural culture, dresses, festivals create enough enthusiasm among the visitors.

Provide something to do for visitors

Dairy tourism also provides the opportunity to outsiders for practicing hands on practices for milking, Cow riding, cow feeding and calf management. The bullock cart riding, practicing agricultural operation, playing rural games with farming community, participating in cooking, chilling in nearby ponds, by arranging cultural programmes with the villagers and doing party, dance in rural local songs create ample opportunity to the urban visitors.

Provide something to buy for visitors

Dairy tourism also provides the outsider visitors to have rural crafts, buy authentic dairy products like desi ghee, pure milk, curd, Paneer other milk products. Even the fresh organic, chemical free vegetables, rural handicrafts, arts can also be bought by the guests during the village fair or festival. This will definitely push the rural small-scale industry by providing enough business opportunities for both the farmers and community members.\

Enterprises That Should Be Present in Dairy Tourism

- | | |
|---|--|
| A. Cattle house | B. Milking centre |
| C. Fodder field (Maize field/Sorghum field) | D. Pond/Water tank for fishing or boating |
| E. Milk Outlet | F. Handicraft Shop |
| G. Childrens`park | H. Bullock cart |
| I. Bio gas plant/Solar panel | J. Cottage/Camp |
| K. Restaurant | L. Picnic ground, Sport Ground/Swimming pool |

Sustainable Practices in Dairy Tourism

Sustainable practices in dairy tourism entail using eco-friendly techniques to reduce the environmental impact while delivering a satisfying visitor experience. For instance, supporting responsible waste management, using renewable energy sources, and using organic farming methods to lessen the need of chemicals. offering educational initiatives to promote understanding of conservation and sustainable agriculture. These initiatives ensure that dairy farming and tourism coexist peacefully, protecting the environment's beauty and resources for future generations.

Benefits of Dairy Tourism

Numbers of vital paths can be decoded by changing the overall scenario of Indian Dairy farming along with agriculture sector by bringing the enterprise driven futuristic cultivation practices. Dairy tourism has the potentiality to act as a breakthrough between both the front-end dairy farmers with their customer-oriented hospitality and the back end urban visitors who always find for recreation. So, it is a win-win situation for both the farmers, other rural villagers and visitors.

Farmers` gain

- Farmers can have a complement income opportunity along with dairy and crop farming.
- Specially during the lean season of low milk production or price fall due to market price farmer can have the alternative gateway to survive through market diversification through dairy tourism.
- Additional employment can be generated for rural landless farm family members.
- A positive attitude towards the dairy farming/dairy entrepreneurship can be inculcated among the rural educated youths.

Community benefits

- Other villagers will enjoy the fruit of overall rural development or socio-economic change through the strengthen of rural economy.
- The cultural blending by the tourism will make a positive impact in rural community as the rural people have a close contact with the urban modern lifestyle.
- Religious exposer for the people of different cast and creed irrespective of their age, perception and motive may establish the message of *Vasudhaiva Kutumbakam*.
- The **ITK (Indigenous Technology knowledge)** can be trapped by the urban people.
- Besides the innovative scheme like **ODOP (One District One Product)** by Govt of India surely can be promoted by the proper processing, marketing and most importantly by branding of the handicrafts, dairy and agro-processed products along with the name of products` place of origin.
- Conservation of bio-diversity within the dairy farms by establishing enterprise like fish farming, bee keeping, cultivation of horticultural plants and fodder cultivation for cattle.
- Linking and promotion of the historical and religious value of the place.

Tourists` gain

- Recreation in the lap of nature and also enjoying first hand training of cattle farming, crop production, dairy product processing.
- Opportunity to visit and interact with the real rural India and gathering authentic experiences.
- Free from frustration with crowded cities and resorts.

Economic Empowerment through Dairy Tourism

In micro (Individual farmer) level

The ways of income generation in a dairy tourism model for an Individual farmer: -

1. By selling tickets to the tourists in per head basis or family package basis.
2. Charging for arranging flooding and lodging in traditional huts for the guests.
3. Charging for cow riding, bullock cart riding, swimming practices in ponds.
4. Selling the locally branded dairy products like milk, curd, ghee, kulfi, sweets to the visitors in the dairy outlets of the farm and also make those products available in online market place like amazon-fresh, Flipkart, BigBasket etc.
5. Selling locally famous authentic products like handicrafts, boutique, wooden and pottery products like utensil, earthen toys for children etc.
6. Earning by auctioning fresh farm vegetables, fruits, fishes, honey among the urban people.
7. Exporting daily produce in different cities.
8. Collaboration with local famous brand and earning sponsorship.
9. Creation of You tube channel and earning from social media as a content creation by uploading dairy farming, maintenance, tourism related vlog or videos.
10. Marketing the by-products of dairy farms like cow dung as biofertilizer and earning urban currencies.

In macro level

1. Earning through dairy cooperative model.
2. The tourism industry attracts the hotel industry and enough chances to earn sizeable profit from it.
3. Creation of multiple job opportunities for local villagers as workers in dairy farms, tourist guide for city people.
4. Marketing and branding of indigenous products for export.
5. Strengthening of small and medium scale industry at grassroot level by injecting urban rupee.
6. Overall economic boost for rural farm families and tourism spending will create multiplier effect on consumerism pattern in village level.

7. Making regional economy Atmanirbhar or self-reliant by promoting the concept of Agri entrepreneurship, Agri-tech Start-up etc.

Bottlenecks Present in The Way of Dairy Tourism for Small Holder Dairy Farmers

- ❖ Lack of initial capital investment for small holder farmers.
- ❖ Low risk bearing ability to start a new venture.
- ❖ Strong attitude in traditional dairy practices and preserving prejudice for dairy tourism type of innovative idea.
- ❖ As most of the Indian dairy farmers belong to small or marginal category, the fragmentation of land makes it difficult to initiate a venture like modern dairy plant, eco-tourism etc.
- ❖ Lack of transportation facilities in remote rural areas of tourism.
- ❖ Low range of skill of villagers to meet the customer/tourists` satisfaction.
- ❖ Sometimes the language barrier between the rural and urban people along with strong taboos, myth in rural areas towards outsiders may create hinderance.
- ❖ Political issues

Promotional Strategy of Cow/Dairy Tourism

Capacity building of the farmers

The farmers should be properly trained and educated about the basics of tourism and dairy farming. Here the extension personnel from veterinary as well as agriculture and specialists from tourism industry can play the active role to train the farmer and make them motivate to start the business in commercial way.

- Making the bank credit smoothly accessible to the maximum number of willing farmers through commercial banks or micro finance agency is absolutely important.
- Weekly or monthly training of the dairy farmers, arranging workshops in village level, showcasing the dairy tourism model and demonstrating it in front of farmers can build capacity of the small holder farmer.
- Motivate the farmer through sharing successful dairy tourism or agro tourism farmer friend, taking the group pf farmers to exposer visit of such type dairy farms.
- Providing monetary incentives in terms of subsidy or cost cutting of various inputs.

- Teaching the farmers regarding how to deal with the guests, make them feel homely, maintain cleanliness in tourist spots, how to get feedback from the outsiders etc.

In order to educate farmers about the vast potential of cow tourism, students and researchers in dairy extension and agriculture extension are welcome to join. A model of dairy tourism was recently presented by M.Sc. research students from the ICAR-NDRI dairy extension division at the National Dairy Mela 2023, which was held in Karnal, Haryana.

Collaboration with other organization

For growing the tourism and dairy industry collaboration with multiple organizations or agencies is necessary. For promotional activity, marketing, brand building and even for well sophisticated infrastructure dairy entrepreneur should go for 3p(public-private partnership) model. Joint venture with hotel or hospitality industry, Partnership with restaurant food and beverage industry etc can also be done to expand the business in large scale.

Other ways of promotion

A satisfied customer is the best advertiser of any product or services. So, businessman should concentrate to please the visitors whole heartedly by means of all the possible services. Besides promotion and marketing in newspaper, radio, television can create enough enthusiasm among urban people. Now in today's era Facebook, tweeter, You-tube, Instagram, LinkedIn are the primary tools to reach a million numbers of people in short span of time. So advertisement in Social media platform will be more effective.

Policy Support and Future Directions

The Union government is exploring a new tourism opportunity. States for this circuit have been identified as Haryana, UP, Rajasthan, Gujarat, Maharashtra, Karnataka, Kerala, and Goa. Himachal Pradesh plans to raise visitation to its "cow sanctuaries". According to reports, the ruling party is working on a plan to connect the tourism industry with eleven new cow sanctuaries. To now, five cow barns totalling Rs 26 lakh each have been constructed at a cost of Rs 1.30 crore with steel foundations and pre-painted sheet roofs. Together with an NGO named Hari Gaussian, the department of animal husbandry is currently running a Gausadan at Sunni that can accommodate 200 animals. Kotla Barog (Sirmour), Thana Kalan Khas (Una), Handa Kundi (Solan), Khairi (Hamirpur), and Luthan (Kangra) are the only cow

snatching grounds left in existence today. Thus by bringing the private sector, NGOs ,dairy cooperatives in one place the virgin market of dairy tourism can be trapped and a new path will be opened for small holder farmers.

Conclusion

Since India's economy is largely rural, rural tourism and agritourism are essential for creating jobs, reducing poverty, and fostering long-term human development. They also considerably contribute to the GDP of any nation. Two and a half times faster than the world growth rate, the Indian tourist industry is expanding at a 10% annual rate. Health tourism (medical tourism), religious tourism, sports tourism, educational tourism, etc. are some of the niche tourist arteries that have recently acquired pace in India. The Indian tourism industry increasingly includes dairy tourism as another artery. Although it is currently in its infancy, it has the potential to take off with the right government incubation. so spreading the idea of agrotourism throughout India, not just the current.

References

- Fusté-Forné, F. (2021). Dairy tourism: A local marketing perspective. *Dairy*, 2(1), 14–24. <https://doi.org/10.3390/dairy2010002>
- Government plans cow circuit to boost tourism. (2019, July 1). The Times of India. https://timesofindia.indiatimes.com/india/government-plans-cow-circuit-to-boost-tourism/articleshow/70016655.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst&pcode=461.
- Mujkherjee, S., & Ranjan, A. (2020). Agritourism iin India: A Virgin Market. *Agriallis*, 2(9), 50-54. <https://agriallis.com/issue/volume-2-issue-9-september-2020/>
- Praharee, T. P. (2019, July 10). Cow-tourism –as latest startup in india | pashudhan praharee. <https://www.pashudhanpraharee.com/cow-tourism-as-latest-startup-in-india/>
- Ayush, Gangotia, A., & Pradhan, B. (2023). Social entrepreneurship and cow tourism: Exploring the new vistas of experiential economy. *Journal of Enterprising Communities: People and Places in the Global Economy*, 17(6), 1495–1510. <https://doi.org/10.1108/JEC-04-2022-0049>