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Dairy Biotechnology: Towards Sustainable Dairy Future

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Agriculture, since times immemorial, has formed the backbone of India's economy, and still remains crucial for food, livelihood and economic security, surpassing all the cultures in this dependency. It directly or indirectly provides employment to about 40% of the country's working population, taking country to one of the top five agricultural economies of the world. Despite of its significant role and status, Indian agriculture is at a serious inflection point, facing a multitude of grave challenges like: lagging yields in key crops, restricted market access, limited water availability, market competitiveness, lack of sufficient post-harvest interventions and value-addition techniques and a general trend of prevailing traditionalism in the sector lacking the ingression of commercial and modern thought at the field level. This compels for tailoring the extant policy towards technological interventions targeting everything from farm inputs to final delivery to the end consumer- aiming consistently for more production per unit or as the Hon'ble Prime Minister **slogans for "*Crop for every Drop*".**

With all its ups and downs since the last 70 years, livestock sector has emerged as a sustainable engine of agricultural growth ensuring both nutritional and economic security as well as reduction in rural poverty; contributing about 26% of the Agricultural Gross Domestic product. With gradual transition from traditional to technological/scientific husbandry, milk production showed an increase of 1100% as against population increase; *vis-à-vis*, 24% in cattle and 153% in buffalo, since 1950s. The country now ranks first in terms of total milk production (~230 Million tonns), with per capita availability being about 460grams/day. But the ranks and availability warrant celebrations, owing primarily to lesser milk yields per animal, slower growth rates, huge proportion of inferior animals, late sexual maturity and lesser number of calves born per animal life. This compels for technological reforms which would revolutionize the Dairy sector and open the gateway for transition from *Animal-population-based* increase to *Animal productivity-based* increase- considering the fact that: i) Milk forms the largest agricultural commodity in terms of the value of the commodity produced in the country; ii) Livestock holding in general and milch-animal holding in particular is far more equitable than land holding; iii) Significant contribution and share in farmers' income, with about 67% of income from "*Farming of animals*" being attributed to income from dairying.

Thus the earnest need of the hour, considering the deleterious and stressful interplay between the huge livestock population with the increasing human population and accruing serious competition for available resources of land, food, water, air and services, necessitates the development and implementation of Dairy Biotechnological tools which shall mitigate the serious challenges, while making us ***future-ready*** for achieving more output per unit animal, land and water. Dairy biotechnology interventions thus assume greater and prime significance for the stakeholders as well as policy makers for realizing the much desired changes and impact at the field level, across the country. The lesser growth rate recorded in dairy sector in the UT and negligibly developed dairy processing scenario, together with acute feed and

fodder scarcity and disease prevalence and frequent epidemics constitute the Pandora's box which needs to be contained and emptied at an earliest. Being unavoidable at one hand, the implementation of biotechnological tools provides not only hope but realistic real-time solutions for ameliorating the scenario, while leading to development of the desired and much needed dairy chain on the other hand. This shall lead to development of sustainable dairy ecosystem by speeding up the dairy-wheel in a direction that commits no overexploitation of the natural resources while reducing farmers' dependency on external inputs at the same time.

The institutional support for appropriate technologies targeting low quality germplasm, non-scientific and indiscriminate breeding, inferior quality feeds and fodder, high disease prevalence, late sexual maturity, vaccine insufficiency, low digestible feeds and fodders, poor growth rate, lesser milk yield and calves born per animal, etc. shall be made readily available at the field level for boosting of both the morale as well as economic security of the stakeholders involved in dairy sector. Few biotechnological interventions practiced in the country as well as in UT since decades, have proven very beneficial to dairy sector and many more which shall certainly contribute to development of superior animal repository and novel dairy products need to be implemented across the country. Biotechnological interventions in dairy sector have played a pivotal role in a number of broader areas which include but are not limited to:

1. **Superior Dairy Animal Production**: Biotechnological tools enable both identification as well as selective propagation of high quality dairy animals. Artificial insemination (AI) as an Assisted Reproductive Technique (ATR) has been used since decades across the country for up-gradation of the local inferior dairy cattle and has proven very successful in raising milk yield and reproductive/productive performance of the ensuing crossbreds with exotic Jersey and HF semen. Use of conventional semen in artificial insemination is now getting replaced by sexed semen which increases probability of female birth by 90%, otherwise being 50% in conventional AI. In order to achieve rapid multiplication of the elite germplasm, ARTs like Multiple ovulation and embryo transfer (MOET), in vitro fertilization (IVF), Ovum-pick Up (OPU-IVF), Reproductive cloning have been developed and implemented at field level across the globe. These techniques exploit the superior genetics of both the parents unlike AI where only superior male genetics is exploited.
2. **Selection of genetically superior animals:** Traditional methods of superior animal selection relied on measurement of phenotypic traits like milk yield, milk fat percentage, growth performance, age at sexual maturity and inter-calving interval, etc., most of which required long waiting intervals and hence hindered faster and reliable evaluation. Modern biotechnological interventions enable identification of markers/ genes associated with high genetic merit and disease resistance and hence faster and reliable selection of the superior animals and their subsequent multiplication for production of the superior replacement stock. This would save too much resources and time consumed on rearing an inferior animal in absence of reliable selection procedures.
3. **Transgenic animal production:** Production of dairy cattle embryos/animals with artificially introduced genes for desirable traits is now a reality and animals/embryos producing insulin, lactoferrin, beta-globulin, etc. in their milk have been produced. Gene edited is being currently practised in animals for enhancing their muscle mass as well as desirable traits. The future of this technique shall ensure *designer animal* production and harvesting of valuable pharmaceuticals from milk, urine and/or muscle of the animals.
4. **Dairy products and value addition:** Enzyme technology as well as technological interventions in traditional fermentation has played a commendable role in improving the quality and value addition of milk and milk products like cheese, yogurt, and other dairy functional foods. The intervention has remarkable applications in dairy product bio-preservation, probiotics, and derivation of milk bioactive peptides, starter cultures and genetic manipulation of both milk and gut micro-biome. These tools are ready for large scale implantation in dairy animals for achieving maximum economic returns.

5. **Feed additives and supplements:** To enhance feed digestibility, nutrient value and hence achieve more output per unit input of feed, biotechnological interventions have a significant role to play in terms of feed additives and supplements. Biotechnological interventions could improve the plane of nutrition through protection of proteins, aminoacids and fat in animal feed. Immune supplements to inhibit pathogenic bacteria, addition of antibodies and genetic manipulation of rumen microorganisms and manipulations for treatment of fibrous feeds would go a long way in dairy sector by enhancing more production per unit feed consumed. Biotechnological interventions for enhancing the quality of dry fodders have much scope in valley considering the winter scarcity of green fodders.
6. **Customized flavour profile of dairy products:** Biotechnological interventions for development of starter cultures and enzymes have the potential to enhance/modify the flavour and appearance of dairy products for higher market returns.

In addition to these broad areas, biotechnological tools have the potential to influence many more areas in the dairy sector right from animal birth to its final disposal in the market and thereafter. Assisted reproductive techniques in particular have the potential to develop a superior quality animal herd at a rate, 50-100 times faster than traditional methods, leading thereby to development of replacement stock that shall produce more per unit animal and hence reduce the completion with humans, while strongly ensuring their nutritional and economic security at the same time and preserving, rather enhancing, the environmental and natural biodiversity which are the pre-requisites for saving the planet and sustaining the life on earth.