OPEN ACCESS
Advances in Animal and Veterinary Sciences

Research Article

# Science, Society and Humanity in Mainstreaming Indigenous Knowledge Research System (IKRS) from Southern Regions of India: An Evidence for Honey Bee Network (HBN) Philosophy

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**Abstract** | Utilization of knowledge, skill to sustain employment opportunities near to place of dwelling offers greater scope for livelihood. Livestock occupation provide such prospects and supported by Indigenous Knowledge Research System (IKRS). Diversified institutional approaches are explored in mainstreaming IKRS for benefit of end users. National Innovation Foundation-India had succeeded in implementing IKRS by recognizing custodian of knowledge in their ecosystem. This research vindicated *Honey Bee Network* philosophy of linking people to people, involvement of informal society in experimentation and intrinsic motivation for social cause. During a collaborative activity with district administration, novel medication in treatment of mastitis was disclosed by *Shri. Boya Petharajanna,* an outstanding traditional knowledge healer. The study stressed importance of *knowledge network* as *Shri Harshadbhai Patel,* traditional knowledge healer facilitated leveraging contacts and experimentation with farmers. An external intervention acted as catalyst in demonstrating ethical values of society in technology transfer approach. It was also noticed that *Shri. N Govindan* traditional knowledge healer from different geographical region practicing same medication. This illustrates utility value of IKRS and this research is first of its kind to share same knowledge/practice applied by healers residing far apart. Characteristics of IKRS in identification, diffusion and institutional engagements during application of frugal innovations were shared. These findings clarified different designs of action research in integration of affordable technologies for enhancing quality livestock service. Further, this is an attempt to network knowledge holders (informal society) through their novel knowledge so as to share different pattern of social relationships.

**Keywords** | Indigenous, Mastitis, Utilizer system, Smallholder, Knowledge network

**Editor** | Alok Sharma, Professor (VMI) & Head, Dept. of Veterinary AH Extension Education, Dr. G. C. Negi College of Veterinary & Animal Sciences, Palampur, Himachal Pradesh, India.
**Special Issue** | 1(2016) "Welfare issues, Environment, Societal learning and Innovation in Livestock Science"
**Received** | June 21, 2016; **Accepted** | July 11, 2016; **Published** | July 20, 2016
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**Citation** | Ravikumar RK, Petharajanna B, Govindan N, Vivekanandan P, Alagumalai V, Subramanium Y, Patel J, Patel H, Hariharan M, Kumar V, Kumar V (2016). Science, society and humanity in mainstreaming indigenous knowledge research system (IKRS) from southern regions of India: An evidence for honey bee network (HBN) philosophy. Adv. Anim. Vet. Sci. 4(1s): 20-31.
**DOI** | http://dx.doi.org/10.14737/journal.aavs/2016/4.1s.20.31
**ISSN (Online)** | 2307-8316; **ISSN (Print)** | 2309-3331



## INTRODUCTION

### Significance of Indigenous Knowledge Research System (IKRS)

Indigenous Knowledge Research System (IKRS) support farmers by assisting their occupation in livestock through healthcare and productivity. This is paramount for small, marginal farmers as they rely on livestock for food security, monetary incentive (Biradar et al., 2013). Farmers with low income find it difficult to avail products or services with high cost (Simula et al., 2015; Rastogi et al., 2015). They try and seek IKRS based on their experience

and knowledge shared in their community (Das and Tripathi, 2009; Rast et al., 2014; Eswaran et al., 2013). These systems help them in regions where modern veterinary infrastructure is limited and in places with minimum/ lack of accessibility (Samal et al., 2003; Maiti et al., 2013; Ganesan et al., 2008). Traditional livestock practices were prevalent as plant based treatment do not have adverse side effects (Rajakumar and Shivanna, 2012; Ghosh, 2002; Beniteza et al., 2012; Gakuubi and Wanzala, 2012) and have better efficacy than conventional drugs (Ndhlovu and Masika, 2013). In developing countries about 80 percent of people rely on indigenous veterinary medications (Mooventhan et al., 2016). However, necessary technical assistance have to be provided to farmers in understanding medications for overcoming animal health constraints (Dione et al., 2014). Public policy need to encourage innovations in support of poor and enable informal system to utilize existing knowledge (Dutz, 2007). Chander and Rathod (2015) indicated in majority of countries public policy and extension system were important instruments in technology generation and innovations to emerge from farmers. Considering escalating cost of farm inputs, application of IKRS will be relevant. Gupta (2012) referred that learning from outstanding knowledge holders and grassroots innovators can offer extremely affordable technologies.

IKRS has to be viewed beyond technological aspects as knowledge holders had established social capital through their empathetic nature and ability to perceive problem of community. Experimentation of IKRS in India with farming community in different regions reinforced Honey Bee Network (HBN) philosophy of recognizing knowledge holders as an essential, ethical way in sustaining creativity (Kumar and Ravikumar, 2016). The HBN was established by Prof Anil K Gupta in 1988 to identify innovative solutions from common people and empower them to form knowledge network (Ustyuzhantseva, 2015). Communities listen and organize with help of knowledge holders due to credibility of indigenous practices working in their situation (Devgania et al., 2015). Tacit value of knowledge systems were still unexplored as medication to treat bloat ailment was found to have positive environmental impact (Munda et al., 2016). It is necessary to share critical awareness of conserving biodiversity by communities as well (Singh, 2010). Changes in livestock rearing pattern compounded with lack of effective technology in field situation resulted in demand for technological alternatives. Low Cost Locally available (LCLA) solutions can be derived from IKRS (Kadivendi et al., 2015; Ghorai et al., 2016) that can maximize farm output and livestock welfare. These technological options were viewed to support sustainable agriculture without poverty by United Nations Centre for Alleviation of Poverty through Sustainable Agriculture (CAPSA-ESCAP, 2015).

## Technology Transfer in Farmers Field

Technology transfer can be successful if only farmer's skill, knowledge and practice become part of intervention program. This depends on nature of advice and outcome of experiments which determine degree of engagement (Zander et al., 2013). Actual experience in farming needs to be reflected while planning strategies for demonstrations (Brian and Chatterton, 1982). Farmers' necessity to be linked with innovations and formal system have to support these innovation systems (Poncet et al., 2010). The challenge is how to introduce new practices as it determine the success of large scale transfer of technology. New idea or practice has to meet imminent requirement of farming system, ease difficulty of application, reduce dependence and to utilize existing resources. This can enable farmers to visualize applicability and maximize desired function of technology with support of intervention agencies. In most circumstances, external support may sensitize and provide advisory role as and when required but not beyond. Different models of engagement have to be unearthed as farmers' management practice differ in countries (Zadok and Fitzpatrick, 2009). Further, farmers tend to reject technologies which were not suitable in their situation (Rao et al., 1995). This is compounded by the fact that availability of alternative technologies promoted by public system at farm field has been a major hurdle in enhancing livelihood.

The importance of on-farm research models has been stressed and success are measured through its inclusiveness (Vatta et al., 2011). IKRS can be an entity as creative communities maintain them for their sustenance, derive these wisdom from their surroundings and try to maximize benefit. Efforts were made for utilizing IKRS, however measures to transfer and derive advantage by linking with knowledge holders have to emerge. Knowledge holders were not connected with stakeholders even with existence of effective informal network among them (Gupta, 1997). Grade et al. (2009) found that organized healers can able to share more information and assist in diffusion. This is an important factor as healers may not always share novel medications (Romha et al., 2015) due to their inherent struggle in learning, protecting them. New approaches have to be considered and linear approach of origin of technological innovations from research stations to end users have to be corrected (Prasad, 2005). In the sphere of livestock innovation system in India, National Innovation Foundation-India had provided desired models of engaging IKRS such as empathetic innovation model (Devgania et al., 2015), peer group innovation/peer group participation model (Munda et al., 2016). However, these knowledge systems have to be integrated with regular service provider or formal systems (Lwoga et al., 2010).

## IKRS and its Implementation: Formation of Active Utilizer System

Effective model of disease control program have to be advanced as livestock population is distributed and maintained by diversified communities. Livestock system has been plagued by poorly trained service providers as accessibility to quality veterinary service was limited due to geographical distance (Lamichhane and Shrestha, 2012). Jansen et al. (2010) refer that technologies and education materials need to be used for measuring success of any intervention. Ability to take suitable decision and availability of technologies while delivering intervention strategies were constraints in disease control program (Ramkumar et al., 2003). Policies to control disease alone may not succeed as farmers' social network plays an important role. Social relations are an essential element in facilitating adoption of practice (Massimi et al., 2016). Variables in terms of human-animal-environment in these small holder livestock production system are interdependent (Cooper et al., 2016). Thus realisation of program depends on participation of farmer, their input and perception of impact of intervention. Reduced financial resource of public system resulted in structural adjustment policies in developing countries, however it is not followed up with appropriate strategies (Woodford, 2004). This had resulted in more vulnerable environment for smallholder livestock production system. Approaches like village animal health workers were tried to work closely with farmer engagement and recommended strategies like preventing ailment business model (Stratton et al., 2015).

Calba et al. (2014) reflected that poor primary health care necessitated seeking service of village level animal health workers that build on trust between them with government officials. Technologies derived through convenience of research and industry system face uphill task of acceptance (Kadivendi et al., 2015). Role of scientists in support of marginal communities based on identification and value addition to technological alternatives does exist (Gupta, 1995). It can be possible only through enhancing dialogue between knowledge holders and dairy animal owners (Gaikwad et al., 2015). In technology utilization process, mobilization of community has been vital factor and formal institutions need to support particularly during phase of implementation (Ravikumar et al., 2015). Acknowledgement of local solution by farmers and recognizing creative healer had broadened scope of evolution knowledge systems (Devgania et al., 2015). Stakeholders have to imbibe values and respect knowledge from informal society for sustenance of frugal innovations (Surtia et al., 2016). The framework in development of active utilizer group for IKRS has been articulated such as *Non Linear Innovation System* and *Open Source Innovation System* (Kumar and Ravikumar, 2016; Ravikumar et al., 2016). Still there is dearth of research in understanding the process and formation of active utilizer system. The problem is more acute with IKRS as formal service system were yet to appreciate potentiality of frugal innovations due to their orientation. There is also an urgent necessity to create environment for participation of youth, elders, knowledge holders for ethical social behaviour towards overall development (Raot et al., 2016).

## Participatory Livestock Policy Framework towards Control of Mastitis

The critical factor for farmers' to seek veterinary service is familiarity with key resource personnel's and their proximity to avail service (Woods et al., 2003). The social norm among farmers play an important role in protecting welfare of animals (Swinkels et al., 2015). The degree of dependence on their social network for seeking information rely on ability to take risk and trust reposed in their system (Sligo and Massey, 2007). These network can work in unison in accomplishment of common social goal through belief, reciprocity thereby creating social capital (Gupta et al., 2003). It was opinioned to strengthen communication strategies as farmers' were unable to access scientific practices (Alarcon et al., 2014). Accessing information by farmers' held through socially mediated process and gender issues are pertinent to address (Leckie, 1996). In disease control strategies requirement for continued capacity building of farmers were stressed as it helps in diffusion of knowledge (Rast et al., 2014). However, there is a necessity for participatory policy formulation wherein intended users play an active role (Josephine et al., 2007). IKRS can very well be applied, acted upon by farming community than conventional medications. Farmers can play active role in IKRS as most inputs for preparation of technology originates from their own surrounding.

Despite several research, control of mastitis ailment remains a challenge which was attributed to multifactorial cause as well as cost of treatment (Moges et al., 2012). The dairy industry in India lose about INR. 6053.21 crores annually due to udder infections (Reshi et al., 2015). Studies also found that animal loses fifteen percent of production potential and affected quarter with reduction up to thirty percent milk producing capacity (Hamadani et al., 2013). The incidence rate of clinical mastitis was estimated at thirteen percent (NAAS, 2013). Mastitis, even in subclinical form affect tissue of mammary gland (Batavani et al., 2007), however, available therapies mostly rely on control of infection. A study by Sinha et al. (2014) indicated about INR 509 (7.63 USD) was spent for control of subclinical mastitis through medication and services. In countries like United States loss to the tune of INR 13,333 (200 USD) per cow per year was reported due to mastitis (Boldyreva, 2014). It was also well established fact that repeated and improper use of chemicals enhance bacterial resistance (Awandkar et al., 2013; Abrahmsen et al., 2014) thereby

reduce effective health care for mastitis. It is also pertinent to meet requirements of regulatory authorities in export of milk or milk products and in most circumstances decision is taken at farm level based on experience and economic factors (Suriyasathaporn et al., 2012). Minimizing negative impact of mammary infections through supportive therapy like Nonsteroidal anti-inflammatory drugs were recommended (McDougall et al., 2016). National program launched in countries like Netherland indicated improvised attitude, knowledge and behaviour of farmers were essential in control of mastitis (Jansen et al., 2010a).

Complementing formal institutional efforts with IKRS can be ideal as it will reduce use of antibiotics in treatment of mastitis. These knowledge systems are prevalent worldwide (Gakuubi and Wanzala, 2012) and it is essential to understand their useful impact in clinical situation. IKRS has to be part of formal institutional service as practices adopted by farmers were not being comprehended adequately by service providers (Ravikumar et al., 2004). Studies call for integrating these knowledge system in veterinary services as farmers' were knowledgeable, experienced in treatment of livestock ailments (Gabalebatse et al., 2013). Therefore, research questions were formulated in aspects of identifying creative knowledge, management of new idea from IKRS, demonstrating importance of social values, ethics embraced by informal society and scientific validation of documented IKRS in farmers' field.

## MATERIALS AND METHODS

The study was conducted during the period 2008-12 to look into technological requirement, availability of alternative source of knowledge, understanding barriers towards knowledge network, experimental spirit of farmers and validation of IKRS against clinical mastitis. A large scale livestock intervention program was initiated with help of District Administration and Animal Husbandry Department, Anantapur, Andhra Pradesh State of India by organizing village meetings, interaction among officials of dairy cooperative societies for identifying and recognizing livestock healer's in-front of their community. The aim of research study is to present process of engaging animal husbandry institutions, mobilizing farmers to share their wisdom, acknowledging and strengthening *knowledge network* for sustaining social value held by them over a period of time. The study shared orientation of informal scientific society viz., farmers, knowledge holders and their values as individual, group so as to have holistic perspective of implementation of IKRS in a village situation. Efficacy trial of disclosed novel medication (DeMast-P) against mastitis in animal was conducted with help of livestock owners in regions of Gujarat and Tamil Nadu, India. This study is an attempt to collaborate with district administration, experimental farmers, and knowledge holders so as to unearth creative potential of grassroots livestock innovation from informal society.

### Clinical Examination – An Important Diagnostic Tool

Clinical examination of udder has been conducted through general examination of udder and the macroscopic examination of milk (Marogna et al., 2012). The macroscopic appearance of milk was classified into apparently normal, curdled milk consistency, creamy yellow colour milk and flakes. Ten clinical cases were chosen for the study. In the study population it was found that 5 animals were in second lactation, three in first & two in Third stage of lactation. Among test animal population one clinical case belongs to buffalo species and remaining nine were crossbred animals. Except for three clinical cases in remaining seven animals, mastitis was limited to single quarter.

### Collection of Milk Sample

Teats were washed thoroughly and dried with a single use paper towel. The first three streams of milk from each teat were discarded. The teat end and orifice was sanitized with cotton swabs and approximately 5 ml foremilk sample were collected from each quarter of cow in a sterile tube. Samples were maintained at refrigerated temperature and transported to the laboratory for microbiological examination. The examination was conducted within 24 hours of sample collection.

### Observation Period

The affected milk quarter were observed for 10 days starting from Day O (pre-treatment period), Day I, Day II, Day III, Day VI and Day X. The diagnosis of the ailment was based on signs, clinical examination and bacteriological culture. Clinical evaluation were studied based on bacterial isolation, tissue irritation and nature of milk. Physical examination and quantification of parameters like swelling, erythema and pain/heat were observed for understanding tissue irritation of udder due to clinical mastitis (Raot et al., 2016). Most of these animals had shown clinical signs for 0-5 days before treatment. Three clinical cases were treated with intramammaries containing ceftiofur (Third generation cephalosporin), cefquinome (fourth generation cephalosporin) and Ceftriaxone and Tazobactam. These animals failed to respond with conventional medications and presented for clinical study. In all clinical cases treatment with unique herbal medication was initiated and directed against causative pathogen. Prescribed duration of treatment was ranged from 2 days to 4 days.

### Codification Based on Nature of Milk and Statistical Analysis

The nature of mastitis affected milk were recorded as Nor-

mal, Apparently normal, Creamy yellow/Flakes, Curdled, Curdled and Fibrosed quarter, Thelitis and scored from 1 to 6 in order of severity. The data were codified and analysed statistically (Gupta, 2000).

## RESULTS AND DISCUSSION

### Management of Livestock Innovation from IKRS

Development of technology in livestock sector mostly rely on research stations and industries response that was based on market potential. However, these were hampered by either non applicability or poor response to treatment owing unique farming situation. Mastitis, an ailment affecting milk production and welfare of animal has been a challenge in small holder livestock production system. Upon invitation by District Administration, National Innovation Foundation-India launched livestock intervention program with the support of veterinary institutions. Village meetings were held in places viz., Utakur, Hindupur, Rachapalli, Kalyandurg and Utyahal of study region. It was found that modern technologies were sporadically available and offered incomplete protection, which required veterinary institutions to recognize knowledge holder *Shri. Boya Petharajanna* in treatment of mastitis. The healer was scouted with the support of Dairy co-operative society, Kalyandurg based on his popularity for treatment in these regions. Acknowledging knowledge holder is vital for civil society to sustain new ideas' or practice (Devgania et al., 2015). Poorly functioning knowledge system in agricultural system may be one such factors for lack of technology and their application (Nwakwasi et al., 2012). Studies reflected that higher degree of novelty of plant based indigenous livestock practices have to be harnessed (Carrio et al., 2012). The study exemplifies nature of indigenous knowledge system and importance to listen, utilize IKRS in existing institutional arrangements for effective livestock service.

The study also found *Shri N Govindan* from region of Salem, Tamil Nadu located 415 KM away from Anantpur, Andhra Pradesh has same knowledge. The applicability of knowledge to practice was held in wider geographical region and reinforce credibility of practice. The healer claims to have cured more than 1000 clinical cases in and around his village for the past 30 years. Field investigations based on farmers recall value indicated at least 70 clinical cases were cured in villages viz., chelliyampalayam, Minnampalli, Agrakaram and Ayothyapattinam in recent past. Multi-locational and multi-ethnic use of any medicinal practice was assumed to be an evaluation criteria for understanding efficacy against clinical condition (Jain and Verma, 2014). The study revealed credence of healer(s) in their vicinity in protecting welfare of animals and control of mastitis ailment. In management of innovations, exchange of knowledge among members of society provide rich dividends (Ravikumar et al., 2016a). The general opinion that modern technologies (conventional medications) alone can work in all situation and in larger geographical area may not hold true as reflected in this study.

Complexity within which IKRS sustain without support of formal working arrangements and utilized by farmer's have to be understood. A systemic support to IKRS if initiated can help to reach desired scale of utilization in extensive regions. This study assumes significance as folk medicines of India were compared in other countries as well (Jain and Srivastava, 2003). Further, there were evidences wherein large herd size farmers do have faith on IKRS (Bashir et al., 2011). There is an urgent necessity to strengthen linkage between farmers' and IKRS as decision making ability of farmers in these regions reflect usefulness of new idea/practice. This also reinstate belief that farmers are keen to seek advice, assistance from knowledge holders in their locale. The framework has to leverage these network relationship of farmers, knowledge holders with the service of formal veterinary institutions. Response to IKRS have to be suitable keeping with characteristics of these systems such as empathy, knowledge, natural resource, network of working relationship, etc., Socially relevant action research are essential for formation of knowledge network (Raot et al., 2016). Studies have to be conducted to understand and build upon the capacity of these factors to enrich IKRS.

### Reinforcement of Social Concern: Beyond Monetary Incentive

Organized efforts of formal institutions were carried out in several livestock intervention program. However, involving informal society in experimenting and leveraging their network to build local institutions were limited. Interaction with traditional knowledge holder *Shri Harshadbhai Patel* from village Bochasan, Anand district of Gujarat had provided a window of opportunity to understand leadership qualities and attitude of knowledge holders towards betterment of society. The village is situated 94 KM away from Ahmedabad, Gujarat State, India and villagers had bestowed greater trust on him. This had enabled communication author to walk into farmers' premise with ease for conducting experimentation. Farmers whose animals were affected with mastitis had shared relevant details to healer during experimental period. Farmers' viz., Vinodbhai Chottabhai Patel, Mahendrabhai Patel, Rajinibhai Patel, Vinubhai Babarbhai Parmar, Mohanbhai Narsibhai Parmar, Mrs. Manekaben Parmar and Ashokbhai Patel were keen to cooperate and implement cost effective herbal solutions derived from IKRS. Their acclamation of healer was palpable during the entire course of study. Demonstration of novel technology by indigenous healer helped research group to establish, strengthen institutionalization

**Table 1:** Case history and clinical examination

| SN | Species | Age | Stage of lactation | Milk / day | Affected quarter | Anorexia | Reduced water intake | Sudden drop in milk yield | Painful swelling in udder |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Crossbred | 5 | Second | 9 | RF | Nil | Nil | Nil | Nil |
| 2 | Crossbred | 4 | First | 8 | RH | Mild | Nil | Nil | Nil[1] |
| 3 | Crossbred | 6 | Second | 10 | LH | Moderate | Mild | Severe | Severe |
| 4 | Crossbred | 6 | Third | 12 | RF | Moderate | Mild | Severe | Severe |
| 5 | Crossbred cattle | 5 | Second | 9 | RF | Mild | Nil | Mild | mild |
| 6 | Buffalo | 8 | Third | 7 | LH | Nil | Nil | Severe | Severe |
| 7 | Crossbred cattle | 5 | First | 8 | RF | Nil | Nil | Nil | Severe |
| 8 | Crossbred cattle | 5 | Second | 11 | LF | Mild` | Nil | Nil | Severe |
| 9 | Jersey Crossbred | 6 | Second | 8 | RH | Nil | Nil | Mild | Nil |
| 10 | Crossbred | 4 | First | 12 | All | Mild | Nil | Severe | Severe[1] |

[1]Animal did not allow to touch affected quarter

of resource person in their premise based on prerequisite of farmers. This is in concurrence with Minh et al. (2014) as formation of network may be moderated through demand of farmers. This had effectively created active utilizer system for use of IKRS practices by end users.

Studies refer that for every single clinical case of mastitis at least 15-40 subclinical cases are expected (Du Preez, 2000). In the study region farmers tried to use antibiotic intramammary infusion with a cost of INR 305 (4.575 USD) per administration. Study conducted by Naresh et al. (2002) indicated that on an average 5 days were required for therapeutic cure with antibiotic intramammary infusion. Hence, an average cost of INR 1525 (22.875 USD) per animal towards cost of medicine alone was likely to be incurred by farmers in study region. This is in concurrence with Devgania et al. (2015). Traditional knowledge healer helped farmers by informing about these clinical cases with research team so as to control mastitis ailment. During on-farm experimentation, social skills such as explaining the purpose with people, maintain trust of villagers and to act as a point of reference through knowledge were demonstrated by healer. The study revealed that the traditional healer had acted as *gatekeeper* in his society through his social skills and expertise in identification of livestock problems. This reiterate the importance to link public domain activities with healers through trust for minimizing cost of inputs (Devgania et al., 2015). The nature of motivation in leveraging contacts by healer within society and with external/formal institutions have to be investigated. This may be related to social goal for welfare of animal, society and belief in utility value of traditional knowledge derived from elsewhere. Honey Bee Network articulates this specific requirement of providing intellectual space to creative community in location nearest to place of intervention. These knowledge system were sustained even with major social transformation due to extraneous forces and can provide benefit to non-indigenous context as well (Kawagley and Barnhardt, 2005). The study vindicated that formation of active utilizer group is an essential step for scaling up of technologies. Factors like leadership, social skills, purposive action for benefit of society and social capital of knowledge holders have to be taken into account while enhancing scope of livestock health care. Communities effort to make impact through their knowledge system involves being part of design, action in their role so as to make appropriate policy response (Popay et al., 2008). The nature of social interaction, different models of recognition, networking with stakeholders can expand and provide intellectual space to creative communities.

## Validation of *DeMast-P*: A Novel Medication from IKRS

Ten clinical cases as referred by farmers were examined for confirmation of mastitis and its impact over physiology of animal. Clinical examination indicated that affected animals were noticed with anorexia, reduced water intake, sudden drop in milk production and painful swelling in udder (Table 1). Sharma and Adlakha (1996) refer that acute staphylococcal mastitis cause fever, hardening of quarters, stoppage of milk secretion and with pus secretion. Tissue irritation was examined by visual examination of udder parameters like swelling, erythema, pain (heat) and nature of milk (Table 2).

**Isolation of Causative Organism:** Very little attention is paid to usefulness of culturing bacteria and developing treatment protocol. Hence milk samples were tested to isolate causative organisms based on cultural characteristics (Table 3). *Staphylococcus aureus* (Gram positive), *Pseudomonas aeruginosa* (Gram negative) and *Klebsiella pneumoniae* (Gram negative) were isolated. *Staphylococcus* sp., was predominantly (73.5%) detected in intramammary infection followed by *Streptococcus* spp., (9.7%) and *Mycoplasma* spp., (4.7%) of positive milk cultures in goat herds (Marogna et al., 2012).

**Table 2:** Physical examination of udder and milk

| Tr-TI & MP Day II | | | | Tr-TI & MP Day III | | | | Tr-TI & MP Day VI | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Swelling | Erythema | Pain/ Heat | Nature of milk | Swelling | Erythema | Pain/ Heat | Nature of milk | Swelling | Erythema | Pain/ Heat | Nature of milk |
| N | N | Mild | AN | N | N | N | AN | N | N | N | N |
| N | N | N | AN | N | N | N | N | N | N | N | N |
| S | S | S | Curdled milk | Mild | Mild | Mild | AN | N | N | N | N |
| S | S | S | Flakes | Mild | Mild | Mild | AN | N | N | N | N |
| Mild | Mild | Mild | N | N | N | N | N | N | N | N | N |
| N | N | N | N | N | N | N | N | N | N | N | N |
| Mild | Mod | Mod | Curdle milk | N | Mild | Mild | AN | N | N | N | N |
| Mod | Mild | Mild | AN | N | N | N | N | N | N | N | N |
| N | N | N | Flakes | N | N | N | Flakes | N | N | N | N |
| S | S | S | Creamy Yellow | S | S | S | Creamy Yellow | Animal was sold | | | |

**N:** Normal; **S:** Severe; **Mod:** Moderate; **AN:** Apparently Normal; **Tr:** Treatment; **TI:** Tissue irritation; **MP:** Milk production

**Table 3:** Nature of milk and bacterial culture

| Clincal Case | Species | Nature of milk (Before treatment) | Bacterial culture |
|---|---|---|---|
| 1 | Crossbred | Apparently normal | No culture |
| 2 | Crossbred | Apparently normal | No culture |
| 3 | Crossbred | Curdled milk, fibrosed quarter | Treated with Ceftiofur hydrochloride |
| 4 | Crossbred | Flakes | Treated with Cefquinome |
| 5 | Crossbred cattle | Flakes | *Pseudomonas aeruginosa* |
| 6 | Buffalo | Thelitis | No culture |
| 7 | Crossbred cattle | Curdled milk | *Staphylococcus* sp., |
| 8 | Crossbred cattle | Curdled milk | No culture |
| 9 | Jersey Crossbred | Flakes | Staphylococcus aureus |
| 10 | Crossbred cattle | Creamy yellow color | *Klebsiella pneumoniae* (Treated with Ceftriaxone and Tazobactam) |

**Table 4:** Impact of indigenous medication against clinical mastitis condition on 2nd day

| SN | Affected Quarter(s) | Before (1st Test) | After (2nd Test) | d (2nd – 1st Test) | $d^2$ |
|---|---|---|---|---|---|
| 1 | Right Fore | 2 | 2 | 0 | 0 |
| 2 | Right Hind | 2 | 2 | 0 | 0 |
| 3 | Left Hind | 5 | 4 | -1 | 1 |
| 4 | Right Fore | 3 | 3 | 0 | 0 |
| 5 | Right Fore | 3 | 1 | -2 | 4 |
| 6 | Left Hind | 6 | 1 | -5 | 25 |
| 7 | Right Fore | 4 | 4 | 0 | 0 |
| 8 | Left Fore | 4 | 2 | -2 | 4 |
| 9 | Right Hind | 3 | 3 | 0 | 0 |
| 10 | All | 3 | 3 | 0 | 0 |
| | **Total** | | | **-10** | **34** |

It was found that three clinical cases were treated with Ceftiofur, Cefquinome and Ceftriaxone & Tazobactam combinations. These clinical cases did not respond to therapy and bacterial resistance has been major cause failure of treatment in clinical cases. The presence of a high proportion of hypermutable strains in *Pseudomonas aeruginosa*, *Staphylococcus aureus* were well documented (Wang et al., 2013). Further, study by Swinkels et al. (2013) did not recommend extending treatment of clinical *Staph. aureus* mastitis with cefquinome. It is also to be noted that response shown in laboratory condition of any drug, may not work well in clinical conditions. Careful interpretation of factors such as loss of cell surface properties in *in vitro* subculture of *S. aureus* strains is required (Aguilar et al., 2000). These adherence properties helps bacteria evade udder (host) defence mechanism. Availability of therapeutic concentration of drugs in udder also play pivotal role in control of mastitis.

**IKRS and its Therapeutic Role against Mastitis:** The formulation *DeMast P* was evaluated for its efficacy in clinical mastitis caused by gram negative (*Pseudomonas aeruginosa* and *Klebsiella pneumonia*) and gram positive (*Staphylococcus aureus*) bacterial organisms. The test formulation was prepared with the help of Society for Research and Initiatives for Sustainable Technologies and Institutions (SRISTI) Natural product laboratory, a laboratory dedicated for green grassroots innovators/outstanding traditional knowledge holders. Based on nature of milk affected with mastitis, the difference of means from 'before' and 'after' administration of test medication was scored. The 't' test of paired observations was calculated for understanding the impact of test medication (Table 4 and 5). The calculated value of $t_{0.05}$ for 9 degrees of freedom (d.f) was found to be 1.94 on 2nd day of observation. This was less than table value $t_{0.05,d.f.9}$ of 2.26 and is reasonable to believe that the medication did not had significant effect on 2nd day of treatment with IKRS. However, on 3rd day of treatment calculated value of $t_{0.05,d.f.9}$ was found to be 3.29. This was more than table value $t_{0.05,d.f.9}$ of 2.26 and reasonable to believe that the medication had significant effect in control of clinical mastitis.

**Table 5:** Impact of indigenous medication against clinical mastitis condition on 3rd day

| SN | Affected Quarter(s) | Before (1st Test) | After (2nd Test) | d (2nd – 1st Test) | $d^2$ |
|---|---|---|---|---|---|
| 1 | Right Fore | 2 | 2 | 0 | 0 |
| 2 | Right Hind | 2 | 1 | -1 | 1 |
| 3 | Left Hind | 5 | 2 | -3 | 9 |
| 4 | Right Fore | 3 | 2 | -1 | 1 |
| 5 | Right Fore | 3 | 1 | -2 | 4 |
| 6 | Left Hind | 6 | 1 | -5 | 25 |
| 7 | Right Fore | 4 | 2 | -2 | 4 |
| 8 | Left Fore | 4 | 1 | -3 | 9 |
| 9 | Right Hind | 3 | 3 | 0 | 0 |
| 10 | All | 3 | 3 | 0 | 0 |
| | **Total** | | | **-17** | **53** |

Clinical conditions were improved upon administering the medication indicating its therapeutic efficacy. The unique formulation had cured various forms of mastitis and efficacy was confirmed against major disease causing bacterial organisms. This demonstrated complementing efforts of IKRS in protecting welfare of livestock. Raot et al. (2016) indicated that socially acceptable product can be developed through IKRS and applied for wider benefit. A conservative estimate of a healer with treatment of seventy clinical cases resulted in saving of INR 1,06,750 (1,601.25 USD) in this study. This had greater ramification, as cost factors were not estimated while supporting initiatives of IKRS. These economic contribution of knowledge holders have to be evaluated. Research may be carried out in understanding impact of indigenous systems by involving farmers who were benefited out of IKRS. Inspite of research on indigenous system, national policies did not involve native wisdom in their program planning. Ramkumar et al. (2003) referred that technologies have to reach end users to achieve the purpose. This study illustrated Non-Linear Innovation System (NLIS) model, wherein novel technologies derived from green grassroots innovations/outstanding traditional practices can be part of such program and widely implemented.

## CONCLUSION

Ability of creative communities to recognize each other's efforts so as to harness experimental spirit of society has been unearthed during experimentation. Knowledge holders had proved their expertise in clinical situation and evinced appropriate interest in leadership roles for effective livestock health care. They had illustrated their capacity to be part of experimental research with help of farmers and in critically analyse results through their observations. The survival of knowledge system and comprehending medicinal utility of IKRS can be through formation of network of healers as a first step. This should be followed up with setting up of active technology utilizer group in their situation. The research study shared nature of social interaction between members of formal and informal institutions while extending service to farmers. The study recommended that recognition by formal institutions will incentivise knowledge holders to share their unique wisdom. There is a requirement to understand monetary and non-monetary incentives, strengthening utilizer system for sustaining experimental spirit of informal society. The study brings out an evidence based on Honey Bee Network philosophy of sustaining, scaling up of knowledge system by recognizing custodian of knowledge, formation of knowledge network and role of institutional support to unearth creative potential from informal system. These are pragmatic step towards realization of Low Cost Locally Available (LCLA) technologies for farming communities. Bonhomie between formal institutional system and knowledge holders is vital for realizing potential of creativity from grassroots.

## ACKNOWLEDGEMENTS

Shri N. Sridhar, Collector, Anantapur for inviting and extending administrative support for implementing livestock innovation for welfare of society. Mr. B Sairaj Santosh, District Rural Development Agency, Dr. Chandrasekhar Reddy, Joint Director, Animal Husbandry Department and Dr. I Papa Rao, Deputy Director, Dairy Cooperative Society, Anantapur, Andhra Pradesh and farmers' in study regions for their valuable support. The financial support

extended under Scheme for Young Scientists and Professionals (SYSY), Department of Science & Technology, GoI received by communication author for a part of clinical experimentation has been dutifully acknowledged.

## CONFLICT OF INTERESTS

Authors declare that they have no conflict of interest.

## AUTHORS' CONTRIBUTION

All authors contributed equally to the manuscript.

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