www.roavs.com EISSN: 2223-0343
RESEARCH OPINIONS IN ANIMAL & VETERINARY SCIENCES

A concept paper on novel technologies boosting production and safeguarding health of humans and animals

Kuldeep Dhama[1]*, Sandip Chakraborty[2], Ruchi Tiwari[3], Amit Kumar Verma[4], Mani Saminathan[1], Amarpal[5], Yashpal Singh Malik[6], Zahra Nikousefat[7] and Moosa Javdani[7] and Rifat Ullah Khan[8]

[1]Division of Pathology; [5]Division of Surgery; [6]Division of Biological Standardization, Indian Veterinary Research Institute, Izatnagar, Bareilly (Uttar Pradesh); [2]Animal Resources Development Department, Pt. Nehru Complex, Agartala; [3]Department of Veterinary Microbiology; [4]Department of Veterinary Epidemiology and Preventive Medicine, College of Veterinary Sciences, Uttar Pradesh Pandit Deen Dayal Upadhayay Pashu Chikitsa Vigyan Vishwa Vidyalaya Evam Go-Anusandhan Sansthan (DUVASU), Mathura (Uttar Pradesh); [7]Clinical Science Department, Veterinary Faculty, Razi University, Kermanshah, Iran; [8]Department of Animal Health, The University of Agriculture, Peshawar, Pakistan

Abstract

In this review, perspective roles and applications of molecular tools and techniques boosting production potentials and protection from economically important diseases are discussed. Importance of advent in genetic engineering, designer products, disease resistant plants and animals, advanced diagnostics, networking programmes, effective and safer vaccines as well as novel and emerging therapies are highlights of the review. The production of designer foods along with progress in 'Omics' as well as analytical fields contributed immensely for safeguarding health of livestock. For plunging losses caused to plant and animal population from pathogens, numerous methods are being adopted by biologists for engineering resistant breeds of animals and plants during last two decades. Advancements have been made in development of innovative detection methods (including modification of polymerase chain reaction) which have contributed in clinical decision making procedures and to determine the molecular epidemiology. Several new generation vaccines viz. DNA vaccines, reverse genetics vaccines, vector based vaccines, protein or peptide-based vaccines, gene-deleted vaccines and chimeric vaccines etc. have been developed or are under developmental phase for combating a wide array of diseases. Mapping for location of herds and flocks, enrichment of knowledge of epidemiologists and diagnosticians, clinicians along with researchers has become possible with the advancement of geographical information system (GIS). In addition bacteriophage, virophage, cytokine, probiotics as well as herbal, nutritional, immunomodulation therapy and cow (panchgavya) therapy have proved to be beneficial. Among them many are cost-effective and cause only minimal adverse reactions. This review gives a brief presentation of all the important innovative technologies boosting production and safeguarding health of humans and animals.

Keywords: Technologies, biotechnology, boosting production, abiotic stress, bioenhancers, safeguarding health, diagnosis, vaccine, therapies

To cite this article: Dhama K, S Chakraborty, R Tiwari, AK Verma, M Saminathan, Amarpal, YS Malik, Z Nikousefat, M Javdani and RU Khan, 2014. A concept paper on novel technologies boosting production and safeguarding health of humans and animals. Res. Opin. Anim. Vet. Sci., 4(7): 353-370.

Introduction

To provide goods as well as services, several agricultural and industrial stages have been reached that has led to the progress of the world. The cultural as well as social evolution of mankind has acted as catalysts for this progress. There is urging to free people from foraging for food along with provision for adequate

***Corresponding author:** Kuldeep Dhama, Principal Scientist, Division of Pathology, Indian Veterinary Research Institute, Izatnagar, Bareilly (Uttar Pradesh) – 243122, India; Email: kdhama@rediffmail.com; Telephone: +91-581- 2310074 (Off.); Fax: +91-581-2303284

nutrition via consistence in supply of food throughout the year. Such forces have led to the development of idea to generate various novel technological tools that would ultimately help to boost production (Lund, 1989; Lotter, 2003; Mac Aulay and Newsome, 2004; Lemaux, 2008; Gopi et al., 2014). The livestock production system has been investigated through a process which is followed by an analysis of the supply as well as demand of livestock products. This gives the idea of an entirely new revolution in the livestock sector. Unlike the revolutions which took place in the past, this particular revolution is largely based on modification in the milk production system and is also concerned with the health of monogastric animals. There is need to improve the production as well as processing technologies on the supply side. This ultimately will help make available economic food grains and reduced bulk transport costs. In such kind of new livestock revolution the production changes have been concentrated in the developed countries. So concerns have been raised regarding the fact that poor people may lag behind, if advanced technological approaches are not undertaken to improve the livestock health in less developed areas of the world (Dent et al., 1995; Steinfeld and Maki-Hokkonen, 1995; Sere and Steinfeld, 1996; Haan et al., 2001; Steinfeld et al., 2006).

In recent years, threats to human health have made newspaper headlines due to spread of diseases and bioterrorism, superbugs, flooding, radiation as well as poisons. A multitude of such threats are posed to our nations that range from infectious diseases of unknown origin to swine flu pandemic. All such diseases and natural calamities can take a heavy toll on human and animal life. It is required to have diligent preparatory plans; active prevention system along with rapid response when there is a rise in incidences and this becomes the job of health protection agencies. Similarly, better diagnostic technologies along with advanced vaccines must be provided to ensure early diagnosis and prevention and eradication of diseases (Murray and Lopez, 1996; Pauwels et al., 2001, German et al., 2005; King et al., 2012). In the present review, perspective role and applications of biotechnological tools and techniques boosting production potentials in animals; safeguarding health of humans and animals, and providing protection from diseases are discussed viz., advent in genetic engineering, designer products, disease resistant plants and animals, advanced diagnostics, networking programmes, effective and safer vaccines as well as novel/emerging therapies. This review gives a brief overview of all these important novel technologies boosting production and safeguarding health of humans and animals.

Novel Technologies Boosting Production

Genetic engineering, transgenic plants and animals: An increase in the amount of genetic variability which is available to the breeders in order to use them beyond the level of conventional breeding methods is simply the primary benefit of genetic engineering. Genetic modification is a technology that changes the genetic machinery of living organisms (Bawa and Anilakumar, 2013). This can be done by combining genes from different organisms and the technique is called as recombinant DNA technology. The new organism resulting from this modification is known as 'Genetically modified (GM)', 'Genetically engineered' or 'Transgenic'. Transgenic varieties of soyabean, corn, cotton and canola are the most common crops. Such genetically modified crops possess properties of either tolerance to herbicides or resistance to insects and in certain cases both. Specific genes are taken from *Bacillus thuringiensis* (a common bacterium of soil) in order to produce genetically engineered insect-resistant varieties of crops. Other genetically modified crops include virus resistant sweet potato, rice rich in nutrients like iron and vitamins, rapid maturing fishes, early yielding fruits and nut trees etc. and plant based oral vaccines (Bawa and Anilakumar, 2013). Unique transformation events have been utilized to produce altogether 50 different kinds of plants which are genetically engineered (Tayo et al., 2010; Pamela, 2011).

Genetic engineering has given a major boost to the milk sector in India (Lalwani, 1989; Munshi and Parikh, 1994; James and Anderson, 2000). Artificial insemination and transfer of embryo have been found useful in manipulating the farm animals genetically (Houdebine, 2009; Gupta and Singh, 2012; Dhama et al., 2014a). Other techniques like sexing of sperm and livestock cloning help in animal breeding programmes raising healthy offspring by the animal farmers, which ultimately lead to production of healthier, safer and high quality food. Nutrigenomics have been found to play a crucial role in male puberty in cattle (Deb et al., 2014). Molecular markers have been reported to possess tremendous useful applications in cattle genetic research (Singh et al., 2014a). For improving the farm animals advancement in the field of quantitative trait mapping will help in improving the animal-breeding approaches traditionally (Alex et al., 2013). Animals with alteration of traits can be produced by engineering the livestock genetically. Presently, no genetically modified animals have yet been released on farms. But research is going on worldwide for development of transgenic animals targeting specific genetic traits like keratin gene (to improve wool of sheep), growth hormone gene (to increase growth rate) and phytase gene (to reduce phosphorous emissions from pigs) (Abdullah et al., 2011). For duplication of animals, cloning can be used and it will be possible to obtain dairy cows that are genetically engineered within next few decades. The cloning of animals is useful particularly for those traits/characters that cannot be harnessed using conventional breeding policies or may take a long time to achieve the goal (James and Anderson, 2000). The production of transgenic sheep as well as goats and cattle has become possible with advancement in procedure of animal cloning (Mc Laren, 2000; David, 2006). Inserting specific de-oxy ribonucleotide (DNA) sequence will help in removal or alteration of specific unwanted gene. Companies are expected to carry out the cloning as well as breeding of elite animals by the year 2025 and the economic benefit out of it will decide the acceptance of the genetically engineered animals (Gama et al., 1992; Murray and Anderson, 2000). Cross-breeding of exotic chickens with indigenous chickens, and other technologies like artificial insemination and chimeric chicken are some of the desirable methods to increase the production (Chowdhury et al., 2014; Dhama et al., 2014a). Recently, induced pluripotent stem cells (iPSCs) have been developed for disease modelling, drug testing, biomarker development and cell based therapies in medicine (Cebrian-Serrano et al., 2013). Animal models have also been utilized for search of new antiprion therapies (Fernández-Borges et al., 2013). Now-a-days, genome editing or targeted genome engineering techniques like bacterial type II CRISPR (clustered regularly interspaced short palindromic repeats)/Cas (CRISPR-associated) immune system has also been developed as an alternative to traditional plant breeding and transgenic methods for improving the production (Belhaj et al., 2013). Spider silk protein production from plants opens up new horizons in the use of technologies for the future (Hauptmann et al., 2013). Similarly, production of transgenic rice (*Oryza sativa*) has been found beneficial to produce human pharmaceuticals like therapeutic proteins or peptides (Wakasa and Takaiwa, 2013).

Designer foods, animals and crops: Designer food also termed as 'functional food' or 'fortified food' is the food that is custom designed in having better health benefits in comparison to traditional food (Rajasekaran and Kalaivani, 2013). When genetic modifications of food crops are done, there is incorporation of one or more genes into the genome of the crop that uses a vector that contains various other genes that include minimum viral promoters. Along with this, there are also presence of terminators of transcription; marker genes for antibiotic resistance and reporter genes. By means of inserting genes into the genome certain unintended effects may also result which are required to be reduced or eliminated by the process of selection (Millstone et al., 1999; Domingo, 2000). The crops that focus on input agronomic traits largely are the first generation of biotechnology products. For continuous improvement of agronomic traits viz., yield as well as resistance to abiotic stress is required. Along with this the other notable factors are: crop plants as feedstocks for biofuels as well as biosynthetics; output traits that are value-added such as improved nutrition as well as food functionality; and for therapeutics as well as industrial products plants as production factories. Involvement of improved traits to develop plants as well as animals for better food production will help to overcome a variety of technical as well as regulatory and perception challenges that are inherent in the perceived as well as real challenges involving modifications that are complex. For metabolic engineering of plants with desired traits both breeding of plants as well as biotechnological techniques are needed traditionally. Along with this progress in 'Omics' as well as analytical fields also contribute to safeguarding health of livestock (DellaPenna, 2007; Newell-Mc-Gloughlin, 2008). Plant biotechnology, particularly by use of low-risk and low cost techniques like micropopagation enables small farmers for obtaining increased crop yields in various countries including, Argentina, Morocco, Uganda and India (DaSilva, 2002). There is an ever increasing interest towards development of designer foods like plants, milk, egg, meat (Mahima et al., 2012a&b). These products are produced according to the nutritional requirements of the human beings by employing nutritional and genetic approaches (Sabikhi, 2007). Foods that are genetically engineered are aimed at having higher amount of nutrients or health promoting substances (Rajasekaran and Kalaivani, 2013).

Designer oil particularly rapeseed oil fortified with micronutrients like polyphenols, tocopherols and phytosterols have been proved effective in prevention of atherogenesis (Xu et al., 2011). On the other hand, phenol enrichment of olive oils and palmitic acid-fortified vegetable oil improves the absorption of calcium (Lee et al., 2008). Designer broccoli have also been produced by fortifying it with selenium and has been found beneficial in prevention of cancer (Hsu et al., 2011). Wheat and maize have been produced that are rich in iron, zinc, β-carotene, lysine and tryptophan (Hoisington, 2002). Milk can be designed by alterations in its casein protein, improving protein quantity and quality, adding healthier fatty acids like conjugated linoleic acid (CLA) and omega-fats, reducing lactose contents etc (Mahima et al., 2012a). Milk allergies in infants can be reduced by deleting gene responsible for beta-lactoglobulin (beta-LG) from animals (Sabikhi, 2007). All these changes can be done through transgenic technology, which can have significant impact on human health (Karatzas and Turner, 1997). With the progress in biotechnology, transgenic animals are produced that secrete milk, lysozyme, human lactoferrins etc so that animal milk can be at par with the human milk (Sabikhi, 2007). Various other forms of designer milk have been developed and evaluated by scientists viz., milk-based beverages fortified with apple or grape seed polyphenols (Axten et al., 2008), fermented milk fortified with lutein, prebiotic and probiotic fortified milk, lactoferrin-enriched fermented milk, calcium and vitamin D fortified milk along with zinc and magnesium; iron-fortified milk; Selenium enriched milk etc (Bonjour et al., 2009; Kruger et al., 2010; Kim et al., 2010; Granado-Lorencio et al., 2010; Sazawal et al., 2010; Rivera et al., 2010; Semba et al., 2010; Hu et al., 2010; Rajasekaran and Kalaivani, 2013). With the advancement in poultry biotechnology, the composition of egg can be changed by nutritional and genetic interventions (Mahima et al., 2012b). Though, amid all food commodities, poultry eggs are considered as major source of dietary protein, in past reduction in per capita consumption of egg was seen and one reason was due to its high lipid contents and rise in heart patient ratio world over. However, biotechnological approaches have provided modified egg contents with availability of designer eggs having less cholesterol and saturated fat, and containing a beneficial content of omega-3 unsaturated fatty acid (US patents/US6316041). Designer diet rich in omega-3 fatty acids and other antioxidants in the poultry increased these contents in the eggs (Sujatha and Narahari, 2011). Designer eggs enriched in vitamin E, lutein, selenium (Se) and docosahexaenoic acid (DHA) have been found effective in increasing the blood level of these parameters in human beings, which ultimately help in improving the human health (Surai et al., 2000; Surai and Sparks 2001; Floros et al., 2010; Rajasekaran and Kalaivani, 2013). Presently, Selenium enriched eggs are common in markets in UK, Ireland, Mexico, Columbia, Malaysia, Thailand, Australia, Turkey, Russia and the Ukraine (Fisinin et al., 2009). It has been well proved scientifically that genetic immunization of ducks with plasmid expressing *H. pylori* UreB produced UreB induced IgY polyclonal and monospecific antibodies against recombinant *H. pylori* urease that will help in reducing the gastric inflammation due to Helicobacter infection (Kazimierczuk et al., 2005). There may also be development of unknown toxic or allergic components which cannot be analyzed thereby leading to serious limitation of criteria for selection. Testing of food toxicity is done by chemical analysis as well as analysis of macro as well as micro nutrients along with known toxins. There is also requirement of better diagnostic methods like mRNA fingerprinting; proteomics as well as secondary metabolic profiling for screening harmful consequences upon health of human caused by food toxicity. This will further strengthen and allow the use of genetically modified crop in the food chain (Ewen and Pusztai, 1999; Kuiper et al., 1999).

Novel technologies safeguarding health

Disease resistant plants and animals: To reduce pathogen caused losses to the plant as well as animal population numerous methods have been adopted by biologists for engineering resistant breeds of animals and plants during last two decades. Based on this mechanism diverse approaches have been developed. International Institute of Tropical Agriculture, Nigeria developed Cassava clones, which are propagated as disease-free plantlets to start-up crop productivity (FAO, 2001). The application of RNA silencing has been focused for producing plants which show resistance to plant viruses as well as viroids; insects as well as recent expansion to fungal pathogens (Schwab, 2006; Duan et al., 2012). Even though most of the plant viruses are de-oxy ribo nucleic acid (DNA) based, most of the plant viruses exist as strands of RNA. For production of genetically modified (GM) crops which are resistant to viruses, specific engineering has been done for the creation of small regulatory disease resistant ribo nucleic acid (dsRNA). Each of the GM crop has been designed for protection against a specific RNA virus. For this purpose it is required to first identify a piece of RNA from the virus which is targetted and subsequently building a DNA. This DNA is a transgene with a sequence which is designed for creation of the viral RNA. Subsequently there is insertion of the transgene into the plant cell genome. This in turn is grown into a plant. In each of the plant as well as its offspring the transgene which is inserted is transcribed into viral RNA. This thereby arms the process of gene silencing for the purpose of looking out for the target virus. In each of the cell viral proteins may be produced by the RNA (Gibbs, 1994; Weiland and Edwards, 1996; Cogoni and Macino, 2000; Dasgupta et al., 2001; Lolle et al., 2005). Alternative strategies have been provided by genetic modification to traditional system of animal breeding. Specific application is provided by such technology wherein there is no existence of genetic variation in a given population or species and wherein it is possible to undertake novel genetic improvements. It is highly essential to bring about genetic modification for mounting an immune response against the pathogen appropriately or for generation of an efficacious system that can cause blockade of pathogen directly. A combination of strategies indeed can act as the most successful approach. In mouse pronuclear injection is a technique involving introduction of a construct of DNA into one of the two pronuclei of the fertilized egg which ultimately led to the production of early transgenic livestock. This technique has been used for the development of the concept of animal bioreactor whereby engineering of animals are done for production of pharmaceutical proteins in their milk. Efforts to produce genetically modified animals with new tools that are exciting, make transgenic animals' application increasingly likely, which proves beneficial to the animal industry. The more traditional tactics will be complemented further by the use of animals that are genetically modified and novel intervention strategies will be provided (Wright et al., 1991; Wilmut and Whitelaw, 1994; Whitelaw and Sang, 2005). Some of the polymorphic genes in the major histocompatibility complex of chicken are associated with resistance to diseases caused by bacteria and parasites; immune diseases as well as neoplasia (Lamont, 1998).

Advanced diagnostics: For the purpose of advanced diagnosis, the early as well as rapid detection and characterization of microbial components including structural protein motifs or genomic constituents have proven invaluable (Dhama et al., 2010, 2012a; Verma et al., 2011; Singh et al., 2013; Chakraborty et al., 2014a). When amplification as well as signal detection systems have been integrated along with online real-time devices the speed as well as sensitivity has increased and the quantification of target molecule has greatly been achieved. The newer generation of molecular diagnostic techniques helps in unparallel detection as well as discrimination methodologies that are vital to detect as well as identify pathogenic agents on the basis of antibody production. Sustainable as well as quality assured application of diagnostics to optimally detect and effectively control diseases is possible with the development of novel technologies. In clinical decision making procedures and to determine the molecular epidemiology, advanced molecular detection methods are essential. They include various versions of ELISA such as sandwich ELISA, LPB-ELISA, indirect ELISA; polymerase chain reaction, real time PCR, loop-mediated isothermal amplification of DNA (LAMP), biosensors and biochips, multiple antigenic peptide (MAP) as synthetic peptide dendrimer (Joshi et al., 2013; Liu et al., 2013), peptide nucleic acid (PNA) visual diagnostics, macroarrays and microarrays, as well as recombinant protein based technologies (Nielsen et al., 1996; Dhama et al., 2010, 2011a, 2012a, 2014b; Malik et al., 2013a; Naveen et al., 2013).

Synthetic peptides are organized to super molecular designs such as dendrimers that increase bio-availability for desired action and are found to be more effective in disease diagnosis. Peptide molecules can be conjugated in different ways to create a branched structure having dendrimeric form or other multimeric forms. The dendrimers can be covalent or non-covalent. Among covalent dendrimers, MAP is known to be the most common form of peptide dendrimer. MAPs are actively used for immunodiagnosis of viral diseases like acquired immuno deficiency syndrome (AIDS), infectious bursal disease (IBD) and hepatitis C. The upcoming and promising applications of MAP and dendrimers are giving birth to newer developments in peptide based disease diagnostics and therapeutics (Joshi et al., 2013).

Development of biosensor is a new approach for detecting either the infectious agent or antibodies. Such assay needs the involvement of a receptor which is usually an antibody for targeting the pathogen or an antibody which is specific to disease along with a transducer converting a biological interaction into a signal which is measurable. Electrochemistry as well as reflectometry and interferometry as well as resonance and fluorimetry are certain transducer technologies, which are under development for future application (Belak et al., 2009; Deb and Chakraborty, 2012; Ayyar and Arora, 2013). Frequent coupling of biosensors are usually done with sophisticated instrumentation for producing analytical tools which are highly specific. Most of them are however still used solely for the purpose of research and development because of the high cost involved in instrumentation; high running cost; and the requirement of highly trained personnels to oversee the testing. In order to detect economically important infectious disease like bovine brucellosis fluorescence polarization assay is available recently (Raies et al., 2009; Verma et al., 2010 a&b; Dhama et al., 2011a, Oquino et al., 2012; Ranjan et al., 2014; Singh et al., 2014b; Sharma and Shukla, 2014). Although these advance diagnostic tools are costly, but development of these techniques for quick and accurate diagnosis of diseases or etiological agents helped a lot in controlling the outbreaks in human and animals ultimately leading to improved health and increased production (Soutullo et al., 2001; Cruz et al., 2002; Emerich and Thanos, 2003; Jain, 2003; Kataria et al., 2005; Deb et al., 2013a&b; Kataria et al., 2013). It has been found in recent times that serial studies in patients are limited for which non-invasive technologies have been developed. This permits the study of the transitional stage of a disease process from acute to chronic type. Such studies are especially important to protozoan diseases in humans like Chagas disease (caused by *Trypanosoma cruzi*) (Jelicks and Tanowitz, 2011).

Advancement has also been made in the field of proteomics which is the study of proteins that include their level of expression; modification post-translationally along with interaction with other proteins. As far as the infectious disease diagnosis is concerned the use of proteomics is still in its infancy but may prove to be of importance considerably. In order to identify antigens which are having novel diagnostic value, proteomics has got useful application. For this purpose screening of serum from uninfected individuals against proteomes of infectious agents, which are immunoblotted, is necessary. Research fields based on proteomics are now underway in the veterinary field. For several pathogens viz., *Brucella melitensis*; *Toxoplasma gondii*; *Eimeria tenella* as well as *Trypanosoma brucei* proteome maps have been made available (Rout and Field, 2001; Cohen et al., 2002; Mujer et al., 2002; Bromley et al., 2003; Yatsuda et al., 2003). For better diagnosis and treating as well as controlling sexually transmitted diseases (STD) various new diagnostic assays based on the use of molecular techniques have been developed. By incorporation of molecular amplification there is marked enhancement of sensitivity for detection of infections which are sexually transmitted and at the same time are difficult for cultivating viz., human papilloma virus (HPV) or *Treponema pallidum*. PCR or ligase chain reaction (LCR) have been used for detection of certain pathogens which are either comparable to or in certain instances better than *in vitro* cultivation of the agent directly. There has been effective utilization of DNA fingerprint analysis of microbial DNA which has been amplified for studying in details the epidemiology as well as pathophysiology of sexually transmitted infections. Cloned proteins along with recombinant antigens have been used additionally for enhancing the advancement of serological techniques. For differentiating infection caused by closely related pathogens (viz., human immunodeficiency virus type 1 and 2; human T-cell lymphotropic virus type 1 and 2) such techniques are helpful (Quinn, 1994).

In recent times nanotechnology is no more a concept or theory but over the years it has become a new enabling technology with tremendous potential for revolutionizing agriculture as well as livestock sector in India. For cellular as well as molecular biology; biotechnology; veterinary physiology and reproduction new tools can be provided by nanotechnology. It can be especially useful for detecting pathogens. Application of nanotechnology can be done in wide areas of research and development that include: agriculture; animal as well as food systems (Scott and Chen, 2002; Patil et al., 2009). For early disease detection in animals biochips can be used. By the use of these chips blood; tissue as well as semen can be analyzed and manipulated. For measuring or detecting chemical bioanalytical sensors can be used. For detecting cancer cells, nanoshells conjugated with targeted agents are available that can be injected into the bloodstream of the animal for seeking and attaching to the cancer cell surface receptors (Hirsch et al., 2003; Luo et al., 2003; Patil et al., 2009).

Networking programmes: For the process of disease reporting and recording; cluster analysis; spread of infection and their modeling; assessment of outbreak situation; and for planning control strategies geographical information system (GIS) is helpful (Dhama et al., 2013a). Mapping for the location of herds as well as flocks and other related facilities has become possible with the advancement of GIS. The knowledge of epidemiologists as well as diagnosticians and clinicians along with researchers has also increased with the use of GIS. At global, national as well local levels multidisciplinary efforts are required to create One Health which is beneficial for our planet. A wide array of crucial issues at the global level viz., international trade as well as travel; global warming; emerging antibiotic resistance; rapid population growth; ecotourism; safety of food; people's migration from rural to urban areas continuously have raised the value of advancement in diagnosis; biosecurity measures; as well as disease surveillance and monitoring activities (Dhama et al., 2011a, 2013b, c, d; Tiwari et al., 2013a; Verma et al., 2014a). Heightened risk of emergence and re-emergence of important zoonotic diseases including deadly disease like rabies, avian flu, and others have also led to advancement of novel diagnostic facilities and vaccinology that contribute to the global health as a whole. The Food and Agricultural Organization has established linkage with economic institutions at the regional levels in various parts of the globe through GIS. It has therefore ultimately led to engagement of man power as well as investment for strengthening veterinary services along with the whole spectrum of disciplines interplaying for determination of animal health.

Safer and new generation vaccines: Development of effective vaccines against many deadly and debilitating diseases has contributed significantly to the success of public health programmes. Despite the consistent efforts in the past success could not be achieved for development of vaccines against most important global diseases of human like Influenza, acquired immuno deficiency syndrome (AIDS), tuberculosis as well as malaria due to the extensive genetic variability shown by the pathogens. There is a great scientific challenge in developing a safer and effective vaccine that will provide better protection against the emerging and re-emerging pathogens (Liu et al., 2012). But due to recent advancement in the field of vaccinology, prevention and control of such diseases have become much easier in the 21st century (Koff et al., 2013). New diseases have been targeted due to recent advancement in vaccine technology viz., recombinant DNA technology, reverse genetics, genomics, proteomics and other molecular technologies stemming from biotechnology, molecular biology and genetic engineering, and their useful applications (Marcelino et al., 2012). These novel technologies revolutionized the development of vaccine candidates and will help in the generation of safer and more effective vaccines (Unnikrishnan et al., 2012). Progress in the scientific field and its application in wider sense will undoubtedly result in improved health-based outcomes but at a significant short term cost progress is achieved. Improved outcomes are the main goal of health care technology which thereby helps in preventing diseases. For prevention as well as control of animal diseases a high priority is vaccination. Residual virulence along with emergence as well as re-emergence of pathogens have limited the uses of traditional vaccines. At mucosal surfaces additionally there is inefficiency in providing protective immunity. Recently, much has been done for the production of reassortant vaccines by the application of methods based on plasmids. Appropriate vaccine strains can be selected for manufacturing influenza viral vaccines too (Gross et al., 1995; Palese, 2006). Molecular methods have also allowed control over the output completely. Many such vaccines like DNA vaccines, reverse genetics vaccines, vector based vaccines, protein or peptide-based vaccines, gene-deleted vaccines and chimeric vaccines and others have been developed or under developmental phase (Dhama et al., 2008a; Avila-Calderon et al., 2013; Wang et al., 2013; Singh et al., 2014c). Vaccine cocktails can be prepared by insertion of multiple proteins into a single vector or by mixing several vaccines manufactured with similar viral vector. Advent in the technology involving the use of virus like particles (VLP) have also helped in advancement of disease control and prevention (Lowy and Schiller, 2006; Mc Cullers and Dunn, 2008). In recent years, there has been development in plant molecular farming that has led to manipulations in plants genetically for making them bioreactors to produce several recombinant proteins by the use of infectious vectors or stable transgenic systems. For reducing the burden of hepatitis as well as diarrhea and other infectious pathogens the development in the field of plant based edible vaccines has increased the potential of oral immunization (Mishra et al., 2008; Dhama et al., 2013e). In an experimental trial on murine model, multi-epitope vaccine was found better in comparison to individual epitope in providing protective immunity against trichinellosis (Gu et al., 2013). Besides, at present the researches are being conducted on the use of better and advanced adjuvants such as nanoparticles that can elicit better immune response (Kumar et al., 2013). These advances in development of new and safer vaccines will significantly reduce the prevalence of diseases in man and animals.

Novel therapies: A great boost has been given by modern medicine to eradication and curing various diseases of mankind as well as animals. But as incurable diseases like cancer and acquired immunodeficiency syndrome (AIDS); diabetes or rheumatoid arthritis still persist. For treating pathogenic bacterial infections and to conserve global system bacteriophage and virophage therapy have been developed, respectively (Karthik et al., 2014). Cytokines have been used as immunomodulators (adjunctive) and therapeutic regimens; gene therapy focuses on diseases caused by individual defect in gene; for suppression of specific gene RNAi technology has been developed. Stem cell therapy is a modern approach to combat various forms of cancer as well as disease conditions (Amarpal et al., 2013). Probiotics as well as herbal, nutritional, immunomodulation/therapy, antioxidants and cow (panchgavya) therapy have proved to be beneficial as they are cost-effective as well as they cause minimal adverse reactions (Verma, 2005; Dhama et al., 2008b, 2013f, g, h; Kumar et al., 2011a; Mahima et al., 2012c, 2013a&b; Shohani et al., 2013; Tiwari et al., 2013b; Rahal et al., 2014a&b). Along with these treatment options, nowadays apoptins, cytokines, phages, enzybiotics, egg yolk antibodies, immunotherapy and nanomedicines have also been recorded as emerging and novel therapeutic regiments possessing potential applications for safeguarding health of human beings and animals (Natesan et al., 2006; Patil et al., 2009; Dhama et al., 2013f, i; Tiwari et al., 2011, 2014a,b&c). All these novel as well as emerging therapies can play important role in safeguarding human and animal health altogether.

In recent time there is also advancement in the development of other novel ideas. The earthworm has been used as drug since a few thousand years. A fibrinolytic enzyme (strong) has been extracted from the earthworm *Lumbricus rubellus* and found useful in patients with thalassemia (Mihara et al., 1993; Cho et al., 2004). Earthworm therapy has been proven to be helpful for the treatment of lyme disease. The enzyme lumbrokinase (a group of six enzymes) is essential for natural treatment of Lyme disease (Mihara et al., 1992). Worm therapy is also helpful for debilitating bowel disease like ulcerative colitis. As there is technological advancement in the field of targeted therapies for the treatment of cancer, identification of candidate genes have become an important issue. Micro-RNA therapy has got important role to play in this aspect for the treatment of several solid tumors viz., breast as well as colorectal cancers (Fojo, 2008).

Advances in countering emerging/re-emerging infectious diseases and zoonosis

In the modern era of ever increasing worldwide population, changing lifestyles and food habbits, globalization trends, tourism avenues, intensified animal produces and industrialization, ecosystem and biodiversity changes, emerging antimicrobial/drug resistance, want for effective and safer treatment regimens and vaccines, immune pressures, global warming, and one health one medicine concept, multidisciplinary and international level networking and coordinated approaches are required for countering economically important and emerging/re-emerging infectious diseases of humans and animals and checking their increasing zoonotic and pandemic threats as well as food safety concerns (Taylor et al., 2001; Slingenbergh et al., 2004; Patz et al., 2005; Rogers and Randolph, 2006; World Health Organization, 2006; Kahn et al., 2007; Wolfe et al., 2007; Jones et al., 2008; Myers and Patz, 2009; Osburn et al., 2009; Dhama et al., 2013b,c&d; Tiwari et al., 2013a; Verma et al., 2014a). In this context, some of the important infectious and emerging/re-emerging pathogens / diseases to be tackled include foot-and-mouth disease, Peste des Petits Ruminants, rotavirus, coronavirus, bovine herpes virus, parvovirus, infectious bovine rhinotracheitis, blue tongue, toroviruses, foamy viruses, avian influenza, infectious bursal disease, Newcaste disease, Marek's disease, avian infectious bronchitis, chicken infectious anaemia, hydropericardium syndrome; brucellosis, leptospirosis, listeriosis, haemorrhagic septicaemia, tuberculosis, paratuberculosis, black quarter, anthrax, *Escherichia coli,* campylobacters, arcobacters, mycoplasma, mastitis, fowl typhoid, pullorum disease, avian colibacillosis, fowl cholera, avian chlamydiosis and fungal and protozoan diseases salmonellosis (Saif, 2003; Kataria et al., 2005, 2013; Dhama et al., 2008c, 2009, 2011b, 2013j,k&l, 2014c,d&e; Bhatt et al., 2011; Kumar et al., 2011b; Patyal et al., 2011; Golia et al., 2012; Singh et al., 2012, 2014b; Sumi et al., 2012; Verma et al., 2012a&b, 2014a&b; Barathidasan et al., 2013; Deb et al., 2013a; Lee et al., 2013; Singh et al., 2014a; Chakraborty et al., 2014a&b; Verma et al., 2014a). Various pathogens posing zoonotic and pandemic threats also need to be countered at global level viz., rabies, West Nile virus, avian flu (bird flu), swine flu, viral encephalitis, dengue, chikungunya, Crimean Congo hemorrhagic fever, Hendra and Nipah viruses, Ebola viruses, plague, anthrax, glanders, brucellosis, salmonellosis, leptospirosis, listeriosis, tuberculosis, psittacosis, colibacillosis, campylobacteriosis and others including of food-borne pathogens (Bengis et al., 2004; Zinsstag et al., 2007; Pawaiya et al., 2009; Dhama et al., 2005, 2011b, 2012b, 2013k,l,m&n; Osburn et al., 2009; Cascio et al., 2011; Grunkemeyer, 2011; Verma et al., 2012b, 2014a&c; Goswami et al., 2014; Kapoor and Dhama, 2014). Wild life animals, migratory/wild birds and other important vectors and reservoirs of various pathogens having significant important roles in spread of infectious agents need to be monitored for avoiding disease risks and threats to animal and poultry production as well as related public health concerns (Daszak et al., 2000, 2004; Taylor et al., 2001; Bengis et al., 2004; King, 2004; Dhama et al., 2005, 2008d, 2013d, 2013e&f; Zinsstag et al., 2007; Chakraborty, 2012; Kumar et al., 2012; Rajendran and Ramakrishnan, 2012; Sakoda et al., 2012; 2013e, 2013f; Verma et al., 2014a). Recent threats and epidemics / pandemic events of few infectious diseases viz., severe acute respiratory syndrome (SARS), avian/bird flu (H5N1) and swine flu (H1N1), along with earlier noted ones like of plague, anthrax, glanders and influenza viruses warrants strengthening of global health issues and devising sound preventive and control measures. Along with this timely preparedness and prompt responses are necessary for combating these deadly and devastating pathogens/diseases having high threats to humans and their companion animals, and posing immense socio-economical significance (Slingenbergh et al., 2004; Amonsin et al., 2008; Pawaiya et al., 2009; Ali et al., 2012; Dhama et al., 2005, 2012b, 2013n; Kapoor and Dhama, 2014; Verma et al., 2014a). For this purpose, strategic and well planned veterinary and medical approached are required (Hamburg and Lederberg, 2003; Osburn et al., 2009; Mahima et al., 2012d; Dhama et al., 2013b).

It is the high time to make practical implementation of advances in diagnostics and molecular detection tools from laboratory to field levels, along with strengthening of disease surveillance, monitoring, networking and early warning systems for providing quick and confirmatory detection of important infectious pathogens of humans and animals (Black et al., 2002; Kataria et al., 2005; Balamurugan et al., 2010; Schmitt and Henderson, 2005; Belak, 2007; Bollo, 2007; Ratcliff et al., 2007; Siddiqui, 2010; Bergquist, 2011; Taddele et al., 2011; Deb and Chakraborty, 2012; Dhama et al., 2010, 2011a, 2012a, 2013a&b, 2014b; Hansa et al., 2012; Deb et al., 2013b; Sharma and Shukla, 2014). Added to this, potential exploration of recent developments in vaccines, vaccine delivery systems and vaccinology, following regular and judicious vaccination programmes, immunomodulatory and effective therapeutic modalities must be given due priority, which would help devising effective and timely prevention and control strategies against various pathogens (Daszak et al., 2004; Meeusen et al., 2007; Dhama et al., 2008a, 2013e,f,g,h &i; Mahima et al., 2012c, 2013a&b; Tiwari et al., 2011, 2014a,b&c; Amarpal et al., 2013; Bhatt et al., 2013; Malik et al., 2013b; Rahal et al., 2014a; Saritha et al., 2014; Singh et al., 2014c). Apart from this, good management practices, heightened biosecurity programmes, maintaining high standards of hygiene and sanitation measures, quarantine, on spot curbing and checking the spread of pathogens, following suitable trade restrictions also need be focused. For all these purposes, a holistic vision for effective and wider implementation of these novel concepts and strategies is warranted along with appropriate funding resources for strengthening various multidimensional research and development programmes. This would altogether help reduce the disease incidences, outbreaks and epidemics; lessen the economic burdens caused by infectious diseases of animals; boost animal production (livestock and poultry industry); protect health of humans and humans, diminish the public health concerns and pandemic threats, and upgrading the socio-economical status of the country.

Conclusion and future perspectives

For boosting productivity and for safeguarding health of humans as well as animals various new approaches have come into existence. Some of them includes advancement in disease diagnostic facilities along with disease resistant breeding programmes; advanced networking programmes; improvement in novel therapeutics; development of safer vaccines along with development in transgenic plants and animals. In the field of biotechnology latest developments particularly in the field of molecular biology; genetic engineering and transgenic technology has got a very large number of applications potentially as far as production of food is concerned. In agricultural and livestock development fields the use of genetically modified crops as well as animals is more common (including those carrying disease resistant traits has already become experimental reality and sooner they will be commercialized). Scientists at the same time are engaged in developing transgenic plants and animals with the intention to supply food with a shift from traditional practices of animal breeding. Advancement in molecular diagnostics field for early recognition of pathogens; development of new generation vaccines that are effective as well as safer; several novel emerging therapies have more effectively aided in safeguarding health of humans and animals. With the advent of molecular cloning, there has been significant expansion of the diagnostic repertoire of the clinical laboratories in order to diagnose diseases in human and animals. In the coming year's nanoscience and naotechnology based approaches concerning health of animals will reform and thereby boost the livestock production. GIS technology will aid more in near future in animal disease surveillance and monitoring. All these concepts of novel technological approaches would ultimately help safeguarding human and animal health as well as boost production potential of the animals.

References

Abdullah, R.B., Khadijah, W., Embong, W. and Soh, H. 2011. Biotechnology in Animal Production in Developing Countries. In: 2nd International Conference on Agricultural and Animal Science IPCBEE vol. 22, IACSIT Press, Singapore.

Alex, A., Singh, U., Alyethodi, R.R. and Deb, R. 2013. A review on draught animal research in India; Constraints and future thrust areas. *Advances in Animal and Veterinary Sciences,* 1: 178-182.

Ali, A., Khatri, M., Wang, L., Saif, Y.M. and Lee, C.W. 2012. Identification of swine H1N2/ pandemic H1N1 reassortant influenza virus in pigs, United States. *Veterinary Microbiology*, 158: 60-68.

Amarpal, Dhama, K., Chakraborty, S., Tiwari, R. and Natesan, S. 2013. Stem cells and their clinical/ therapeutic applications in biomedical and veterinary science. The perspectives. *Research Opinions in Animal and Veterinary Sciences*, 3: 261-279.

Amonsin, A., Choatrakol, C., Lapkuntod, J., Tantilertcharoen, R., Thanawongnuwech, R., Suradhat, S., Suwannakarn, K., Theamboonlers, A. and Poovorawan, Y. 2008. Influenza virus (H5N1) in live bird markets and food markets, Thailand. *Emerging Infectious Diseases,* 14: 1739-1742.

Avila-Calderon, E.D., Lopez-Merino, A., Sriranganathan, N., Boyle, S.M. and Contreras-Rodríguez, A. 2013. A history of the development of Brucella vaccines. *Biomedical Research International,* 743509, doi:10.1155/2013/743509.

Axten L.G, Wohlers, M.W. and Wegrzyn, T. 2008. Using phytochemicals to enhance health benefits of milk: impact of polyphenols on flavor profile. *Journal of Food Science,* 73: H122–H126.

Ayyar, B.V. and Arora, S. 2013. Antibody-based biosensors for detection of veterinary viral pathogens. *Advances in Animal and Veterinary Sciences*, 1: 37-44.

Balamurugan, V., Venkatesan, G., Sen, A., Annamalai, L., Bhanuprakash, V. and Singh, R.K. 2010. Recombinant protein-based viral disease diagnostics in veterinary medicine. *Expert Review of Molecular Diagnostics,* 10: 731-753.

Barathidasan, R., Singh, S.D., Kumar, M.A., Desingu, P.A., Palanivelu, M., Singh, M. and Dhama, K. 2013. Recurrent outbreaks of infectious bursal disease (IBD) in a layer farm caused by very virulent IBD virus (vvIBDV) in India: Pathology and molecular analysis. *South Asian Journal of Experimental Biology,* 3: 200-206.

Bawa, A.S. and Anilakumar K.R. 2013. Genetically modified foods: safety, risks and public concerns-a review. *Journal of Food Science and Technology*, 50: 1035-1046.

Belak, S., 2007. Molecular diagnosis of viral diseases, present trends and future aspects: A view from the OIE collaborating centre for the application of polymerase chain reaction methods for diagnosis of viral diseases in veterinary medicine. *Vaccine*, 25: 5444-5452.

Belak, S., Thoren, P., Le Blanc, N. and Viljoen, G. 2009. Advances in viral disease diagnostic and molecular epidemiological technologies. *Expert Review of Molecular Diagnostics,* 9: 367-381.

Belhaj, K., Chaparro-Garcia, A., Kamoun, S. and Nekrasov, V. 2013. Plant genome editing made easy: targeted mutagenesis in model and crop plants using the CRISPR/Cas system. *Plant Methods*, 9: 39.

Bengis, R.G., Leighton, F.A., Fischer, J.R., Artois, M., Mörner, T. and Tate, C.M. 2004. The role of wildlife in emerging and re-emerging zoonoses. R*evue Scientifique et Technique de l Office International des Epizooties,* 23: 497-511.

Bergquist, R. 2011. New tools for epidemiology: a space odyssey. *Memórias do Instituto Oswaldo Cruz,* 106: 892-900.

Bhatt, P., Shukla, S.K., Mahendran, M., Dhama, K., Chawak, M.M. and Kataria, J.M. 2011. Prevalence of chicken infectious anemia virus (CIAV) in commercial poultry flocks of Northern India: A serological survey. *Transboundary and Emerging Diseases,* 58: 458-460.

Bhatt, P., Shukla, S.K., Wani, M.Y., Tiwari, R. and Dhama, K. 2013. Amelioration of chicken infectious anaemia virus induced immuno-suppression by immunomodulator and haematinic supplementation in chicks. *Veterinarski Arhiv*, 83: 639-652.

Bollo, E. 2007. Nanotechnologies applied to veterinary diagnostics. *Veterinary Research Communications,* 1: 145-147.

Bonjour, J.P., Benoit, V., Pourchaire, O., Ferry, M., Rousseau, B. and Souberbielle, J.C. 2009. Inhibition of markers of bone resorption by consumption of vitamin D and calcium-fortified soft plain cheese by institutionalised elderly women. *British Journal of Nutrition*, 102: 962-966.

Bromley, E., Leeds, N., Clark, J., McGregor, E., Ward, M., Dunn, M.J. and Tomley, F. 2003. Defining the protein repertoire of microneme secretory organelles in the apicomplexan parasite *Eimeria tenella*. *Protiomics*, 3: 1553-1561.

Cascio, A., Bosilkovski, M,, Rodriguez-Morales, A.J. and Pappas, G. 2011. The socio-ecology of zoonotic infections. *Clinical Microbiology and Infection,* 17: 336-342.

Cebrian-Serrano, A., Stout, T. and Dinnyes, A. 2013. Veterinary applications of induced pluripotent stem cells: Regenerative medicine and models for disease? *Veterinary Journal*, 198: 34-42.

Chakraborty, S. 2012. Prevalence of Nipah viral infection in Asiatic region - An overview. *International Journal of Tropical Medicine and Public Health,* 1: 6-10.

Chakraborty, S., Kumar, A., Tiwari, R., Rahal, A., Malik, Y.P.S., Dhama, K., Amarpal and Prasad, M. 2014a. Advances in diagnosis of respiratory diseases of small ruminants: a review. *Veterinary Medicine International* (In press).

Chakraborty, S., Kumar, N., Dhama, K., Verma, A.K., Tiwari, R., Kumar, A., Kapoor, S. and Singh, S.V. 2014b. Foot-and-mouth disease, an economically important disease of animals. *Advances in Animal and Veterinary Sciences*, 2: 1-16.

Cho, H., Choi, E.S., Lim, H.G. and Lee, H. 2004. Purification and characterization of six fibrinolytic serine proteases from earthworm *Lumbricus rubellus*. *Journal of Biochemistry and Molecular Biology,* 37: 199-205.

Chowdhury, V.S., Sultana, H. and Furuse, M. 2014. International perspectives on impacts of reproductive technologies for world food production in Asia associated with poultry production. *Advances in Experimental Medicine and Biology*, 752: 229-237.

Cogoni, C. and Macino, G. 2000. Post-transcriptional gene silencing across kingdoms. *Current Opinion in Genetics and Develop*ment, 10: 638-643.

Cohen, A.M., Rumpel, K., Coombs, G.H. and Wastling, J.M. 2002. Characterization of global protein expression by two-dimensional electrophoresis and mass spectrometry: proteomics of *Toxoplasma gondii*. *International Journal of Parasitology*, 32: 39-51.

Cruz, H., Rosa, C. and Oliva, A. 2002. Immunosensors for diagnostic applications. *Parasitology Research,* 88: 4-7.

Dasgupta, R., Garcia, B.H. and Goodman, R.M. 2001. Systemic spread of an RNA insect virus in plants expressing plant viral movement protein genes. *Proceedings of the National Academy of Sciences USA,* 98: 4910-4915.

DaSilva, E.J. 2002. Biotechnology and the developing world. *Electronic Journal of Biotechnology,* 5: 1.

Daszak, P., Cunningham, A.A. and Hyatt, A.D. 2000. Emerging infectious diseases of wildlife: threats to biodiversity and human health. *Science*, 297: 443-449.

Daszak, P., Tabor, G.M., Kilpatrick, A.M., Epstein, J. and Plowright, R. 2004. Conservation medicine and a new agenda for emerging diseases. *Annals of the New York Academy of Sciences,* 1026: 1–11.

David, E. 2006. Transgenics and vertebrate cloning as tools for species conservation. *Conservation Biology*, 20: 723-732.

Deb, R. and Chakraborty, S. 2012. Trends in Veterinary diagnostics. *Journal of Veterinary Science and Technology*, 3: 1.

Deb, R., Kumar, A., Chakraborty, S., Verma, A.K., Tiwari, R., Dhama, K., Singh, U. and Kumar, S. 2013a. Trends in diagnosis and control of bovine mastitis – A review. *Pakistan Journal of Biological Sciences,* 16: 1653-1661.

Deb, R., Chakraborty, S., Veeregowda, B.M., Verma, A.K., Tiwari, R. and Dhama, K. 2013b.

Monoclonal antibody and its use in the diagnosis of livestock diseases. *Advances in Bioscience and Biotechnology*, 4: 50-62.

Deb, R., Chakraborty, S., Mahima, Verma, A.K., Tiwari, R. and Dhama, K. 2014. Nutrigenomics and its role in male puberty of cattle - a mini review. *Pakistan Journal of Biological Sciences*, 17: 329-334.

DellaPenna, D. 2007. Biofortification of plant-based food: enhancing folate levels by metabolic engineering. *Proceedings of the National Academy of Sciences, USA,* 104: 3675–3676.

Dent, J.B., Edwards-Jones, G. and Mc Gregor, M.J. 1995. Simulation of ecological, social and economic factors in agricultural systems. *Agricultural Systems*, 49: 337-351.

Dhama, K., Chauhan, R.S., Kataria, J.M., Mahendran, M, and Tomar, S. 2005. Avian influenza: the current perspectives. *Journal of Immunology and Immunopathology*, 7: 1-33.

Dhama, K., Mahendran, M., Gupta, P.K. and Rai, A. 2008a. DNA vaccines and their applications in veterinary practice: current perspectives. *Veterinary Research Communications*, 32: 341-356.

Dhama, K., Mahendran, M., Tomar, S. and Chauhan, R.S. 2008b. Beneficial effects of probiotics and prebiotics in livestock and poultry: the current perspectives. *Intas Polivet,* 9: 1-13.

Dhama, K., Mahendran, M., Somvanshi, R. and Chawak, M.M. 2008c. Chicken infectious anaemia virus: an immunosuppressive pathogen of poultry- A Review. *Indian Journal of Veterinary Pathology,* 32: 158-167.

Dhama, K., Mahendran, M. and Tomar, S. 2008d. Pathogens transmitted by migratory birds: Threat perceptions to poultry health and production. *International Journal of Poultry Sciences,* 7: 516-525.

Dhama, K., Chauhan, R.S., Mahendran, M. and Malik, S.V.S. 2009. Rotavirus diarrhea in bovines and other domestic animals. *Veterinary Research Communications,* 33: 1-23.

Dhama, K., Gowthaman, V. and Singh, S.D. (2010). Animal disease diagnosis and control: the recent trends. *Livestock Line*, 4: 28-32.

Dhama, K., Sawant, P.M., Kumar, D. and Kumar, R. 2011a. Diagnostic applications of molecular tools and techniques for important viral diseases of poultry. *Poultry World*, 6: 32-40.

Dhama, K., Mahendran, M., Tiwari, R., Singh, S.D., Kumar, D., Singh, S.V. and Sawant, P.M. 2011b. Tuberculosis in birds: Insights into the Mycobacterium avium infections. *Veterinary Medicine International*, Vol. 2011, Article ID 712369, 14 pages, doi:10.4061/2011/712369.

Dhama, K., Wani, M.Y., Tiwari, R. and Kumar, D. 2012a. Molecular diagnosis of animal diseases: the current trends and perspectives. *Livestock Sphere*, 1: 6-10.

Dhama, K., Verma, A.K., Rajagunalan, S., Deb, R., Karthik, K., Kapoor, S., Mahima, Tiwari, R., Panwar, P. K. and Chakraborty, S. 2012b. Swine flu is back again: A review. *Pakistan Journal of Biological Sciences*, 15: 1001-1009.

Dhama, K., Verma, A.K., Tiwari, R., Chakraborty, S., Vora, K., Kapoor, S., Deb, R., Karthik, K., Singh, R., Munir, M. and Natesan, S. 2013a. A perspective on application of Geographical Information System (GIS); and advanced tracking tool for disease surveillance and monitoring in Veterinary epidemiology. *Advances in Animal and Veterinary Sciences,* 1: 14-24.

Dhama, K., Chakraborty, S., Kapoor, S., Tiwari, R., Kumar, A., Deb, R., Rajagunalan, S., Singh, R., Vora, K. and Natesan, S. 2013b. One world, one health – veterinary perspectives. *Advances in Animal and Veterinary Sciences*, 1: 5-13.

Dhama, K., Tiwari, R., Chakraborty, S., Kumar, A., Karikalan, M., Singh, R. and Rai, R.B. 2013c. Global warming and emerging infectious diseases of animals and humans: Current scenario, challenges, solutions and future perspectives. A review. *International Journal of Current Research,* 5: 1942-1958.

Dhama, K., Karthik K, Chakraborty, S., Tiwari, R. and Kapoor, S. 2013d. Wildlife: a hidden warehouse of zoonosis - a review. *International Journal of Current Research,* 5: 1866-1879.

Dhama, K., Wani, M.Y., Deb, R., Karthik, K., Tiwari, R., Barathidasan, R., Kumar, A., Mahima, Verma, A.K. and Singh, S.D. 2013e. Plant based oral vaccines for human and animal pathogens-a new era of prophylaxis: current and future prospective. *Journal of Experimental Biology and Agricultural Sciences,* 1: 1-12.

Dhama, K., Chakraborty, S., Mahima, Wani, M.Y., Verma, A.K., Deb, R., Tiwari, R. and Kapoor, S. 2013f. Novel and emerging therapies safeguarding health of humans and their companion animals: A review. *Pakistan Journal of Biological Sciences*, 16: 101-111.

Dhama, K., Chakraborty, S. and Tiwari, R. 2013g. Panchgavya therapy (Cowpathy) in safeguarding health of animals and humans – A review. *Research Opinions in Animal and Veterinary Sciences*, 3: 170-178.

Dhama, K., Mani, S., Chakraborty, S., Tiwari, R., Kumar, A., Selvaraj, P. and Rai, R.B. 2013h. Herbal remedies to combat cancers in humans and animals – a review. *International Journal of Current Research,* 5: 1908-1919.

Dhama, K., Chakraborty, S., Wani, M.Y., Tiwari, R. and Barathidasan, R. 2013i. Cytokine therapy for combating animal and human diseases – A review. *Research Opinions in Animal and Veterinary Sciences,* 3: 195-208.

Dhama, K., Chakraborty, S., Verma, A.K., Tiwari, R., Barathidasan, R., Kumar, A. and Singh, S.D. 2013j. Fungal/ mycotic diseases of poultry-diagnosis, treatment and control: A review. *Pakistan Journal of Biological Sciences,* 16: 1626-1640.

Dhama, K., Chakraborty, S., Tiwari, R. and Singh, S.D. 2013k. Avian chlamydiosis (psittacosis/ ornithosis): diagnosis, prevention and control, and its zoonotic concerns. *Research Opinions in Animal and Veterinary Sciences,* 3: 157-169.

Dhama, K., Chakraborty, S., R. Barathidasan, Tiwari, R., S. Rajagunalan and Singh, S.D. 2013l. *Escherichia coli,* an economically important avian pathogen, its disease manifestations, diagnosis and control, and public health significance: a review. *Research Opinions in Animal and Veterinary Sciences,* 3: 179-194.

Dhama, K., Rajagunalan, S., Chakraborty, S., Verma, A.K., Kumar, A., Tiwari, R., and Kapoor, S. 2013m. Food-borne pathogens of animal origin-diagnosis, prevention, control and their zoonotic significance: a review. *Pakistan Journal of Biological Sciences,* 16: 1076-1085.

Dhama, K., Chakraborty, S., Tiwari, R., Kumar, A., Rahal, A., Latheef, S.K., Wani, M.Y. and Kapoor, S. 2013n. Avian/bird flu virus: poultry pathogen having zoonotic and pandemic threats – a review. *Journal of Medical Sciences,* 13: 301-315.

Dhama, K., Singh, R.P., Karthik, K., Chakraborty, S., Tiwari, R., Wani, M.Y. and Mohan, J. 2014a. Artificial insemination in poultry and possible transmission of infectious pathogens: A review. *Asian Journal of Animal and Veterinary Advances,* 9(4): 211-228.

Dhama, K., Karthik, K., Chakraborty, S., Tiwari, R., Kapoor, S., Kumar, A. and Thomas, P. 2014b. Loop-mediated isothermal amplification of DNA (LAMP) – a new diagnostic tool lights the world of diagnosis of Animal and Human Pathogens: A review. *Pakistan Journal of Biological Sciences,* 17: 151-166.

Dhama, K., Singh, S.D., Barathidasan, R., Desingu, P.A., Chakraborty, S., Tiwari, R. and Kumar, A.M 2014c. Emergence of avian infectious bronchitis virus and its variants need better diagnosis, prevention and control strategies: A global perspective. *Pakistan Journal of Biological Sciences,* 17: 751-.767.

Dhama, K., Chakraborty, S., Pawaiya, R.V.S., Tiwari, R. and S. Kapoor 2014d. Foamy viruses affecting animals and humans and their public health concerns: A review. *Asian Journal of Animal and Veterinary Advances*, 9: 107-122.

Dhama, K., Pawaiya, R.V.S., Chakraborty, S., Tiwari, R. and Verma, A.K. 2014e. Toroviruses affecting animals and humans: A review. *Asian Journal of Animal and Veterinary Advances* (In Press).

Domingo, J.L. 2000. Health risks of genetically modified foods: Many opinions but few data. *Science,* 288: 1748-1749.

Duan, C.G., Wang, C.H. and Guo, S.H. 2012. Application of RNA silencing to plant disease resistance. *Silence*, 3: 5.

Emerich, D. and Thanos, C. 2003. Nanotechnology and medicine. *Expert Opinion in Biological Therapy,* 3: 655-663.

Ewen, S.W.B. and Pusztai, A. 1999. Authors' reply. *The Lancet,* 354: 1727-1728.

FAO/WHO. 2001. Evaluation of allergenicity of genetically modified foods. Joint FAO/WHO Consultation (22-25 January, 2001, Rome, Italy) Report on Allergenicity of Foods Derived from Biotechnology, FAO, Rome, Italy, p: 27.

Fernandez-Borges, N., Elezgarai, S.R., Eraña, H. and Castilla, J. 2013. Animal models for testing anti-prion drugs. *Current Topics in Medicinal Chemistry,* 13: 2504-2521.

Fisinin, V.I., Papazyan, T.T. and Surai, P.F. 2009. Producing selenium-enriched eggs and meat to improve the selenium status of the general population. *Critical Reviews in Biotechnology,* 29:18-28.

Floros, J.D., Newsome, R. and Fisher, W. 2010. Feeding the world today and tomorrow: the importance of food science and technology. *Comprehensive Reviews in Food Science and Food Safety*, pp: 1-28. doi: 10.1111./j.1541-4337.2010. 00127.x.

Fojo, T. 2008. Commentary: Novel therapies for cancer: why dirty might be better. *The Oncologist*, 13: 277-283.

Gama, L.T., Smith, C. and Gibson, J.P. 1992. Transgene effects, introgression strategies and testing schemes in pigs. *Animal Production*, 54: 40.

German, J.B., Hammock, B.D. and Watkins, S.M. 2005. Metabolomics: building on a century of biochemistry to guide human health. *Metabolomics*, 1: 3-9.

Gibbs, M. 1994. Risks in using transgenic plants? *Science,* 264: 1650-1651.

Golia, S., Hittinahalli, V., Reddy, M. and Karjigi, S. 2012. PCR as a faster mode of supportive tool in laboratory diagnosis of *Mycobacterium tuberculosis*. *Journal of Pure and Applied Microbiology*, 6: 1913-1916.

Gopi, M., Karthik, K., Manjunathachar, H.V., Tamilmahan, P., Kesavan, M., Dashprakash, M., Balaraju, B.L. and Purushothaman, M.R. 2014. Essential oils as a feed additive in poultry nutrition.

Advances in Animal and Veterinary Sciences, 2: 1-7.

Goswami, T.K., Singh, D.K., Saminathan, M., Verma, A.K. and Dhama, K. 2014. An emerging threat of Crimean Congo hemorrhagic fever: call for preparedness. *Advances in Animal and Veterinary Sciences*, 2: 8-14.

Granado-Lorencio, F., Herrero-Barbudo, C., Olmedilla-Alonso, B., Blanco-Navarro, I. and Pérez-Sacristán, B. 2010. Lutein bioavailability from lutein ester-fortified fermented milk: in vivo and in vitro study. *Journal of Nutrition and Biochemistry,* 21:133-139.

Gross, P.A., Hermogenes, A.W., Sacks, H.S., Lau, J. and Levandowski, R.A. 1995. The efficacy of influenza vaccine in elderly persons: A meta-analysis and review of literature. *Annual International Medicine,* 123: 518-527.

Gu, Y., Wei, J., Yang, J., Huang, J., Yang, X. and Zhu, X. 2013. Protective immunity against *Trichinella spiralis* infection induced by a multi-epitope vaccine in a murine model. *PLoS One,* 8: e77238.

Gupta, R.K. and Singh, V.K. 2012. Artificial insemination: Boon for Indian dairy industry. *Research News for U (RNFU*), 5: 49-51.

Grunkemeyer, V.L. 2011. Zoonoses, public health, and the backyard poultry flock. *Veterinary Clinics of North America: Exotic Animal Practice,* 14: 477-490.

Haan, C., de Schillhorn van Veen, T., Brandenburg, B., Gauthier, J., Le Gall, F., Mearns, R. and Simeón, M. 2001. Livestock development: Implications for rural poverty, the environment and global food security. The World Bank, Washington DC, pp. 96.

Hamburg, M.A. and Lederberg, J. 2003. Microbial threats to health. Institute of Medicine of the National Academies. National Academy Press, Washington DC, USA. 53-55.

Hansa, A., Rai, R.B., Dhama, K., Wani, M.Y. 2012. ELISA and RT-PCR based detection of Bovine Coronavirus in Northern India. *Asian Journal of Animal and Veterinary Advances,* 7: 1120-1129.

Hauptmann, V., Weichert, N., Rakhimova, M. and Conrad, U. 2013. Spider silks from plants - a challenge to create native-sized spidroins. *Biotechnology Journal*, 8: 1183-1192.

Hirsch, L.R., Stafford, R.J., Bankson, J.A., Sershen, S.R., Rivera, B., Price, R.E., Hazle, J.D., Hala, N.J. and West, J.L. 2003. Nanoshell-mediated near-infrared thermal therapy of tumors under magnetic resonance guidance. *Proceedings of the National Academy of Sciences,* 100: 13549-13554.

Hoisington, D. 2002. Opportunities for nutritionally enhanced maize and wheat varieties to combat protein and micronutrient malnutrition. *Food and Nutrition Bulletin,* 23: 376–377.

Houdebine, L.M. 2009. Methods to Generate Transgenic Animals, in Engelhard, M., Hagen, K. and Boysen, M. (eds.) Genetic Engineering in Livestock: New Applications and Interdisciplinary Perspectives (Ethics of Science and Technology Assessment, 34: 31-48.

Hsu, F.C., Wirtz, M., Heppel, S.C., Bogs, J., Krämer, U., Khan, M.S., Bub, A., Hell, R. and Rausch. T. 2011. Generation of Se-fortified broccoli as functional food: impact of Se fertilization on S metabolism. *Plant and Cell Environment,* 34: 192-207.

Hu, Y., McIntosh, G.H., Le Leu, R.K. and Young, G.P. 2010. Selenium-enriched milk proteins and selenium yeast affect selenoprotein activity and expression differently in mouse colon. *British Journal of Nutrition,* 104: 17–23.

Jain, K. 2003. Nanodiagnostics: application of nanotechnology in molecular diagnostics. *Expert Review of Molecular Diagnostics- Expert Reviews,* 3: 153-161.

Jelicks, L.A., Tanowitz, H.B. 2011. Advances in imaging of animal models of Chagas disease. *Advances in Parasitology,* 75: 193-208.

Jones, K.E., Patel, N.G., Levy, M.A., Storeygard, A. and Balk, D. 2008. Global trends in emerging infectious diseases. *Nature,* 451: 990-993.

Joshi, V.G., Dighe, V.D., Thakuria, D., Malik, Y.P.S. and Kumar, S. 2013. Multiple antigenic peptide (MAP): a synthetic peptide dendrimer for diagnostic, antiviral and vaccine strategies for emerging and re-emerging viral diseases. *Indian Journal of Virology,* 24: 312-320.

Kahn, L.H., Kaplan, B. and Steele, J.H. 2007. Confronting zoonoses through closer collaboration between medicine and veterinary medicine (as 'one medicine'). *Veterinaria Italiana*, 43: 5-19.

Kapoor, S. and Dhama, K. 2014. Insight into influenza viruses of animals and humans. Springer International Publishing AG, Gewerbestrasse 11, 6330 Cham, Switzerland, pp: 1-222.

Karatzas CN, Turner JD. 1997. Toward altering milk composition by genetic manipulation: current status and challenges. *Journal of Dairy Science,* 80: 2225–2232.

Karthik, K., Muneeswaran, N.S., Manjunathachar, H.V., Gopi, M., Elamurugan, A. and Kalaiyarasu, S. 2014. Bacteriophages: effective alternative to antibiotics. *Advances in Animal and Veterinary Sciences,* 2: 1-7.

Kataria, J.M., Mohan, M.C., Dey, S., Dash, B.B. and Dhama, K. 2005. Diagnosis and immuno-prophylaxis of economically important poultry diseases: A Review. *Indian Journal of Animal Sciences*, 75: 555-567.

Kataria, J.M., Dhama, K., Nagarajan, S., Chakraborty, S., Kaushal, A. and Deb, R. 2013. Fowl adenovirus causing hydropericardium syndrome in poultry. *Advances in Animal and Veterinary Sciences*, 1: 5-13.

Kazimierczuk, K., Cova, L., Ndeboko, B., Szczyrk, U., Targosz, A., Brzozowski, T. and Sirko, A. 2005. Genetic immunization of ducks for production of antibodies specific to *Helicobacter pylori* UreB in egg yolks. *Acta Biochimica Polonica*, 52: 261–266.

Kim, J., Ko, Y., Park, Y.K., Kim, N.I., Ha, W.K. and Cho, Y. 2010. Dietary effect of lactoferrin-enriched fermented milk on skin surface lipid and clinical improvement of acne vulgaris. *Nutrition,* 26: 902-909.

King, L.J. 2004. Emerging and re-emerging zoonotic diseases: challenges and opportunities. 72nd General Session, World organization for animal health, Office des International Epizootics, Paris. pp: 1-9.

King, D.P., Madi, M., Mioulet, V., Wadsworth, J., Wright, C.F., Valdazo-Gonzalez, B., Ferris, N.P., Knowles, N.J. and Hammond, J. 2012. New technologies to diagnose and monitor infectious diseases of livestock: Challenges for sub-Saharan Africa. *Onderstepoort Journal of Veterinary Research*, 79(2), Art. #456, 6 pages. http://dx.doi.org/10.4102/ojvr. v79i2.456.

Koff, W.C., Burton, D.R., Johnson, P.R., Walker, B.D., King, C.R., Nabel, G.J., Ahmed, R., Bhan, M.K. and Plotkin, S.A. 2013. Accelerating next generation vaccine development for global disease prevention. *Science*, 340 (6136): 1232910. doi: 10.1126/science.1232910.

Kruger, M.C., Schollum, L.M., Kuhn-Sherlock, B., Hestiantoro, A., Wijanto, P., Li-Yu, J., Agdeppa, I., Todd, J.M. and Eastell, R. 2010. The effect of a fortified milk drink on vitamin D status and bone turnover in post-menopausal women from South East Asia. *Bone,* 46: 759–767.

Kuiper, H.A., Noteborn, H.P.J.M. and Peijnenburg, A.A.C.M. 1999. Adequacy of methods for testing the safety of genetically modified foods. *The Lancet,* 354: 1315-1316.

Kumar, R., Verma, A.K., Kumar, A., Srivastava, M., Srivastava, A. and Lal, H.P. 2011a. Probiotics in therapeutic management of diarrhoea in dogs. *Journal of Canine Development and Research,* 37-43.

Kumar, A., Verma, A.K. and Rahal, A. 2011b. Mycoplasma bovis, a multi disease producing pathogen: An Overview. *Asian Journal of Animal and Veterinary Advances*, 6: 537-546.

Kumar, T.A., Saravanan, S. and Sasikala, M. 2012. Isolation of *Salmonella* from broiler chicken meat of local markets with reference to food safety. *Journal of Pure and Applied Microbiology,* 6: 1501-1502.

Kumar, A., Verma, A.K., Rahal, A., Panwar, P.K. and Dhama, K. 2013. Recent trends in development of adjuvant of vaccine. *Trends in Medical Research*, 8: 32-35.

Lalwani, M. 1989. Technological change in India's dairy farming sector: Distribution and decomposition of output gains. *Indian Journal of Agricultural Economics*, 44: 55-66.

Lamont, S.J. 1998. The chicken major histo-compatibility complex and disease. *Review of Scientific Technology Office International Epizootics*, 17: 128-142.

Lee, H.Y., Chai, L.C., Nakaguchi, Y., Nishibuchi, M. and Radu, S. 2013. Review on protocol development for detection and identification of *Listeria monocytogenes* in foods. *Journal of Pure and Applied Microbiology,* 7: 2523-2530.

Lee, Y.S., Kang, E.Y., Park, M.N., Choi, Y.Y., Jeon, J.W. and Yun, S.S. 2008. Effects of sn-2 palmitic acid-fortified vegetable oil and fructooligo-saccharide on calcium metabolism in growing rats fed casein based diet. *Nutrition Research and Practice,* 2: 3–7.

Lemaux, P.G. 2008. Genetically engineered plants and foods: a scientist's analysis of the issues (Part 1). *Annual Review of Plant Biology*, 59: 771–812.

Liu, Z., Jiang, T., Qin, E., Ran, D. and Qin, C. 2012. Progress in new vaccine strategies against influenza: a review. *Sheng Wu Gong Cheng Xue Bao,* 28: 550-556.

Liu, F., Li, J.L., Chen, H.Y., Zhang, H.Y., Wang, X.B., Cui, B.A. and Wei, Z.Y. 2013. Detection of porcine parvo virus using loop mediated isothermal amplification. *Journal of Pure and Applied Microbiology,* 7: 311-315.

Lolle, S.J., Victor, J.L., Young, J.M. and Pruitt, R.E. 2005. Genome-wide non-mendelian inheritance of extra-genomic information in Arabidopsis. *Nature,* 434: 505–509.

Lotter, D. 2003. Organic agriculture. *Journal of Sustainable Agriculture*, 21: 59–128.

Lowy, D.R. and Schiller, J.T. 2006. Prophylactic human papillomavirus vaccines. *Journal of Clinical Investigation,* 116: 1167–1173.

Lund, D. 1989. Food processing: from art to engineering. *Food Technology*, 43: 242–308.

Luo, D. 2003. Yearbook of science and technology. McGraw-Hill, New York, pp. 93-95.

Mac Aulay, J. and Newsome, R. 2004. Solving the obesity conundrum. *Food Technology*, 58: 32–37.

Mahima, Verma, A.K., Kumar, A., Kumar, V. and Rahal, A. 2012a. Designer milk for human health: A future need. *International Journal of Dairy Science*, 7: 70-72.

Mahima, Verma, A.K., Kumar, A., Kumar, V. and Rahal, A. 2012b. Designer egg: future prospects. *Asian Journal of Poultry Science*, 6: 97-100.

Mahima, Rahal, A., Deb, R., Latheef, S.K., Samad, H.A., Tiwari, R., Verma, A.K., Kumar, A. and

Dhama, K. 2012c. Immunomodulatory and therapeutic potentials of herbal, traditional/ indigenous and ethnoveterinary medicines. *Pakistan Journal of Biological Sciences,* 15: 754-774.

Mahima, Verma, A.K., Kumar, A., Rahal, A. and Kumar, V. 2012d. Veterinarian for sustainable development of humanity. Asian Journal of Animal and Veterinary Advances, 7: 752-753.

Mahima, Verma, A.K., Tiwari, R., Karthik, K., Chakraborty, S., Deb, R. and Dhama, K. 2013a. Nutraceuticals from fruit and vegetables at a glance: a review. *Journal of Biological Sciences,* 13: 38-47.

Mahima, Ingle, A.M., Verma, A.K., Tiwari, R., Karthik, K., Chakraborty, S., Deb, R., Rajagunalan, S., Rathore, R. and Dhama, K. 2013b. Immunomodulators in day to day life: A review. *Pakistan Journal of Biological Sciences*, 16: 826-843.

Malik, Y.S., Kumar, N., Sharma, K., Haq, A.A., Kumar, A. and Prasad, M. 2013a. Sequence and phylogenetic analysis of bovine rota virus isolates (G6 genotypes) from India. *Advances in Animal and Veterinary Sciences,* 1: 41-43.

Malik, YS, Sharma, K., Jeena, L.M., Kumar, N., Sircar, S., Rajak, K.K. and Dhama, K. 2013b. Toll-like receptors: the innate immune receptors with ingenious anti-viral paradigm. *South Asian Journal of Experimental Biology,* 3: 207-213.

Marcelino, I., de Almeida, A.M., Ventosa, M., Pruneau, L., Meyer, D.F., Martinez, D., Lefrançois, T., Vachiery, N. and Coelho, A.V. 2012. Tick-borne diseases in cattle: applications of proteomics to develop new generation vaccines. *Journal of Proteomics*, 75: 4232-50.

Mc Cullers, J.A. and Dunn, J.D. 2008. Advances in vaccine technology and their impact on managed care. *Pharmacy and Therapeutics*, 33(1): 35-38.

Mc Laren, A. 2000. Cloning: pathways to a pluripotent future. *Science*, 288: 1775–1780.

Meeusen, E.N., Walker, J., Peter, A., Pastorate, P.P. and Jungersen, G. 2007. Current status of veterinary vaccines. *Clinical Microbiology Reviews,* 20: 489-510.

Myers, S.S. and Patz, J.A. 2009. Emerging threats to human health from global environmental change. *Annual Review of Environment and Resources*, 34: 223-252.

Mihara, H., Maruyama, M. and Sumi, H.1992. Novel thrombolytic therapy discovered from traditional oriental medicine using the earthworm. *Southeast Asian Journal of Tropical Medicine and Public Health,* 23(Suppl. 2): 131-140.

Mihara, H., Nakajima, N. and Sumi, H. 1993. Characterization of protein fibrinolytic enzyme in earthworm, *Lumbricus rubellus. Bioscience Biotechnology and Biochemistry*, 57: 1726-1731.

Millstone, E., Brunner, E. and Mayer, S. 1999. Beyond substantial equivalence. *Nature,* 401: 525-526.

Mishra, N., Gupta, P.N., Khatri, K., Goyal, A.K. and Vyas, S.P. 2008. Edible vaccines: A new approach to oral immunization. *Indian Journal of Biotechnology*, 7: 283-294.

Morse, S.S. 1995. Factors in the emergence of infectious diseases. *Emerging Infectious Diseases,* 1: 7.

Mujer, V.C., Wagner, M.A., Eschenbrenner, M., Horn, T., Kraycer, J.A., Redkar, R., Hagious, S., Elzer, P. and Delvecchio, V.G. 2002. Global analysis of *Brucella melitensis* proteomes. *Annals of the New York Academy of Sciences*, 969: 97-101.

Munshi, K.D. and Parikh, K.S. 1994. Milk Supply Behavior in India: Data Integration, Estimation and Implications for Dairy Development. *Journal of Development Economics,* 45: 201-223.

Murray, C.J.L. and Lopez, A.D. 1996. Evidence-based health policy-lessons from the Global burden of disease study. *Science*, 274: 740–743.

Murray, J.D. and Anderson, G.B. 2000. Genetic engineering and cloning may improve milk, livestock production. *California Agriculture*, 54: 57-65.

Natesan, S., Kataria, J.M., Dhama, K., Bhardwaj, N. and Sylvester, A. 2006. Anti-neoplastic effect of chicken anemia virus VP3 protein (apoptin) in Rous sarcoma virus-induced tumours in chicken. *Journal of General Virology,* 87: 2933-2940**.**

Naveen, K.A., Singh, S.D., Kataria, J.M., Barathidasan, R. and Dhama, K. 2013. Detection and differentiation of pigeon paramyxovirus serotype-1 (PPMV-1) isolates by RT-PCR and restriction enzyme analysis. *Tropical Animal Health and Production,* 45: 1231-6.

Newell-Mc Gloughlin, M. 2008. Nutritionally improved agricultural crops. *Plant Physiology*, 147: 939-953.

Nielsen, K., Gall, D., Jolley, M., Leishman, G., Balsevicius, S., Smith, P., Nicoletti, P. and Thomas, F. 1996. A homogenius fluorescence polarization assay for detection of antibody to *Brucella abortus*. *Journal of Immunological Methods*, 195: 161-168.

Oqino, S., Fuchs, C.S. and Giovannucci, E. 2012. How many molecular subtypes? Implications of the unique tumor principle in personalized medicine. *Expert Review of Molecular Diagnostics*, 12: 621-628.

Osburn, B., Scott, C. and Gibbs, P. 2009. One World – One Medicine – One Health: emerging veterinary challenges and opportunities. R*evue scientifique et technique de l office international des epizooties,* 28: 481-486.

Palese, P. 2006. Making influenza virus vaccines? *Emerging Infectious Diseases*, 12: 61-65.

Pamela, R. 2011. Plant genetics, sustainable agriculture and global food security. *Genetics,* 188 (1): 11–20.

Patil, S.S., Kore, B.B. and Kumar, P. 2009. Nanotechnology and its applications in Veterinary and Animal Science. *Veterinary World,* 2: 475-477.

Patyal, A., Rathore, R.S., Mohan, H.V., Dhama, K. and Kumar, A. 2011. Prevalence of *Arcobacter* spp. in humans, animals and foods of animal origin including sea food from India. *Transboundary and Emerging Diseases*, 58: 402–410.

Patz, J.A.D., Holloway, C.L.T. and Foley, J.A. 2005. Impact of regional climate change on human health. *Nature,* 438: 310-317.

Pauwels, R.A., Buist, A.S., Calverley, P.M.A., Jenkins, C.R. and Hurd, S.S. 2001. Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease. *American Journal of Respiratory and Critical Care Medicine*, 163: 1256-1276.

Pawaiya, R.V.S., Dhama, K., Mahendran, M. and Tripathi, B.N. 2009. Swine flu and the current influenza A (H1N1) pandemic in humans: A review. *Indian Journal of Veterinary Pathology*, 33: 1-17.

Quinn, T.C. 1994. Recent advances in diagnosis of sexually transmitted diseases. *Sexually Transmitted Diseases,* 21(Suppl. 2): S19-S27.

Rahal, A., Mahima, Verma, A.K., Kumar, A., Tiwari, R., Kapoor, S., Chakraborty, S. and Dhama, K. 2014a. Phytonutrients and nutraceuticals in vegetables and their multi-dimensional medicinal and health benefits for humans and their companion animals: A review. *Journal of Biological Sciences,* 14: 1-19.

Rahal, A., Kumar, A., Singh, V., Yadav, B., Tiwari, R., Chakraborty, S. and Dhama, K. 2014b. Oxidative stress, prooxidants and antioxidants: the interplay. *BioMed Research International,* Volume 2014, Article ID 761264, 19 pages. http://dx.doi.org/ 10.1155/2014/761264

Raies, M., Verma, A.K., Yadav, S.K., Pal, B.C., Mahima and Jain, U. 2009. Genetic and antigenic relationship between foot and mouth disease virus serotype Asia-1 isolate and vaccine strain. *Online Journal of Veterinary Research*, 13: 114-119.

Rajasekaran, A. and Kalaivani, M. 2013. Designer foods and their benefits: A review. *Journal of Food Science and Technology,* 50: 1–16.

Rajendran, D. and Ramakrishnan, J. 2012. A comparative study on efficacy of potential bio-control agents in dynamic environments. *Journal of Pure and Applied Microbiology,* 6: 1977-1983.

Ranjan, K., Prasad, G., Kumar, P. and Minakshi, P. 2014. Molecular characterization of segment 6 of Blue tongue serotype 16 of sheep origin from India. *Advances in Animal and Veterinary Sciences,* 2: 98-103.

Ratcliff, R.M., Chang, G., Kok, T. and Sloots, T.P. 2007 Molecular diagnosis of medical viruses. *Current Issues in Molecular Biology*, 9: 87-102.

Rivera, J.A., Shamah, T., Villalpando, S. and Monterrubio, E. 2010. Effectiveness of a large-scale iron-fortified milk distribution program on anemia and iron deficiency in low-income young children in Mexico. *American Journal of Clinical Nutrition,* 91: 431–439.

Rogers, D.J. and Randolph, S.E. 2006. Climate change and vector-borne diseases. *Advances in Parasitology,* 62: 345-381.

Rout, M.P. and Field, M.C. 2001. Isolation and characterization of subnuclear compartments from *Trypanosoma brucei*. Identification of major repetitive nuclear lamina component. *Journal of Biological Chemistry*, 276: 38261-38271.

Sabikhi, L. 2007. Designer milk. *Advances in Food and Nutrition Research*, 53: 161-198.

Saritha, N.S., Veeregowda, B.M., Leena, G., Chakraborty, S., Tiwari, R., Dhama, K. and Singh, S.V. 2014. Biomedical waste management. *Advances in Animal and Veterinary Sciences,* 2: 1-6.

Saif, Y.M., Barnes, H.J., Glisson, J.R., Fadly, A.M., McDougald, L.R. and Swayne, D.E. 2003. Diseases of poultry. 11th edn. Ames, Iowa State Press, USA.

Sakoda, Y., Ito, H. and Uchida, Y. 2012. Reintroduction of H5N1 highly pathogenic avian influenza virus by migratory water birds, causing poultry outbreaks in the 2010–2011 winter seasons in Japan. *Journal of General Virology*, 93: 541-550.

Sazawal, S., Dhingra, U., Dhingra, P., Hiremath, G., Sarkar, A., Dutta, A., Menon, V.P. and Black, R.E. 2010. Micronutrient fortified milk improves iron status, anemia and growth among children 1–4 years: a double masked, randomized, controlled trial. *PLoS One*, 5: e12167.

Schmitt, B. and Henderson, L. 2005. Diagnostic tools for animal diseases. R*evue scientifique et technique de l office international des epizooties,* 24: 243-250.

Schwab, R. 2006. Highly Specific Gene Silencing by Artificial MicroRNAs in Arabidopsis. *Plant Cell Online,* 18: 1121-1133.

Scott, N.R. and Chen, H. 2002. National planning workshop. www.nseafs.cornell.edu.

Semba, R.D., Moench-Pfanner, R., Sun, K., de Pee, S., Akhter, N., Rah, J.H., Campbell, A.A., Badham, J., Bloem, M.W. and Kraemer, K. 2010. Iron-fortified milk and noodle consumption is associated with lower risk of anemia among children aged 6–59 mo in Indonesia. *American Journal of Clinical Nutrition,* 92: 170–176.

Sere, C. and Steinfeld, H. 1996. World Livestock Production Systems – Current Status, Issues and Trends. *Animal Production and Health*, Paper No. 127. FAO, Rome, Italy, pp: 89.

Sharma, T.K. and Shukla, R. 2014. Nucleic acid aptamers as an emerging diagnostic tool for animal pathogens. *Advances in Animal and Veterinary Sciences,* 2: 50-55.

Shohani, M., Khosravi, A. and Reza, A. 2013. The impact of probiotics and prebiotics on serum levels of allergy associated Th1 and Th2 cytokines. *Journal of Pure and Applied Microbiology,* 7: 1821-1830.

Siddiqui, M.Z., 2010. Monoclonal antibodies as diagnostics: An appraisal. *Indian Journal of Pharmaceutical Science,* 72: 12-17.

Singh, S.D., Barathidasan, R., Kumar, AM, Deb, R., Verma, A.K. and Dhama, K. 2012. Recent trends in diagnosis and control of Marek's disease (MD) in poultry. *Pakistan Journal of Biological Sciences,* 15: 964-970.

Singh, D., Verma, A.K., Kumar, A., Srivastava, M.K., Singh, S.K., Tripathi, A.K., Srivastava, A. and Ahmed, I. 2013. Detection of canine parvovirus by polymerase chain reaction assay and its prevalence in dogs in and around Mathura, Uttar Pradesh, India. *American Journal of Biochemistry and Molecular Biology*, 3: 264-270.

Singh, U., Deb, R., Alyethodi, R.R., Alex, R., Kumar, S., Chakraborty, S., Dhama, K. and Sharma, A. 2014a. Molecular markers and their application in cattle genetic research – A review. *Biomarkers and Genomic Medicine,* (In Press). http://dx.doi.org/10.1016/j.bgm.2014.03.001

Singh, S.V., Sohal, J.S., Kumar, N., Gupta, S., Chaubey, K.K., Rawat, K.D., Chakraborty, S., Tiwari, R. and Dhama, K. 2014b. Recent approaches in diagnosis and control of Mycobacterial infections with special reference to *Mycobacterium avium* sub species *paratuberculosis*. *Advances in Animal and Veterinary Sciences*, 2: 1-11.

Singh, A.K., Verma, A.K., Neha, Tiwari, R., Karthik K., Dhama, K. and Singh, S.V. 2014c. Trends and advances in vaccines against protozoan parasites of veterinary importance: A review. *Journal of Biological Sciences,* 14: 95-109.

Slingenbergh, J., Gilbert, M., de Balog, K. and Wint, W. 2004. Ecological sources of zoonotic diseases. R*evue scientifique et technique de l office international des epizooties,* 23: 467-484.

Soutullo, A., Verwimp, V., Riveros, M., Pauli, R. and Tonarelli, G. 2001. Design and validation of an ELISA for equine infectious anemia (EIA) diagnosis using synthetic peptides. *Veterinary Microbiology*, 79: 111-121.

Steinfeld, H. and Mäki-Hokkonen, J. 1995. A classification of livestock production systems. *World Animal Review*, 84/85: 83-94.

Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M. and de Haan, C. 2006. Livestock's Long Shadow: Environmental Issues and Options. FAO, Rome, Italy, pp: 390.

Sujatha, T. and Narahari, D. 2011. Effect of designer diets on egg yolk composition of 'White Leghorn' hens. *Journal of Food Science and Technology*, 48: 494-497.

Sumi, V., Singh, S.D., Dhama, K., Gowthaman, V., Barathidasan, R. and Sukumar, K. 2012. Isolation and molecular characterization of infectious bronchitis virus from recent outbreaks in broiler flocks reveals emergence of novel strain in India. *Tropical Animal Health and Production*, 44: 1791-1795.

Surai, P.F., MacPherson, A., Speake, B.K. and Sparks, N.H. 2000. Designer egg evaluation in a controlled trial. *European Journal of Clinical Nutrition*, 54: 298-305.

Surai, P.F. and Sparks, N.H.C. 2001. Designer eggs: from improvement of egg composition to functional food. *Trends in Food Science and Technology*, 12: 7–16.

Taddele, M.H., Rathore, R., Dhama, K. and Agarwal, R.K. 2011. Epidemiological characterization of S. Gallinarum serotypes of poultry origin in India, employing two PCR based typing methods of RAPD-PCR and PCR-RFLP. *Asian Journal of Animal and Veterinary Advances,* 6: 1037-1051.

Taylor, L.H., Latham S.M. and Woolhouse, M.E.J. 2001. Risk factors for human disease emergence. *Philosophical Transaction of the Royal Society,* B. 356: 983-989.

Tayo, T., Longjam, N., Mezhatsu, V. and Deb, R. 2010. Genetically modified (GM) crops lifeline for livestock – a review. *Agricultural Reviews*, 31: 279-285.

Tiwari, R., Dhama, K., Wani, M.Y., Verma, V., Vaid, R.K. and Chauhan, R.S. 2011. Bacteriophage Therapy - A novel tool for combating bacterial diseases of poultry – a review. *Journal of Immunology and Immunopathology*, 13: 55-66.

Tiwari, R., Chakraborty, S., Dhama, K., Rajagunalan, S. and Singh, S.V. 2013a. Antibiotic resistance-An emerging health problem: Causes, worries, challenges and solutions- A review. *International Journal of Current Research*, 5: 1880-1892.

Tiwari, R., Chakraborty, S. and Dhama, K. 2013b. Miracle of herbs in antibiotic resistant wounds and skin infections: treasure of nature – a review/ perspective. *Pharma Science Monitor,* 4: 214-248.

Tiwari, R., Chakraborty, S., Dhama, K., Wani, M. Y., Kumar, A. and Kapoor, S. 2014a. Wonder world of phages: potential biocontrol agents safeguarding biosphere and health of animals and humans - current scenario and perspectives. *Pakistan Journal of Biological Sciences*, 17: 316-328.

Tiwari, R., Dhama, K., Chakraborty, S., Kumar, A., Rahal, A. and Kapoor, S. 2014b. Bacteriophage therapy for safeguarding animal and human health: A review. *Pakistan Journal of Biological Sciences,* 17: 301-315.

Tiwari, R., Dhama, K., Chakraborty, S. and Kapoor, S. 2014c. Enzybiotics: New weapon in the army of antimicrobials: A review. *Asian Journal of Animal and Veterinary Advances,* Vol. 9 (In press).

Unnikrishnan, M., Rappuoli, R. and Serruto, D. 2012. Recombinant bacterial vaccines. *Current Opinions in Immunology*, 24: 337-42.

Verma, A.K. 2005. Cowpathy and Human Health. *The Indian Cow: Scientific and Economic Journal*, 2: 39-45.

Verma, A.K., Mahima, Pal, B.C., Yadav, S.K., Kumar, A. and Raies, M. 2010a. Phylogenetic relationships between foot-and-mouth disease virus serotype 'A' isolates and vaccine strains. *Online Journal of Veterinary Research*, 14: 87-95.

Verma, A.K., Raies, M., Jain, U., Yadav, S.K., Mahima and Pal, B.C. 2010b. Differentiation of Foot-and-Mouth Disease infected and vaccinated animals using 3ABC non-structural protein. *Indian Journal of Veterinary Medicine*, 30: 84-86.

Verma, A.K., Sinha, D.K. and Singh, B.R. 2011. Detection of Salmonella from clinical samples of dogs by PCR. *Indian Journal of Animal Science*, 81: 552-555.

Verma, A.K., Kumar, A., Mahima and Sahzad. 2012a. Epidemiology and diagnosis of foot and mouth disease: a review. *Indian Journal of Animal Sciences*, 82: 543-551.

Verma, A.K., Kumar, A., Dhama, K., Deb, R., Rahal, A, Mahima and Chakraborty, S. 2012b. Leptospirosis - Persistence of a dilemma: an overview with particular emphasis on trends and recent advances in vaccines and vaccination strategies. *Pakistan Journal of Biological Sciences,* 15: 954-963.

Verma, A.K., Dhama, K., Chakraborty, S., Kumar, A., Tiwari, R., Rahal, A., Mahima and Singh, S.V. 2014a. Strategies for combating and eradicating important infectious diseases of animals with particular reference to India: Present and future perspectives. *Asian Journal of Animal and Veterinary Advances*, 9: 77-106.

Verma, A.K., Kumar, A., Sahzad, Reddy, N.C.R. and Shende, A.N. 2014b. Sero-prevalence of infectious bovine rhinotracheitis in dairy animals with reproductive disorders in Uttar Pradesh, India. *Pakistan Journal of Biological Sciences,* 17: 720-724.

Verma, A.K., Saminathan, M., Neha, Tiwari, R., Dhama, K. and Singh, S.V. 2014c. Glanders-A re-emerging zoonotic disease: a review. *Journal of Biological Sciences*, 14: 38-51.

Wakasa, Y. and Takaiwa, F. 2013. The use of rice seeds to produce human pharmaceuticals for oral therapy. *Biotechnology Journal,* 8: 1133-1143.

Wang, C., Sun, Y. and Qiu, H. 2013. Progress in new-type vaccines against classical swine fever. *Sheng Wu Gong Cheng Xue Bao*, 29: 880-890.

Weiland, I. and Edwards, M. 1996. A single nucleotide substitution in the alpha a gene confers oat pathogenicity to barley stripe mosaic virus strain ND18. *Medical Practice Management*, l9: 62-67.

Whitelaw, C.B.A. and Sang, H.M. 2005. Disease-resistant genetically modified animals. *Review of Scientific Technology Office International Epizootics*, 24: 275-283.

Wilmut, I. and Whitelaw, C.B.A. 1994. Strategies for production of pharmaceutical proteins in milk. *Reproduction, Fertility and Development*, 6: 625-630.

Wolfe, N.D., Dunavan, C.P. and Diamond, J. 2007. Origins of major human infectious diseases. *Nature,* 447: 279-283.

World Health Organization, 2006. The control of neglected zoonotic diseases: A route to poverty alleviation. Report of a joint WHO/DFID-AHP meeting, 20 and 21 September 2005, WHO Headquarters, Geneva, with the participation of FAO and OIE.

Wright, G., Carver, A., Cottom, D., Reeves, D., Scott, A., Simons, P., Wilmut, I., Garner, I. and Colman, A. 1991. High level expression of active human alpha-1-antitrypsin in the milk of transgenic sheep. *Biotechnology*, 9: 830-834.

Xu, J., Zhou, X., Deng, Q., Huang, Q., Yang, J. and Huang, F. 2011. Rapeseed oil fortified with micronutrients reduces atherosclerosis risk factors in rats fed a high-fat diet. *Lipids Health and Diseases,* 13: 96.

Yatsuda, A.P., Krijgsveld, J., Cornelissen, A.W., Heck, A.J. and De Vries, E. 2003. Comprehensive analysis of the secreted protein of the parasite *Haemonchus contortus* reveals extensive sequence variation and differential immune recognition. *Journal of Biological Chemistry*, 278: 16941-16951.

Zinsstag, J., Schelling, E., Roth, F., Bonfoh, B., De Savigny, D. and Tanner, M. 2007. Human benefits of animal interventions for zoonosis control. *Emerging Infectious Diseases,* 13: 527-531.