Biological Forum – An International Journal 13(2): 557-564(2021)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

The Potential of Production of Meat Analogue by using Indian Legumes - A Review

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(Received 14 May 2021, Accepted 05 July, 2021)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: The excess consumption of resource-intensive foods, such as animal-based products is partly responsible for undesirable effects on human health and the environment. In order to lessen the exploitation of natural resources and animal husbandry, one important alternative is to reduce meat consumption by replacing or substituting plant-based meat analogues restructured meat binder or formed meat mimeticks. Processing of leguminous proteins into plant based meat analogues or alternatives are inevitable to meet consumer demands and building of resilience in food supply chain. Researchers from the academic institutions and FMCG sectors are actively exploring leguminous proteins to replace or substitute for animal meat sourced proteins. Legume proteins have a fairly well balanced amino acid profile, and shown high potential for substituting animal meat via formulating and developing of healthy, protein dense, reduced LDL levels, free of cholesterol, and nutritionally equivalent or greater than meat like products. The major challenges in transformation of different legume proteins into meat analogues are dependent on functional characteristics of individual protein sources. This review article focuses potentiality of Indian leguminous proteins as suitable plant-based meat analogues, and explains various sources of proteins, role of different ingredients, processing and structural modifications. Therefore, based on research findings, novel meat analogues may source of similar nutrients as they are present in traditional meat products, though they contain composite ingredients and used ultra processing methods.

Keywords: Legume proteins; meat analogue; soy protein; textured vegetable protein; meat alternatives.

INTRODUCTION

The present global population is 7.3 billion and estimated to touch 9.8 billion by 2050 with anticipation an increase of demand for vegetarian food and animal-based foods of 50% and 70%, respectively (Choudhury *et al.,* 2020). The rising world population, increased purchasing power, rapid urbanization and industrial development are causing an augmentation of food production and an escalated demand for animal meat protein (Pintado and Delgado-Pando, 2020). Animal based food products are the foremost protein source for the most of the people live in developed countries, with increasing per-capita consumption at a world level, but they need a huge quantity of natural resources such as arable lands, fodder, pastures, animal feed for livestock and water (De Angelis *et al.*, 2020). Further, excess consumption of resource-intensive foods, such as animal-based products, is associated with high greenhouse gas emissions, placing a heavy burden on the food system (Ferawati *et al.,* 2021). This is an alarming issue with respect to the affordability of feeding the world population without affecting the nature (Kyriakopoulou *et al.,* 2019). Presently, the production of animal meat needs 70 percent of world agricultural land and to make 1 kg chicken, 1 kg mutton and 1 kg beef takes 4325 liters, 5520 liters, 13000 liters of water respectively (Poshadri *et al.,* 2018). One of the foremost concerns is the poor efficiency of animal protein production. It is calculated that production of 7 kg plant based animal feed yields only 1 kg of animal milk or meat for human consumption (Nadathur *et al.,* 2017). According to research carried out, the protein conversion efficiencies for common meat animals are as follows: beef (2.5 ± 0.6%) < pork (9 ± 4.5%) < poultry (21 ± 7%). This indicates a remarkable loss of protein in production of animal proteins (Choudhury *et al.,* 2020; Henchion *et al.,* 2017). However, it is not possible to produce huge quantity of meat products for future demands due to limited availability of natural resources such as land and water for sustainability of livestock farming. Further, rapid increase in animal welfare issues and adverse effect on the environment and climate changes decreases the availability of meat (Lee *et al.,* 2020). Foods borne illness is frequently associated with the consumption of animal meats and are responsible for hospitalization of people and economic loss. In addition to this the excess consumption of red meat can cause coronary heart disease (CHD), aggravates the obesity epidemic, and greater the risk of joint inflammation and colon cancer (Sun *et al.,* 2020). Therefore, majority of people limits the consumption of animal meat or completely exclude it from their diets for health reasons. The consciousness of overutilization of natural resources has given rise to explore for plant based protein foods that imitate the fibrous texture of meat (Schreuders *et al.,* 2019; Elzerman *et al.,* 2015). Transition to a more sustainable diet with higher intake of plant-based foods has been identified as a key factor in improving health and reducing environmental pressure on the current food system (Ferawati *et al.,* 2021; Röös, *et al.,* 2017). The substitution or replacing of animal protein with plant protein has therefore become a crucial research issue (Wi *et al.,* 2020; Apostolidis & McLeay, 2016). Joint business partnerships, contracts between entrepreneurs and venture-capital firms have played an important role in the unprecedented growth of the market in the last 3 years. Many global restaurant joints and food industries are also ventured in to the alternative meat market, marketing their own brands of plant-based meat analogues (Sha and Xiong, 2020). The ongoing plant-based meat market is expected to rise from $4.6 billion in 2018 to $85 billion in 2030 (UBS, 2019) and, as a breakthrough by year 2026, touch $30.9 billion (Watson, 2019). This surge in market growth appears to be advantageous position for further advancement and innovation (Sha and Xiong, 2020). However, animal derived foods such as milk, meat, chicken and eggs are usually high in protein with well-balanced amino acid content, thus outmost care must be taken while designing plant-based meat analogue to ensure balance of nutrients in the foods (M. Vogelsang-O'Dwyer *et al.,* 2021). Plant proteins constitute a high sustainable and healthier option and for the preparation of meat analogues and other alternative products. However, taking into account wide availability, resilience in supply, price and processing functionality, legume proteins (soy, pea nuts) and pulses (pea, chick pea, lentils, faba bean) proteins and gluten sourced from wheat are most commonly used as the base material for alternative meat products (Sha and Xiong, 2020; do Carmo *et al.,* 2021).

Legumes comprise soybean and groundnuts belongs to oil seeds category, while pulses are the dried seeds of leguminous plants. Cow peas, red gram, Bengal gram, dry broad beans, lentils, vetches, Bambara beans, lupins, and other minor pulses are the common pulses cultivating worldwide (Bhaskar *et al.,* 2019). Cultivation of pulses in different multiple cropping systems or farming situations enriches the soil fertility and agro –biodiversity and also ensures resilience to climate changes and boost ecosystem services. Pulses contain high amounts of nutrients than vegetables and are sustainable and affordable source of protein for all sections of people in the world. Legumes have high nutritional value and a well-balanced ratio of proteins (20–26%) and carbohydrates (4–23%), which proposes that they are the sustainable and potential dietary protein base food for majority of vegetarian population across the globe. Furthermore, the high protein dense legumes are regarded as 'poor man's meat (Iriti and Varoni, 2017). A total legumes production in India during 2018-19 is 42.07 million tones and the share of pulses; soybean and ground nut were 52.5%, 31.5% and 16.0% respectively. India accounts for over one third of the total world area and over 20 per cent of total world production. Now India is the largest consumer and producer of pulses in the world with the production of 23.15 million tonnes of pulses from an area of over 29 million hectares in the year 2019-20. Pulses are nutritional dense and comprises of 23 per cent protein, supply gluten-free and low glycemic carbohydrates and provide 7 to 17 grams of fibre per one-half cup (125 ml). They are also an excellent source of iron, potassium, magnesium, zinc and B vitamins including folate, thiamin and niacin. Pulses are also particularly rich in B complex vitamins including folic acid, thiamin, niacin (FAO,IYP-2016) and comprises important bioactive components and have therapeutic action like glycemic control, protect against hypercholesterolemia, cancer and type 2 diabetes (Curran, 2012). Leguminous proteins with cereals are an excellent complementary food for infants and young children to meet their daily nutritional requirements.

Meat analogues are manufactured from plant protein products with other suitable ingredients mimic to meat in its functionality, being a like in fibrous appearance, when fried or cooked (do Carmo *et al.,* 2021). Meat analogues can be produced using low- and high moisture extrusion cooking. The most commonly used technology to prepare meat analogues is the high-moisture extrusion technology with a twin-screw extruder. This cooking technology produces various sized pieces of texturized protein, mimic to muscle meat, useful to produce chunk-type meat analogues (Ferawati *et al.,* 2021; De Angelis *et al.,* 2020). Plant-based meat analogues are typically cut to a specific shape, with the desired sizes of commercial marketable products in the market sizing from 6 to 20 mm (Sun *et al.,* 2020).

This updated review attempts to provide an overview of Indian legumes based proteins, their functionality, novel processing techniques and potential for opportunities for the designing of plant-based meat alternatives or meat analogues. The legume proteins based meat analogues are formulated and developed as sustainable sources of protein in the coming days for supportive and complementing the little viability nature of the conventional animal meat production system.

LEGUME PROTEIN AS INGREDIENTS FOR MEAT ANALOGUE

The legume proteins have different functional properties, the functional property helps in developing of innovative food ingredients and also formulation of different protein rich foods with desired sensory attributes. Assessing the functional properties of legume proteins allows comparison of potentiality of different protein based ingredients and their rheological behavior in the final food product. The functional properties such as solubility, water holding capacity, water absorption, emulsifying ability, foaming, Oil absorption etc are the most important properties assessed to know the functional behavior of each protein in food matrix (Vogelsang-O'Dwyer *et al.*, 2021; Boye, *et al.*, 2010). The different types of proteins have characteristic physicochemical, structural and functional properties and these independent properties helps in formulating of meat based analogues. The most commonly used legume proteins in the preparation of meat analogues are soybean protein, groundnut protein, lentils protein, chick pea protein, yellow pea protein and faba bean protein. The major storage proteins found in pulses are globulins and albumins. The globular proteins legumin (11S) and vicilin (7S) are major proteins predominantly present in pulses. The major albumin proteins found in pulses are protease inhibitors, amylase inhibitors, enzymatic proteins and lectins (Bhaskar *et al.*, 2019; Boye *et al.*, 2010). Legume proteins such as soybean, pulses and oil seeds are predominately used as a basic ingredient for developing of innovative plant-based meat analogues (Table 1). The soybean protein extracted from defatted soy flour such as soy protein concentrates, soy protein isolates and hydrolysated proteins is the major base ingredient in structured meat analogues due to its surplus availability, low cost, fibrous structure resembles meat texture after hydration and balanced amino acid profile (PDCCA is 1) which is close to quality of animal protein (Sun *et al.*, 2020; Malav *et al.*, 2015). The addition of pulses in varied forms and levels in structuring of meat analogues or meat alternatives enhances their nutrition values and health benefits (Pintado and Delgado-Pando, 2020; Purohit *et al.*, 2016). When pulse proteins are added as meat binders, the presence of starch and different soluble and insoluble fiber in pulses acts as hydrocolloids, as they can hydrolyze to form complex gel net works with in meat proteins to replace partial or removal of meat proteins. These protein- fiber-starch networks can hold the water and other constituents of meat analogues and imparts juiciness to meat analogues. The formation of strong bonds between proteins and other constituents helping to achieve desired moisture levels in the meat matrix during processing. Plant-based protein ingredients such as pulse proteins, wheat gluten, tubers proteins have been widely employed to substitute up to 50% of meat in the final products (Pintado and Delgado-Pando, 2020).

Table 1: Major legume proteins responsible for structuring of plant-based meat analogues.

Plant based protein source	Major proteins	Functionality
Soybean	β-conglycinin	Proteins aggregation, gel net working with fiber for moisture retention during cooking and extrusion; oil-absorption or binding and emulsifying of other ingredients.
Legumes	Glycinin, Vicilin	Gelation; emulsification; water-holding
Oil seeds	Legumin, Albumins, Globulins, Glutelins	Used to complement other cereals or pulse proteins to enhance meat like fibrous texture; elasticity and extensibility

Soybean: Among nine major oilseeds leguminous Soybean (39%) and Groundnut (26%) contribute more than 65 % of total oilseeds production in India. India is presently producing 10.8 million metric tons of soybean (*Glycine max*) and contributing to 3.0% of total world soybean production. Soy protein is the most common used vital protein in the production of meat analogue products. β-Conglycinin (7S) and Glycinin (11S) are the major proteins present in soybean and accounts for 37% and 30%, respectively (Alves and Tavares, 2019; Ustunol, 2014). During processing β-Conglycinin protein coagulates upon heating and forms a soluble and non compacted aggregate, whereas Glycinin (11S) transforms to dense and insoluble aggregates (Nishinari *et al.*, 2014). In the literature several researchers reported that consumption of soy protein have positive, health benefits like improvement heart functioning and lipid metabolism (Bohrer, 2019; Xiao, 2008). In terms of nutritional advantages, soy protein hydrolysates, processed soy protein ingredients like soy protein concentrates and soy protein isolates have been shown to have enhanced bioavailability of essential amino acids contrasted with raw or other minimally processed soy protein (Bohrer, 2019; Young, 1991). This increased bioavailability of essential amino acids in processed soy protein has enabled to achieve Protein Digestibility-Corrected Amino Acid Scores (PDCAAS) of 1.00, which is the maximum attainable PDCAAS score. The animal protein derived from animal meat, chicken, eggs and dairy products have the PDCAAS score of 1. Thus soy protein is apt ingredient in structuring of meat analogues (Hertzler *et al.,* 2020). However, soy protein is relatively low in few essential amino acids especially lysine and methionine content compared with animal based proteins (Bohrer, 2019; Hertzler *et al.*, 2020).

The soy protein concentrates and soy protein isolates have greater role in structuring of meat analogues by improving sensory attributes as compared to raw or minimally processed soy protein. The use of unprocessed or minimally processed soy proteins in structuring of meat analogues imparts dark color and characteristic bean flavor to products (Bohrer, 2019; Hertzler *et al.,* 2020). Soy processed protein also improves the texture of meat analogues. (Malav *et al.,* 2015) stated that most of the meat analogues processing industries would use a blend of textured and non-textured soy protein for improved texture. However, in the literature many researchers stated that use of additional protein sources along with soy protein in formulating of meat analogues would improves the functional and nutritional properties.

Peas: Peas (*Pisum sativum* L.) are important source of protein for humans and animals. Currently India is producing 5.4 million metric tons of peas from an area of 0.5 million hectors. The major peas producing countries in the world are China, Canada and the European Union. Peas contains 22-24 percent protein and the major proteins present in peas are albumins (20%) and globulins (50-60 %). Vicilin, legumin, and convicilin are the important globular proteins present in peas and legumin (11S) and vicilin (7S) constitute approximately 50–60% of peas total protein content (Alves and Tavares, 2019). The protein vicilin (7S) is highly flexible in nature as compared to legumin (11S) and is suitable for structuring of meat analogues due to superior interfacial activity (Lam *et al.,* 2018). Pea proteins having superior functional properties such as emulsification ability and foaming thus it is used as an important ingredient in different food and beverage applications. Peas contain low oil content and do not require any additional extraction of fat for processing into protein concentrates or protein isolates unlike soy proteins extraction (Venkidasamy *et al.,* 2019). Peas protein concentrates or pea protein isolates are obtained by dry fractionation and wet fractionation.

Chickpeas: Chickpea (*Cicer arietinum* L.) is an important leguminous crop cultivated in tropical and subtropical areas, which has been used as potential functional ingredient for the food processing industry (Deshpande & Poshadri, 2011). India is the largest producer of chickpea occupies an area of 10.17 m ha with the production of 9.93 million metric tones which is about 63 per cent of the total pulses production in India (Raghuveer *et al*., 2020). It is important to note that chick pea continues to be the largest consumed pulse in home as well as industrial purpose comprising of about 50 per cent of total pulse production in India (Raghuveer *et al.,* 2020). Chickpeas comprise different carbohydrates (11% sugar and 17% fiber) and proteins. Chick pea proteins are rich in lysine and arginine but deficient methionine and cystine (Chibbar *et al.,* 2010). They have moderate fat and fibre content and also contain approximately 22% of the total proteins. The chick pea proteins are processed to protein hydrolysates to improve the bioavailability of essential amino acids and functional properties to explore as an important ingredient in meat analogues production (Venkidasamy *et al.,* 2019). Chick pea has high amount of fat and mostly comprises polyunsaturated fatty acids and also contain plant sterols like campesterol, β-sitosterol, and stigmasterol in their oil. Chick pea also source of an important minerals such as calcium, phosphorous, potassium, magnesium, and chromium and also contains water soluble vitamins like vitamin B1, B2, niacin and folic acid. They also contain anti nutritional factors such as protease inhibitors, which impairs the action of trypsin and chymotrypsin (Venkidasamy *et al*., 2019).

Lentils: India is the one of major producers of Lentils (*Lens culinaris*) in the world and it is an important source of nutritious food for both human and animals. India occupies first position in area of cultivation and second position in production of Lentils in the world. The major proteins present in lentils are globulin (47%) and albumin comprises different essential and non essential amino acids. Among all the pulses, lentils has the second highest starch percentage (47.1%) and contain greater quantity of insoluble dietary fibers. Due to its greater digestibility and high biological value of Lentils protein, the foods prepared from Lentils are supplemented to the patients for speedy recovery. Lentils are also very good source thiamine, folate and different minerals (Tiwari and Shivhare, 2016). Bioactive peptides obtained from lentil proteins have therapeutic activities such as antihypertensive, antioxidant, and antifungal. In literature it is reported that lentil protein concentrates and protein isolates have exhibited excellent emulsifying properties, water holding capacities, oil absorptions capacities. The water holding capacity of lentil proteins was an equivalent to that of pea proteins, and more than that of chickpea. Oil absorption capacity of red lentil protein concentrates was higher than that of other pulses (Khazaei *et al.,* 2019)

MEAT ANALOGUE PRODUCTION TECHNIQUES

During production of plant based meat analogues or meat alternatives various ingredients are added to improve the sensory attributes like texture, flavor and appearance. The role and functionality of each ingredient are explained in Table 2. To maintain desired fibrous texture in plant based meat analogue, the techniques like spinning, thermoplastic extrusion, and steam texturization have been employed for the structural arrangement of plant protein, as plants are generally consist of amorphous tissue (Lee *et al.*, 2020; Dekkers *et al.*, 2018). Among structuring techniques, extrusion is the most commonly used processing technique as it is an economical method and can produce different shapes and sizes of meat analogues (Lee *et al.*, 2020).

Table 2: Major food Ingredient added in the production of plant based meat analogues.

Food Ingredients	Functions	Average usage level (%)
Water	• Uniform distribution of food Ingredient used • Acts as an emulsifying agent, • Characteristic juiciness of end product, • Low cost ingredient	50-80
Texturized composite vegetable proteins	• Water holding capacity • Gives characteristic texture and mouth feel to end product • Appearance; • Enhancing the levels of protein and other nutrients in the final product • Contribute increased levels of insoluble fiber	10-25
Non textured proteins	• Moisture retention • Emulsifying of ingredients • Gives characteristic texture and mouth feel to end product • Enhancing the levels of protein and other nutrients in the final product	4-20
Seasonings and spices	• Imparts meaty like savory, roasted, fatty, serumy • Enhancing the flavor of other ingredients like salt and umami taste • Masking the flavor of raw materials	3-10
Edible Fat or vegetable oil	• Emulsification • Improves the body texture, Flavor and mouth feel • Juiciness • Undergo non enzymatic browning or Maillard reaction	0-15
Binding ingredients	• Useful in structuring of meat and holding of water and oils for juiciness	1-5
Coloring agents	• Improves product appearance • Food colours or synthetic dyes	0-0.5
Minerals	• To fortifying minerals and bind water.	—
Vitamins	• Fortification	—
Antioxidants	• To prevent oxidative rancidity and discoloration.	—
Antimicrobial agent	• Preservation of product	—
Source: Asgar *et al.*, 2010 ; Lee *et al.*, 2020; Sha and Xiong, 2020)		

PROCESSING

Commercially extrusion cooking is widely used to produce protein rich fibrous structured products from the plant based cereals or leguminous proteins. There are two important structuring processes for production of structured meat analogues with extrusion: low moisture texturized vegetable proteins and high moisture meat analogues (HMMA). In case of low-moisture extrusion cooking, protein concentrates, cereal flours or pulses flours or combinations are cooking at high temperatures and pressures to transform into expanded fibrous texturized vegetable proteins. These dry extruded products are moisturized before used it as meat analogue in culinary preparations.

Fibrous high moisture meat analogues (HMMA) have more than 50% moisture content. During extrusion cooking the proteins present in cereals or pulses are plasticized or molten in the extruder barrel due to combined effect of heating, pressure, hydration and frictional forces. When the plant proteins melts inside the barrel due to drag forces material is conveyed towards the die opening, it gets straightened by the laminar flow and is cooled to stop the expansion of the product. High moisture extrusion cooking technologies were widely investigated in the eighties and nineties for production of meat analogues (Dekkers *et al.*, 2018; Arêas, 1992). (Mitchell and Areâs, 1992 explained the extrusion cooking of protein transformation into texturization by suspension model. In this model they stated that protein biopolymer melts and forms phases like homogenous continuous phase and dispersed insoluble phase. During extrusion cooking of protein concentrates at high temperature and pressure the dispersed insoluble phase is formed. Sometime the insoluble dispersed phase formed in the raw materials before processing into meat analogues. The presences of high amount of insoluble components in raw materials or ingredients affect the protein net working and result in poor fibrous structures in meat analogues. Even though extrusion technology has been using widely for processing of many cereals and legumes over the years but the control of processing conditions and developing of new extruded products is still mostly depends on experimental studies (Emin and Schuchmann, 2017). However, extrusion processing technology is comparatively energy intensive and it is the wide accepted processing method for the production of meat analogues. (Ferawati *et al.*, 2021) were assessed the commercial production of fibrous structured high-moisture meat analogues (HMMA) by using extrusion cooking technology from the locally sourced and imported yellow pea and faba bean protein concentrates and isolates. The texture of high-moisture meat analogues were mainly influenced by the content of ash, fiber and protein of the raw materials. The water holding capacity of meat analogue is also affected due to the changes in protein source. The extrusion processing parameters such as temperature in the extruder barrel, screw speed and desired moisture content in the final product were significantly affected the texture of high-moisture meat analogues. They also reported that functional high-moisture meat analogues can be produced from protein isolates obtained locally grown pulses. (De Angelis *et al.*, 2020) were produced meat analogues by extrusion of four different mixes of composite ingredients such as i) dry fractionated pea protein, ii) pea protein isolates iii) soy protein isolates and iv) oats proteins. They observed intense odor and taste in case of meat analogues produced from the composite blend of dry fractionated pea protein with oats protein through sensory evaluation. They also reported that meat analogues produced from protein isolates have more balanced sensory attributes. The production of meat analogues from dry fractionated proteins usher the production of sustainable and clean labeled plant based meat analogues. Researchers also used the freeze structuring technique for the production of plant based meat alternatives with unique textural properties by using composite raw materials such as pea protein and wheat protein in five blending ratios such as 17: 0; 13: 4; 8.5: 8.5; 4:13 and 0:17. The results indicated that plant based meat analogue produced from the blend of pea protein: wheat protein (4:13) ratio was most accepted analogue as compared to other blending proportions due to formation of fibrous meat like microstructure. The analogue textural characteristics and meat like fibrous structure were found to be related to plant protein ingredients visco-elastic properties and were greatly influenced by the degree of network formation between the protein moieties. It is also observed that the addition of pea protein in the production of meat analogue increased the hardness, chewiness as well as rheological characteristics of the analogue. The interesting trend was noticed that the addition of excess of quantity of wheat protein in production of plant based meat analogues decreased the textural and viscoelastic nature of products. It was also observed that the blending of protein ratio did not influence the final moisture content (~60%) and protein content (~25 %w/ w) of the meat analogue (Yuliarti *et al.*, 2021).

(Wi *et al.*, 2020) prepared meat analogue by mixing of soy protein isolates and textured vegetable protein and other vegetarian liquid binding additives. The addition of liquid ingredients in the production of meat analogues resulted in high availability of free water and lowered the visco-elasticity of products. This further, causes high cooking loss, increases hardness, lower the porous structure and have poor water holding capacity. Interestingly the addition of oil during production of meat analogues increases the visco-elasticity, water holding capacity and decreases the cooking loss. It was also observed that oil treatment increases hardness value due to hydrophobic interactions of protein and form dense structure. Researchers also blended wheat gluten with pea protein isolates for production of fibrous meat like structured analogue using heating with shear induced structuring (Schreuders, *et al.*, 2019). The experimental results are partially in line with meat analogue prepared from wheat gluten and soy protein isolate but the latter yields anisotropic materials in a much different temperature range. Both blends of product formulations have the ability to incorporate air, the air bubbles were arranged and undergo deformation during processing to give the meat like fibrous products. Extrusion cooking carried out at 140°C for pea protein with gluten materials have same strength as reported in case of soy protein with wheat gluten . Extrusion cooking of blend of pea protein with gluten at 110 and 120°C resulted meat analogue have strength that was close to a chicken meat reference (50–100 kPa) but weaker than their counterparts with soy (220–300 kPa). A composite blend of leguminous pea protein with gluten is the potential combination for the manufacturing of structured plant based meat analogue but its final applications are differ with the meat analogues produced from soy protein-gluten blends.

CHALLENGES

Plant protein based meat analogues are marketed greatly as healthy and eco-friendly foods seeing that plant proteins are plentiful and posse's greater health benefits over conventional animal proteins. Yet, beliefs are differed, due the manufacturing of plant protein based meat analogues or meat alternatives requires ultra processing technologies to derive base functional ingredients like protein isolates and extracts, increasing the cost of production. Developing of 100 percent meat mimic in terms of nutritional quality and sensory profile is a challenging task due to the presence of more than 1000 water-soluble and fat-soluble or insoluble constituents of original meat (Bohrer, 2019). Exploring and transforming of cheap source of plant proteins and other important ingredients or additives for the production of meat analogues or meat alternative is critical to ensure continues supply of meat analogues in to the all kinds of markets. Another challenging issue is consumer acceptance of the novel meat analogues. It is necessary to conduct consumer research study to obtain data about the demographic profile, sensory attributes of consumers, cooking and consumption pattern (Guinard *et al.,* 2016). Some of the key issues such as cost of production, scaling up of laboratory production techniques, quality control during production, ensuring of nutritional quality and sensory attributes and regulatory standards or policies required for meat analogues are unaddressed in production of meat analogues or meat alternatives for greater market penetration (Choudhury *et al.,* 2020).

CONCLUSION

A balanced blend of leguminous and cereal protein based products offer a well balanced diet for both vegetarians and traditional meat consumers. There is a huge growth and ample of opportunities for food researchers, startup companies, entrepreneurs and venture capitalists to explore new protein sources and innovations in production technologies to support rapidly evolving meat analogues market. Optimizing the textural related sensory attributes of plant based meat analogues are a main goal for innovative product new development and culinary applications. Tweaking the existing recipes, creative product formulations and use of innovative processing methodologies are the major steps in developing fibrous meat like quality attributes. The addition of a different kind of vegan based additives plays a key role in order to produce real meat quality attributes such as micro structured fibrous texture, water holding capacity of meat, mouth feel, after taste and flavor. There are numerous concerns about the plant based meat analogue nutrition profile, quality control during production, food safety, source of ingredients particularly with the clean label, cost, and consumer confidence. Conventional animal husbandry and meat production has been directly challenged by plant-based meat analogues or meat alternative companies to fulfill the global protein demand. Production of plant based meat analogues also had provided several opportunities for start-ups and as well established food processing companies to develop and marketing of innovative products or repackage of older concepts to top up the existing space in the world market.

Conflict of interests. The authors have declared that no conflict of interest exists.

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How to cite this article: Poshadri, A. and Pawar, V.S. (2021). The Potential of Production of Meat Analogue by using Indian Legumes- A Review. *Biological Forum – An International Journal*, *13*(2): 557-564.