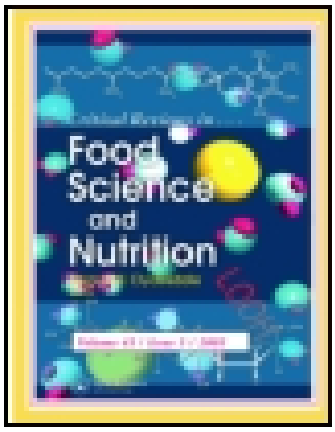

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Meat analogue: A Review

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ABSTRACT

The health conscious consumers are in search of nutritious and convenient food item which can be best suited in their busy life. The vegetarianism is the key for the search of such food which resembles the meat in respect of nutrition and sensory characters, but not of animal origin and contains vegetable or its modified form, this is the point when meat analogue evolved out and gets shape. The consumers gets full satisfaction by consumption of meat analogue due to its typical meaty texture, appearance and the flavor which are being imparted during the skilled production of meat analogue. The supplement of protein in vegetarian diet through meat alike food can be fulfilled by incorporating protein rich vegetative food grade materials in meat analogue and by adopting proper technological process which can promote the proper fabrication of meat analogue with acceptable meat like texture, appearance, flavor etc. The easily available vegetables, cereals and pulses in India having great advantages and prospects to be used in food products and it can improve the nutritional and functional characters of the food items. The various form and functional characters of food items are available world over and attracts the meat technologists and the food processors to bring some innovativeness in meat analogue and its presentation and marketability so that the acceptability of meat analogue can be over grown by the consumers.

Key words: meat analogue, protein supplement, vegetables, cereals and pulse, meaty texture, appearance.

INTRODUCTION

Meat is the first preference by choice of non-vegetarian consumers worldwide as it can satisfy all the urges to consume one typical textured, flavourful, juicy, chewy food which will fulfill their nutritional requirements too. But from the beginning meat has always been tagged with some negative impression with it. Some time the reason is ritualistic, some time it is the question of healthiness and is referred to as an environmentally unfriendly food choice due to an inefficient use of land and energy, and emission of gases by meat production (McMichael et al., 2007). Policy makers and organizations involved with sustainable consumption and production are hoping to see consumers making a shift to a more sustainable product. There are certain alternative products for meat on the market, so called meat substitutes or meat replacers. However, the market shares of these products are still very low compared to meat, estimated only 1–2% of the meat market (De Bakker and Dagevos, 2010). To overcome this entire dizzy situations food researchers and processors invented one easy way to overcome the dilemma of meat lovers, they formulated “meat analogue”, which could accomplish the satisfaction of meat consumption by consumers and could provide the nutrition and health as well. Analogue can be defined as compound that is structurally similar to another but differs slightly in composition, here the meat analogue is the food which structurally similar to meat but differs in composition. Meat analogue, also called a meat substitute, mock meat, faux meat, or imitation meat, (Sadler, 2004) approximates the aesthetic qualities (primarily texture, flavour, and appearance) and/or chemical characteristics of specific types of meat. It may also refer to a meat-based, healthier and/or less-expensive alternative to a particular meat product, such as surimi. Generally, meat analogue is understood to mean a food made from non-meats ingredients, sometimes without

dairy products. The market for meat imitations includes vegetarians, vegans, non-vegetarian seeking to reduce their meat consumption for health or ethical reasons, and people following religious dietary laws, such as Kashrut, Halal and Buddhist. Some vegetarian meat analogues are based on centuries-old recipes for wheat gluten, rice, mushrooms, legumes, tempeh, or pressed-tofu, with flavouring added to make the finished product taste like chicken, beef, lamb, ham, sausage, seafood, etc. *Yuba* is another soy-based meat analogue, made by layering the thin skin which forms on top of boiled soy milk. Some more recent meat analogues include textured vegetable protein (TVP), which is a dry bulk commodity derived from soy, soy concentrate, mycoprotein-based *Quorn* which uses egg white as a binder making them unsuitable for vegans, and modified defatted peanut flour.

Meat analogs can be formed into sheets, disks, patties, strips, and other shapes. They usually absorb at least 3 times their weight in water when cooked in boiling water for at least 15 min (Riaz, 2004). Meat analogs have a striated, layered structure similar to muscle meat. Analogs simulating coarse ground-meat products may contain textured proteins (such as textured soy flour and concentrates) that are available in various colors and particle sizes. The entire characteristic attributes found in a meat product i.e. texture, flavor, color, and so on, must be added to the analog by the product developer precisely. Acceptable texture and flavor often prove to be the biggest development challenges (Egbert and Borders, 2006).

Many efforts have been made to prepare the best substitute of meat which can fulfil all the requirements of a satisfied meat eater but an explanation for the lack of a success of meat substitutes is, among other things, a lower sensory quality (Elzerman, 2006) due to current

technological constraints to mimic a meat-like taste, texture and nourishment, especially the fulfillment of required proteins.

Search for vegetarian meat ingredients

The supply of easily available and cheap protein resources to the malnourished consumer World over especially in developing countries is the biggest challenge to the producers, processors and technologists. The costly animal protein can easily be substituted by vegetable protein. Vegetable proteins have a lower price than muscle proteins and, consequently, can reduce the cost of the meat product. High meat prices have prompted the food industry to produce nonmeat proteins. An important reason for the increased acceptance of vegetable proteins, such as texturized soy protein (TSP), is their low cost (Singh et al., 2008).

Furthermore, animal proteins are scarce in many under-veloped countries and protein-energy malnutrition is among the most serious problems faced by developing countries today (Boye et al., 2010). Due to animal diseases, such as mad cow disease, global shortage of animal protein, strong demand for “healthy” (cholesterol free and low in saturated fat), and religious (halal) food, and for economic reasons, there is a pressure for the direct consumption of vegetable proteins in food products. Some even see the potential for a quite rapid end to the meat economy because of rising vegetarianism and the influence of the animal rights movement (Maurer, 2002).

Common Meat Substitutes

Tofu: derived from soybeans is perhaps the most widely recognized meat alternative; it provides an excellent source of protein, calcium, and iron. It is usually available in block form

and while bland on its own, is highly absorbent and readily takes on the flavors of marinades, sauces, and other dressings.

Tempeh: is another fairly common soy-derived meat alternative, of Indonesian origin, Tempeh is a fermented soybean cake made from cooked soybeans and grains such as rice and millet, combined with the *Rhizopus oligoporus* culture. Tempeh is commercially available in strip and cake form and can be used in many of the same culinary contexts as tofu. Because it contains whole soybeans it has a denser, "meatier" texture (William and Aoyagi, 1989).

Seitan: it is often known "wheat meat" or "wheat gluten," is another common vegetarian meat substitute. Seitan is made from wheat flour and is produced by washing wheat flour dough until the starch dissolves, resulting in a chewy mass of proteinacious gluten.

Chewy and flavorful, seitan is a great option for people who have no problems with gluten, but its best avoided by the large number of people with gluten sensitivities (Schepker, 2012).

Protein with a vegetable origin is an alternative to animal protein for food applications due to the widespread variety of sources, such as legumes, oilseeds, cereals, and fungi. In this article, we have summarized information about the molecular, nutritional, and functional properties of alternative protein sources to meat.

Preparation of meat analogue

The conventional production of meat analogue consists of two main stages: emulsion preparation and formation of a chunk. An emulsion is typically prepared by mixing, chopping and emulsifying proteins, salts, fat and other inclusions to form a matrix of proteins that encapsulates the fat and the non- soluble inclusions. The emulsion is then heated under pressure

that is aimed in a specific direction. The pressure arranges and orients protein chains and helps a three-dimensional network to be formed. The heat denatures the proteins and sets the matrix irreversibly so the final chunk product retains its shape. Extrusion cooking is a process by which meat analogs are produced (Burgess and Stanley, 1976). This process has been used in processing food for a number of years. Meat analogs can be produced at either low moisture conditions, fewer than 35% by use of a single-screw extruder, or at high moisture conditions, above 50% by use of a twin-screw extruder (Lin et al., 2000).

The beneficial utilization of nonmeat proteins in meat analogue

Soy protein

Soybeans (*Glycine max*) are leguminous crop, primarily being utilized as traditional food in various form, such as soymilk (Fukushima, 1994), tofu and fermented products (Fukushima, 1981), now have attracted people's attention as an economic and high-quality vegetable protein source for humans. Soybeans vary widely in nutrient content typically contain 35% to 40% high-quality protein with well-balanced composition of amino acids, 15% to 20% fat, 30% carbohydrate, and 10% to 30% moisture (Golbitz and Jordan, 2006), also rich in fiber, iron (Fe), calcium (Ca), zinc (Zn), and B vitamins. Soy-protein products are divided into three general categories based on their protein content: soy flour and grits (50 per cent protein on a moisture-free basis, mfb); soy protein concentrates (70 per cent protein, mfb); and isolated soy proteins (90 per cent protein, mfb).

When simulating coarse ground meat, manufacturers will typically use a combination of textured and non-textured soy proteins. The textured proteins include textured soy flours, textured soy concentrates, and textured combinations of vegetable proteins (eg, soy and wheat),

all of which are available in a variety of sizes and colours. These proteins are used to provide texture and mouthfeel, contribute to appearance and bind water. They also are used for protein fortification and nutrition and as a source of insoluble fibre. Textured soy proteins are extremely versatile food ingredients due to their meat-like textures after hydration and amino acid composition that provides similar protein quality to that of animal proteins. These attributes will be helpful for their increasing acceptance as major ingredients in meat and as meat analogs throughout the world. Non-textured proteins can be used in conjunction and can include soy-protein concentrates and isolated soy proteins. These proteins are used to help with fat and water retention, emulsification (thereby contributing to mouthfeel and texture), protein fortification, and nutrition. In analogues simulating emulsified meats, such as hotdogs/bologna, functional soy concentrates and isolated soy proteins are often used for the same reasons.

Legume protein

Legume seeds are a unique supply of protein in the diet. In most species, seed protein content varies from 20% to 30% of total dry weight (Riascos et al., 2010). They occupy an important place in human nutrition, especially in the diets of low-income earners of developing countries. Legumes are considered the poor man's meat. Due to these reasons to improve the nutritional quality, texture, and other functional properties of the product or for economic reasons, the use of legume protein products in processed food as ingredients has been increased manifolds.

Oilseed protein

The proteins found in oilseeds are classified as biologically active proteins (enzymes) storage proteins, or structural proteins, of these proteins, the storage proteins are the most

abundant and prominent in oilseeds. The levels of protein in these seeds are 13% to 17% for safflower, 23% for cottonseed, approximately 25% for rapeseed (Asgar, 2010).

Cereal protein

Cereals are the most important food crop and the products are the most important foods. These are utilized as seed (rice, barley, oats, and maize), flour (wheat, rye, and maize), or flakes (barley, oats, and maize). The protein contents, represented as the percentage of dry matter, of the above cereals are as follows: wheat (8% to 17.5%), maize (8.8% to 11.9%), barley (7% to 14.6%), rice (7% to 10%), oats (8.7% to 16%), and rye (7% to 14%). The cereal proteins are as follows: albumins (soluble in water), globulins (soluble in salt solutions), gliadins (soluble in alcohol/water mixtures), and glutelins (soluble in dilute acid or alkali) (Guerrieri, 2004). Food products containing wheat gluten provides an endless array of textured vegetable protein ingredients that can be utilized as meat extenders and meat analogue products (Orcutt et al., 2006). Wheat gluten can be used in combination with soy flour or soy concentrate to produce meat extenders (Riaz, 2004). Gluten can be used as an extender in ground meat patties and as a binder for sausage products and can bind chunks or trimmings to create restructured items. In poultry rolls, the binding ability of gluten can reduce cooking losses during processing and preparation and improve slicing characteristics. Hydrated gluten may be extruded, texturized, or spun into fibers to produce a variety of meat analogs.

Mycoprotein

Nutritional benefits arise from mycoprotein is due to its chemical composition. The cell walls of the hyphae (cells) are the source of dietary fiber (chitin and glucan). The cell membranes are the source of polyunsaturated fat and the cytoplasm is the source of high-quality

protein (Rodger, 2001). It is cholesterol free and low in saturated fats with a favourable fatty acid profile and a fiber content that is comparable to other vegetarian protein sources. Because of its high fiber content, the consumption of mycoprotein significantly reduces blood cholesterol levels (Denny et al., 2008) and may encourage reduced energy intake. Generally the filamentous fungus is best chosen for the production of a meat substitute because it was believed that the mycelia can impart a fibrous texture, comparable to that of meat, to the final product (Edelman et al., 1983). To make a similar-product texture with mycoprotein, the fungal biomass is mixed with a binding agent such as egg albumin, flavoring agents and other ingredients depending on the desired final products (Denny et al., 2008). After heating, the protein binder is converted to a gel that binds the hyphae together. The resulting products have similar textural properties to those found in meat products (Rodger, 2001).

Conclusion

The food we generally consume should be with higher amount of good quality protein, it should be easily available and economically viable. The protein rich meat analogue can effectively fulfil the daily protein requirements of a consumer. Vegetables and its derivatives, which are easily available and not so costly, can easily be the substituted for the supply of protein and other essential nutritional components instead of animal protein, therefore meat analogue can be prepared using this as raw materials. In the future, food manufacturers needs to offer meat analogues with health and nutritional benefits, convenience and with improved flavour and texture simulating meat. Economical viability and nutritional self sufficiency has make the meat analogue the preference of today's consumers, the further technological developments in meat analogue production and processing can fetch extreme popularity of meat analogue in near future.

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Table 1: Common forms of meat analogues

Coarse ground-meat analogues	Emulsified meat analogues	Loose fill
Burgers	Deli 'meats'	Taco fillings
Sausages	Frankfurters	Chili mixes
Batter/breaded nuggets	Spreads	Sloppy Joe
Meat' balls		
Pizza toppings		

(Source: Borders, 2007)

Table 2. Major nonmeat protein sources suitable for Meat analogues

Type of protein	Sources	References
β-conglycinin	Soybean	(Sun et al., 2008)
Glycinin, Vicilin	Legumes	(Kang et al., 2007)
Legumin, Albumins, Globulins Glutelins	Oil seeds	(Marcone, 1999)
Gluten Gliadins Glutenins	Wheat, rye, and barley	(Green and Cellier, 2007)
Mycoprotein	*Fusarium venenatum* (Filamentous fungus)	(Denny et al., 2008)

Table 3. Typical meat analogue ingredients and their purpose

	Ingredient	Purpose	Usage level (%)
I.	Water	Ingredient distribution, Emulsification, juiciness, cost	50 to 80
II.	Textured vegetable proteins: textured soy flour, textured soy concentrate, textured wheat gluten, textured protein combinations such as soy and wheat	Water binding, Texture and mouthfeel, Appearance, protein fortification/nutrition Source of insoluble fiber	10 to 25
III.	Nontextured proteins: isolated soy proteins, functional soy concentrate, wheat gluten, egg whites, whey proteins	Water binding, emulsification Texture/mouthfeel Protein fortification/nutrition	4 to 20
IV.	Flavors/spices	Flavor, savory, meaty, roasted, fatty, serumy Flavor enhancement (for example, salt) Mask cereal notes	3 to 10
V.	Fat/oil Flavor	Texture/mouthfeel, Succulence, Maillard reaction/browning	l 0 to 15
VI.	Binding agents: wheat gluten, egg whites, gums and hydrocolloids, enzymes, starches	Texture/"bite," water binding, may contribute to fiber content, can determine production processing conditions	1-5
VII.	Coloring agents: caramel colors, malt extracts, beet powder, FD&C colors	Appearance/eye appeal, Natural or artificial	0 to 0.5

(Source: Egbert and Borders, 2006)

Table 4. Meat analogue favouring characteristics of textured soy products

Attributes	Product based on		
	Soy flour	**Soy concentrate**	**Soy isolate**
Flavour	Moderate to high	Low	Low
Retort stable	Yes	Yes	Yes
Flavour development on retorting	High	Low	Low
Flatulence	Yes	No	No
Form/shape	Granules or chunks	Granules or chunks	Fibres
Cost (dry basis)	Low	Low	High
Recommended hydration level	2:1	3:1	4:1
Cost of hydrated protein	Low	Low	High
Fat retention	Moderate	High	Moderate
Optimum usage level in meat extension (% hydrated level)	15-20	30-50	35-50

(Source: Campbell, 1981)

