# Sustainable utilisation of edible animal byproducts for nutritional security

For optimal physiological, cognitive, and emotional development and function children and adults require access to food of optimum quantity and quality at all stages of their lifespan.

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However, due to poor economical conditions there is improper nutritional supply to over two billion people in the world, especially in developing countries. People have been reported to be suffering from the deficiency of key food nutrients such as vitamins and minerals (including vitamin A, iodine, iron and zinc).

Meeting the nutritional needs of these people will require about 20g of animal protein (meat, fish, egg and milk) per person per day or 7.3kg per year. Therefore, protein sources such as edible animal byproducts could be employed to reduce the menace of malnutrition and food insecurity. It has been proposed that studies involving the use of edible animal byproducts as food ingredients should be promoted and evaluated.

OcKerman and Basu (2004) reported that edible animal byproducts contain essential nutrients such as vitamins (B1, B2, B6, and folic acid), proteins, minerals and fat, with important polyunsaturated fatty and amino acids which are comparable to those in muscle tissue.

Animal byproducts constitute nearly 60-70% of the slaughtered carcase, of which nearly 40% are edible and 20% inedible.

Over the years, the utilisation of different edible animal byproducts generated during slaughtering of livestock as food which is enriched with protein, vitamins and minerals by nutrient deficient people has been successfully carried out without any adverse effect.

Simultaneously this process has always encouraged the easy disposal of these byproducts which could create a threat to the environment as a huge source of pollution. However, there are emerging gaps that need to be further addressed regarding the food security and sustainability of these products.

## Livestock and Indian society

Half the world's people live in rural areas in developing countries and their dependency for food supply totally relies on the food produced by smallholders in their local area.

Livestock contribute 40% of the global value of agricultural output and support the livelihoods and food security of almost 1.3 billion people over the world. Livestock are an integral part of smallholder farming systems.

Rearing of livestock plays an important role in enabling smallholders to have resilient livelihoods and to avoid both food insecurity and poverty, as livestock can contribute up to 33% of household income. Overall, 75% of rural people and 25% of urban people depend on livestock for their livelihoods.

## Source of human food

Livestock contributes one-third of the protein that people consume: poor people depend on animal-source food (especially dairy products) to ensure that their diets deliver the nutrients necessary for cognitive and physical development.

Meat and meat products form an important segment of the human diet because they provide essential nutrients which cannot be easily obtained through vegetables and their derived products, which in turn provides a means of reducing malnutrition and increasing household food and food security.

Over the last 20 years, demand for meat and meat products has increased in many parts of the world (including Africa, Asia, Europe and the USA) and this has led to a rapid surge in livestock production for sustainable food security.

In recent decades, consumption of animal meat in developing countries has risen by 5% per year.

## Animal byproducts and human nutrition

The process of converting livestock to meat in abattoirs usually generates a lot of byproducts, which can be further utilised by humans as food or reprocessed as secondary byproducts for both agricultural and industrial use.

The yield of these byproducts has been reported to account for about 10-15% of the value of the live animal in developed countries, although animal byproducts account for about two-thirds of the live animal weight after slaughter.

Basically, animal byproducts include all parts of a live animal that are not part of the dressed carcase, such as liver, heart, rumen contents, kidney, blood, fats, spleen, meat trimmings etc.

Edible meat byproducts contain many essential nutrients. Along with blood, several other meat byproducts, like lung, kidney, brains, spleen, and tripe, have a higher level of moisture than meat. Some organ meat, including liver and kidney, contains a higher level of carbohydrate than other meat materials.

The amino acid composition of meat byproducts is different from that of lean tissue, because of the large amount of connective tissue. As a result, byproducts such as ears, feet, lungs, stomach and tripe contain a larger amount of proline, hydroxyproline and glycine, and a lower level of tryptophan and tyrosine.

The vitamin content of organ meats is usually higher than that of lean meat. Kidney and liver contain the largest amount of riboflavin (1.697-3.630mg/100g), and have 5-10 times more than lean meat. Liver is the best source of niacin, vitamin B12, B6, folacin, ascorbic acid and vitamin A. Kidney is also a good source of vitamin B6, B12, and folacin.

A 100g serving of liver from pork or beef contributes 450-1,100% of the RDA of vitamin A, 65% of the RDA of vitamin B6, 3,700% of the RDA of vitamin B12 and 37% of the RDA of ascorbic acid. Lamb kidneys, pork, liver, lungs, and spleen are an excellent source of iron, as well as vitamins.

The copper content is highest in the livers of beef, lamb and veal. They contribute 90-350% of the RDA of copper (2mg/day). Livers also contain the highest amount of manganese (0.128-0.34mg/100g).

However, the highest level of phosphorus (393-558mg/100g) and potassium (360-433mg/100g) in meat byproducts is found in the thymus and sweetbreads.

With the exception of brain, kidney, lungs, spleen and ears, most other byproducts contain sodium at or below the levels found in lean tissue.

Mechanically deboned meat has the highest calcium content (315-485mg/100g). Many organ meats contain more polyunsaturated fatty acids than lean tissue.

Brain, chitterlings, heart, kidney, liver and lungs have the lowest level of monounsaturated fatty acids and the highest level of polyunsaturated fatty acids.

## Environmental impact

A huge amount of edible byproducts are generated during the slaughter of animals in India. But the scientific techniques of their processing into value added nutritional supplements are not standardised.

Most often these byproducts are discarded into the environment unscientifically which creates a potential source of environmental pollution and hazards. Therefore the sustainable utilisation of these byproducts will reduce the threat to the environment and will find ways to convert them into various value added nutritional supplements to nutrient-deficient Indian consumers.

## Effective utilisation of animal byproducts

Animal byproducts can be grouped into non-carcase meat, which are regarded as edible byproducts. These are products that are approved by the registered public health inspector and considered safe for human consumption after inspection in the abattoir.

Most edible organ meats like liver, heart, lungs, tongue, gizzard, trotter, tail, ear, snout, brains, marrow, testicles, kidney, sweetbreads and tripe from cattle, sheep, goat, chickens and game, have the potential to provide essential nutrients where meat and meat products are limited or insufficient to meet the nutritional requirements of people.

Today, the world is facing a huge problem with food insecurity and climate change, which has resulted in malnutrition, especially in developing countries.

In the past, byproducts were a favourite food in Asia, but health concerns have led to an increased focus on non-food uses, such as pet foods, pharmaceuticals, cosmetics and animal feed.

Traditional markets for edible meat byproducts have gradually been disappearing because of low prices and health concerns. Regulations require that edible byproducts be examined by a public health inspector immediately after slaughter and approved to be free from infections (such as fasciolosis, fibrosis, echinococcosis, tuberculosis, hydatidosis and abscess) and physical abnormalities before processing for human consumption.

If diseases and abnormalities such as bruises are found in any organs and carcases, the affected parts or whole organs are usually condemned and discarded or declared unsafe for human consumption. Other byproducts such as the intestine and stomach are thoroughly washed and heat-treated to remove any dirt and to also destroy any microbes present that might cause infection or pose a health risk to consumers.

Organ meats are available in slaughterhouses, butchers and meat markets at relatively cheaper prices than meat from skeletal muscles. This contributes to high demand and affordability from an average meat consumer.

Organ meat contains vitamin E and several B-complex vitamins. It also contains a favourable n-6/n-3 fatty acid ratio, antioxidant, anti-hypertensive, anti-inflammatory, antithrombotic, cytomodulatory, immunomodulatory, hypocholester-olaemic, metal ion chelating and brain enhancing bioactive compounds.

In comparison with skeletal meat, proteins, coenzyme (CoQ10), L-carosine, anserine, L-carnitine, conjugated linoleic acid, glutathione, raurine, creatine and dietary fibres in organ meat are higher.

Vitamin E is present in the liver where it acts as an antioxidant. Taurine, also found in the liver regulates immune dysfunction. Also, choline which is a phospholipid and neurotransmitter precursor is present in the liver where it offers protection against oxidative stress.

Thiamine, riboflavin, niacin, biotin, pyridoxine, cyanocobalamin and panthothenic acid in the kidney, heart, liver, brain, pancreas and brain act as coenzymes or their precursors.

Omega-3 fatty acids, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) are also available in organ meat.

As sources of digestible protein and micronutrients, organ meats have the prospect of being utilised in the design of healthy meat products with no side effects. Organ meat is naturally enriched with bioactive peptides with potentials for antihypertensive, antimicrobial, antioxidant, antithrombotic and opioid activities.

Although uneven proportions of nutrients are available in organ meat, an efficient combination of various organs can be transformed into personalised meat products with superior health benefits. Many of the known bioactive peptides from organ meat can perform regulatory functions that exceed normal and adequate nutrition under in-vivo and in-vitro conditions.

Improvement of intestinal health, nutrient intake, feed conversion efficiency, mineral bioavailability, immunity building against diseases and reduction of heat stress are some of those functions.

Peptides are specific protein fragments that regulate cellular and intercellular physiologic responses. They are often inactive within the native proteins but can be released from precursor proteins during gastrointestinal digestion or food processing by enzymatic hydrolysis, bacterial fermentation or in vivo digestion or proteolysis.

Thus, incorporating all these meat-based nutrients in the diet can be beneficial under stressed livelihood to boost body haemostatic and improve general well-being of malnourished consumers.

## Indian scenario

A study by Jayathilakan et al. (2012) showed that the efficient utilisation of meat byproducts is important for the profitability of the meat industry. It has been estimated that 11.4% of the gross income from beef and 7.5% of the income from pork comes from the byproducts.

Edible meat byproducts contain many essential nutrients. Some are used as medicines because they contain special nutrients such as amino acids, hormones, minerals, vitamins and fatty acids.

According to Devatkal et al. (2004), the liver obtained from slaughtered animals is the most widely used edible organ. It is used in many processed meats, such as liver sausage and liver paste. The liver is the largest gland in animals. The liver of mature cattle usually weighs about 5kg, while that of a pig weighs approximately 1.4kg.

Liver extract is produced by mixing raw ground liver with slightly acidified hot water. The stock is concentrated into a paste in a vacuum at a low temperature, and is used as a raw material by the pharmaceutical industry. Liver extract can be obtained from pigs and cattle, and has been used for a long time as a source of vitamin B12, and as a nutritional supplement used to treat various types of anaemia.

Animal intestines are used as food after being boiled in some countries. Animal intestines are also used in pet food or for meat meal, tallow or fertiliser. However, the most important use of the intestines is as sausage casings. Animal intestines, when removed from the carcase, are highly contaminated with microbes and very fragile. They must be cleaned immediately after the slaughter of the animal.

Emulsion-based mutton nuggets incorporating chicken byproducts, i.e., skin, gizzard and heart (SGH) from spent hens, were evaluated by Kondaiah et al. (1993).

Incorporation of SGH resulted in better acceptability of mutton nuggets compared to those containing mutton fat.

The meat industry uses the bulk of the blood proteins employed as ingredients in the food industry, mainly as a binder but also as natural colour enhancers, emulsifiers, fat replacer and meat curing agents.

Binders have traditionally been used in meat products to counter the textural and sensorial changes brought about by processing. In addition to absorbing the moisture that is released from meat during thermal processing, they are used to bind water and fat to stabilise meat emulsions in ground meat products.

Protein hydrolysate was prepared from pre-treated sheep visceral mass (including stomach, large and small intestines) by enzymatic treatment at 43 ± 1 °C (at the in situ pH 7.1 ± 0.2 of the visceral mass) using fungal protease. The enzyme readily solubilised the proteins of the visceral mass as indicated by the degree of hydrolysis (34%) and nitrogen recovery (›64%).

Hydrolysis with an enzyme level of 1% (w/w of total solids) at 43 ± 1°C with a pH around 7.0 for 45 minutes was found to be the optimum condition. The yield of protein hydrolysate was about 6% (w/w). The amino acid composition of the protein hydrolysate that was very hygroscopic was comparable to that of casein.

Use of buffalo head meat and heart meat in comminuted meat products not only brings more returns but also improves the quality and nutritive value of meat products.

Generally physico-chemical properties are relevant to the processing conditions and quality of the finished products like stability of the protein matrix for binding water and fat, cooking yield and texture.

It is, therefore, necessary to study the physico-chemical properties of raw offal meats like head meat and heart meat and select ideal levels of their incorporation for processing of meat products.

Functional properties of some selected buffalo meat byproducts have also been reported. Ready-to-eat emulsion-type buffalo meat sausages were developed by using a combination of 80% meat components with 20% pork back fat.

The meat components constituted 70 parts buffalo skeletal meat and 30 parts offal meat (rumen meat and heart meat in equal proportions).

## Conclusion

The appropriate disposal of edible animal byproducts can be accomplished by converting them into human food rich in essential nutrients. This also aids in reducing the chance of environmental pollution. However, there are emerging gaps that need to be further addressed regarding food security and sustainability of the products. ■

References are available from the authors on request