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# Efficiency of *Citrus* Fruits to Improve Functional Properties of Livestock Products

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**Abstract**

*Citrus* fruits are flowering trees belonging to genus shrubs and *Rutaceae* family. These are beautiful and fragrant plants, spreaded to all continents of the India. *Citrus* fruits are rich source of vitamins C (ascorbic acid), dietary fiber and bioactive compounds, which plays important role in protection of human health. Livestock foods are nutritional foods, but it lacks in dietary fiber and bioactive compounds. Due to the existence of functional ingredients in the citrus fruits and its byproducts, these fruits can be used for designing livestock food. Hence, enrichment of milk and meat products with *citrus* fiber is a best alternative to increase functional quality of the product and cater to the consumer demand.

## Introduction

Livestock products are distinctive foods due to its taste, nutritional value, digestibility and easy availability, however these foods lack in the vitamins C (ascorbic acid), dietary fiber and bioactive compounds. Recently consumers are demanding for healthy food due to increasing awareness with respect to diet as well as health. Healthy food can be prepared with incorporation of natural (Fruit and vegetable) healthy ingredients as functional compounds. *Citrus* fruits are the best source of functional compounds and there is a great opportunity for improving functional properties of livestock oriented food products with addition of citrus fruit as natural ingredients. *Citrus* fruit is a well known fruit, most abundantly distributed worldwide; however it mainly grown in the part of Southeast Asia, Northeast India and China. Major citrus producing states in India are Karnataka, Pondicherry, Tamil Nadu, Andhra Pradesh, Maharashtra, Jammu Kashmir, Himachal Pradesh, Madhya Pradesh, Orissa, Jharkhand etc. Orange, Lemon, Grape Fruit and Mandarin fruits accounts approximately 98% of the total citrus production.

*Varieties of Citrus Fruit:*

Different varieties of citrus fruits are available in market for human consumption. Following varieties of citrus fruits are commonly found in India.

- *Citrus aurantifolia* (Lime or Kagzi Nimbu)
- *Citrus reticulata* (Orange or narangi)
- *Citrus sinensis var. mosambi* (Mosumbi)

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- *Citrus medica* (Lemon)
- *Citrus sinensis var. sinensis* (Malta)
- *Citrus limon* (Galgal)
- *Citrus limenta* (Sweet Lime, Meetha Nimbu)
- *Citrus grandis* (Shaddock or Pomello, Chakotra) and
- *Citrus pardesii* (Grape fruit)

Most commonly Oranges, Lemons and Grape Fruits are used for daily consumption. *Citrus medica* commonly known as *Lemon* grown for sale as fresh fruit, which is highly acidic fruit. *Citrus reticulate* also known as *Orange or Narangi or Santra*. It grows in all tropical as well as rain fed area of the country. Rind of oranges is easily separable from pulp portion, and pulp is sweet or acidic. *Grapefruits (Citrus pardesiilocally)* plants grow in tropical as well as hot-humid subtropical environment. These fruits are more acidic, contains small amount of juices and a thicker peel.

Citrus fruit are processed mainly to produce juice and most often the peel is discarded as a waste which is subdivided into epicarp or flavedo (coloured peripheral surface), mesocarp or albedo (white spongy soft middle layers). Waste material from citrus fruits accounts upto 50% of total fruit weight (Bocco et al., 1998). Fruits is composed of principal components such as $H_2O$ soluble sugar, fibre, organic acids, amino acids, protein minerals, oils, lipids, vitamins as well as flavonoids, proportion of these components varies in different parts of the citrus fruits i.e. juice, albedo flavedo, pulp and seeds (Braddock, 1995).

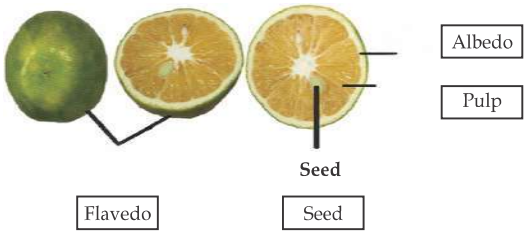


**Table 1:** Nutritional characteristics of common citrus fruits

| Per 100 g | Orange | Grapefruit | Lemon |
|---|---|---|---|
| Energy (kcal) | 47 | 53 | 20 |
| Carbohydrates (g) | 11.75 | 10.66 | 9.32 |
| Protein (g) | 0.96 | 0.77 | 1.10 |
| Total fat (g) | 0.12 | 0.14 | o.30 |
| Cholesterol (g) | 0 | 0 | 0 |
| Dietary fiber (g) | 2.40 | 1.60 | 2.80 |
| Vitamin C /ascorbic acid (mg) | 53.20 | 31.20 | 53 |
| β-Carotene (µg) | 71 | 686 | 3 |
| α-Carotene (µg) | 11 | 3 | 1 |

*Source:* USDA National Nutrient Database for Standard Reference, Release 24, 2011a.

*Bio Active Compounds*

Major bio active compounds are health promoting, which are present in the form of phyto-chemical. Fruit and vegetables are well loaded with bioactive compounds, fruits are particularly high in a class of phyto-chemical known as the limonoids (Hasegawa and Miyake, 1996).

**Table 2:**

| Limoniods content of citrus essential oils | |
|---|---|
| Orange | 91.40% |
| Grape fruit | 95.12% |
| Lemon | 65.44% |

In variety of fruit, citrus fruit is rich in bioactive compounds (flavonoids, vitamin C, carotenoids and phenolic compounds) with antioxidant properties, which may provide additional health-promoting effects (Marín et al., 2007). citrus byproducts is good sources of phenolic compounds, however major portion of phenolics is available in peel (Balasundram et al., 2006). Peel as well as leaves of Citrus sinesis and Citrus Auravtium are potent source of phytochemicals- Geranyloxy Ferulic (GOFA) and Boropinic Acid (Genovese et al., 2014), which has pharmacological effect against cancer, chemo preventive anti-inflammatory, neuroprotectitve and anti helicon bacter pylorigent. Orange, lime and lemon juice prevents kidney stone formation (Pak, 2004), grape fruit lowers blood pressure and interferes with calcium blockers (Sica, 2006).

Flavonoids are polyphenolic compounds and mostly found in pulp, peel and rag tissues. The hesperidine, narirutin, Naringin, erocitrin flavonoid mainly present in citrus fruit (Schieber et al., 2001). Another class of O- methylate deglycones and flavones such as nobiletin and tangeretion which are relatively common polymethoxylated flavones (PMFS) (Li et al., 2014). Citrus peel contains highest amount of PMFS compared to edible parts of fruit (Wang et al., 2014). Citrus flavonides plays role in modulating hepatic metabolism (Cha et al., 2001) as well as in prevention of lipid peroxidation (Frutos et al., 2002), such as orange juice prevents and modulates inflammatory processes (Assis et al., 2013), grape fruit have antigentoxic effect (Alvarez Gorazales et al., 2010).

*Citrus* bio active compounds helps in prevention of atherosclerosis, certain types of cancer as well as diabetes (Garcia et al., 2001). The phyto phenolics content also contributes in the mechanism of health promotion and disease prevention with pro-carcinogene deactivation, DNA repair, maintainance and suppression of N Nitrosamine formation as well as change of oestrogen metabolism (Shahid, 1997). *Citrus* fruits exert favorable effect on human health by prevention of degenerative disease due to the presence of phenols, amino acids, essential oils pectins, carotenoids, flavonoids and vitamin C (Wang et al., 2014) as well as wide range of promising biological properties due to their phenolic profile as well as anti oxidant properties. (Montanary et al., 1998).

*Dietary Fibre*

Citrus fruits encompass dietary fiber in addition to bio active compounds. Dietary fiber (DF) are of two types i.e. soluble DF and insoluble DF. The good fibers should have a ratio of 1:2 for SDF/IDF (Jaime et al., 2002). Dietary fibers plays a significant role in prevention, reduction and treatment of chronic diseases such as bowel, gastrointestinal discarders, obesity, diabetes, CVD, cancer, also enhances physiological function i.e. reduction in blood cholesterol maintain insulin level (Champ, 2003) and maintains human health. The daily requirement of dietary fiber in the diet for women is 21-25gm and for men is 30-35gm (food and Nutrition Board Institute of Medicine., 2001). Dietary fibers not only exhibit health benefits but it also improves technological properties during processing i.e. increases water holding capacity, oil binding properties, lowers viscosity and gel forming ability of product (Hyun Jung and Hyun-Dong, 2012).

Livestock products viz, milk and meat are important source of protein and essential nutrients, however these products lacks in the dietary fiber and bioactive compounds. In preview of consumer awareness regarding their diet, health along with demand for healthy food to prevent health hazards as well as Hippocrates statement "Let food be the medicine and medicine be the food" there is necessity of development of functional livestock products.

*Functional food*: A food that beneficially affects one or more target functions in the body beyond adequate nutritional effects in a way that is relevant to either an improvement of health status, well-being and/or reduction of disease risk.

Citrus fruit and its byproducts contains non digestible carbohydrate (diet fiber) and bio active compound (Main et al., 2002) as a functional ingredient and which helps in designing food (functional food) livestock products such as fat replacer, enrichment of dietary fiber, antioxidant and alteration of microorganisms i.e. promotes health beneficial and reduce harmful bacteria growth as well as reduction residual nitrite content.

*Dietary fiber enrichment in livestock products*

Dietary fiber is one of the most important and commonly used functional ingredients in food products (Sanchez-Zapata et al., 2010). Functional properties of citrus ingrédients were prooved by many reserchers with assesment of citrus ingredients incorporated livestock products. existence of associated bioactive compounds, such as flavonoids, polyphenols and carotene in citrus fibers depict importance as are better quality fibers than other dietary fibers (Fernandez-Gines et al., 2003; Wolfe et al., 2003). Citrus fiber enrichment also helps to develop low cost and value added products, so that every individual can afford the consumption of products and facilitate to overcome the fibre deficit (Fernandez Gines et al., 2003). Garcia et al. 2002 stated that 1.5% of cereals and fruits fiber was final fiber content of reduced-fat, dry-fermented sausages, which improves nutritional properties and provides an acceptable sensory profile. Lemon albedo was added at different concentration (2.5% to 10%) to cooked sausages (Fernández-Ginés et al., 2004) and dry-cured sausages (Aleson-Carbonell et al., 2004) and perceived sensory properties of 2.5% to 7.5% lemon albedo added sausages similar to the conventional sausages. Fernandez- Lopez et al. (2004) developed cooked sausages with addition of lemon albedo (raw and cooked) as a good source of dietary fiber and concluded that it can also be employed as functional ingredient in other meat products. Sarıcoban et al. (2008) obtained better results with respect to emulsion on addition of 5 % lemon albedo as a potential source of dietary fiber in frankfurter-type meat products formulation. However Eda et al. (2015) determined the usability of lemon fiber (LF-2%, 4%, 6%) and carrot fiber (CF-2%, 4%, 6%) to produce low fat beef hamburgers and found best results for 2% fiber added products.

Fernandez Gines et al. (2003) observed that addition of orange fiber powder (0.5% to 2%) to cook sausages (bolognas) comprised good sensory score and improved the nutritional value of the sausage; however 2% citrus fiber content gives harder & springy texture. Fernandez- Lopez et al.

(2007) also employed successfully different levels of orange fiber as potential functional ingredient in dry cured sausage without affecting its quality. Similarly Fernandez Lopez et al. (2008) did not found any negative effects on flavour of orange fiber (0, 1, 2%) added "salchichon" (Spanish dry-fermented sausages). Sendra et al. (2008) noted good acceptability for citrus fiber enriched fermented milk i.e. yougurt, however found more acceptability of orange fiber enriched fermented milks than the others.

*Residual nitrite reduction*

In meat industry, nitrite is especially employed to develop colour of the product and to inhibit outgrowth of micro-organism i.e. Clostridium botulinum. However, higher residual level of nitrite is anis an emerging issue as it contributes in the formation of the carcinogenic compound i.e. nitrosamine. Therefore effort should done to reduce the residual levels of the nitrite in the products through processing alterations, which may be an acceptable alternative to reduce exposure of human body to nitrite through processed meats. Considering necessity scientists insisted to exploit citrus fruit for reduction of residual nitrite level. Aleson-Carbonell et al. (2004) and Fernandez-Lopez et al. (2004) observed reduction in the residual nitrite content respectively in dry-cured sausages and bologna sausage on addition of different levels of lemon albedo (2.5 to 10%). Similarly residual nitrite reduction were also noted by Fernandez Gines et al. (2003) for cooked sausages (bolognas) on addition of orange fiber powder (0.5% to 2%), Fernandez Lopez et al. (2007) for dry-cured sausages prepared with addition of orange fiber (0, 5, 10, 15 and 20 g/kg), Fernandez Lopez et al. (2008) for orange fiber (0, 1 and 2%) added "salchichon" and Viuda Martos et al. (2010) for orange fibre treated mortadella, Barıs et al. (2012) for different levels of orange fiber (0, 2 and 4%) added sucuk.

*Fat replacer in livestock products*

Health consious peoples are demanding for less fat, low calories and less cholesterol containing livestock products. Low-fat and high-fiber foods can help reduce the risk of cardiovascular diseases, obesity, colon cancer, and other disorders (Mansour and Khalil, 1997). Fat is an essential component in meat product which imparts flavour, juiciness and texture, hence it cannot be directly reduced by using less fat or direct replacement with other types of fat (Jimenez-Colmenero, 2000), but addition of suitable ingredient can replace fat without affecting the quality.

*Citrus* fruits characterize a potential source of dietary fiber, which can be employed as potential fat replacers (Mendoza et al., 2001) without affecting physical, chemical, and sensory properties of the products. Fernandez-Gines et al. (2004) found that the presence of raw and cooked albedo in bolognas decreased ($p < 0:05$) the fat content, this decrease was found higher in bolognas with raw albedo than cooked albedo. Fat contents of sausages were reduced with increased level of citrus fiber (5-20%). Addition of citrus fiber as a fat replacer increased energy values, but decreased cholesterol contents Emel and Nalan, (2005). However Tainara et al. (2013) added peel, pulp and seeds as well as peel in the ice-cream formulation. They stated that orange fiber reduced approximately 70% fat content of ice cream, which is a good alternative for fat replacement. Similarly, Tainara et al. (2014) observed that the addition of orange juice industry by-products did not change important properties of ice cream, but it reduces approximately 50% mean fat content of light lemon ice cream. However, Sendra et al. (2008) declared that the fiber particles reduced creaminess of fermented milks. Eda et al., (2015) used lemon fiber (LF-2%, 4%, 6%) and carrot fiber (CF-2%, 4%, 6%) to produce low fat beef hamburgers. Irrespective of fiber type (LF/CF) fat and cholesterol contents of Beef Hamburger decreased significantly.

*Promotes growth of beneficial bacteria*

Bactria images bad way in everyone's mind but viable bacteria in the fermented milk products have a positive health effect due to the beneficial action. Fermentation of food is as old a custom; purpose of the fermentation is not only to preserve the food, but also to improve its flavor, consistency, texture and nutritive value. Fibers may also interact with the microbial populations of fermented livestock products; either residual essential oil may inhibits growth bad bacteria or fiber components as oligosaccharides may enhance growth of good bacteria known as probiotic bacteria. To exert beneficial effects in the host, it is essential that probiotic bacteria should be alive and abundant in the product at the time of consumption. Usually recommended counts are from 106 to 108 CFU/g, but there is no general agreement regarding achievement of probiotic effects due to unsuccessful efforts for reaching the probiotic concentration (Lourens-Hatting and Viljeon, 2001). *Citrus* fibers promotes the growth of beneficial bacteria which

was also confirmed by Sendra et al. (2008) who stated that the presence of citrus fiber enhanced the growth and survival of yogurt starter bacteria viz, L. acidophilus and L. Casei and B. bifidum. Fernández Lopez et al. (2008) also added orange fibre to "salchichon", a dry fermented sausage, which promoted the growth of micrococcus without affecting flavour of the products. Baris et al. (2012) stated that the growth of ripening bacteria viz, lactic acid bacteria and Micrococcus / Staphylococcus was positively affected on addition of 4% orange fiber in sucuk.

*Enhancement of the shelf life of the product*

Livestock products are best media for growth of microbes and the presence of air induces fat and protein oxidation. Storage leads to gradual deterioration in the quality and nutritive value of products and production of potentially toxic reaction products such as malonaldehye (MDA) and cholesterol oxidation products (COPs) (Verma and Sahoo, 2000) and to develope rancid flavour of the product (Cottone, 2009). Prevention of microbial growth and oxidative rancidity during storage and retail display is essential to maintain the quality and safety of livestock products. It can be achieved by applying preservation technologies (Aymerich et al., 2008). Generally synthetic preservatives are used to restrict the microbial growth and thereby extending the shelf life of livestock products. However synthetic preservatives are health hazardous, hence now days these are less preferred by consumers over bio-preservatives due the awareness of the consumers regarding health. Plant extracts are main sources of Bio-preservatives, containing phenolic compounds as secondary metabolites; these compounds have capacity as an antioxidant by reducing power of free hydroxyl groups and antimicrobial by binding protein. To cater the constantly increasing demand of consumers for the chemical and antibiotic free food and multi-drug resistance of food borne pathogens, recently natural available citrus fruits are commonly used for extending the shelf life of the products.

*Citrus* products counter acts the oxidation of products and enhances the shelf life. Aleson-Carbonell et al. (2003) observed more slowly increase in TBARS values of sausages containing different levels of lemon albedo than control. Fernandez-Lopez et al. (2004) also reported antioxidant effect of rosemary, orange, and lemon extracts in cooked Swedish-style meatballs. Orange fiber had positive effect with respect to retarding oxidation with enhancement of the shelf-life of sausage (Fernández-Ginés et al., (2003), Fernández-López et al., (2007), (2008) and Viuda-Martos et al., (2010). Hanan et al., (2013) evaluated microbial growth, lipid oxidation and color change of raw ground beef meat stored at 4±1°C by using fruit by-products such as Grapefruit rind powder (GRP), orange rind powder (ORP) and mandarin rind powder (MRP) with or without γ irradiation and observed significantly lower TBARS values for all treated (GRP<ORP<MRP) samples than control throughout storage refrigerated period. However, Inserra et al. (2014) were fed dietary citrus pulp (24% and 35%) feeding to the lamb and found positive effect on reducing lipid oxidation of meat over refrigerated storage.

Antimicrobial activity of oils and vapours of citrus fruits evaluated against wide variety of spoilage and pathogenic microorganisms (Roy et al., 2012). This acitivity of citrus fruit is mainly due to bioactive compounds viz, ferulic acid, hydrocinnamic acid, yaniding glucoside, hisperidin, vitamin C, carotenoid, and naringin, which also imparts important nutritional and flavoring value (Ghafar et al., 2010). Prakash et al. (2013) stated that the fruit peel extracts of *Maclura pomifera* (Orange), *Citrus limetta* (Sweet lime or Mousambi) and *Mangifera indica* (Mango) had moderate to mild inhibiting effect on pathogenic bacteria. Mishra et al. (2012) tested specifically antimicrobial acitivity of citrus fruits against *E. coli* organism and observed significant effect against the various strains of *E. coli.* Fisher and Carol, (2008) reported that the essential oils of *citrus* fruits like orange, lemon had good antimicrobial activity against *Escherichia coli O157*, *Campylobacter jejuni, Listeria monocytogens, Bacillus cereus* and *Staphylococus aureus.* Lee and Najiah, (2009) found range of MIC values from 7.8 to 31.3 mg mL−1 for crude extract of *Citrus microcarpa* against *Escherichia coli* (ATCC 25922), *Citrobacter freundii* (ATCC 8090), *Aeromonas hydrophila* (ATCC 49140), *Pseudomonas aeruginosa* (ATCC 35032), *Streptococcus agalatiae* (ATCC 13813), *Edwardsiella tarda* (ATCC 15947), and *Yersinia enterocolitica* (ATCC 23715). Fernandez-Lopez et al. (2004) also reported the antibacterial effect of rosemary, orange, and lemon extracts in cooked Swedish-style meatballs. Viuda Martos et al. (2010) revealed that the orange fiber have a positive effect on reducing the growth of unwanted microbes and increasing the shelf-life of the sausage. The counts of artificially inoculated pathogenic bacteria viz, (*Escherichia coli, Salmonella typhimurium* and *Bacillus cereus*) into ground beef meat were significantly ($p < 0.05$) reduced by the addition of Mandarin

rind powder, orange rind powder, grapefruit rind powder (Hanan et al., 2013).

*Enhances Technological Parameters during Processing*

Researchers found appreciable changes in the technological properties of milk meat products. *Citrus* fibers plays important role in various functional properties of food products, in addition to the health and nutritional characteristics. Water holding capacity, viscosity, gel-forming ability, and fat binding capacity are major functional properties of dietary fiber. Incorporation of citrus dietary fiber increases water holding capacity as fibers occupies water in the fiber pores, which ultimately increases cooking yields and reduces the caloric contents of livestock products. Viscosity is a resistance to flow, increase in the molecular weight or chain length of the fiber, increases the viscosity of fiber in solution and provides rheological properties in food system. Experiential increase in the viscosity of the orange fiber added yogurt was observed by Sendra et al. (2008). Formulation of the product containing citrus fibers disperses and/or binds fat due to which fat content of the products reduces (Decker and Park, 2010; Weiss et al., 2010). Better texture profile and greater sensory acceptability were observed on addition of 1.5% fruit fiber along with 10% of pork fat in dry-fermented sausages by Garcia et al. (2002). Sarıcoban et al. (2008) declared that the addition 5% of lemon albedo increased the emulsion capacity (EC) and as well as enhance the functional and technological properties for frankfurter-type meat products. However, addition of lemon fiber resulted in a lighter, redder, and more yellow color ($p<0.05$) as well as increase in moisture content and cooking yield of low fat burger due to its better water binding properties (Eda et al., 2015).

*Limitations*

Citrus fruits are good source of vitamin C, but mostly it fade away during heat treatment (processing) like blanching, boiling, cooking, cooking under pressure and sterilization of foods. Citrus fibers can cause acidic or bitter taste because of its low pH. Product texture as well as juiciness gets affected on addition of higher level of citrus fiber. Bioactive compounds of citrus fruit and its byproducts are sensitive to heat treatment which results in losses of it.

*Future scope*

The development of meat products enriched with citrus fruit & it byproducts is indeed a novel area. Furthermore, investigations on pretreatment of citrus component to reduce bitterness, stability and interactions of phyto-chemicals with other food ingredients during processing and storage need to be initiated. Research is needed to understand their interactions with meat products citrus constituents to improve physicochemical and textural quality of product. Real challenge actually lies in effective development and marketing of these functional meat products.

## Conclusions

- *Citrus* fruit is a good source of vitamin C, phyto-chemical and flavonoids it's available in various forms.
- Milk and meat products are naturally lacking in dietary fiber, vitamin C and phyto-chemicals.
- Incorporation of *citrus* fruit in milk and meat products, in addition to the nutritional properties it can also provide functionality to the product.
- The active ingredients of *citrus* fruits are sensitive to heat treatment so the proper technology for product development and quality assessment is a most important to exploit the beneficial effects of citrus fruit in milk & meat products.

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