CONSUMER PREFERENCES AND MARKET TRENDS: CUSTOMIZING POULTRY PRODUCTS FOR CUSTOMER-BASED POULTRY MARKETS

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ABSTRACT: With the raise of socioeconomic status health conscious people are demanding quality food products at premium prices to maintain their health. This has led to the development of designer eggs and meat. Customized poultry farming is a new shift in poultry farming in terms of value-added products that can revolutionize the poultry industry. Using advanced technology to address customers-driven demands may support the industry in the 21st century. Designer/functional foods are nutraceutical and/or fortified/enriched or value-added foods that are currently gaining popularity throughout the globe. The designer meat and eggs are produced by manipulating the poultry feed via health boosting agents like omega fatty acids (omega 3, omega 6, omega 9, and conjugated linoleic acid (CLA), etc.), antioxidants, lutein, minerals, vitamins (B, D, E, and K, etc.), herbs or other health-promoting non- nutritional additives. Therefore this review article intends to bring forth the different nutritional manipulations for the production of designer meat and eggs for customized poultry products marketing and its future scope/prospects.

Keywords: Customized farming, designer eggs, designer meat, niche market, health benefits.

INTRODUCTION

An egg is an excellent and nutrients rich healthy food commonly used throughout the world. It provides all essential amino acids, several minerals (calcium, iron, potassium, and phosphorus), and vitamins (vitamin A, B2, B9, B6, B12, and choline) for humans. During the last few decades with the economic development, people are highly conscious of the link between balanced food and good health. Food is functional together only when considered with its basic nutritional effect it helps to maintain human health. Apart from that, technological involvement has been used to improve economic traits like growth rates, feed efficiency, livability, disease resistance, egg and meat quality, etc. A significant impact of these modern technologies can be seen in the layer and broilers segments of the poultry industry. The useful effects of n-3 (omega-3) long-chain PUFA on human health are widely known. This is because the production of omega-3-enriched eggs is a rapidly expanding niche market and consumers have realized the health benefits of a diet rich in omega-3 fatty acids. Functional foods have improved general health conditions and are helpful to decrease the risk of the disease. Focusing on the customer's demand functional foods can be enhanced with added ingredients providing health benefits beyond their nutritional value.

Health-conscious people are interested in paying high prices for poultry products enriched with essential fatty acids (EFA) i.e. polyunsaturated fatty acids (PUFA) and omega-3 fatty acids, vitamins, and minerals. Numerous studies proposed that an elevated amount of PUFA in the diets of humans can promote infant's health and lessens the risks of heart attack, stroke, and atherosclerosis. The positive effects of omega fatty acids includes faster development, enhanced brain function/mental health, good heart health, better transport of oxygen to tissues, reducing inflammatory disorders, preventing rheumatoid arthritis, and other diseases. Therefore several attempts have been made to modify the eggs by addition of certain ingredients that are beneficial for the health or by eliminating or decreasing harmful constituents to avoid the chronic diseases. Such modification have resulted in the development and production of functional/designer eggs through dietary approaches either through dietary manipulation of specifi

certain nutrients, or specific drugs or bioactive compounds or herbs that have functional and/or therapeutic properties. Designer eggs and meat not only greatly open an excellent way for customers to improve their life standards but also a new niche for producers to improve their business and resources in the food industry.

Poultry production has been revolutionized using newer technology for industry automation and continuous evolution in poultry products according to changing requirements with time and is likely to continue to change much faster in the coming years. Poultry products (eggs and meat) have already gained a symbol of health, so to reduce the incidences of chronic diseases numerous efforts have been made to alter/design the nutritional profile of meat and/or egg composition by making certain changes in poultry diets formulations to improve the consumers' health. Designed the poultry products through dietary approaches either through supplementation of specific nutrients, or certain herbs or specific drugs that have functional and therapeutic properties is quite simple and economical. Based on the available scientific research this review study, therefore, suggested that designer eggs and meat should be considered of particular interest to get the share in the global market.

Health Benefits of Designer Eggs/Meat: Eggs are an important source of quality proteins, fats, vitamins, and microelements for consumers. However, Li et al. [82] reported that egg composition for a while has controversial opinions amongst nutritionists due to saturated fat content and cholesterol (3 g, respectively 200-300 mg/100 g), therefore, people especially those having cardiovascular problems are limited to consuming as few eggs as possible. It is believed that higher egg intake may be responsible for raising cholesterol and can cause cardiovascular problems in humans. Hu et al. [78] found that Cholesterol-rich eggs can increase the total food consumption by 32%. Weggemans et al. [77] found that 100 mg of egg cholesterol increased total plasma cholesterol by 0.057 mmol/l in clinical trials. Kuang et al. [83] stated that cholesterol homeostasis is influenced by food intake, endogenous biosynthesis, utilization, and excretion. Whereas, various studies observed that egg cholesterol has a limited effect on blood cholesterol levels [79; 80; 81]. So there is a need to adopt some strategies to raise the unsaturated contents of eggs such as linseed oil and its seeds are used in the feed of laying hens to increase the omega-3 fatty acid content in yolks and to reduce cholesterol content [1; 6; 7].

Cruickshank (1934) was the first scientist who documented that the nutrient profile of eggs can be changed and later in the 80s, Sim and their coworkers produced nutrient-enriched (rich in n-3 fatty acids) and designer eggs and called these eggs as Professor Sim's Designer Eggs. Van Elswyk in 1997 developed enriched eggs with CLA Designer eggs in the market are enriched with higher vitamin contents or enriched with lutein and selenium (Se) to prevent eye and other health disorders. Narahari [76] in India developed designer eggs rich in carotenoids, Se, vitamin E, Omega-3 PUFA i.e. alpha-linolenic acid (ALA), eicosapentaenoic acid (EPA), docosapentaenoic acid, (DPA), Docosahexaenoic acid (DHA), and trace minerals as well as rich in bioactive compounds i.e. Allicin, Euginol, Betaine, Lutein, phytosterols (β-sitosterol, Campesterol, Brassicasterol, Stigmasterol, etc), Lumichrome, Sulforaphane, Lumiflavin, and Taurine (See Table 1).

Table 1: Active Ingredients in designer egg and their effect on health of human

Source	Effect on public health	Active ingredient
Turmeric powder	antioxidant, Antimicrobial	Flavonoid compounds
Citrus pulp	Reduces LDL cholesterol	Niranginin
Sugar beet, grape pulp	Reduces plasma homocysteine	Betaine
Basil leaves	Immunomodulators	Eugenol, eugenic acid
Brans	Decreases LDL cholesterol	Tocotrienols
Spices	Stimulates insulin secretion, antimicrobial	Quercitin, citogenin
Broccoli, cauliflower, cabbage	Anticarcinogenic and antioxidant	Sulforaphane
Garlic, onion and their leaves	Lower LDL, Cholesterol	Allicin, Allylic sulfide
Milk, eggs, and meat products	Impede atherosclerotic plaque formation	Taurine
Flax seed, oil insects, worms	Reduces LDL cholesterol, hypertension	Omega-3 PUFA
Tomato pomace, grape pulp	Lower LDL, anti-carcinogenic	Lycopene
Alfalfa, marigold petal, red pepper blue-green algae, spirulina, , corn gluten meal, and capsicum	Antioxidant, anti-carcinogenic	Carotenoid pigments
Bay leaves	Improves vision, Antioxidant	Lutein
Brewery waste, yeast	Lowers LDL cholesterol	Statin
Seeds, weeds, legumes	Increase HDL, reduces blood sugar	Phytosterols

Designer foods offer health functions also provide essential nutrients (vitamins and minerals etc.) to promote health due to their ability to prevent disease. By enhancing the nutritional content, designer foods can help address specific health concerns, such as osteoporosis (via calcium-fortified foods) or heart disease (via omega-3 enriched foods). These products help individuals to achieve a more balanced diet, particularly when access to certain nutrients is limited. Designer foods can play a role in preventing and managing chronic diseases such as cardiovascular diseases, diabetes, and osteoporosis. Enrichment of probiotics and prebiotics in functional foods can improve digestive health and boost the immune system. Functional food provides a convenient way for people to consume necessary nutrients without significantly altering their diets and provides specific dietary needs, such as gluten-free or lactose-free products for individuals with intolerances. Currently, there is a significant impact of fortification on the ability of foods to prevent disease using advanced technologies has been documented. Nutraceutical, medicinal, and pharmacological effects of designer foods on human health are proven.

Examples of designer foods include Omega-3 enriched eggs, fortified cereals and energy bars, probiotic yogurts and drinks, vitamin-enhanced water and juices, fiber-fortified bread and snacks, antioxidant-rich beverages and supplements, cardio-protective spreads and margarine, immune-boosting dairy products and supplements, cancer-fighting foods like tomatoes and soy products, and brain-health promoting foods like blueberries and dark chocolate. Iodine-rich eggs (700 µg iodine per egg) are designed for people who are suffering from iodine deficiency. Iodine-rich eggs are also helpful in reducing plasma cholesterol and cause no adverse effects [141].

Some of the health benefits of consuming omega-3 fatty acids include lowering triglyceride levels to reduce the risk of heart disease and stroke, raising HDL (good) cholesterol, lowering blood pressure, lowering the risk of developing lupus, eczema, and rheumatoid arthritis, lowering blood pressure and heart rate which in turn helps to lower the risk of cardiovascular disease. Omega-3 fatty acids also play a protective role in cancer and other conditions, lowering triglycerides and helping to ease inflammation, improving blood vessel function, lowering the risk of arrhythmias that cause cardiac deaths also supporting the development of the brain and nervous system in fetuses and babies.

IgY (antibody to treat Staphylococcus, Pseudomonas, Streptococcus, Salmonella, E. coli, and human rotavirus) of egg is cheaper than mammalian IgG, a laying hen produces about 298mg in 6 weeks, The diet enriched with omega - 3fatty acids and higher anti-oxidants levels can increase the IgY enriched eggs. Various herbs (red pepper, rosemary, turmeric, onion, garlic, spirulina, citrus pulp arogyapacha fenugreek, fenugreek seeds, ashwagandha, flaxseed, etc.) in the diet of laying hens have been reported to increase the IgY concentration in the eggs i.e. Tulasi (Basil leaves) @ 0.3-0.5 % in the diets of layers have showed the higher level of IgY and Vitamin E in the eggs1 [139].

The production of eggs with better lutein contents can be important as it has been shown a preventive effect on incidences of macular degeneration in humans [84]. Innovative designer eggs are the result of advanced scientific development in egg production, hence, gaining higher demand in the local market but also high valued export commodity [85]. Designer eggs are available in the world market under various brand names defined by ingredients variations by geographic area, the population for which they are intended, or by the chicken breeding system. Stupin et al. [86] reported the effects of n-3 PUFA-enriched eggs on endothelium-independent and endothelium-dependent vasodilation in the microcirculation or activation of the endothelium in young people as a result of the anti-inflammatory potential. NutriPlus eggs, Bounty Eggs, Omega-3 eggs, Se Plus, DHA Eggs, Suguna Eggs Vitamin D eggs, Columbus eggs, Eggs Plus, Mr. Eggs and many others brands are available in the global market and are gaining popularity day by day. In Europe, the role of nutrition in health care has become more pronounced during the last few decades [3].

CLA is an isomer of unsaturated fatty acids (18-carbon structure) having two conjugated double bonds. These organic acids have shown antiadipogenic, anticarcinogenic, anti-inflammatory, and anti-diabetic properties [142; 143]. Laying hens fed the diet with 5.0% CLA can lay eggs having 310 to 1000 mg CLA/egg which is helpful in addressing the mentioned problems [144]. Europeans are usually interested in innovative products and like use of advanced technology in food production compared to American consumers [2; 87]. From the literature, it can be concluded that the main reasons for purchasing new innovative functional products are healthcare, better product quality, brand recognition, and practical packaging. However, there are reasons for reluctance to purchase such products which include short supply information, too high prices, and poor market availability. The young population that has higher economic status are more interested to purchase functional products as compared to those with lower economical status, however, the older purchase these products purely for their positive health effect [88; 89; 90; 91].

Designer eggs/meat offer several benefits when consumed as part of a balanced diet (See Table 2). Omega-3 fatty acids in designer eggs/meat help lower triglycerides, reduce blood pressure, and prevent blood clots, all of which contribute to a reduced risk of heart

disease. DHA in designer eggs/meat supports brain health, improving memory, focus, and cognitive function also supports eye health, reducing the danger of age-related macular degeneration. Omega-3 FA in designer eggs/meat have anti-inflammatory properties, which can help reduce the risk of chronic diseases like cancer, arthritis, and autoimmune disorders. DHA in designer eggs/meat is essential for fetal brain and eye development during pregnancy. Designer eggs/meat offer a more balanced fatty acid profile, with a higher ratio of omega-3 to omega-6 fatty acids, which is essential for overall health and well-being. Designer eggs/meat are a convenient way to increase omega-3 intake, especially for those who do not consume seafood or supplements. Designer eggs/meat support healthy growth and development in children and adolescents. Consuming designer eggs/meat as part of a balanced diet may reduce the risk of chronic diseases like cardiovascular disease, cancer, and cognitive decline. Designer eggs/meat offer a nutritious and convenient way to support overall health and well-being.

Table 2: Benefits of designer meat and eggs in poultry production

Benefit	Designer Meat	Designer Eggs	References
Quality	Enhanced tenderness, flavor, and texture via selective breeding or processing	Improved taste, texture, and satiation based totally on feed and genetic modifications.	[39; 70; 123]
Nutritional Value	Full of healthy elements such as omega-3 fatty acids or lower levels of fat. Normal eggs have 90-100 μg /g yolk vitamin E level whilst herbal-supplemented designer eggs have 220 – 240 μg / g vitamin E in the yolk	Enhanced with better and health-friendly fatty acids (omega-three), vitamins, or other beneficial nutrients.	[8; 17; 47; 48]
Health Benefits	Using advanced biotechnology techniques it is possible to genetically modify chicken to produce eggs for health benefits. Eggs/meat items enhanced for better health properties can address particular nutritional requirements i.e. insulin and antibodies.	Enhanced with better omega-three fatty acids, vitamins, or different nutrients and or insulin or specific antibodies	[48; 49; 50;51 63; 64; 65]
Sustainability	Green initiatives and moral manufacturing appeal to eco-aware consumers.	Can be advertised as a part of green practices if produced sustainably.	[52]
Consumer Appeal	Customized cuts and flavors for special and health-targeted consumers.	Distinctive attributes appeal to health-aware purchasers and area of interest markets.	[53; 54; 55; 56]
Economic Value	Premium merchandise can command better charges and create new sales streams.	Potentially better rate factor because of top-class attributes and branding.	[57; 67; 68; 69]
Market Differentiation	Distinguishes produce via innovative breeding, processing, and marketing.	Stands out thru labeling, packaging, and precise features.	[28; 66; 67;]
Consumer Trust	Traceability and transparency foster purchaser self-assurance in meat fine and sourcing.	Clear and neat manufacturing processes and permissions can construct belief and logo loyalty.	[20; 58; 59; 60]
Product Longevity	Advanced packaging and processing strategies increase shelf existence and decrease waste.	Designer eggs have improved shelf life with good packaging.	[33; 61; 62]
Educational Opportunities	Offers academic costs about meat production, sustainability, and fitness benefits.	Provides options for instructional campaigns for almost fitness and vitamin benefits.	[36]

These eggs can be found in many supermarkets and are labeled to highlight their enhanced nutritional benefits, making it easier for consumers to make healthier choices. Shakoor et al. [96] found that n-3 egg PUFA consumption has a positive effect on reducing cholesterol, triglycerides, LDL cholesterol, and blood pressure, and supports an increase in HDL cholesterol concentration. Designer eggs provide an easy and versatile way to enhance nutrient intake without making significant changes to one's diet. Thus, eggs supplemented with n-3 PUFA may be useful in maintaining normal heart function. They can be used in the same way as regular eggs in cooking and baking,

ensuring that nutritional benefits are included in a wide variety of dishes.

The effects of N-3 FA Sources On Production Parameters in Hens: There are conflicting reports on the effects of flaxseed supplementation on fodder production parameters. Scheider Froning (1996) reported a decrease in body and egg weight. Weight of fed birds, yolk size, eggshell percentage consume flax seeds for 8 weeks. This is thought to be caused by laxatives the effects of flax seeds and increasing the speed of digestion. Experimental diets were calculated as isonitrogenic and isoenergetic, containing powder or complete.

Feeding hens with n-3 fatty acid sources results in eggs with a higher n-3 fatty acid content, which can benefit human health. However, it is crucial to consider the optimal inclusion levels and the impact on production parameters, such as egg production, feed intake, and egg quality, to ensure the well-being of the hens and the sustainability of the production system. Generally, the inclusion of n-3 FA sources like flaxseed and fish oil does not negatively affect the number of eggs produced. In some cases, slight improvements or maintenance of production levels are observed. Improved fatty acid profiles can enhance overall hen health, potentially leading to sustained egg production over time.

Scheideler and Froning (1996) found an increased egg production rate in response to dietary linseed whereas Jiang et al. (1991) and Caston et al. (1994) reported no effect of linseed on egg production. Van Elswyk (1997a) reported a correlation between dietary fish oil and/or meal and reduced yolk weight. This might be due to the influence of n-3 FA on lipid metabolism and circulation estradiol. Herber and Van Elswyk (1996) observed a temporary decrease in egg yolk weight in hens fed 1.5 *Moringa olifera* whereas Van Elswyk et al. (1998) reported smaller egg yolks in birds fed only 165 mg DHA from *Moringa olifera*. Several researchers (Van Elswyk et al. 1992; Whitehead et al. 1993; Marshall and Van Elswyk 1994; Van Elswyk et al. 1994; Ayerza and Coates 1999) also reported the effect of dietary effects of *Moringa olifera* on egg yolk of laying hens.

Nutritional strategies to produce designer eggs: Eggs are an excellent source of essential nutrients and interest in modifying the nutritional contents of eggs for better effect on health has increased in recent decades [5]. “Designer” eggs include nutrients, or substances that have beneficial effects on various physiological processes related to human health [4]. Particular important compounds include n-3 PUFA: long chain – LC PUFA [92], α-linolenic acid (ALA), EPA, and DHA. The composition of the feed of laying hens is modified by various types of active compounds in different concentrations to change metabolic pathways that affect the synthesis and deposition of desirable active compounds in the eggs which help to improve cardiac health, support brain and eye development, particularly in infants and children and prevent cancer, and cognitive disorders [93].

Designer eggs are a great option for individuals looking to increase their omega-3 intake, particularly those who do not consume seafood or supplements. They can be used in cooking and baking just like regular eggs, and offer a nutritious and convenient way to support overall health and well-being.

Polyunsaturated fatty acids like ALA (n-3) and linoleic-LA (n-6) acids are essential for human health [93]. LA is metabolized to arachidonic acid, while ALA is to EPA and DHA. These long-chain essential fatty acids include phospholipids contributing to the flexibility of cell membranes and lowering plasma cholesterol. Studies have shown that regular consumption of omega-3-enriched eggs can significantly increase blood levels of omega-3 fatty acids, thereby delivering the associated health benefits. Research also indicates that the bioavailability of certain nutrients like vitamin D and lutein from eggs is high, making them an effective way to boost nutrient intake. EPA and DHA help to decrease cardiovascular and central nervous system disease, mental illness, inflammation, and immunity risk of infections [92]. Nutritionists recommend increasing n-3 PUFA consumption. The best source of n-3 PUFAs can be found in fish oil (Higher in eicosapentaenoic acid and docosahexaenoic acid), algae oil (high in DHA), **Flaxseed** (rich in alpha-linolenic acid), Vegetable oil, and seaweed (rich source of ALA) oil [94], microalgae or their combination to enrich edible eggs with ALA, EPA and DHA [89; 90; 91]. Therefore these additives are used with certain concentrations in the diet of laying hens so that these cannot interfere with the organoleptic properties of the egg.

Eggs are an excellent source of protein, fat, vitamins (A, D, E, K, B1, B2, B5, B6, B7, B9, B12), and minerals (calcium, iron, magnesium, Phosphorus, Se, sodium, and zinc) and are considered a global functional product representing a “complete” required food for growth and regulation of metabolic processes [93; 95]. However, presently there is a trend to modify the nutrient composition of eggs according to customers' demands i.e. production of eggs having varying protein contents for different age groups peoples or modifying the minerals or fat profile of eggs. The primary method to modify the fatty acid profile in eggs/meat is through the hens' diet. Specific feed ingredients are chosen to enhance the desired fatty acids in the eggs/meat. Selective breeding of hens that naturally produce eggs/meat with a more favorable fatty acid profile [123]. Managing the environment to reduce stress and improve overall hen health, which can also impact eggs/meat composition. Some consumers may notice differences in taste or texture, although these are generally minor. These

eggs/meat can be used in the same way as regular eggs/meat, including frying, scrambling, boiling, and baking.

Oxidative Stability and Sensory Quality of n-3 FA Enriched Eggs: In eggs and tissues, n-3 FA increases susceptibility to peroxidation [102]. Dietary n-3FA tocopherols also reduce egg stickiness and further impair egg oxidative stability [103]. From LCn-rich eggs increase the risk of lipid oxidation. 3 instead of LNA. Both are LNA and LCn-3 eggs stable over a 4-week storage period [104; 105]. Oxidative Stability refers to the resistance of egg yolk lipids to oxidation, which can lead to rancidity and off-flavors. This is crucial for maintaining the freshness and shelf-life of eggs.Omega-3 fatty acids are polyunsaturated, making them more prone to oxidation compared to saturated fats. Supplementation with antioxidants such as vitamin E in the hen's diet can improve oxidative stability by protecting the n-3 FAs from oxidation. Carotenoids and Se are also effective in enhancing oxidative stability. Higher storage temperatures accelerate oxidation. Storing eggs at lower temperatures (refrigeration) can slow down the oxidative process. Exposure to light can promote oxidation. Eggs should be stored in opaque containers or dark environments to minimize light-induced oxidation. Sensory Quality refers to the taste, odor, texture, and overall acceptability of the eggs. Sensory quality is critical for consumer satisfaction and marketability. Fish Oil Can lead to a fishy taste and odor in eggs, which may be undesirable to some consumers. Deodorized fish oil or lower inclusion rates can mitigate this issue. Dietary enrichment of laying hens diet with herbs and their oils can improve the fatty acids profile of eggs. Flaxseed generally has a neutral impact on taste, but very high levels can impart a slightly bitter taste. Algal Oil typically does not negatively impact taste or odor, making it a preferred source for sensory quality. Oxidation of n-3 FAs can produce volatile compounds that lead to rancidity and off-flavors. The use of antioxidants and proper storage can prevent the formation of these undesirable compounds. The sensory quality and oxidative stability of n-3 fatty acid-enriched eggs were evaluated in a study in Greece where the researcher found that the eggs having a higher n-3 fatty acid content and a lower n-6 to n-3 fatty acid ratio can contribute to a more favorable fatty acid profile.

Table 3: Innovative approaches for designer eggs production

Strategy	Benefits	Description	References
Flavor and Color Variations	Creates interest and appeals to customers searching out novelty.	Market eggs with awesome colors or flavors accomplished via distinctive breeds or feed.	[39]
Premium Quality and Specialty Eggs	Differentiates products and objectives for health-aware customers.	Offer eggs with precise attributes (e.g., better omega-3, organic, strong point breeds).	[38]
Unique Branding and Packaging	Enhances visible enchantment and presents a memorable experience.	Custom packaging with appealing designs and customized options.	[37]
Sustainability Focus	Appeals to environmentally aware customers.	Highlight green and moral farming practices in advertising materials.	[41]
Collaborations and Limited Editions	Attracts interest and creates buzz around restrained version products.	Partner with chefs, influencers, or manufacturers for unique product releases.	[42]
Storytelling and Transparency	Builds agree with and emotional reference to customers.	Share testimonies approximately the farm, farmers, and sustainable practices via diverse media.	[40]
Interactive and Educational Experiences	Educates customers and complements emblem loyalty.	Provide farm tours or virtual experiences and educational content about the eggs.	[44]
Seasonal Themes	Drives seasonal sales and engages customers with timely promotions.	Offer themed eggs all through vacations or unique occasions with particular packaging.	[43]
In-Store Experiences	Increases visibility and encourages trial purchases.	Create enticing in-save shows or tasting occasions to sell fashion dressmaker eggs.	[46]
Social Media and Digital Campaigns	Expands reach and interact with a tech-savvy audience.	Use social media systems for promotions, behind-the-scenes content, and purchaser engagement.	[45]

Vitamin E supplementation in the diet has been proven. To solve the problems of eggs, Cherian et al. (1996) Eggs contain LNA or LCn-3 TBARS is equal compared to eggs fed a saturated diet fat in commercial

egg production n-3 FA, this is common practice dietary intake of vitamin E in amounts up to 100 IU kg-1 [106]. On the contrary, it is theoretically improved that the stability of flaxseed oil is different when fed whole and ground. It has been proven (Eymond and van Elswyk 1995). Decreasing the sensory quality of eggs fed with fish oil or FM has been known for a long time (Vondell 1932; Holdas and May 1966. 101; Wakeling 1982). Koehler and Beers (1975) deterioration of egg taste depends on the type, content, and storage period of FM fed to chickens. Pacific Ocean hick flour received the lowest taste score. Meal 10 percent of most FM diets produced unsightly eggs the taste decreases and the sensory quality of the eggs deteriorates with a shelf life of 4 weeks depending on the FM. The main cause is the bad smell of eggs laid by feeding chickens with seafood panelists called it "suspicious." Generally bland sensory properties are due to the interaction of several compounds. Odors associated with volatile compounds Fish oil has been previously reviewed by Stansby (1990).

The eggs also had a higher content of alpha-tocopherol and beta-carotene, which can contribute to their oxidative stability. The study concluded that the n-3 fatty acid-enriched eggs had good sensory quality and oxidative stability, making them a good choice for consumers looking for a healthier egg option.

Oxidative stability and sensory quality of n-3 FA enriched meat: Oxidative stability of poultry meat is affected by its fatty acid composition. LNA-rich meat is prone to lipid oxidation and usually contains more TBARS than meat high content of saturated or monounsaturated fats [107; 108]. O'Keefe et al. [109] reported higher TBARS in precooked meat enriched with LCn-3 after 2 d cooling. The highest concentration of lipid oxidation products was found in meat with higher LCn-3, viz the effect increased over time. Thus, storage time and conditions have a large effect on lipid stability [105]. There are many volatile products derived from lipid oxidation, which can have a significant effect on the flavor characteristics of meat [110]. Vitamin E supplementation increases the vitamin E content in carcasses and supplies it with better stability of lipids in meat, thereby reducing volatile substances and possibly reducing undesirable tastes [107; 111; 112; 113]. Given the above, sensory quality issues have been widely reported in n-3 FA-enriched meat. As described for eggs, it is somewhat difficult to compare the results of sensory evaluation of meat [114].N-3 fatty acid-enriched meat is prone to lipid oxidation, which can be detrimental to its quality. However, studies have shown that adding antioxidants like vitamin E to the diet of the animals used to produce the meat can help prevent oxidation and improve the shelf life of n-3 fatty acid-enriched meat products

However, a review of the literature suggests that off-flavors become apparent when dietary fish oil ranges from between 0.75 and 1.5% [115; 116; 117]. High levels of FM in food can also cause off-flavor broilers. Dean et al. [118] reported detectable flavors in broilers fed 9% FM. Recommendations from other authors agree with this report [100; 101]. However, care must be taken when including FM with a high oil content [119; 120]. Unlike broilers fed with fish oil and/or FM supplementation diets, birds fed with linseed in amounts up to 10% no produce meat with an undesirable flavor ([117]. LNA and LCn-3 preferential deposition discussed higher for poultry, along with large differences in the total fat content of meat portions, can cause problems when designing poultry meat enriched with n-3 FA. [117] addressed this problem by testing the sensory quality of different portions of cooked meat from broilers who were fed different combinations of linseed and MO for 7 or 14d. Sensory quality of breast and thigh meat of birds fed 10% linseed for 14 days was comparable to controls. In contrast, feeding birds a 0.75% MO diet for 14 days resulted in a lower sensory quality of thigh meat than controls, while the breast meat remained unchanged.

The addition of natural extracts to n-3 fatty acid-enriched meat products can improve their sensory attributes while increasing their nutritional value and health safety. These extracts can prevent significant changes in PUFAs, improve the nutritional value of food, and prolong shelf life. However, the use of synthetic antioxidants can cause discoloration and off-flavors of products, and they have been suspected to be toxic and have hazardous effects on human health.

Interactions between components must also be considered when compiling practical diets. Only 5% of dietary FM can produce off-flavors when combined with high-content rapeseed meal [121]. Salmon et al. [122] suggested that broilers fed 5% FM with added DL-methionine (0.05%) and choline chloride (0.1%) could show undesirable meat spots (See Table 4).

Designer Meat is enhanced with higher protein quality, lower unhealthy fats, and is enriched with omega-3 fatty acids, vitamins, and minerals. The goal is to create a product that is healthier than traditional meat. Designer eggs are often produced by feeding hens a diet rich in omega-3 fatty acids, antioxidants, and other nutrients. This results in eggs with higher omega-3 content, lower cholesterol, and enhanced levels of vitamins and minerals.

Table 4: Comparative nutrient profile in conventional and designer meat/eggs.

Nutrient	Traditional Meat	Designer Meat	Traditional Eggs	Designer Eggs
Protein	20-25g / 100g	22-28g /100g (higher quality)	6g / egg	7g / egg (with higher bioavailability)
Fat	10-15g / 100g (varying in cuts)	5-12g /100g (leaner, healthier fats)	5g / egg	4g /egg (lower in saturated fats)
Omega-3 Fatty Acids	Minimum	200-500mg / 100g	Minimum	100-200 mg/egg (enriched content)
Cholesterol	60-80mg / 100g	50-70mg / 100g (lower concentration for good health)	185 mg/egg	150 mg/egg (less level)
Vitamins i.e. B6, B12 etc.	0.5-1.5µg / 100g	1.0-2.5µg / 100g (enhanced)	0.6µg / egg	1.0µg / egg (improved)
Minerals (e.g., Iron)	2-3mg / 100g	3-5mg / 100g (higher content)	1 mg/egg	1.5 mg/egg (improved)
Antioxidants	Low	High (added natural antioxidants)	Low	High (improved with lutein, zeaxanthin)
Caloric Content	150-250kcal / 100g	120-200kcal / 100g (less calorie for good health)	70-80kcal / egg	60-70kcal / egg (fewer calories for good health)
Sodium	50-70mg / 100g	40-60mg / 100g (less level for good health)	70 mg/egg	60 mg/egg (less level for good health)

Table 5: Nutrient Variation of Designer Meat/Eggs.

Nutrient Variation	Designer Eggs	Designer Meat	References
Protein Quality	Having an ideal amino acid profile and bioavailability made by genetic modifications.	Having improved protein pleasing and digestibility exploding selective breeding.	[21;33]
Fat Content	Having less fat content or good fat composition e.g., higher omega-3.	Having improved or altered fat composition, and decreased saturated fat content.	[25; 26; 35]
Mineral Content	Having improved concentration of essential minerals such as calcium and iron.	Having improved modified mineral profile achieved by special feeding or genetic modifications.	[27; 28]
Vitamin Content	Higher levels of vitamins A, D, E, or others through fortified diets.	Having extra nutrients or stepping forward through breeding practices.	[19; 20]
Omega-3 Fatty Acids	Increased levels of healthy fatty acids are modified by feed or genetics.	Enhanced through enriched feed or breeding.	[17; 18]
Antioxidants	Increased antioxidant levels, such as lutein and zeaxanthin, through diet.	Higher antioxidant levels are achieved by unique feed or processing techniques.	[23; 24]
Shelf Life	Have extended shelf life due to improved nutrient stability.	Extended shelf life with enriched nutrient preservation.	[33; 34]
Cholesterol Levels	Have less cholesterol content modified by dietary or genetic mediations.	Lowered cholesterol level by feed modifications or breeding.	[29; 30]
Flavor Compounds	Improved flavor imparted by diet or genetic factors.	Modified flavor profiles achieved by feed and processing techniques.	[31; 32]
Overall Nutritional Profile	Broad improvement in nutritional worth custom-made to consumer needs.	Complete enrichment of meat good and dietary benefits.	[35; 36]

Nutrient	Designer Eggs	Designer Meat	References
Protein	7g per egg (enhanced with higher bioavailability)	22-28g per 100g (higher quality, bioavailability)	[8]
Fat	4g per egg and lower saturated fats as well	5-12g per 100g (leaner, healthier fats)	[8]

Omega-3 Fatty Acids	100-200mg/egg, fortified	200-500mg/100g fortified	[10]
Cholesterol	150mg /egg (10%less)	50-70mg/100g	[11; 140]
Vitamins (e.g., B12)	1.0µg/egg (fortified)	1.0-2.5µg/100g, enhanced through supplements.	[12]
Minerals (e.g., Iron)	1.5mg/egg (fortified)	3-5mg/100g (fortified)	[13]
Antioxidants	High (with lutein, zeaxanthin)	High (natural antioxidants like tocopherols)	[14]
Caloric Content	60-70kcal/egg (lower calories)	120-200kcal/100g (lower calories)	[15]
Sodium	60mg/egg (lower content)	40-60mg/100g (lower content)	[16]

Chicken egg components: Chicken eggs are composed of several distinct components, each with unique nutritional and functional properties. An egg consists of a yolk in the middle surrounded by albumen, both enclosed in a shell. Formation a yolk development occurs in the hen's left ovary. After ovulation, egg production continues on the left fallopian tube wherever the albumen is stored and later in the receptacle. Shell, white, and yolk make up 9% - 12%, 60%, and 30% to 32% of eggs. The outermost part hard shell of the egg, primarily composed of calcium carbonate (CaCO3) provides a hard barrier protecting the egg's contents from physical damage and microbial invasion. It contains thousands of tiny pores that allow gas exchange (O_2, CO_2, and metabolic gases) between the egg and its environment. The shell is 94% calcium carbonate and varying eggshell colors are due to the genetics of the hen secreting white or brown pigments but can be blue or green as in some American breeds of chicken. Color affects regional consumer demand, but it does not affect the quality or taste of the eggs. Over the hard shell an outer coat, cuticle, helps remove bacteria and dust. Inner and Outer Membranes are located just inside the shell to serve as additional protective barriers against bacterial invasion and help maintain the egg's shape and integrity. Egg White (Albumen) consists of approximately 90% water and 10% proteins, with trace amounts of carbohydrates, vitamins, and minerals. Ovalbumin is the most abundant protein, accounting for about 54% of egg white protein. It has numerous functional properties, including foaming and gelation. Ovotransferrin binds to iron and exhibits antibacterial properties. Ovomucoid is an allergenic protein that inhibits proteolytic enzymes. Lysozyme possesses antibacterial properties by breaking down bacterial cell walls. Avidin binds biotin (a B vitamin), making it unavailable; important in raw eggs but denatured by cooking. The total solids of white and yolk are 11% - 12% and 50% - 52% respectively. White or egg white is composed of 90% water and 10% protein (See Table 5).

Egg Yolk is roughly 50% water, 33% lipids, and 17% proteins, along with vitamins, minerals, and pigments. Its main components include Lipids (triglycerides, phospholipids mainly lecithin, and cholesterol), Proteins (Livetin, phosvitin, and lipoproteins), vitamins, and Minerals: Rich in fat-soluble vitamins (A, D, E, and K, B6, B12, folic acid, riboflavin, and pantothenic acid), important minerals (Fe, P, and Se) and pigments (Carotenoids, such as lutein and zeaxanthin). Hence yolk provides essential fatty acids, fat-soluble vitamins, and high-quality proteins and also acts as an emulsifier in culinary applications (e.g., in mayonnaise and sauces). The yolk color is varying (light yellow or intense yellow, etc.) that depends on the diet of the laying hens. However, the color of the yolk has no relation to the nutritional value of the egg. Inside the yolk is a germ cell (or germ disc) which is the site of cell division if the egg is fertile.

Chalazae of the egg are twisted, rope-like structures made of protein that anchors the yolk in the center of the egg white. It helps to keep the yolk centered and prevents it from touching the shell, which provides protection and maintains egg quality. Air Cell is found at the larger end of the egg, between the inner and outer membranes, and develops as the egg cools after being laid, causing the contents to contract and separate from the shell and facilitating the respiration of the developing embryo in fertilized eggs. However, the air cell enlarges due to moisture and carbon dioxide loss through the shell pores as the egg ages.

The nutrient composition of eggs is somewhat stable in terms of protein, lipids, essential amino acids, phospholipids, phosphorus, and iron (See Table 2). Other essential components include fatty acids, content of minerals, carotenoids, vitamins, antioxidants, and cholesterol content (See Table 2) affected by the hen's diet and are more variable. These differences in component percentages may be due to strain, age, and environmental conditions.

Table 5: The nutrient composition (may vary) of the egg (50 gm).

Components(units)	Amount	Components(units)	Amount
Water	74.5(g)	PUFAs	1.8(g)
Protein	12.1(g)	Potassium	147(mg)
Lipid	12.1(g)	Folic acid	65.0(micro gms)
Energy	162(Kcal)	Iron	2.1(mg)
Calcium	56.0(mg)	Cholecalciferol	1.8(micro gms)
Egg white	58.5(%)	Magnesium	12.0(mg)
Carbohydrates	0.68(g)	Cyanocobalamin	66.0(micro gms)
Iodine	25**(mcg)**	Riboflavin	0.3(mg)
Saturated fatty acids	3.3(g)	Zinc	1.44(mg)
Egg yolk	31(%)	Carotenoids	10(micro gms)
Cholesterol	410(mg)	Pyridoxine	0.12(mg)
Se	10(micro g)	Thiamine	0.09 (mg)
Eggshell	10.5(%)	Retinol equivalents	227.0 (micro gms)
Monounsaturated fatty acids	4.9(g)	Phosphorus	180.0(micro gms)
Tocopherols	1.93(micro gms)	Niacin	0.1(mg)

After 1 year production cycle egg proportions declines thus flock are needs to be replaced by younger pullets as the hen ages, however, molting is also an option to restore the egg production of older hens. Also, the right production methods tend to reduce these ingredient differences and make the eggs easier for marketing. Generally the age of the hen, genetics, environment, and feed quality specially modified with added game nutrients role in determining the quality of eggs and their healthy nutrients.

Vitamin E Enrichment in Eggs: Vitamin E-enriched eggs are a great option for those looking to increase their vitamin E intake. Since eggs enriched with ω-3 fatty acids are more sensitive to lipid oxidation, dietary addition vitamin E is normally suggested to stabilize egg lipids and to prevent rancidity to extend the life of the products. Galobart et al (2001a) investigated that dietary vitamin E supplementation did not have a significant effect on the daily intake of feed, productivity, egg weight, and laying rate. Vitamin E acts as a powerful antioxidant, protecting cells from oxidative stress and damage caused by free radicals. Helps in maintaining cardiovascular health by preventing the oxidation of LDL cholesterol. Enhances immune response and helps in maintaining overall health. Supports skin health and may have anti-aging effects. People with eye problems, athletes, smokers, older people, and those with immunosuppressed need more intake of this essential nutrient.

Eggs enriched with vitamin E have better oxidative stability, reducing the risk of lipid oxidation and rancidity. This leads to a longer shelf life and improved freshness. Enhanced oxidative stability also maintains the taste and odor of the eggs, ensuring a better sensory experience for consumers. Enriched eggs provide an additional dietary source of vitamin E, contributing to the overall nutrient intake of individuals, especially those who may have low vitamin E intake from other sources

Puthpongsiriporn et al. [97] and Panda et al. [98] reported that dietary vitamin E supplementation can increase the egg production of laying hen and rises the antioxidant level of egg yolks and plasma in White Leghorn hens kept under heat stress. The results showed an improved feed consumption, egg production, strength of vitelline membrane, egg white and yolk height, and foam stability of eggs laid by heat-stressed hens fed a diet containing vitamin E @60 IU/kg feed. Kucuk et al. [99] noted this dietary vitamin E improved the performance of laying hens significantly in cold environments, including feed conversion speed, body weight, and egg production. Leeson et al [106] recommended that the level of vitamin E in the diet (using flaxseed in the diet) of laying hens should be 100 IU/kg to increase n-3 fatty acids and consumer acceptability for eggs.

Selenium Enrichment in Eggs: Se is a rare mineral which is required to lessen oxidative damage to cell membranes in animals. It is a vital part of numerous selenoproteins, including Glutathione peroxidase (GSH-Px), and at least six forms of GSH-Px. GSH-Px plays a role in the cell's antioxidant protection (Arthur, 1997). Mineral sources (selenate and selenite) and organic sources of Se supplements like selenium yeast are used in regular corn soybeans meal-based layered diet for production of Se-see-enriched eggs.

Ensuring compliance with regulations regarding the maximum allowable levels of selenium in eggs and animal feed. Clear labeling to inform consumers about the selenium content and health benefits of enriched eggs. Educating consumers about the importance of selenium

in the diet and the benefits of choosing selenium-enriched eggs.

Properly formulating the diet with Supplementation with organic Se and balancing selenium levels with other nutrients ensure optimal health of laying hens as well as the quality of eggs (Habbe, 1998). Selenium supplementation like sodium selenite and selenocysteine increased the concentration of selenomethionine in egg yolk and also increased the vitamin E contents of the yolk. Lutz et al (2004) investigated that increasing diet significantly by taking an organic selenium supplement can improve egg production, egg weight, feed conversion ratio, albumen height, and specific weight of egg when using Sel-PlexTM. However, managing the cost of selenium supplementation or biofortification is essential to ensure economic feasibility.

Antioxidant enrichment in eggs: Eggs are enriched with natural antioxidants i.e. vitamin-E, vitamin-C, flavinoid compounds, carotenoid, pigments, lecithin, and phosvitin. Designer eggs contain high levels of synthetic antioxidants like ethoxyquin and herbal antioxidants like curcumin, carnosine, lycopene, sulforaphane, and aquercetin, depending on the herbs used in laying hens feed. [21] Henceforth, supplementing the antioxidants is essential to maintain the shelf life of food products.

Adding vitamin E (alpha-tocopherol) to the hens' diet through supplements or fortified feed. Vitamin E is a potent antioxidant that protects cell membranes from oxidative stress. Including sources of vitamin A, such as beta-carotene, in the diet. Beta-carotene is converted into vitamin A in the body and acts as an antioxidant. Feeding hens with ingredients rich in carotenoids, like marigold extract or algae, enhances egg yolk color and antioxidant content. Incorporating natural plant extracts with antioxidant properties, such as rosemary extract or grape seed extract, into the hens' diet. Supplementing with omega-3 fatty acids, which have antioxidant effects, can indirectly enhance antioxidant capacity in eggs. Dietary supplement of vitamin E is usually used in commercial omega 3 enriched products to decrease the oxidation of omega 3 fatty acids, and to prevent the formation of free radicals which produce an undesirable fishy/rancid smell and bad taste.

Table 6: Different bioactive compounds enriched in designer eggs and their effects

Bioactive compound	Researchers	Amount in egg	Mechanisms of Action
Lysozyme	[71; 73; 74]	3.4	Suppress oxidative pressure genes and reactive oxygen species
Phospholipids	[71; 73; 74]	10	Hydrolyl amines (NH2OH) in the side chains of phospholipids hunt the radical and acts as antioxidant properties
Carotenoids	[71; 73; 74]	<1	Aromatic rings and the unsaturated backbone of carotenoids help to neutralize singlet oxygen
Ovomucin	[71; 73; 74]	3.5	Prevent H2O2-induced oxidative stress in embryonic kidneys of humans.
Ovokinin	[73; 74]		Derivative of ovalbumin, and useful to lower high blood pressure in rats
Ovalbumin	[73; 74]	54	Free thiols (SH) in ovalbumin control the redox status and bind metal ions, so show antioxidant action when conjugated with saccharides
Phosvitin	[72; 73; 74]	4	Show antioxidant function based on metal chelating ability and chelates iron hence protecting against Fe-induced oxidative damage also showed bactericidal effect against *E. coli*,
Ovotransferrin	[71; 73; 74]	12	Possess SOD-like superoxide-reducing activity because of its mental chelating capability
Cystatin	[73; 74; 75]	0.05	Modify the synthesis and release of NO production and thus play a significant role in cellular antioxidant pathways

Benefits of designer eggs/meat with anti-oxidants include decreased susceptibility to lipid peroxidation. Designer eggs/meat can be good sources of antioxidants

In this digital era, technology plays a key role in improving farm management. We discuss the evolution of record-keeping systems and their transition from manual processes to efficient and user-friendly digital solutions. Discover the key features and benefits of Customized Layer Farm Records. Real-time data availability, efficient record updates, and data-driven decision-making are just some of the benefits that enable

layer farmers to maintain healthier and more productive flocks.

Implementation and integration: Implementing custom records can seem daunting, but this section guides a seamless integration process. We address common challenges faced during implementation and offer strategies to ensure these systems are harmoniously aligned with existing farm operations. The blog shares real stories of successful layer farmers who have adopted Customized Layer Farm Records. These anecdotes offer practical insights and inspiration, highlighting how customized records have significantly improved egg production, flock health, and resource allocation.

Designer meat production: Poultry production is entering a horizon of innovative products development. About 3-5% of the production has been categorized as nutrient-dense designer meat/eggs for value addition or to differentiate from regular chicken products. Since poultry meat have already got a healthy image, a number of attempts have been made to alter chicken meat by adding ingredients that are good for health or by removing harmful components. This modification resulted in the development of functional foods that help to boost the health and nutritional status of consumers through dietary approaches. Designer chicken can be made in three ways i.e. nutritionally enriched, value-added, and/or value-added processed.

Techniques like CRISPR/Cas9 are used to modify the genetic makeup of poultry to enhance desirable traits such as faster growth rates, disease resistance, or improved meat quality. Introducing genes from other species or altering existing genes to achieve specific characteristics, such as leaner meat or increased omega-3 fatty acids. Adjusting the diet of poultry to enrich meat with specific nutrients, vitamins, minerals, or bioactive compounds. Feeding poultry with plants or feed additives enriched with nutrients like omega-3 fatty acids, antioxidants, or vitamins to enhance the nutritional profile of meat. Cultivating poultry cells in a laboratory setting to grow meat without raising and slaughtering live animals. This approach offers the potential for customizable meat products with reduced environmental impact.

Poultry-engineered meat production refers to the practice of breeding and raising chickens and other birds to produce meat with special characteristics such as Heritage varieties bred for unique flavors and textures. Organic and free-range meat from birds raised free-range and without the use of synthetic chemicals i.e. fertilizers, pesticides antibiotics, etc. Slower-growing birds for better flavor and texture and increased omega-3 contents to increase the nutritional value of meat by feeding birds a diet rich in omega-3 fatty acids. Reducing fat content in poultry meat by feeding strategies.

Producing poultry meat with specific nutritional profiles beneficial to human health, such as reduced saturated fats, increased omega-3 fatty acids, or enhanced levels of vitamins and antioxidants. Potential to engineer disease-resistant poultry, reducing the need for antibiotics in farming practices. Requires less land, water, and feed compared to conventional poultry farming, contributing to lessen environmental footprint and greenhouse gas emissions. Potential to improve animal welfare by minimizing the need for intensive farming practices. Ability to modify poultry meat characteristics, such as taste, texture, juiciness, and tenderness, to cater to diverse consumer preferences. Potential to reduce allergenic components in poultry meat through genetic modifications [4; 5]. Probiotics (10-20 grams/kg feed) i.e. saccharomyces, Bacillus, Lactobacillus, Bifidobacterium, etc. are recommended in the diet of broiler chickens causing many health benefits for animals. Maintaining the balance of intestinal flora, etc. strengthening intestinal absorptive cells, increasing nutrient digestibility, developing and improving health growth performance.

Carcass characteristics and augmentation of nutrient bio-availability: Carcass characteristics in poultry refer to the physical attributes of the bird's body after processing, which are important for evaluating meat quality and determining economic value. These characteristics can vary based on factors such as breed, age at slaughter, management practices, and genetic factors. Different technologies that use physical, chemical, and biological treatments are now available to improve the bioavailability of nutrients in non-conventional feeds including wet processing, cleaning with water, regeneration with and/or without enzymes, dry processing using acidic agents, sodium chlorite treatment, autoclave sterilization, roasting, alkaline or acid treatment to increase food hygiene, fungal processing, and food fermentation. Mineral chelates, prebiotics, probiotics, and feed disinfectants have also been shown to play an important role in enhancing immune responses. Improving the bioavailability of nutrients is important because it can improve overall health and well-being, prevent nutritional deficiencies/diseases, and promote immunity for better health development. Nutrition in eggs standardization of nutrition in eggs and vaccination of eggs can improve post-hatch growth and immunity of chicks. Certain nutrients can modulate genes related to growth and immunity [123].

Table 7: Innovative approaches for "designer meat" in poultry production

Strategy	Benefits	Description	References
Selective Breeding	Guarantees constant improvement in focused characteristics for meat products.	Develop roosters with required meat characteristics through selective breeding techniques	[123]
Health-Driven Innovations	Addressing demands of customers with particular dietary needs for certain nutrients in the products or health concerns.	Develop meat with fitness or health benefits i.e. decreased allergens or improved vitamins or minerals or essential bioactive compounds for better health and/or treating health issues.	[125; 126; 127; 128; 129]
Feed Enrichment	Enhances the dietary value of eggs/meat by using nano-particles of minerals or other nutrient enrichment for appeals to health-aware consumers.	Incorporate specialized feed to beautify meat/egg characteristics, consisting of expanded omega-3,6 or 9 fatty acids or decreased fat content of meat.	[125; 126; 127; 128; 129; 130; 131; 132; 134]
Culinary Customization	Enhances client honor or morals and supplies to an area of interest markets	Offer customer-based meat cuts or arrangements principally based totally on client choices or purchasing trends.	[135; 136; 137]
Genetic Modification	Improving meat acceptance, and satisfaction and providing specific investor preferences.	Utilizing genetic engineering to beautify meat characteristics like tenderness, dietary addition., or flavor	[133; 138]
Sustainability Practices	Attracts eco-aware customers and meets regulatory standards	Emphasize sustainable, environmentally friendly, and moral farming practices to deliver meat with a lower environmental effect.	[125; 126; 127; 128; 129; 130; 131; 132; 134]
Innovative Packaging	Decreases waste and keeps the meat stays fresh, attractive to quality-demanding buyers.	Use packing technology that creates a bigger shelf life and preserves the freshness and quality of meat.	[125; 126; 127; 128; 129; 130; 131; 132; 134]
Traceability and Transparency	Builds customers' beliefs and guarantees product integrity.	Implement structures to confirm the supply and manufacturing strategies of meat products free from contaminations.	[125; 126; 127; 128; 129; 130; 131; 132; 134]
Post-Harvest Processing	Enhances the culinary process to extend shelf life.	Implement superior processing techniques to enhance meat quality, texture, and flavor.	[145; 146; 147; 148; 149]
Digital and Online Marketing	Increases market attaining complements emblem visibility.	Use virtual structures for focused advertising and marketing and patron engagement concerning revolutionary meat products.	Martinez et al. [10]

Conclusion: Designer eggs/meat are poultry products that are made to meet customer demands for improved taste, quality, desired nutritional contents, leaner or more nutritious products, health benefits, and ethical production methods. Enriched eggs/meat are developed through specialized genetic selection and breeding programs, feeding techniques, and innovative farming practices. Designer eggs/meat represents a good opportunity in growing customized premium poultry markets. Generally, designer eggs/meat are enhanced with certain nutrients i.e. Omega-3 fatty acids, vitamins, antioxidants, and selenium contents, etc. by changing the dietary inclusion of specific ingredients i.e. flaxseed, fish oil, and other nutrient-rich feed additives, etc. in the poultry diets. Enriched eggs/meat offer several health benefits i.e. enhanced brain function, improved cardiovascular health, and better nutrition, thus, attracting health-conscious consumers to pay high prices for enriched foods that support their dietary targets. There is also a growing preference for free-range, non-GMO, and organic products, which further support the production of designer meat and eggs of poultry. However, designer eggs/meat is more expensive and complex as it requires careful feeding management, farm housing/conditions, animal health, and the costs of special production methods. Moreover, educating customers about the benefits of designer products is challenging.

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