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Processing and utilization of desert poultry skin and its quality control: A review

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Abstract
Poultry production has been growing very fast rate to maintain the constant supply of its meat and eggs throughout the country. The poultry meat consumption increase very fast rate due to no religious taboos, low fat content in meat, increase per capita income and urban population. During the slaughtering of poultry, larger amount of byproducts are generated, in which some of edible and other inedible byproducts. Edible by-products are utilized for preparation of different types of products; however, inedible by-products utilization is very limited. Chicken sleeves considered as major waste, mostly through on the ground, which cause environmental hazards. Rendering is important technique for conversion of chicken skin to usable, stable and high quality chicken fat. Yield of rendered chicken fat are increase when rendering time temperature are increased. Physicochemical characteristic like acid value, free fatty acid value, thiobarbituric acid reactive substance value, p-anisidine value saponification value and iodine value of rendered chicken fat obtained by different type of rendering methods are fall below the standards specified by food safety standard authority of India. Chicken fat contain lower amount of saturated fatty acids as well as lower thrombogenic index, atherogenic index and higher hypocholesterolemic/hypercholesterolemic ration, which decrease the incidence of cardio vascular disease. Healthy diets are also containing lower quantity of saturated fatty acids, thrombogenic index, atherogenic index and higher hypocholesterolemic/hypercholesterolemic ration ratio. Rendered chicken fat were have low amount of moisture and other nutrient, which required for growth of microbes and also have very less quantity of microbes. So it can be utilized in daily routine healthy diet.

Keywords: Poultry skin, rendering, atherogenic index, thrombogenic index, rendered fat

Introduction

(Bonifer & Froning, 1996) [10] offers a lot more prominent potential for value added items. Underutilization of poultry skin brings about deficiency of possible incomes as well as results in the additional and expanding cost of removal as well as may make significant aesthetic and disastrous health conditions. So use of poultry sleeves for extraction of poultry skin fat with the assistance of rendering measure is the most ideal approach to lessen natural contamination (Ogbuewu *et al.* 2012) [64]. Rendering is an interaction by which waste material of animal origin changed over helpful material like rendered poultry fat and staying left out material, use for extraction of collagen and gelatin. Poultry meat items market have been becoming incredibly quick, because of lean meat attributes and its utilization isn't prohibited by any religion in India, which open the roads for fuse of poultry skin fat in various sort of meat items to expand their healthy benefit (Arnaud *et al*. 2004) [2]. Poultry fat can be utilized as cooking oil to build the flavor of dishes or as crude materials to fabricate chicken powder and biodiesel fuel (Chiu *et al*. 2008) [16].

Rendering of poultry skin

Rendering alludes any preparing, which used for the extraction of fat from animal waste material by the activity of warmth, which makes the fat cells burst and the liquefied fat run just as prompts animal material free from water and pathogenic microorganism like *Salmonella, Clostridium* (Woodgate and Van Der Veen, 2004) [85]. The point of rendering is finished extraction of fat from the greasy tissue parts from animal waste material. Extraction of fat from the animal burn through material relies upon the time, temperature, and pressing factor of rendering. Rendered chicken fat utilized in food industry is created by an alternate kinds of strategies, such as skimming the coasting fat off the outside of pots in which chicken parts are bubbled (Pereira *et al.* 1976) [69], dry or wet rendering in the scope of 100 to 140 °C

(Ockerman and Hansen, 1988) [63], and constant low-temperature rendering, in which fat is softened from chicken tissues at temperatures of 60 to 95 °C. In wet rendering, either bubbling water or steam is added to the material making fat ascent to the surface, at that point squeezed to eliminate a water-fat combination, which is then isolated into fat, water and fine solids by phases of centrifuging. In dry rendering, the crude material warmed into steam-jacketed vassal until a large portion of water has vanished. The fat is rendered by drying out the crude material (Zagklis *et al*. 2020) [88]. Quality of the rendered fat depends upon the handling and rendering condition (Baladincz and Hancsók, 2015) [5]. The solid material can be use production of either pet food or livestock feed, as well as used to improve the fertilizing efficiency of the soil (Woodgate and Van Der Veen, 2004) [85]. Microwave rendered chicken fat is acceptable quality and low in moisture substance and fatty acid profile of microwave rendered fat were like the unrefined fat acquired by Soxhlets extraction measure (Zhang *et al.* 2013) [90]. Microwave rendering created best return and lightest hued oven skin fats (Sheu and Chen, 2002) [76]. Solvent extraction extricates practically the entirety of the oils, simply 0.5 to 0.7% remaining oil leaving in the crude materials (Aryee and Simpson, 2009) [3]. To diminish solvent utilization and extraction time compressed solvent extraction procedure decision of technique (Dunford and Zhang, 2003) [24]. This strategy is utilized for the quantitative assurance of all out lipids and fatty acid composition in animal tissues (Schumann and Siekmann, 2000) [74], normally organic solvents in blends, for example, chloroform and methanol are utilized, in the (Bligh and Dyer, 1959) [9] and (Folch *et al.* 1957) [30] systems. Microwave extraction and supercritical liquid extraction measure are likewise utilized for extraction and evaluations of total lipids in the material for scientific reason.

Yield and recovery of fat from chicken skin

The yield and recovery of fat from poultry waste material are depending on the extraction conditions. The degrees of comminution, microwave power, extraction temperature, and time were expanded, yield of rendered fat increase. However, extraction temperature had lower effect on yield and fat recovery than extent of comminution.

Table 1: Effect of rendering procedure on fat yield and its recovery rate

Rendering procedure	Tissue material	Fat yield	Fat recovery rate (%)	References
Wet rendering	Breast skin	-	Lowest recovery 51.5% at 50 °C and highest recovery of fat 89.6% at 80 °C	Piette *et al*. 2001 [70]
	Breast skin	24.8% at 40 min	48.9% at 40 min	Sheu and Chen, 2002 [76]
	Broiler skin	23.3% at 40 min	44.9% at 40 min	Lin and Tan, 2017 [49]
	Abdominal leaf fat	72.9% around 105 °C for 30 min	-	Pereira *et al*. 1976
Conventional oven baking	Breast skin	31.6% at 40 min	62.3% at 40 min	Sheu and Chen, 2002 [76]
	Broiler skin	30.45 at 40 min 180 °C temperature	58.9% at 40 min	Lin and Tan, 2017 [49]
Deep fat frying	Breast skin	33.4% at 8 min	65.8% at 8 min	Sheu and Chen, 2002 [76]
Griddle rendering	Breast skin	25.8% at 10 min	50.9% at 10 min	Sheu and Chen, 2002 [76]
Dry rendering	Chicken waste	75.95% at 90 °C for 2 h, 0.5 bar pressure	-	Farmani *et al*. 2016 [26]
	Abdominal leaf fat	71.1% around 105 °C for 20 min	-	Pereira *et al*. 1976 [69]
	Chicken skin	Yield of fat 35.08, 30.97, 25.50% at 40, 50 and 60 °C temperature respectively for 120 min	Recovery of fat 84.74, 74.80, 61.59% at 40, 50 and 60 °C temperature respectively for 120 min	Sakunde *et al*. 2020 [72]
Microwave rendering	Breast skin	47.5% at 8 min	99.2% at 8 min	Sheu and Chen, 2002 [76]
	Broiler abdominal fatty tissue	70.55% at 2.75 W/g microwave power level for 10 min	96.5% at 2.75-3 W/g microwave power level for 10 min	Zhang *et al*. 2013 [90]
	Broiler akin	38.4% and 36.6% at 3.6 or 2.4 W/g high and low microwave power for 10 min respectively	74.2% and 70.1% at 3.6 or 2.4 W/g high and low microwave power for 10 min respectively	Lin and Tan, 2017 [49]

Physico-chemical characterization

The physico-substance properties of fat are fundamentally rely upon their composition and propositions properties are used in distinguishing proof and discovering their virtue. The actual qualities of palatable fats are controlled by its chain length, presence of unsaturation and their dissemination in the glycerol spine (Kowalska *et al*. 2020 [43]; Marangoni and Narine, 2002) [53]. Oxidation of fat is essentially cause by debasement of lipids and the primary response required fatty acids production is known as peroxidation. During the oxidation of fatty acid various kinds of primary and secondary item are framed and the substance idea of these mixtures fluctuates with sub-atomic weight and polarity (Dobarganes and Márquez-Ruiz, 2003) [22]. Quality of fat diminish, due formation of oxidation item during oxidation of oil, assume significant part in the development of sickness. (Kanazawa *et al*. 2002 [40]; Staprans *et al*. 1996) [79]. There are a few sort of physical and synthetic strategies are created to evaluate the degree of oxidative detritions (Giménez *et al*. 2011) [34]. Peroxide value estimations is the most normally utilized strategy, its estimates the concentration of hydroperoxides, through spectrophotometric in the UV district and some advance instrument additionally used to survey the oxidative detritions of fat like Gas chromatographic (GC) (Frankel, 1984) [31], Chemiluminescence (Baj *et al*. 2009) [4], Fluorescence (Barrett *et al*. 2011) [7], Infrared spectroscopy (Daoud *et al*. 2020) [20], HPLC (Barriuso *et al*. 2013) [8], LC-MS (Levison *et al*. 2013) [48] and Nuclear magnetic resonance

(Xia and Budge, 2017) [86]. In any case, these techniques require the utilization of intricate and costly instruments as well as exceptionally prepared experts. Now a day gas chromatography has been use for detail investigation of oxidation measure and to identify presence unstable oxidation compound in the fat and oil and has been utilized to contemplate the oxidation interaction in more detail, mostly focusing on volatile compounds (Snyder *et al*. 1988) [78].

Peroxide value

The peroxide value determines all substances, in terms of milli-equivalents of peroxide per kilogram of sample that oxidize potassium under the conditions of test (Kouba and Mourot, 2011) [42]. It's the method used to determine conjugated dienes and trienes through spectrophotometer and is one of the way for the detection of primary oxidation products (Damodaran *et al*. 2007) [19]. It has been mainly associated development of rancidity in fat, oil as well as lipids containing foods, leads to development of off-flavor compound in the products and act as good indicator for oxidation of oil and fat. Therefore, the quality and storage life of fat and oil negatively affects by presence of hydroperoxide (Dermis *et al*. 2012) [21]. It having numbers of limitation like time consuming, require large amounts of sample, generates waste (Dobarganes and Velasco, 2002; Ruíz and Lendl, 2001; Velasco *et al*. 2002) [23, 71, 81]. This method has a lower detection limit of 0.5 mEq peroxide/kg sample (Frankel, 2005) [32]. Chicken skin fat obtained by all rendering methods had peroxide value lower than 10 meq/kg, the limit allowed by the standards of Codex Alimentarius for edible fats and oils (Lin and Tan, 2017) [49]. The poultry skin collected and processed within 24 h of collection having lower peroxide value but peroxide value increases (˷3.5 meq/kg) as the processing time increases (Viau and Gandemer, 1991) [82]. Dry rendered fat have higher peroxide value than wet rendered fat (Pereira *et al*. 1976) [69]. Dry rendered fat have higher peroxide value due to higher rendering temperature and more oxygen incorporation during the rendering process. The peroxide value of griddle rendered fat was higher than other rendering methods; they also found that there was no significant difference between peroxide values of fats obtained from other methods (Sheu and Chen, 2002) [76]. When changing the time and temperature of rendering did not significantly affect the rate of lipid peroxide formation during 5°C storage (Gong *et al*. 2007) [35]. The higher the warming temperature or the more drawn out the warming time, higher peroxide value of rendered chicken fat (Cheng *et al*. 1993) [15]. As the microwave power expanded from 2.0 W/g to 2.75 W/g, simultaneously peroxide value decreased, because of decrease moisture content in rendered fat (Zhang *et al*. 2013) [90]. The extent of skin grinding or extraction temperature were not influenced the peroxide values of freshly rendered fat, but it's increased during storage at 22 °C (Piette *et al.* 2001) [70]. The peroxide value is below the one found by (Ferrari and Koller, 2001) [29], for chicken skin fat, which was 2.8 meq/kg. The peroxide value of rendered duck fat was 1.6, 4.5, 6.1 and 7.8 times higher compared with lard, olive oil, butter and tallow, respectively (Gong *et al*. 2007) [35].

Acid value

The acid value is described as the amount of milligrams of potassium hydroxide needed to neutralize the free fatty acid present in one gram of fat. It is an overall proportion of rancidity as free fatty acids are typically formed during decay of oil glycerides (Xie and Chai, 2016) [87]. An augmentation in the measure of FFA in an example of oil or fat demonstrates hydrolysis of fatty substances. Such response happens by the activity of lipase enzyme and it is and pointer of lacking preparing and capacity conditions i.e., high temperature and relative humidity, tissue harm. The wellspring of the enzyme can be the tissue from which the oil or fat was removed or it tends to be a foreign substance from different cells including microorganisms. Rendered fat doesn't having acid value in excess of 2 mg KOH/g (Lee *et al*. 2012) [47]. The higher acid value (1.01 mg KOH/g) in water cooking rendered fat than fats rendered by different techniques (0.90, 0.87, and 0.87 mg KOH/g for OB, LPMR and HPMR fats), individually, without huge contrast between treatments (Lin and Tan, 2017) [49]. Microwave rendered fat obtained from 2.00 W/g power had highest acid value (1.60) accompanied by the chicken fat got at 2.25 W/g and 2.50 W/g (Zhang *et al.* 2013) [90].

Free fatty acid value

Free fatty acid is expressed as percentage of free oleic acid of total sample weight. Among all physicochemical parameters, FFA content is considered as an extremely critical factor and connected with the quality as well as financial estimation of consumable oils (Mahesar *et al*. 2014) [52]. Generally FFAs are the hydrolysis item creating because of the oil and fat oxidation during long time stockpiling or preparing at raised temperature and warming or fricasseeing. All fat contains some free carboxylic acids, but these are removed by the refining process. The level of these free unsaturated fats is estimated constantly to check the refining proficiency. The fat is blended in with alcohol and the alcohol layer eliminated and titrated with sodium hydroxide with phenolphthalein as indicator. The measure of free fatty acid in fat means that the level of spoilage that has occurred. By and large the free fatty acid substance ought not to be over 2% in tallow. The amount of free fatty acid in fat is an indication of the degree of spoilage that has taken place. (Sharma *et al.* 2013) [75].

Thiobarbituric acid value

The Thiobarbituric acid value is characterized that the secondary oxidation products, results of oils and fats respond with 2-thiobarbituric acid buildup condensation products the absorbance of which is estimated at 530 nm, the frequency of one of their absorption maxima. TBA test depended on the response among TBA and MDA (malondialdehyde) and production of color products (Fasseas *et al*. 2008) [27]. The TBA value is communicated by mg malondialdehyde (MDA) per 1 kg chicken fat. TBA value of the rendered fat is depending on the rendering procedure use for extraction of fat. Microwave rendered fat had low TBA value than other rendering techniques (Lin and Tan, 2017 [49]; Sheu and Chen, 2002) [76]. Zhang *et al.* (2013) [90] revealed that as the microwave power increases TBA value of rendered fat decreases, most noteworthy TBA value (0.43) in chicken skin rendered fat at microwave power level of 2.00 W/g. however, chicken skin rendered at 2.75 W/g had the most minimal TBA. The TBA value, acid value and peroxide value of chicken fat are influenced by the level of oxidation. Oxidation of oils ads reduced the quality and the development of smelly flavors. When the TBA value arrived at 0.5–1.0 mg MDA/kg, off scents and flavors could be distinguished in most food (Chang *et al*,. 1961) [14]. Thus, the oxidation level of oil and fat is a significant quality measure for food industry (Muik *et al*. 2003) [60]. A few components which fundamentally influence the oxidation of food sources are water activity (a_w), temperature and oxygen content in interface. When a_w of food is lower than 0.1, the speed of oxidation is extremely high. What's more, during increment for 0.1 to 0.3, speed of oxidation diminished steadily (Kahl *et al*. 1992) [39]. The oxidative rancidity in chicken meat couldn't be recognized when the TBA value was <1.0 mg MDA/kg (Carvalho *et al*. 2019) [13]. But other hand, the rate of oxidation increased likewise increments with temperature (Mishra *et al*. 2012) [57].

Iodine value

It demonstrates the level of unsaturation i.e., the quantity of twofold bonds present in the length of the chain. The iodine value is low for animal fats and high for vegetable oils. The iodine value is a proportion of the overall level of unsaturation in oil parts, as controlled by the take-up of halogen. The higher the iodine value, the lower is the liquefying point. The iodine value (g iodine/100g) of lard-55-65; for tallow its 40-53 and for chicken skin fat it varies from 70-85 (Sharma *et al*. 2013) [75]. The iodine numbers of chicken fat samples were 74.5 and 76.4 and values were within the range of 63 to 80 for chicken fat (Brekke *et al*. 1975) [11]. The iodine numbers of chicken skin fat was two time higher than in the mammals (Feddern *et al.* 2010) [28], being close to the values of 78.5 and 76 g I_2/100 g found by (Luddy *et al*. 1954) [51] and (Chiu *et al*. 2008) [16] respectively, for chicken adipose tissue.

Moisture content in chicken skin fat

High quality fat is basically moisture free. Water in fat is unwanted as it acts a vehicle for the development of fat-parting microorganisms and the activity of fat parting catalysts. Pure poultry fat had moisture level around 0.25% (Nair and Warren, 1964) [61]. Fat obtained from different rendering procedure had different moisture content. Oven baked broiler skin fat had least moisture content (0.19%), while water cooked fat had most noteworthy moisture (1.43%) (Sheu and Chen, 2002) [76]. The higher moisture content in water cooked chicken skin fat because of deficient partition of fat and water (Lin and Tan, 2017) [49]. When the microwave power level expended from 2.00 W/g to 2.50W/g simultaneously moisture content in rendered chicken fat diminished from 2.33 to 1.50% and no moisture was recognized when force level expanded further to 2.75W/g or more (Zhang *et al*. 2013) [90]. Moisture content in the chicken fat tissue was dissipated, particularly when temperature go beyond 100 °C. The temperature of fat extraction uniquely expanded which cause no water buildup in separated fats except for higher temperature accelerate oxidation and in the end decays fat quality (Mishra *et al*. 2012) [57].

Color of rendered chicken skin fat

Color is quite possibly the main components influencing the shopper's choice when choosing or buying products like chicken skin fat. Color of rendered chicken fat varies from light yellow to deep yellow. However, numerous variables like hereditary elements, age of animals, and area in animal body and feeds (xanthophylls and carotenoids in feeds) property to the distinctions in color of skin and fat (Sirri *et al.* 2010) [77]. The L*, a*, and b* estimations of tests were most usually used to decide the color of various samples; these qualities communicated the lightness, redness, and yellowness respectively (Chumngoen and Tan, 2015) [17]. Microwave rendered fat was lighter color accompanied by water cooking, traditional oven preparing, and frying pan rendering (Sheu and Chen, 2002) [76]. However microwave rendered fat more yellow (Zhang *et al.* 2013) [90] and red in color than water cooked and oven baked fats (Lin and Tan, 2017) [49]. Zhang *et al.* 2013 [90] also found that chicken fat rendered at 2.0 W/g microwave power level was more yellow and lighter in color then other microwave power. Redness of rendered fat is not much affected by degree of crushing, extraction temperature while lightness and yellowness affected essentially yet with a little greatness of distinction. Color of fat is additionally affected by the Maillard response occurs during the rendering cycle. There are various factor influence the maillard response in food like moisture content, temperature, sugars, climatic oxygen, and kinds of amino acids (Martins *et al.* 2000) [55].

Fatty acid profile of poultry skin fat

Fatty acid composition of different poultry species fat mainly depends on the food ingested. Every poultry species fat contains common type of fatty acids, most of them having C16 to C18 (Karmakar *et al*. 2010) [41]. Most relevant saturated fatty acid present poultry fat are palmitic (C16:0) and stearic acid (18:0) and linoleic (C18:2), linolenic (C18:3) and arachidonic acid (C20:4) as unsaturated fatty acid (Nollet and Toldrá, 2011) [62]. The most predominant fatty acid present in poultry fat is oleic acid, followed by palmitic, palmitoleic and stearic acid (Méndez-Lagunas *et al*. 2015) [56]. Six different type of fatty acid: C14:0, C16:0, C16:1, C18.1ω9, C18.2ω6, C18.3ω3 were reported by (Feddern *et al.* 2010) [28] in rendered chicken skin fat.

Table 2: Typical fatty acid profile of poultry fat (As % of total fatty acids) (Peña-Saldarriaga, Fernández-López and Pérez-Alvarez, 2020 [68]; Zduńczyk *et al.* 2011) [89]

Fatty acid	Common name	Poultry fat
C14:0	Myristic acid	0.4
C16:0	Palmitic acid	21.6
C16:1	Palmitoleic acid	6.3
C18:0	Stearic acid	3.2
C18:1	Oleic acid	30.0
C18:2	Linoleic acid	28.4
C18:3	Linolenic acid	2.4
C20:4	Arachidonic acid	3.4
C22:5	Docosapantaenoic acid	0.3
C22:6	Docosahexaenoic acid	0.8
∑Saturated		29.1
∑MUFA		33.2
∑PUFA		37.6
∑ώ6		28.4
∑ώ3		2.4
Ration ώ6/ώ3		11.3

Due to presences of lower amount of saturated fatty acid (30-34%), poultry fat are in liquid or semi-liquid form at room temperature (Öner and Altun, 2009) [66]. Unsaturated fatty acids are that essential fatty acid that have important role in human health. Poultry fat contain higher amount of oleic acid that may help decrease the circulating level of low density lipoprotein (LDL) cholesterol in humans as well as having hypocholesterolemic action, because did not decrease the circulating level of high density lipoprotein (HDL) cholesterol (“good cholesterol”), reduce the risk of coronary heart disease by reducing blood cholesterol levels in non-hypertriglyceridemic individuals (Lopez-Huertas, 2010 [50]; Ospina-E *et al.* 2010 [67]; da Silva *et al.* 2010) [18] and is considered a “healthy” fat (Kwon and Choi, 2015) [44]. ώ3 and ώ6 fatty acids are those fatty essential fatty acid that are not synthesized by humans, but are necessary for different biological process, there for should be include in human diet (da Silva *et al*. 2010) [18]. Fatty acid profile of the various chicken tissue (skin adipose tissue, and flesh) showed no significant difference in fatty acid profile and found that oleic acid (˷43%) is most abundant fatty acid, followed by palmitic acid (27%) and linoleic acid (14%) (Sheu and Chen, 2002) [76]. Rendered duck fat had high amount of oleic acid (18:1) than tallow, butter and soya bean oil (Gong *et al.* 2007) [35]. Poultry fat contains lowest amount of C16:0 (9.4%) contrasted with beef (11.6%), sheep (20.8%) and porcine fat (54.8%), because of fatty acid distribution at sn-2 position in poultry fat (Mottram *et al*. 2001) [59] as well as poultry fat has high substance of C18:1 (40.5%), C18:2 (29.4%) and C18:3 (4.1%) in this in this equivalent position (sn-2) contrasted with other animal fats. According to poultry fat is more nutritious and physiological available than other animal fat because of its higher contain of unsaturated fatty acid (80%) and lower amount of saturated fatty acid (20%) in the sn-2 position of poultry fat TAG (Brockerhoff *et al.* 1966) [12].

Nutritional quality indexes of fat

To estimate the nutritional quality of dietary fat got from past investigation determined through calculation given by (Ulbricht and Southgate, 1991) [80] namely atherogenic index (AI) and thrombogenic index (TI) and ratio of hypocholesterolemic and hypercholesterolemic fatty acids (HH) (Santos-Silva *et al.* 2002) [73]. Atherogenic index is use to determine the atherogenic potential of different fatty acids. Now a day to determine the atherogenicity of food items, atherogenic index is good method. Equation for calculating the atherogenic index (AI) is:

$$AI = [C12:0 + (4 \times C14:0) + C16:0]/\Sigma UFA \quad (A)$$

The AI demonstrates the connection between the amount of SFAs and the amount of unsaturated fats (UFAs). Saturated fatty acids like C12:0, C14:0, and C16:0 are the atherogenic or hyperlipidimic fatty acids, except for C18:0 (Vitina *et al*. 2012) [84]. Other hand UFAs inhibits the atherogenic potential because they inhibits gathering of plaque and reduce the levels of phospholipids, cholesterol, and esterified fatty acids (González-Félix *et al*. 2016 [36]; Monteiro *et al*. 2018 [58]; Omri *et al*. 2019) [65]. Consequently, the utilization of food sources or items with a lower AI can lessen the degrees of absolute cholesterol and LDL-C in human blood plasma. Thrombogenic index was also use to describe the thrombogenic capability of different fatty acids. The calculation of thrombogenic index is proposed by Ulbritcht and Southgate. The thrombogenic index equation is:

$$TI = (C14:0 + C16:0 + C18:0)/[(0.5 \times \Sigma MUFA) + (0.5 \times \Sigma n - 6\ PUFA) + (3 \times \Sigma n - 3\ PUFA) + (n - 3 / n - 6)] \quad (B)$$

The TI is use to demonstrating the propensity to form clumps in veins and gives the contribution of various FAs, which indicates the connection between the favorable to thrombogenic FAs (C12:0, C14:0, and C16:0) and the counter thrombogenic omega- 6 and omega-3 fatty acids (Ulbricht and Southgate, 1991) [80]. In this way, the utilization of food sources or items with a lower TI is helpful for CVH. To determine the effect of different fatty acid on cholesterol, Santos-Silva proposed the HH index. The HH ratio determines the relation between hypocholesterolemic and hypercholesterolemic fatty acids. C12:0, C14:0, C16:0 are the hypercholesterolemic fatty acids. The equation is:

$$HH = (cis - C18:1 + \Sigma PUFA)/(C12:0 + C14:0 + C16:0) \quad (C)$$

The HH proportion may all the more precisely reflect the impact of the FA composition on CVD in compassion to PUFA/SFA ratio. A salutary diet is portrayed by low hypercholesterolemic, atherogenic and thrombogenic files (Laudadio and Tufarelli, 2011) [46]. Poultry meat with high unsaturated fat substance is best for consumers because of its low cholesterol (hypocholesterolemic profile), LDL/HDL and lower atherogenic file (Marangoni *et al.* 2015) [54].

Conclusion

An Indian poultry sector is very fast growing sectors in comparison to other sectors of the country because of continuously increase the demand of its meat and eggs which leads to large amount of byproducts are generated. Conversion of byproducts to utilizable material is good approach to reduce environmental hazards as well decrease the production cost of poultry. Rendering technique convert poultry waste to high quality, utilizable products. Rendered fat obtained from chicken skin having peroxide value, acid value, anisidine value and FFA value lower than acceptable limits, higher proportion of unsaturated fatty acids, lower value of AI, TI index, so it can be used to replace vegetable oil for health point of view.

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