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THE CHANGES IN THE AMINO AND FATTY ACID PROFILES IN THE SEMIFINISHED FOODSTUFFS BASED ON BROILER MEAT AND COMPONENTS OF CHICKEN EGGS AFTER DIFFERENT TYPES OF THERMAL TREATMENT

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Abstract

The changes in the amino and fatty acid profiles in the semifinished foodstuffs (SFFs) based on broiler meat and coagulated chicken egg melange after different types of thermal treatment (water or steam boiling, braising, baking, frying) were studied. The amino acid profiles were determined on Knauer analyzer; tryptophan by standard method. The biological value of the treated products was assessed using amino acid balance coefficients calculated by the method of N. N. Lipatov. It was found that the changes in the initial amino acid profiles of the SFFs were the least after water and steam boiling; braising and baking were found to increase the contents of the essential amino acids. The amino acid profiles in the treated SFFs were close to the reference values. The best criteria of their biological value (coefficient of rationality of amino acid composition, comparable redundance) were found after water and steam boiling. It was found that all types of thermal treatments insignificantly affected the parameters of fatty acid balance within the SFFs; the changes found were primarily related to slight increase in total content of saturated fatty acids and increase in total content of polyunsaturated fatty acids (PUFAs) in compare to initial profiles, by 2.64–3.88% depending on the treatment type. The changes in ω-6/ω-3 PUFAs ratios were more substantial especially after braising.

Introduction

The development and reinforcement of the health status in human of different ages cannot be achieved without consumption of the foodstuffs with high content of essential nutrients (well-balanced protein and fat, etc.). The increasing demand for these foodstuffs is a constant trend of the food market worldwide.

The everyday consumption of poultry meat can provide consumers with vitally important essential amino acids (tryptophan, lysine, and methionine) in the most beneficial ratio 1:3:3 [1,2]; these amino acids take part in the biosynthesis of different tissue proteins and also play certain special functions in human. However, the protein of broiler meat is known to be valine-deficient and hence the foodstuffs fully balanced for all essential amino acids should be additionally corrected for the valine content since the deficit (or absence) of this amino acid can result in the severe dysfunctions of the central nervous system and myasthenia [3].

Another important aspect of healthy nutrition is the balance in the fatty acid profile of the dietary lipids since saturated (SFA), monounsaturated (MUFA), and polyunsaturated (PUFA) fatty acids are the main structural and functional components of cell membranes. The special attention should be paid to the essential PUFAs which cannot be synthesized by animals and human and should be provided via feed or food, primarily linolic (LA, C18:2, ω-6) and α-linoleic (ALA, C18:3, ω-3) acids. These PUFAs are the precursors of a wide range of different eicosanoids, hormone-like substances protecting and maintaining structural and functional integrity of cells and cell components [4,5,6]. The ω-3 and ω-6 PUFAs are the necessary dietary nutrients for all vertebrates since their presence and ratio influence the status of lipid metabolism, susceptibility to the cardiovascular diseases, disturbances in neural and ophthalmic functions, allergic diseases, inflammations [5,7,8,9,10]. On the gene level these PUFAs control gene expression in different organs [8,9] and tissues [11,12,13]. The substantial part (ca. 50–70%) of dietary PUFAs is catabolyzed to meet energy requirements in human [14,15]. Only minor part of the dietary essential PUFAs undergoes the biotransformation to eicosahexaenic and docosahexaenic acids [4,16], main fatty acids in the retinal membranes and the precursors of local cell-regulating hormones affecting the inflammation, bloodstream regulation, prepartum fetal loss, etc. [17].

Poultry meat contains large amounts of the PUFAs; however, the ω-6 acids are predominant and the ω-6/ω-3 PUFAs ratio is relatively large (12:1 in lipids of broiler meat and 25:1 in turkey) in compare to the recommended level (no more than 1:10).

With all aforementioned taken into account, the development of new technologies or modification of the existing

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foodstuffs involving the additional supplementation with ingredients with high biological and nutritive value is as urgent task for modern food industry.

The enrichment of foodstuffs with protein and fat ingredients usually involves the supplementation with collagen-rich animal meat products [18] and butter or vegetable (mostly sunflower) oils, respectively. All these ingredients are rich in ω-6 PUFAs and the resulting dietary ω-6/ω-3 PUFAs ratio is far from optimal. The use of the ingredients based on poultry eggs and their components can be the valuable alternative since these ingredients could be the source of high-quality protein containing almost all essential amino acids [19]. The content of valine and some other essential amino acids in chicken eggs is higher in compare to protein of broiler meat.

Egg lipids contain simple fats, phospholipids (including lecithin, cephalin, sphingomyelin), cerebrosides, sterides, sterines (cholesterol). Choline presents up to 75% of egg phospholipids; concentration of lecithin is 6-fold higher in compare to cholesterol promoting the better bioavailability of egg lipids. However, the most value ingredients within the eggs are essential PUFAs deficient in other standard foodstuffs in human diets.

Eggs also have certain important technological properties like foam and gel production, emulsifying ability, ability to make a product "airy". The most important technological factor is the gel producing ability of the albumen [20].

The coagulation of egg components is a prospective technology of maximal preservation of the useful properties of the eggs. The studies on the changes in the latter induced by different factors resulted in the development of protein-rich food ingredients based on the coagulated egg components (melange, albumen, yolk) with grainy texture [21]. The use of these ingredients as the additives to meat can increase the contents of full-value protein and fat in standard and functional food commodities to enhance their biological value.

The use of chopped meat-based semifinished foodstuffs (SFFs) in human diets requires the knowledge on the changes in nutritional and biological value which occur in the SFFs during the last stage of cooking, different types of thermal treatment. These types are known to differently affect the composition of the SFFs [21,22]. However, there is a lack of available data on the changes in the biological value of the SFFs after the thermal treatment; this knowledge is necessary for the formulation of diets for different categories and ages of consumers, receipts of special and functional nutrition. There is also a lack of information regarding the effects of thermal treatments on the combined SFFs containing poultry meat and egg-based ingredients.

The aim of the study presented was the investigation of the effects of different types of thermal treatment (cooking) on the parameters of biological value of the combined SFF containing broiler meat and coagulated chicken egg melange (CCEM).

Materials and methods

The SFF in this study was the cutlet-like semifinished product contained chopped broiler meat (55%), CCEM (20%), milk powder (12%), wheat bread (9%), dried onion (3%), salt (0.8%), and spices.

The CCEM was preliminary produced via the heating of acidified melange of chicken eggs until the formation of a clot with the texture similar to grainy curd [23]. The yield of CCEM was 82.7% of initial melange; CCEM produced contained 14.3% of protein and 12.1% of fat.

The types of the thermal treatment used for the cooking of the SFF included water boiling (water/SFF ratio 0.5:1.0), steam boiling, traditional techniques of braising, baking, and frying; the amino and fatty acid profiles of cooked SFF were compared to the respective parameters before the treatments.

The amino acid profiles were determined on Knauer analyzer; tryptophan by standard method according to Russian standard GOST 34132. The biological value of the protein within the treated products was assessed using amino acid balance coefficients calculated by the method of N. N. Lipatov [24]. The following criteria were used: amino acid score (AS); coefficient of rationality of amino acid composition (Rc); "comparable redundance" of essential fatty acids (σ), utilitarian coefficient (αj).

Fatty acid profiles were determined via capillary gas-liquid chromatography. The total amounts of SFAs, MUFAs, and PUFAs were determined; their ratios and ω-6/ω-3 PUFAs ratios were calculated.

The percentages of moisture, protein, and fat in the products were determined according to GOST 31470.

The temperature of the thermal treatments was controlled by the thermometer with the scale from –50 to +300 °C and maximum relative measurement error ±0.5 °C.

Results and discussion

The preliminary comparative investigation of the amino and fatty acid profiles in the intact SFF with CCEM in compare to the SFF without CCEM supplementation has revealed the significant increases in the contents of essential amino acids: methionine by 35%, valine and isoleucine by 22–23%, threonine, leucine, phenylalanine, and lysine by 14–15% while the content of tryptophan in the CCEM-supplemented SFF has been slightly lower; the ratio of essential ω-6/ω-3 PUFAs has been better in the CCEM-supplemented SFF. The conclusion has been made that the balance of the amino and fatty acids has been better in the supplemented product. The σ criterion has been lower in the CCEM-supplemented SFF while the Rc criterion has been higher; these findings have evidenced the better biological value of this product.

The comparative investigation of the amino and fatty acid profiles in the CCEM-supplemented SFF after different types of thermal treatment (cooking) in compare to the intact one revealed that all treatments affected the contents of moisture, fat, and protein (Table 1).

Table 1. The changes in basic nutritive parameters in the SFF depending on cooking (thermal treatment) type

Treatment type	Content, %		
	Moisture	Fat	Protein
Raw (untreated)	70.9	6.7	14.3
Water boiled	70.9	6.3	14.5
Steam boiled	69.4	6.5	15.3
Braised	69.6	6.4	15.3
Baked	62.7	10.0	18.1
Fried	65.2	10.3	16.1

The moisture content underwent little changes during the thermal treatments. Moisture loss after braising, steam boiling, and frying was 1.3; 1.5 and 5.7%, respectively; the highest moisture loss was found for baking (8.2%).

The thermal treatments resulted in the increases in protein content within the cooked SFF: baking by 3.8%, frying by 1.8%, braising and stream boiling by 1.0%, water boiling by 0.2%.

The changes in fat content in cooked SFF were different: braising, water and stream boiling resulted in the slight decreases in fat content while baking and frying increased this parameter by 3.0 and 3.3%, respectively.

The study of amino acid profiles of the proteins of intact and cooked SFF revealed the trend to higher contents of essential amino acids after all types of cooking (Figure 1).

The limiting amino acid in raw SFF was lysine with AS criterion 0.68 units. Different types of thermal treatment resulted in different changes in the amino acid profiles of protein within the SFF. The least affected amino acid profiles (in compare to the raw SFF) were found for water and steam boiling. Braising and baking resulted in higher contents of essential amino acids; AS for essential amino acids in these cases were close to the reference levels (close to 1.0) with the exception of tryptophan (AS1.82). No limiting amino acids were found in baked SFF though AS for certain essential amino acids (leucine, lysine, threonine, tryptophan, phenylalanine, and tyrosine) were substantially higher than 1.0 (Table 2). The utilitarian coefficients αj (the content of essential amino acids in relation to the respective physiologic requirements of consumer) in the cooked SFF were close to the intact one.

The calculated criteria of biological value (coefficient of rationality of amino acid composition Rc and "comparable

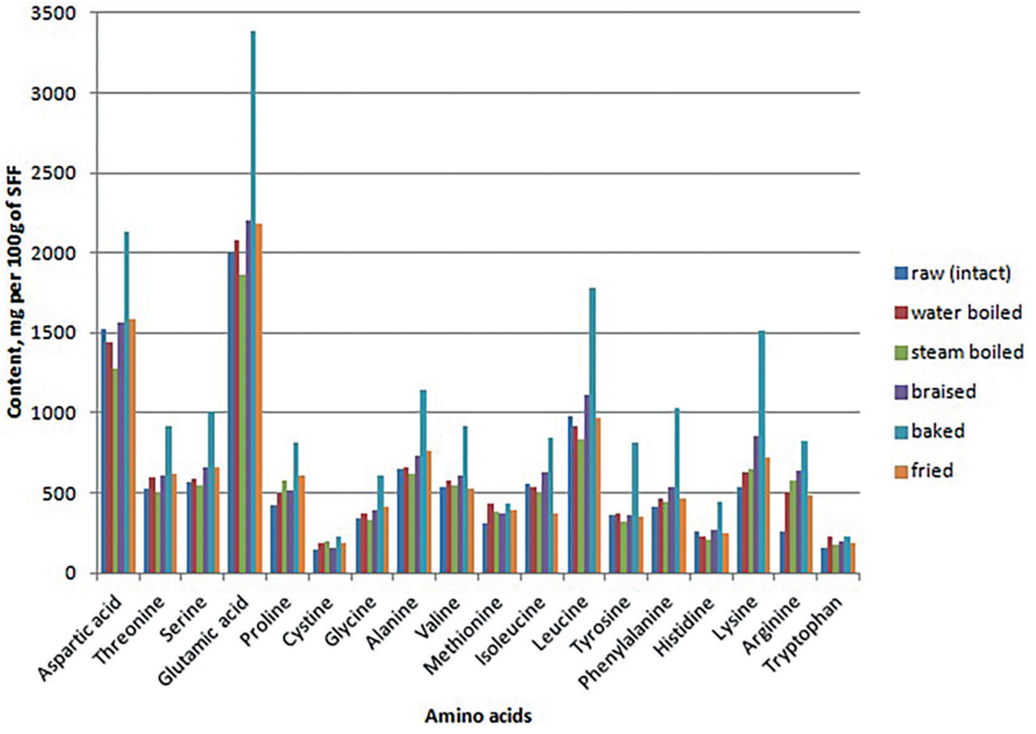

Figure 1. Amino acid profiles of the SFF depending on the type of the thermal treatment

Table 2. The essential amino acid scores (AS) and utilitarian coefficients (αj) in raw and cooked SFF

Amino acids	Raw		Water boiled		Steam boiled		Braised		Baked		Fried	
	AS	αj	AS	αj	AS	αj	AS	αj	AS	αj	AS	αj
Valine	0.76	0.89	0.79	1.00	0.72	1.00	0.80	1.00	1.02	1.00	0.65	0.89
Isoleucine	0.98	0.69	0.92	0.86	0.83	0.87	1.03	0.78	1.17	0.87	0.58	1.00
Leucine	0.98	0.69	0.91	0.87	0.78	0.92	1.04	0.77	1.41	0.72	0.86	0.67
Lysine	0.68	1.00	0.79	1.00	0.78	0.92	1.02	0.78	1.52	0.67	0.82	0.71
Methionine+cystine	0.91	0.75	1.23	0.64	1.08	0.67	0.98	0.82	1.03	0.99	1.42	0.41
Threonine	0.92	0.74	1.03	0.77	0.83	0.84	1.00	0.80	1.26	0.81	0.96	0.60
Tryptophan	1.11	0.61	1.54	0.51	1.19	0.61	1.82	0.44	1.29	0.79	1.15	0.50
Phenylalnine+tyrosine	0.90	0.76	0.96	0.82	0.83	0.87	0.98	0.82	1.70	0.60	0.85	0.68

redundance" of essential fatty acids σ) showed that water and steam boiling resulted in the best parameters of biological value of protein within the FFS (Table 3).

Table 3. The criteria of biological value of raw and cooked SFF

Treatment type	Coefficient of rationality of amino acid composition Rc	"Comparable redundance" of essential fatty acids σ	Biological value
Raw (untreated)	0.77	10.61	77.5
Water boiled	0.83	7.12	76.9
Steam boiled	0.86	5.57	84.0
Braised	0.80	9.04	71.6
Baked	0.76	11.17	70.7
Fried	0.67	17.79	66.9

The study of the individual fatty acid profiles in the cooked CCEM-supplemented SFF (Table 4) and total contents of SFAs, MUFAs, and PUFAs (Table 5) revealed that water boiling, steam boiling, braising, and baking slightly increase the total SFA content (by 1.37; 1.89; 4.32 and 2.29%, respectively); the most substantial changes were found after braising. The total contents of MUFAs with these treatment types were similar to the level of the raw product.

Table 4. Fatty acid (FA) profiles in raw and cooked SFF

FA	FA type	Content, % of total FA					
		Raw	Water boiled	Steam boiled	Braised	Baked	Fried
Butyric	C4:0	0.13	0.10	0.09	0.13	0.09	0.12
Capronic	C6:0	0.09	0.07	0.07	0.08	0.07	0.08
Caprylic	C8:0	0.06	0.05	0.05	0.06	0.05	0.06
Caprinic	C10:0	0.14	0.13	0.14	0.15	0.14	0.12
Lauric	C12:0	0.17	0.18	0.18	0.18	0.17	0.14
Tridecanoic	C13:0	0.03	0.03	0.03	0.13	0.03	0.05
Myristinic	C14:0	0.89	0.93	0.97	1.02	0.94	0.75
Myristoleic	C14:1	0.14	0.14	0.13	0.07	0.14	0.10
Pentadecanoic	C15:0	0.17	0.17	0.20	0.47	0.18	0.22
Palmitic	C16:0	22.43	23.53	24.20	25.49	24.12	19.42
Palmitoleic	C16:1	3.93	3.93	3.94	3.77	3.85	3.11
Margaric	C17:0	0.14	0.14	0.15	—	0.15	0.11
Margaroleic	C17:1	0.05	0.05	0.06	—	0.07	0.05
Stearic	C18:0	6.50	6.79	6.96	7.67	7.11	6.07
Oleic	C18:1	35.33	36.31	36.71	36.31	35.52	32.95
Elaidinic	C18:1(t9)	1.62	1.64	1.66	1.57	1.63	1.39
Linolic	C18:2(n6)	25.76	24.24	23.06	22.28	23.32	33.72
γ-linoleic	C18:3(n6)	0.18	0.13	0.13	—	0.12	0.15
α-linoleic	C18:3(n3)	0.42	0.35	0.32	0.28	0.33	0.33
Arachidonic	C20:0	0.08	0.08	0.09	—	0.09	0.11
Gondoinic	C20:1	0.34	0.38	0.38	—	0.38	0.35
Eicosatrienoic	C20:3	0.43	0.41	0.31	0.34	0.33	0.30
Geneicosaenoic	C21:0	0.22	0.23	0.20	—	0.20	0.14
Begenic	C22:0	—	—	—	—	—	0.18
Docosenoic	C22:1	0.72	—	—	—	—	—

Table 5. The contents of total SFAs, MUFAs, and PUFAs in raw and cooked SFF, % of total FA

Total	Cooking type					
	Raw	Water boiled	Steam boiled	Braised	Baked	Fried
SFAs	31.05	32.42	33.34	35.37	33.34	27.56
MUFAs	42.16	42.45	42.83	41.72	41.59	37.94
PUFAs	26.79	25.13	23.83	22.90	24.10	34.49

The slight changes in the fatty acid profiles in cooked SFF were primarily related to the decreases in the PUFAs contents; in water-boiled, steam-boiled, braised and baked SFF this decrease was 2.64; 2.96; 3.88 and 2.68%, respectively. The ω-6/ω-3 PUFAs ratios were affected more substantially especially in the case of braising; the least change in this ratio was found in water-boiled SFF. Generally, all types of cooking (thermal treatments) had little influence on the fatty acid balance.

Conclusion

The amino and fatty acid profiles in the SFF supplemented with coagulated chicken egg melange after different types of cooking (thermal treatments) were studied.

Different types of cooking differently affected the contents of protein, fat, amino and fatty acids within the product.

The least changes in the parameters of biological and nutritive value of the SFF was found with water- and steam-boiling. Braising and baking were found to increase the contents of essential amino acids; the resulting contents of the latter were close to the respective reference levels (AS close to 1.0) with the exception of tryptophan (AS1.82). No limiting amino acids were found in baked SFF though AS for certain essential amino acids (leucine, lysine, threonine, tryptophan, phenylalanine, and tyrosine) were substantially higher than 1.0 (i. e. higher in compare to the reference levels).

The highest biological value (as revealed by the coefficient of rationality of amino acid composition Rc and "comparable redundance" of essential fatty acids σ) had steam-boiled SFF; overall index of biological value for this treatment was the highest (84.0) in compare to the raw SFF (77.5).

The effects of different types of thermal treatment on the fatty acid profiles of SSF were insignificant. The slight changes in the fatty acid profiles in cooked SFF were primarily related to the increases in the SFAs and decreases in the PUFAs contents; in water-boiled, steam-boiled, braised and baked SFF this decrease was 2.64; 2.96; 3.88 and 2.68%, respectively. The ω-6/ω-3 PUFAs ratios were affected more substantially especially in the case of braising.

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