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EVALUATION OF MEAT SEMI-FINISHED PRODUCTS ENRICHED WITH LENTIL FLOUR

Abstract: *Nowadays, global urbanization and limitations in the nourishment have influence for unbalanced diet and chronic diseases. Deep processing of the secondary meat raw materials by fortification of essential compounds and inorganic elements allows for the development of new technologies of functional food products with a reduced cost value. The work purpose was a study of new chopped semi-finished products (cutlets) fortified by lentil flour in amount from 10% until 50% of total weight. For the reaching of it, following tasks were discussed: creation of technology, sensory assessment, analysis of organoleptic and physicochemical characteristics, and identifying of the macro- and microelements contents by using the scanning electron microscope and inductively coupled plasma mass spectrometer. Next meat byproducts: tongue, kidneys, heart, tripe of beef carcasses were used as secondary raw materials. Also, a domestic plant crop Lentil (Lens culinaris) was added. According to the organoleptic and sensory indicators, as the best sample containing 70% of meat secondary raw materials and 30% of lentil flour was selected. Also, it was discovered that addition of lentil flour to the recipe improves the nutritional value of cutlets by increasing content of proteins, carbohydrates, and minerals. The presence of macro- and microelements content was identified by the Mass-spectrometry method and using the Scanning Electron Microscope. It was found that protein content ranged from 17.95±1.15 to 20.93±1.25 g/100 g compared to control sample of 17.07±0.72 g/100 g. The carbohydrate content was 3.64±0.33 to 7.91±0.72 g/100 g compared to control sample of 3.09±0.30g/100 g. The studied samples have mineral components such as sodium (16.68-23.45 %), magnesium (0.89-2.15%), phosphorus (5.09-9.48%), potassium (8.14-13.50%), and calcium (0.75-2.25%). The developed semi-finished meat product fortified by lentil flour can be offered as a functional food product enriched by proteins, minerals, and vitamins.*

Key words: *Cutlets, Fortification, Functional food, Lentil, Meat, Byproduct.*

Introduction. Meat and meat by-products remain a key source of complete, easily digestible protein, iron, essential amino acids and micronutrients in the human diet [1]. However, the growing global demand for affordable meat products, together with the need to improve their nutritional value, has intensified interest in fortifying meat formulations with functional plant-based ingredients [2, 3, 4]. Beef by-products (tongue, kidneys, heart, tripe) represent an underutilized but valuable raw material. They are rich in proteins, lipids, biologically active peptides and micronutrients. Their rational use has both nutritional and economic-ecological significance for the meat processing sector, since increased utilization reduces raw material loss and processing waste [5, 6, 7].

Chopped semi-finished products (cutlets) based on beef by-products are a promising format for introducing plant-based functional additives, as their minced structure allows for even distribution of a fortifying component and modification of the finished product's texture and stability [8, 9]. Among domestic legume crops suitable for this purpose, lentil (Lens culinaris) is of particular interest. Lentil flour is characterized by a high protein content (up 36%, including a full essential amino acid complex) and a substantial proportion of starch and dietary fiber, combined with a low fat content [10,11]. In minced meat systems, these components are technologically significant. Lentil protein and starch contribute to water- and fat-binding capacity, improving cutlet juiciness and structural stability during heat treatment, while dietary fiber affects moisture retention and yield. This combination makes lentil flour a suitable functional additive for partial substitution of meat raw material in chopped semi-finished products, potentially compensating for the lower protein and higher connective-tissue content typical of by-product-based mince.

Lentil flour was chosen because of its technological suitability for processing offal-based minced meat, which is characterised by a high moisture content and reduced ability to form a structure

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compared with muscle meat. Lentil flour possesses solubility, gelling, emulsifying, and foaming properties, which have made it a promising ingredient for enriching meat, dairy, and bakery products [12]. Compared with proteins from other pulses, lentil protein exhibits gelling and emulsifying properties comparable to those of pea and soya proteins, as well as superior foaming ability, which contributes to its use in formulations for emulsion-type meat products [13].

The study aimed to develop formulations of chopped semi-finished products from beef by-products with the addition of lentil flour and to evaluate their organoleptic, physicochemical, and mineral characteristics.

2. Materials and methods

Chopped semi-finished products preparation. The technology for producing chopped semi-finished products was developed based on Patent № 37642, 'Method for the production of minced semi-finished products'[14].

The main ingredients used in the production of minced semi-finished products were beef offal (tongue, kidneys, heart, and tripe), lentils, fresh onions, breadcrumbs and spices, sourced from local suppliers in Shymkent, Kazakhstan. Table salt was sourced, and liquid egg melange was used in accordance with the requirements of GOST 30363-2013.

The lentils were purchased at a local market in Shymkent, Kazakhstan. Lentil flour was produced in the laboratory by grinding the seeds to a powdery consistency with a particle size of no more than 250 μm. Before being added to the recipe, the lentil flour was pre-hydrated in a flour:water ratio of 1:3.

Beef offal was thoroughly washed, soaked in salted water for 12 hours, and then partially frozen at a temperature of −16 to −18 °C for 1.5-2 hours before mincing. The frozen raw materials were initially minced using a mincer with a grid aperture diameter of 2-3 mm, followed by further fine mincing to a particle size of 300-500 μm. Onions were peeled, washed and minced using a mincer with a screen aperture diameter of 2-3 mm. The minced offal, hydrated lentil flour, chopped onion, egg mixture (1.6-1.8%), salt (1.0-1.2%), spices, and breadcrumbs (7.0-7.5%) were mixed in a mincer for 3-5 minutes until a homogeneous mass was obtained. Flat oval patties weighing 50 ± 5 g and 1.5-2 cm thick were formed by hand from the resulting mixture. Before packaging, the semi-finished products were coated in breadcrumbs and frozen at a temperature of −16 to −18°C.

Six recipes were prepared to assess the optimal level of substitution of meat offal with lentil flour. The ratio of beef offal to hydrated lentil flour varied, whilst the quantities of onion, egg mixture, salt, spices, and breadcrumbs remained constant across all recipes. The experimental design was as follows:

Sample 1 (Control) – cutlets without additives, containing 100% beef by-products.
Sample 2 – 90:10, cutlets containing 90% beef by-products and 10% lentil flour.
Sample 3 – 80:20, cutlets containing 80% beef by-products and 20% lentil flour.
Sample 4 – 70:30, cutlets containing 70% beef by-products and 30% lentil flour.
Sample 5 – 60:40, cutlets containing 60% beef by-products and 40% lentil flour.
Sample 6 – 50:50, cutlets containing 50% beef by-products and 50% lentil flour.

Sensory assessment. Sensory assessment of chopped semi-finished products with additive of Lentil was a process used to evaluate and measure the sensory characteristics. It involves engaging the human senses, such as taste, smell, sight, touch, and sometimes hearing, to gather subjective data about the perceived attributes of a particular item. One of the methods of determining sensory assessment is a point test. Participants rate the products on a scale ranging from like extremely to dislike extremely, indicating their preference or acceptance of the sensory attributes. Appearance, color, smell, and taste were evaluated using a five-point scale (Alibekov et al., 2021). This universal system of assessment uses these four categories to determine the overall quality of the product. Each rating corresponds to a whole number from 1 to 5, where 5 represents the highest quality (80-100%) and 1 represents very low quality or unacceptability (0-20%).The color of the diced semi-finished products was assessed to ensure the absence of undesired shades and to match the color of a reference sample. When evaluating taste and smell, significant emphasis was placed on the cleanliness of the scent, the absence of any foreign tastes or odors, and the distinctness of the flavor. The consistency was determined by filling the samples into a test glass.

Organoleptic characteristics. Organoleptic quality assessment was carried out on a five-point scale. The tasting was conducted by a tasting commission that included teaching staff and students of the training and research laboratory. The organoleptic evaluation was carried out by taster

specialists, a total of 11 people with experience in assessing the quality of meat products, as part of the tasting commission. Organoleptic characteristics consist of the following parameters: appearance, color, taste, and smell, which, in accordance with GOST 32951-2014 were analyzed. The appearance, color, and condition of the surface of chopped semi – finished (cutlets) with the addition of Lentil flour are determined visually by external inspection; smell – on the surface of the product. If it is necessary to determine the odor in the depth of the product, take a special wooden or metal needle, insert it into the thickness, then quickly extract and determine the odor remaining on the surface of the needle; consistency - by pressing with a spatula or fingers.

Physicochemical characteristics. Physicochemical parameters of chopped semi – finished (cutlets) – proteins, fats, carbohydrates, moisture, ash, were identified in accordance with the GOST 32951-2014 – Semi-prepared meat and meat-containing product.(General technical conditions).

The mass fraction of protein was determined using the Kjeldahl method in accordance with GOST 25011-81 ‘Meat and meat products'. Methods for the determination of protein.

The mass fraction of fat was determined using the Soxhlet method in accordance with GOST 23042-2015 ‘Meat and meat products'. Methods for the determination of fat.

The moisture content was determined by drying in an oven at a temperature of (103±2)°C in accordance with GOST 9793-2016 ‘Meat and meat products'. Methods for the determination of moisture.

The mass fraction of total ash was determined in accordance with GOST 31727-2012 ‘Meat and meat products'. Method for determining the mass fraction of total ash.

The carbohydrate content was calculated ‘by difference’ as the remainder of 100 per cent after subtracting the mass fractions of protein, fat, moisture and ash, determined by the methods specified above:

Carbohydrates (%) = 100 − (protein % + fat % + moisture % + ash %).

Statistical data were treated using Microsoft Excel. All experiments were repeated three times. Data are presented as an average value ± a standard deviation of the value.

Mineral contents of minced semi-finished products (cutlets) enriched with lentil flour were determined using inductively coupled plasma mass spectrometry (ICP-MS), whilst scanning electron microscopy (SEM) was used to assess the microstructure of the samples and visualise the distribution of mineral-containing particles.

Sample preparation for mineral analysis was carried out in accordance with GOST 26929-94. The samples were pre-dried, mineralised (oxidised), and prepared for instrumental analysis. The quantitative determination of macro- and trace elements was carried out using ICP-MS, which allows for the sensitive and accurate determination of trace elements in foodstuffs (Thompson and Walsh, 1988).

Results and discussion. The study revealed that the quantitative content of the additive has a significant impact on the organoleptic characteristics of the food product and on the sensory assessment of its quality.

Based on Figure 1, cutlets from offal containing 30% addition of lentil flour have the best results in points. The sample containing 40 and 50% lentil flour stood out with a pronounced smell and an unpresentable appearance that can negatively affect the consumer properties of the finished product.

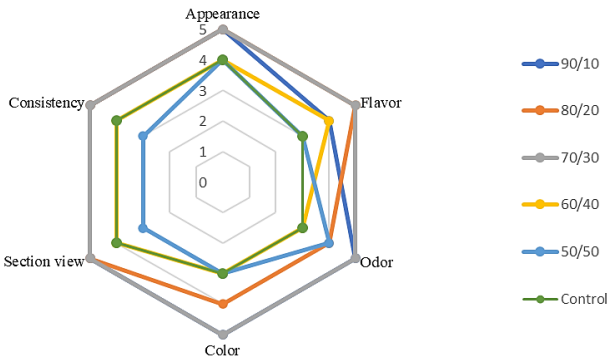


Figure 1 – Sensory assessment of meat chopped semi – finished product – cutlet fortified by Lentil

Table 1 showed the organoleptic parameters of the samples obtained, which were compared with GOST 32951-2014 Meat and meat-containing semi-finished products. General technical conditions. Appearance, odor, color, section view, and consistency of the chopped semi-finished product (cutlets) with lentil addition completely satisfy the required standards.

Table 1 – Organoleptic characteristics of chopped semi - finished (cutlets) products

The name of the indicator	Control Sample without additives	Sample with Lentil	GOST 32951-2014
Appearance (shape, surface condition):	Crushed homogeneous mass without bones, cartilage, evenly mixed, rounded shape		The crushed homogeneous mass was thoroughly blended, ensuring the absence of bones, cartilage, tendons, coarse connective tissue, blood clots, and films, achieving a uniform mixture.
Odor	The smell is pleasant, characterized of this type of product, odorless		characterized of this name of the semi-finished product, considering the prescription components used, including spices, sauces, marinades, and breading provided by the recipe
Color	Characterized of this semi-finished product		characterized by the color of the raw materials used: lump meat, poultry offal, and other prescription components
Section view	Mix the minced meat well, the mass is homogeneous	Minced meat is well mixed, mass is homogeneous, with the addition of lentil flour	Crushed, homogeneous mass
Consistency	Dense, gentle	Dense, gentle	Dense, gentle

Physicochemical characteristics According to the developed model recipes, the content of the main nutrients was investigated. The study results are shown in Table 2.

Table 2 – Physicochemical characteristics of chopped semi - finished (cutlets)

Name of indicators g/100g	Control, without any additives	Sample %, 90:10	Sample %, 80:20	Sample %, 70:30	Sample %, 60:40	Sample %, 50:50
Proteins	17.07±0.72	17.95±1.15	18.16±0.85	18.93±1.13	19.78±1.23	20.93±1.25
Fats	15.9±0.78	15.4±0.86	14.86±0.87	14.7±0.83	13.8±0.870	13.8±0.70
Carbohydrates	3.09±0.30	3.64±0.33	5.40±0.31	5.81±0.45	7.77±0.39	7.91±0.72
Moisture	61.04±3.05	60.11±2.35	59.78±2.99	58.46±2.92	56.55±2.85	55.36±2.44
Ash	2.9±0.14	2.9±0.14	1.,8±0.09	2.1±0.10	2.1±0.12	2.0±0.11

According to the results presented in Table 2, the physicochemical composition of the cutlets changed with increasing proportions of the additive. The protein content gradually increased from 17.07±0.72 g/100 g in the control sample to 20.93±1.25 g/100 g in the 50:50 sample. At the same time, the fat content decreased slightly from 15.9±0.78 to 13.8±0.70 g/100 g.

The carbohydrate content ranged from 3.09±0.30 g/100 g in the control sample to 7.91±0.72 g/100 g in the 50:50 sample. The moisture content gradually decreased from 61.04 ± 3.05 to 55.36 ± 2.44 g/100 g as the proportion of additives increased. The ash content varied within relatively narrow limits – 1.8-2.9 g/100 g.

Intermediate values were observed for the 60:40 and 70:30 samples, with protein contents of 19.78±1.23 and 18.93±1.13 g/100 g, fat contents of 13.8±0.87 and 14.7±0.83 g/100 g, and carbohydrates of 7.77±0.39 and 5.81±0.45 g/100 g, respectively. The moisture content was 56.55±2.85 and 58.46±2.92 g/100 g, and the ash content was 2.1±0.12 and 2.1±0.10 g/100 g, respectively.

The compositions of macro- and microelements of the investigated chopped semi-finished (cutlets) with the addition of lentil samples are presented in the following data.

Table 3 – Mineral composition of investigated chopped semi – finished products (cutlets)

Name of element	Samples, mass fraction, %						
	Traditional beef origin	Control, without any additives	№ 1 50:50	№ 2 80:20	№ 3 70:30	№ 4 60:40	№ 5 90:10
O	20,92	27,41	32,68	30,50	31,00	31,70	28,99
Na	23,45	20,89	18,92	18,97	18,06	16,68	20,11
Mg	0,89	1,49	2,12	2,15	1,79	1,88	1,75
Si	-	-	0,32	0,31	-	0,32	-
P	5,09	8,13	9,48	9,41	8,78	8,03	8,13
S	0,33	-	0,39	0,36	0,36	0,57	-
Cl	37,79	27,01	21,02	22,46	20,77	20,43	28,46
K	10,80	8,14	12,90	10,56	11,28	13,50	10,79
Ca	0,75	1,80	2,17	2,25	2,10	1,90	1,77
C	-	4,70	-	3,04	5,86	4,66	-
Fe	-	0,43	-	-	-	0,33	-

According to the results presented in Table 3, the addition of lentil flour affected the mineral composition of the minced semi-finished products. Compared with the control sample, the formulations containing lentil flour generally exhibited higher levels of potassium (K), calcium (Ca), magnesium (Mg) and phosphorus (P). These changes may be linked to the mineral composition of lentils, which are recognised as an important source of essential minerals [10,11].

The magnesium content increased from 1.49% in the control sample to a range of 1.75-2.15% across the lentil-fortified samples, with the highest values observed in the 50:50 and 80:20 samples (2.12% and 2.15%, respectively). Magnesium is involved in many physiological processes, including enzyme activity, energy metabolism, and the maintenance of neuromuscular functions [15].

The phosphorus content reached 9.48% and 9.41% in the 50:50 and 80:20 samples, respectively, whilst lower values (8.13%) were observed in the control sample. The calcium content in the experimental samples also increased compared with traditional beef cutlets and the control sample. Calcium plays an important role in bone metabolism, muscle contraction and physiological regulatory processes [16].

Potassium levels in the lentil-enriched samples were generally higher than in the control sample. Potassium is one of the main intracellular minerals involved in maintaining electrolyte balance and cardiovascular function [16].

The comparative analysis of the macro- and microelements contents of the samples indicated that the addition of lentil flour to the minced meat from offal modifies a structure of the finished cutlets. More uniform structure is observed for the cutlets with the addition of lentil flour in a ratio of 70:30 which was confirmed by organoleptic assessments of ready-made cutlets made from beef tongue, kidneys, heart, and meat tripe with the addition of lentil flour.

In terms of taste, these cutlets are not inferior to traditional ones; they have available low-cost value for the nutrition of various categories of the population. Frozen semi-finished products can be stored in the freezer at the temperature minus T= -18°C within 3 months by saving of the organoleptic properties and technological properties, in addition, semi-finished products are easily defrosted and convenient for preparation.

Conclusions. Based on the presented data, chopped semi-finished products (cutlets) from secondary raw materials by using lentil flour in an amount from 10% to 50% of the total weight allows to increase in the nutritional value of the food products by increasing the content of protein, carbohydrates, and minerals. All samples were evaluated considering their physico-chemical, organoleptic, and sensory characteristics. The sample of a semi-finished product from secondary raw materials and lentils in a ratio of 70/30 fully complied with the requirements of GOST 32951-2014 "Semi-prepared meat and meat-contained product. General technical conditions" and can be successfully produced in the field of public catering, it was found that the protein content in the developed products ranged from 17.95±1.15 to 20.93±1.25 g/100 g compared with the control sample of 17.07±0.72 g/100 g. The carbohydrate content ranged from 3.64±0.33 to 7.91±0.72 g/100 g, compared to the control sample of 3.09±0.30 g/100 g. According to the study, chopped semi-finished products using lentils contained mineral components such as sodium (16.68-23.45%), magnesium (0.89-2.15%), phosphorus (5.09-9.48%), potassium (8.14-13.50%), and calcium (0.75-

2.25%). Thus, the use of secondary raw materials and lentils allows for the obtaining of food products for healthy nutrition of various population groups that are not inferior in quality to traditional meat products, save the primary muscle meat raw material, and increase the nutritional value of the finished product. Allowing the expansion of the range of semi-finished products in the production of food products with a specific pleasant taste.

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ОЦЕНКА МЯСНЫХ ПОЛУФАБРИКАТОВ, ОБОГАЩЕННЫХ ЧЕЧЕВИЧНОЙ МУКОЙ

В настоящее время глобальная урбанизация и ограничения в рационе питания способствуют развитию несбалансированного питания и хронических заболеваний. Глубокая переработка вторичного мясного сырья путем обогащения необходимыми соединениями и неорганическими элементами позволяет разрабатывать новые технологии функциональных пищевых продуктов со сниженной себестоимостью. Целью работы являлось исследование новых рубленых полуфабрикатов (котлет), обогащённых чечевичной мукой в количестве от 10 до 50% от общей массы. Для достижения поставленной цели были определены следующие задачи: разработка технологии производства, проведение сенсорной оценки, анализ органолептических и физико-химических характеристик, а также определение содержания макро- и микроэлементов с использованием сканирующего электронного микроскопа и масс-спектрометрии с индуктивно связанной плазмой.

В качестве вторичного сырья использовали говяжьи субпродукты: язык, почки, сердце и рубец. Также применяли растительное сырьё – чечевицу (Lens culinaris). По органолептическим и сенсорным показателям оптимальным был признан образец, содержащий 70% мясного сырья и 30% чечевичной муки. Установлено, что внесение чечевичной муки в рецептуру повышает пищевую ценность котлет за счёт увеличения содержания белков, углеводов и минеральных веществ. Наличие макро- и микроэлементов определяли методом масс-спектрометрии и с использованием сканирующего электронного микроскопа.

Установлено, что содержание белка варьировало от 17,95±1,15 до 20,93±1,25 г/100 г по сравнению с контрольным образцом (17,07±0,72 г/100 г). Содержание углеводов составило от 3.64±0.33 до 7.91±0.72 г/100 г по сравнению с контрольным образцом (3.09±0.30 г/100 г). Исследуемые образцы содержали такие минеральные компоненты, как натрий (16,68-23,45%), магний (0,89-2,15%), фосфор (5,09-9,48%), калий (8,14-13,50%) и кальций (0,75-2,25%).

Разработанный мясной полуфабрикат, обогащённый чечевичной мукой, может быть рекомендован в качестве функционального пищевого продукта, обогащённого белками, минеральными веществами и витаминами.

Ключевые слова: *котлеты, Витаминизация, функциональное питание, чечевица, мясо, субпродукт.*

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ЖАСЫМЫҚ ҰНЫМЕН БАЙЫТЫЛҒАН ЕТ ЖАРТЫЛАЙ ФАБРИКАТТАРЫН БАҒАЛАУ

Қазіргі таңда жаһандық урбандалу және дұрыс тамақтанудың шектелуі теңгерімсіз тамақтану мен созылмалы аурулардың таралуына әсер етуде. Құндық көрсеткіші төмендетілген функционалдық тағам өнімдерінің жаңа технологияларын әзірлеу үшін екінші реттік ет шикізатын маңызды қосылыстармен және бейорганикалық элементтермен байыта отырып терең өңдеу өзекті болып табылады. Зерттеу жұмысының мақсаты жалпы масса құрамына 10%-дан 50%-ға дейінгі мөлшерде жасымық ұнын қосу арқылы байытылған жаңа туралған жартылай дайын өнімдерді (котлеттерді) зерттеу болды. Осы мақсатқа жету үшін келесі міндеттер қарастырылды: өнім өндіру технологиясын әзірлеу, сенсорлық бағалау жүргізу, органолептикалық және физика-химиялық қасиеттерін анықтау, сондай-ақ макро- және микроэлементтердің құрамын сканерлеуші электрондық микроскоп және индуктивті байланысқан плазмалы масс-спектрометрия әдісі арқылы зерттеу.

Екінші реттік шикізат ретінде ірі қара малдың субөнімдері – тіл, бүйрек, жүрек және месқарын пайдаланылды. Сонымен қатар отандық өсімдік шикізаты – жасымық (Lens culinaris) қолданылды. Органолептикалық және сенсорлық көрсеткіштер бойынша құрамында 70% ет субөнімдері және 30% жасымық ұны бар үлгі ең тиімді нұсқа ретінде таңдалды.

Зерттеу нәтижелері жасымық ұнын рецептураға енгізу ақуыздардың, көмірсулардың және минералдық заттардың мөлшерін арттыру арқылы котлеттердің тағамдық құндылығын жоғарылататынын көрсетті. Макро- және микроэлементтердің болуы масс-спектрометриялық

әдіс және сканерлеуші электрондық микроскоп көмегімен анықталды. Ақуыз мөлшері бақылау үлгісіндегі 17,07±0,72 г/100 г көрсеткішпен салыстырғанда 17,95±1,15-тен 20,93±1,25 г/100 г аралығында өзгерді. Көмірсулар мөлшері бақылау үлгісіндегі 3,09±0,30 г/100 г көрсеткішпен салыстырғанда 3,64±0,33-тен 7,91±0,72 г/100 г аралығында болды.

Зерттелген үлгілерде натрий (16,68-23,45%), магний (0,89-2,15%), фосфор (5,09-9,48%), калий (8,14-13,50%) және кальций (0,75-2,25%) сияқты минералдық компоненттер анықталды. Жасымық ұнымен байытылған әзірленген ет жартылай дайын өнімі ақуыздарға, минералдық заттарға және дәрумендерге бай функционалдық тағам өнімі ретінде ұсынылуы мүмкін.

Түйін сөздер: *котлеттер, дәрумендер, Функционалды тамақтану, жасымық, ет, ет.*

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