Studies on a new extrusion-cooking proces for manufacture of vegetable meat analogs

KAZIMIERZ DANOWSKI, AUGUSTYN JAKUBOWSKI, JACEK ZGAIŃSKI

Institute of Meat-and Fat Industry Poland

Texture and consistency /bite/ of vegetable protein products are critical to consumer acceptance, if these products are to simulate existing meat foods. To enable manufacture of soy meat analogs, closely resembling pieces of cooked meat, a new modyfied extrusion-cooking process has been developed. The difference in the new method, as compared with the previous ones, is in the use of a special tempered head extending the barrel of an extruder. The conditions existing in this head make possible carrying out two consecutive processes: the first one consisting in expansion of the flowing protein mass, with formation of many bubbles, and the second one, where the bubbles undergo compression and the forming layered mass becomes more fibrous under action of the longitudal shearing forces. The defatted soy flour has been used as the main raw material: addition of blood plasma or casein, up to 20% on the protein basis, is not only possible but also desirable in many cases, because of imparting to the product better properties /e.g.consistency, color/.

Studium über einen neuen Extrusion-Kochprocess für die Herstelung von Fleischanalogen pflanzlicher Herkunft

KAZIMIERZ DANOWSKI, AUGUSTYN JAKUBOWSKI, JACEK ZGAIŃSKI

Institut für Fleisch-und Fettindustrie Polen

Aussehen, Struktur und Konsistenz /beim Kauen/ der eiweisshaltigen Lebensmittel pflanzlicher Herkunft haben entscheidende Bedeutung für die Annahme von dem Konsument, wenn diese Produkte übliche Fleischprodukte ersetzen sollen. Um die Herstellung der Fleischanalogen aus Sojabohnen zu ermöglichen, und zwar solcher, die den Stücken von gekochtem Fleisch ähnlich sind, eine neue, modifizierte Extrusion-methode entwickelt wurde. Der Unterschied zwischen dieser Methode and bisherigen beruht auf der Verwendung von einem speziellen, temperierten Kopf, der als eine Verlängerung der Extruderrohre montiert wird. Die Bedingungen herrschende in diesem Kopf erlauben Durchführung von zwei, nacheinander verlaufenden Prozessen: dem ersten, bestehenden, aus der Expansion der fliessenden Proteimasse mit Entstehung von zahlreichen Blasen, und den zweiten, wo die Blasen zusammen-gedrückt werden, und wo die entstehende geschichtete Masse eine faserige Struktur unter der Wirkung von axialen Scherkräften bekommt. Das entölte Soyabohnenmehl wurde als wichtigster Rohstoff werwendet; die Zugabe von Blutplasma und Kazein, bis zu 20%, auf Einweissgehalt gerechnet, ist nicht nur möglich sondern auch erforderlich in manchen Fällen, weil sie Eigenschaften des Produktes verbessern /z.B. Konzistenz, Farbe/.

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La recherche sur un procede nouveau d'extrusion de proteines végetales pour l'obtention d'analogues de la viande.

DANOWSKI KAZIMIERZ, JAKUBOWSKI AUGUSTYN et ZGAINSKI JACEK

Institut des Industries de la Viande et des Corps Gras, Warszawa, Pologne

Les paramètres de la consistance et de la structure jouent un role trés important dans l'appréciation du substitut de la viande par les consommateurs. On a developpé un procédé nouveau d'extrusion-chauffage, pour l'obtention d'un analogue de la viande bouillie de boeuf, à partir de proteine de soja.
La méthode est basée sur l'application d'un finisseur avec une température programmée à l'appareil d'extrusion. On y trouve deux phénomènes consecutifs:
- l'expansion de la plasma proteique liquide avec la formation de nombreux ballons gaseux
- la compression et l'allongement de la structure fibreuse des proteines.
Comme matière première on a utilisé la farine de soja dépelliculée et deshuliée; on a trouvé que l'addition de plasma à partir de sang soit de caseine au niveau de 20%, est même désirable dans certains cas pour améliorer la consistance et la couleur du produit.

Изучение нового процесса термической экструзии для получения аналогов мяса растительного происхождения.

Казимеж ДАНОВСКИ, Аугустин ЯКУБОВСКИ, Яцек ЗГАИНЬСКИ
Институт Мясной и Жировой Промышленности, Варшава, ПНР.

Внешний вид, структура и консистенция (при жевании) растительных, белковых продуктов являются чрезмерно важными для потребительского одобрения, если эти продукты должны хорошо подделываться под существующую мясную пищу. Чтобы создать возможность производства соевых аналогов мяса, очень напоминающих куски вареного мяса, был разработан новый, модифицированный метод термической экструзии. По сравнении с существующими, этот новый метод отличается специальной, темперированной головкой присоединенной к выходному отверстию экструзионной машины. Условия существующие в этой головке создают возможность проведения двоих последовательно наступающих процессов: первого, состоящего в экспансии текучей белковой массы с образованием многочисленных пузырков, и второго, где пузырки подвергаются сдавливанию и образующаяся слоистая масса становится более волокнистой под влиянием осевых режущих сил. Обезжиренная соевая мука употреблялась как главный исходный материал; добавка плазмы крови или казеина, даже 20% считая по содержанию белка, является не только возможной, но и полезной во многих случаях, потому что обусловливает она улучшенные свойства продукта (например: консистенцию, цвет).

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KAZIMIERZ DANOWSKI, AUGUSTYN JAKUBOWSKI, JACEK ZGAIŃSKI

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Introduction

Extrusion-cooking, as applied to the manufacture of edible protein products, is defined as the process by which moistened proteinaceous material is plasticized in a tube equipped with rotating compressing screw, by a combination of moisture, pressure, heat and mechanical shear, and extruded by the same screw through an orifice at the end of the tube. The material in the tube exists in semifluid, plastic state, and his temperature exceeds this one of boiling water /usually above 120°C/. When the extruded material leaving orifice enters atmosphere, the dissolved water boils and many steam bubbles are formed in the solidifying mass. If the simple circular, short orifice is used, the product obtained consists of long, puffed strands, which can be cut into pieces. After hydration those pieces become spongy, soft and don´t resemble meat pieces. Many attempts has been made to improve the texture and consistency of the product and give better resemblance of meat to it. The first satisfactory results were obtained independently by two American firms: Griffith Laboratories and Wenger Manufacturing . The first firm used a special tempered die, shaped as a piece of cooled pipe extending the tube of an extruder, positioned after the outlet orifice and having somewhat bigger inner cross-section area than the orifice. The steam bubbles in plasticized mass emerging from the orifice can expand mainly in the axial, longitudal direction because of the confining walls of the pipe. This controlled bubble expansion stretches the cooling mass imparting to it fibrous, layered structure. The product has been named GSVP /Griffith`s Structured Vegetable Protein/. The second firm uses simply double extrusion. The first extruder equipped with ordinary outlet orifice produces puffed, not wholly solidified product, which is immediately fed to the second extruder compressing the bubbles and stretching the formed layers into fibers. This way of manufacture enables to achieve the best resemlance of meat pieces, as yet. Wenger`s product, advertised as a meat analog, has been named Uni-Tex.

The idea of our invention lies in carrying out the second extrusion without use of the second extruder, which has been replaced by a head of special construction.

Apparatus and method

The apparatus used in our method consisted of a conventional extruder with the outlet orifice replaced by a special tempered head. The extruder was the pilot-plant one with the average output 25 kg/h and volume compression 1:2,5 /Lalesse Univercel/. The head began with an circular orifice leading from the extruder tube into a tempered, longitudal chamber of specific shape and dimensions, covered from inside with a friction diminishing plastic and having eventually additional outlet orifice bigger than the first one and specifically shaped. The conditions existing in this head made possible carrying out two consecutive processes: the first one consisting in expansion of the flowing protein mass, with formation of the many bubbles, and the second one, where the bubbles undergo compression and the forming layered mass becomes more fibrous under action of the longitudal shearing forces.

The defated soy flour or grit with PDI = 15 ÷ 85 has been used as the main raw material; addition of blood plasma or casein, up to 20% on the protein basis, is not only possible,

but also desirable in mamy cases, bacause of imparting to the product better properties /e.g.consistency, color/. The mixture of raw materials was kneaded with the suitable quantity of water. The last stage of kneading was accompanied by letting the direct steam into mixer. The total amount of added water didn't exceed 40% by wt. The best conditions for the extrusion were: temperature of the extruder tube: I-st zone 95-100°, II-nd 130-175°, screw rotation: 50-100 rpm. The conditions within the head itself were determined by the head construction and temperature of the tempering water.

Results

The obtained product is very similar to the double extruded Wenger's Uni-Tex. This similarity can be regarded as the best proof, that the process caried out in the head doesn't differ much from the second extrusion. The texture and structure are in both cases almost the same and after hydration bear close resemblance to the cooked meat pieces. Table 1 gives the main features of two our products as compared with mentioned foreign products /GSVP and Uni-Tex/. The second our product contains 20% blood plasma. The water absorbtion is comparatively low, due to the small puffing and dense structure. The difference between the amount of water held by the soaked product after draining away the water and the amount of water held by the same soaked product after centrifuging /1000 G/ away the water, gives the amount of puffing as % volume. With possible exception of GSVP, all the products show very low amount of puffing. Dense structure helps to obtain good, chewy consistency, similar to this of cooked meat. Fig 1 shows the consistency curves obtained with use of some kind of Kramer shearing press. It is easy to see the striking similarity between our products and the cooked meat, from this, very essential, point of view. The addition of blood plasma helps to improve consistency. As compared with foreign products, our products resemble the cooked meat much more; GSVP is too soft and Uni-Tex too brittle. Flavor and taste of the vegetable protein products are often critical to consumer acceptance, if these products are to be used in significant percentage. The sensory score of our products and Uni-Tex is similar, but not very high; the specific soybean flavor can be easily detected. However we have found, that hot extraction with water or suitable water solution enables to remove most of the undesirable flavor and taste /table 1/.

Conclusions

The application of the special tempered head attached to an extruder made possible the manufacture a vegetable protein product simulating pieces of cooked meat. Because of its simplicity the new method can compete with Wengers double extrusion giving similar product.

Fig. 1

Consistency of extruded meat analogs and cooked meat.

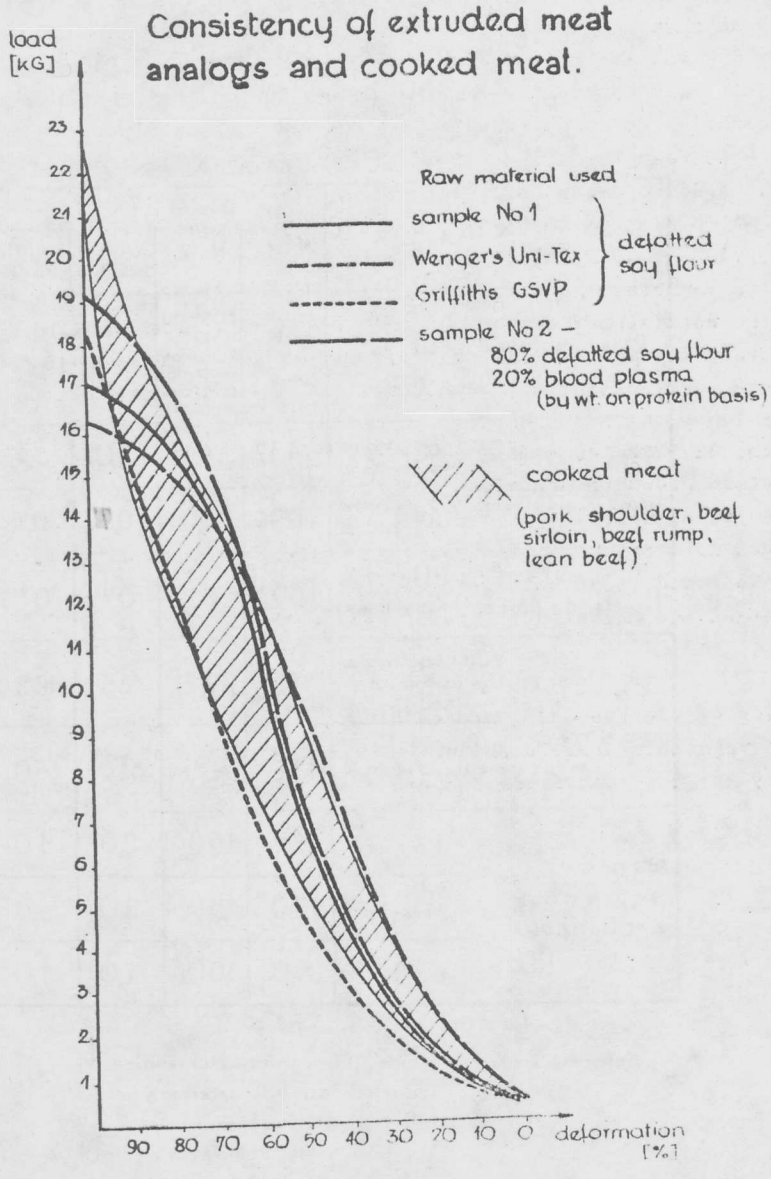

Table 1

Item		Sample			
		No 1	No 2	Wenger's Uni-Tex	Griffith's GSVP
Raw material used		defatted soy flour	80% soy flour 20% blood plasma (protein basis)	defatted soy flour	
Water absorbtion (water mass absorbed / mass of dry sample) soaked sample	drained off	1,17	1,15	1,02	1,17
	centrifuged	0,94	1,03	0,77	0,78
Amount of puffing (voids as part of total volume)		0,23	0,12	0,25	0,39
Consistency	cutting through the sample at [kG]	17,0	19,2	16,3	18,3
	deformation at the load of 5kG [%]	41,8	40,5	34,0	55,0
Sensory score, as intesity of	taste	1,5	1,5 (1,0)	2,0	1,0
	flavor	2,0	1,5 (0,5)	2,0	1,0
	color	5,0	3,0 (2,0)	4,0	1,0

Sensory score: Taste, flavor and color values of toasted soy grit determined as 3. The values given in brakets pertain to the sample after hot water extraction.