A C T A A L I M E N T A R I A P O L O N I C A
Vol. XIV (XXXVIII) No. 3-4
1988

DANIEL DUTKIEWICZ
MACIEJ BRZESKI
PIOTR BYKOWSKI

PROCESSING TECHNOLOGIES OF ANTARCTIC KRILL ON BOARD WITH REGARD TO MINIMIZING ENERGY*)

Sea Fisheries Institute, Gdynia

Key words: Antarctic krill, fishing trawler, energy consumption.

Concise review of krill processing methods for food, fodder and by-products under fishing trawler conditions is given. Quality of the products and energy consumption were the main evaluation criterions.

INTRODUCTION

The enormous stocks of Antarctic krill (*Euphausia superba* Dana), a crustacean resembling shrimp in appearance and taste but several times smaller in size, is regarded by many national and FAO specialists as a very valuable source of protein-based human food, high protein animal feeds as well as of such by-products as chitin — a valuable and interesting natural polymer.

For the past ten years Poland has been conducting an extensive research of krill utilization based on the stocks discovered near Antarctica. A great deal been done to develop product and processes and to find optimal utilization of krill resources, including engineering development of a high-performance processing plant which could take advantage of the small size of krill and other specific characteristics of the raw material to achieve high rates of thoughput in small trawler space, with little manpower and under limited energy supply. As a result, original technologies and equipment for krill processing into human food, animal feed and technical products were worked out and tested on a commercial scale, partly under sea conditions in 1985 and 1986. The undertaking of a regular krill fishery by the Polish fleet depends now only on the demand for krill products on the foreign and domestic markets.

*) Paper presented on JUFoST Symposium "Optimal Utilisation of Raw Materials in Food Production" Cracow, 22-24 September 1986

KRILL AS A SOURCE OF FOOD PRODUCTS

The proteins, in the form of meat, constitute the main value of this still under-utilized food resource and can be obtained with a yield of 10 to 22% depending on the processing method and size of the processed krill. Because of the high fluoride content, mainly in the carapace (Tab. 1), and the specific phenomenon of fluoride migration from the carapace to the krill muscle, any krill technology of processing it into such food products as frozen tail meat or coagulated paste and krill mince meat, should be based on a mechanical separation of the shells.

Table 1. Fluoride content in krill and krill meat [2, 3]

Storage time -25°C (month)	Whole krill		Krill meat	
	F ppm dw	shell % dw	F ppm dw	shell % dw
0	1299	9.05	64±3	0.06
12	1299	9.05	135±3	0.06

WHOLE TAIL MEAT

Tail krill meat is the primary product made from this crustacean and, at the same time, it is the most difficult to obtain. Research conducted in this field in Poland has resulted in the following three main methods for the production of meat:

i) by attrition of boiled frozen krill,
ii) by crushing of boiled krill followed by flotation to remove the shells,
iii) by roller peeling [1]

Attrition of the shell from fast-frozen boiled krill takes place on rotating discs and perforated walls of the machine. Krill thrown by the centrifugal force from the discs onto the walls, moves downwards and the shells are removed by an air exhaust system.

In the second method steam-boiled krill is fed into the centrifuge and thrown onto the rods of the stationary crown of this special machine. The process loosens the shell and further separation takes place by water flotation, repeated two or three times.

Krill peeling by the roller method consists in drawing the shell into a slit between two rotating rollers. Friction forces the muscle from the shell which, together with the head and intestines, is removed through the slit as waste. The meat remains in the slit and falls out at the end of the rollers and is finally cleaned by fresh water flotation, drained and frozen in blocks.

A comparison of approximate electric energy consumption for each of the above methods, as well as steam consumption and calculation of productivity from 1 m^2 of on-board factory surface area needed for the processing line installation — in 1 hour, are given in Tab. 2.

Sensory evaluation of various kinds of krill intact tail meat obtained by the discussed methods demonstrates that meat obtained by attrition and by crus-

Table 2. Energy consumption and lines productivity of various krill food products

Processing method/product		Electric energy kW/100 kg of products	Steam consumption kg/100 kg of products	Productivity kg of products/ (1 m^2·1 hour)
Attrition/tail meal		15.0	700	5.0
Crushing and flotation (tail meat)	centrifruge	20.0	800-900	4.0
	air	180.0	800-900	4.0
Roller-Peeling (tail meat)		15.0	350	10.0
Coagulate		8.0-10.0	700-800	15.0-20.0
Precipitate		6.0-10.0	600-800	12.0-20.0
Raw mince		10.0	100-150	10.0

hing-flotation has lower functional properties due to previous heat treatment during processing. On the contrary roller-peeled krill meat preserves its functional properties throughout the process and also after defrosting. Toxicological and supplemental investigations of this kind of krill tail meat was carried out in Poland according to the method recommended by PAG (Protein Advisory Group of Joint FAO/WHO Commitee). On the basis of the results achieved Polish Health Authorities have issued clearance for using this product as a food. Similar statement for this product was issued by the U.S. Food and Drug Administration several years ago. Thus, the meat may be used for a variety of products from a very tasty shrimp-like cocktail, soups, krillfishburgers, krill sticks and canned products.

MINCET MEAT PRODUCTS

A few simple technologies of minced products were développed in Poland in the first phase of work on krill processing [1].

The production process of krill coagulated paste consisted in pressing out protein in the form of juice or paste from krill by means of a screw press, thermal coagulation of the juice, separation of coagulated protein from the liquid, cooling of the paste and freezing.

The krill mincing process makes use of a drum (opening diameter of 3-4 mm) and fine separation is done in a drum equipped with a double screen with an opening diameter of 0.5-1 mm. It differs from the coagulated paste process in that the raw material is precooked.

An original process for making krill precipitate, a product resembling krill mince, is based on the use of krill's own enzymes. The autoproteolysis of krill musce proteins carried out in controlled conditions causes rapid hydrolysis of

proteins and results in a reduced viscosity of the krill-water mixture what allows for a good separation of liquid from the shells in centrifuges. The liquidized protein phase is thermally coagulated, drained, homogenized and frozen.

Although the processes seem simple, the resulting products have a number of drawbacks. For example the main factor, which has caused a reduction of coagulate production in the USSR and halted work on method improvement in Poland, is the low sensory quality of the product. However, according to the authors of krill precipitate, the product has shrimp-like desirable taste, flavour and pinky colour [4]. In that situation, production of good quality raw mince meat seems to be a very promissing option. A comparison of energy consumption data are given in Tab. 2.

KRILL AS A SOURCE OF FODDER MEAL

At the beginning of the worldwide interest in krill, it was believed that krill would be used mainly for the production of high-protein animal feeds. In industrial practice, a traditional method of krill-meal production is being used: cooking and pressing or centrifuging and drying. However, when heated, krill behaves differently than finfish: krill proteins coagulate, stick to the heating surface and lump. This causes a lengthening of the cooking time; it is also necessary to increase temperature by the use of directly injected steam which requires an increased consumption of fresh water, a scarce medium on most fishing vessels [5]. For example for the production of fish meal on the existing meal plant type FM-55 steam consumption is about 1250 kg per hour; but krill meal production requires an additional 300 kg of steam per hour. After only slight modifications of the existing plants, utilizing the stick water heat, it is possible to improve the process and reduce energy consumption.

KRILL PROCESSING BY-PRODUCTS

While krill is harvested in huge quantities and processed on board the fishing trawlers for mass reduction, krill processing waste can constitute a great problem. The waste concentrated as far as possible and frozen on board is an excellent raw material for the production of very intriguing natural polymers-chitin and chitosan and also natural pigment — caroteinoids which can have a positive influence on the economic evaluation of the total utilization of krill resources.

CONCLUSIONS

The interest in krill harvesting and processing is still comparatively modest due to the long distance from the countries involved (eg. European countries or Japan) to the grounds and the lack of a stable market for krill products. For this

reason krill ought to be used mainly for the production of high quality food. Tendency for total optimal utilization of the batch has to be seriously considered.

Food products obtained by the processing energy cost as low as possible which means low oil consumption ought to reach also high prices. According to the Polish concept of krill exploitation one of them is krill meat produced on roller-peeling machine. To process whole krill for 1 ton of tail meat it is necessary to use approximately 450 kg of oil including the capture of krill as compared with 550 kg of oil necessary for the production of 1 t of coagulated paste and 900 kg of oil per 1 t of krill fodder meal. Evaluation of discussed data shows that energy consumption for krill processing on factory trawlers into food, fooder and preserving the shell-waste for further processing does not differ greatly from traditional fish harvesting and processing. Because of the low profitability of animal feed production from krill over 50 per cent of the catch should be used for human food production if the venture is to be economically feasible [1]. This is a quite realistic solution if 4-6 roller-peeling machines are installed on a typical factory trawler.

Such a system of krill exploitation based on a total utilization of relatively low krill batches could be economical and profitable and is particulary important in terms of Southern Ocean living resources preservation.

LITERATURE

1. Budziński E., Bykowski P., Dutkiewicz D.: FAO Fish. Tech. Pap., 1985 (268).
2. Bykowski P., Kostuch S., Kowalczuk M.: Med. Wet., 1981, **37** (10), 609.
3. Bykowski P., Kowalczuk M., Kostuch S.: Roczn. PZH 1986, **23** (2), 107.
4. Kołakowski E. et al.: Biul. Morskiego Inst. Rybackiego (Bull. Sea Fish. Inst.) Gdynia 1984, **15** (1-2), 45.
5. Krępa J.: ibidem 1983, **14** (5-6), 50.

Manuscript received: October 1987.
Authors address: 81-345 Gdynia, Zjednoczenia 1.

D. Dutkiewicz, M. Brzeski, P. Bykowski

PRZETWARZANIE KRYLA ANTARKTYCZNEGO NA STATKU W WARUNKACH MINIMALNEGO ZUŻYCIA ENERGII

Morski Instytut Rybacki, Gdynia

Streszczenie

W ostatnim okresie przeprowadzono w Polsce intensywne badania zasobów kryla antarktycznego. W wyniku tego opracowano wiele oryginalnych technologii i urządzeń do pełnego wykorzystania kryla jako składnika żywności, pasz i produktów technicznych. Technologie te były sprawdzone częś-

ciowo w warunkach morskich. Ocena produktów żywnościowych z kryla, pod względem ich jakości, zużycia energii i wydajności linii technologicznych, pozwala na wyciągnięcie następujących wniosków:

— produkcja paszy z kryla powinna być ograniczona ze względu na wysokie zużycie energii,

— ponad 50% złowionego kryla powinno być użyte do produkcji żywności, szczególnie roller peeled tail, meat.

Taki system wykorzystania kryla jest zupełnie realny w odniesieniu do zużycia energii i nie różni się od tradycyjnego przetwarzania ryb na statkach. Nie powoduje on żadnego wzrostu zagrożenia życia na Oceanie Południowym.