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Nutrient Composition and Protein Quality of Giant Snail Products

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Abstract

The nutrient content and protein quality of Giant snail (*Acchatina*) meats (white, yellow, and gray) were determined for fresh and processed products. Fresh snail meats contained 81~82% moisture, 11~14% protein, 0.9~1.3% fat, and 1.2~1.4% ash. Proximate composition of fresh meat varied ($p<0.05$) with meat colour and gray meat had the lowest protein and highest ash content among samples. The major minerals of fresh snail meats were calcium (318~570mg%), potassium (170~190mg%), and magnesium (74~103mg%). Gray meat showed the higher calcium and lower sodium level than the other snail meats. No differences were found between fresh snail meats on amino acid profile, and total essential amino acid was 46% of total amino acids in all snail meats. *In vitro* protein digestibility of fresh snail meats were ranged from 76 to 81% which were lower than that of marine mollusks. Processing resulted in some increase (1.7~5.7%) in protein digestibility but no differences were found in C-PER after processing. The 25% saline water extractable mucous materials from fresh snail meat influenced in decreasing digestibility of other protein sources from 2% (casein) to 11% (filefish protein).

Key words : snail meat, proximate composition, *in vitro* protein quality, mucous materials

INTRODUCTION

Snail is an important foodstuff in France as appetizer (Hors D'oeuvre) and it has been widely cultivated in Korean farmlands for a promised higher income from the early 1980's. In the few species of foodstuff snails, the Giant snail (*Acchatina fulica*) is commonly consumed in Korea. Though there is a small commercial products such as meat extracts, fresh or canned products for gourmets, Giant snails are not marketed widely. However this restricted consumption is felt to linked with the prejudices of snails as oriental medicine or special foreign cooking materials, the major concern of Korean consumers is its real nutritional value and the influence of processing upon the food quality. Very few reports on Korean snail quality were published by Kim *et al.*[1] who determined the chemical composition of Korean slug and land snail as oriental medicine sources. And Park *et al.*[2] investigated the fatty acid composition of two species of Giant snail (*Acchatina fulica* and *Ampullarius insularus*).

Our objectives were to determine the effect of processing on the proximate composition and protein quality of Giant snails. The dietary effect of mucous materials from snail meat on other protein sources were also compared.

MATERIALS AND METHODS

Materials

Three or four month old Giant snails were obtained with the courtesy of Junchun Food Co., in Kimhae, Korea. According to meat color, live snails were divided into three groups (white, yellow and gray) and tried fasting for one week before sampling.

Processing

Live snails were soaked in 10% saline water for 5 min. and then boiled in tap water for 10min. After peeling and eviscerating, the snail meat was rinsed in cold running water and reboiled for 30min. Boiled snail meats were freeze dried and ground to pass through an 80 mesh screen. Ground samples were packaged in watertight plastic bottle and stored at -40° C for later experiments. Before being canned, live

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snails were boiled in tap water for 25min. Peeling and eviscerating were done as boiled products. Conditions of seasoning, sterilizing (121° C, 25min.) and cooling for boiled topshell (*Neverita didyma*) canning[3] were employed in snail meat canning. Canned products were also freeze dried and stored as done in boiled products.

Extraction of mucous materials

Live snail meats were sliced thinly and chopped into 2~3mm cubes. Chopped meats were blended with 25% saline water (meat : saline water=1 : 1.5, w/w) for 10min. The mixture filtered using cheese cloth and the filtrates were stored at −40° C.

Nutrient analyses

Moisture, lipid, protein (N×6.25) and ash were determined by the standard procedures of AOAC[4]. For mineral analysis, samples were ashed using a nitric acid-perchloric acid digestion procedure[5]. Minerals were determined by atomic absorption spectrophotometer (Instrumentation Laboratory Inc., IL video 12 AA/AS).

In vitro protein quality assay

Amino acid composition of the samples were determined using the procedure of Spackman *et al.*[6]. The samples were hydrolyzed with 6N HCl, under vacuum, for 24 hours at 110° C to release the acidic, neutral and basic amino acids. Tryptophan was released using an alkaline hydrolysis[7]. Sulfur-containing amino acids were quantitatively oxidized using performic acid followed by a 6N HCl hydrolysis[8]. The *in vitro* protein digestibilities of all samples were measured by the AOAC[9] procedure using four enzymes including trypsin (Sigma, 14,600 BAEE unit/mg solid), α-chymotrypsin (Sigma, 41units/mg solid), peptidase-(Sigma, 50units/g solid) and bacterial protease (*streptomyces griceus*, Sigma, 58units/mg solid). The reference protein used in digestibility assay was ANRC casein. Trypsin inhibitor (TI) contents were determined using the procedure of Ryu[10] which was modified from Rhinehart's method[11]. Results of TI assay were expressed in trypsin inhibitor equivalents, which equals the mg of purified soybean trypsin inhibitor per gram sample. C-PER (Computed Protein Efficiency Ratio) was calculated using the corrected procedure of AOAC[9]. Protein digestibility was determined via four enzyme procedures and amino acid profiles were used in the calculation of C-PER.

Determining inhibitory effect

The inhibitory effect of the mucous materials against protein digestibility was determined according to the AOAC[9] procedure which was modified from Satterlee *et al.*[12]. Mucous materials were mixed with various kinds of protein solution (1g/%N dry base in 10 ml of glass distilled water) at the ratio of 1 : 9, 2 : 8, 3 : 7, or 4 : 6 (mucous material : protein solution, v/v). And then the mixture were reacted for 2 hrs before measuring *in vitro* protein digestibility.

RESULTS AND DISCUSSION

Proximate composition and mineral content

Cultivated live snails used in the experiments were 3 or 4 months olds and weights with shells were ranged from 24 to 30 grams. Edible portion of all samples averaged 38.6% of 100g total snail weight with shell which is 10~12% higher than that of marine shellfishes (Table 1). Moisture, protein, lipid and ash contents varied ($p<0.05$) among snail meats from the different meat color with white meat lowest in moisture. White meat contained more protein than others, followed by yellow and gray meats. Yellow meat had more lipid than others while gray meat showed the highest ash content among samples. All snail meats generally contained higher protein and lower lipid than common livestocks meats. Reported proximate compositional data for snail meats were not available but

Table 1. Proximate composition of edible meat of snails

(g/100g edible portion)

Sample	Edible portion*	Moisture	Protein**	Lipid	Ash
Gray	37.6	82.18	11.53	0.91	1.39
Yellow	37.0	82.36	13.42[a]	1.28[b]	1.29
White	38.7	81.20[a]	13.69[a]	0.97	1.25[c]

*gram/100g of snail with shell
**%N×6.25
a-c Significant at the [a]$p<0.001$, [b]$p<0.01$ and [c]$p<0.05$ levels by *t*-test

those were similar to marine mollusks[13]. Variations of proximate compositions between meat color may be due to feeding behavior or to individual maturity variations. The mineral content of edible snail meats is listed in Table 2. In edible meats, major minerals such as calcium, ranges from 317 to 572mg% followed by potassium (170~193mg%), magnesium (73~103mg%) and sodium (23~60mg%) in order. The sum of those major minerals was equivalent to 92.34% of total mineral content, and calcium and magnesium content were about five or three times higher than another wild snail meat[1]. There was some variations between Ca and Mg content with meat color. Gray meat had the highest content of both Ca and Mg whereas, yellow meat had the highest K content. Meat color of snails might be closely related to Cu content that gray meat had about 300% higher Cu level than in white meat and 80% higher than in yellow meat. On the other hand, when compared with the mineral content of oysters[14] which is known as an excellent mineral source, snail meats demonstrated 1.5~2 times (Mg) and 5~10 times (Ca) higher levels but had significantly lower content in Na (25~50%), Cu (3% below) and Zn (3% below) than those in oysters.

Table 2. Mineral contents of edible snail meats

(mg/100g edible meats)

Mineral	Gray	Yellow	White
Ca	572.32	317.54	399.73
Mg	103.47	73.92	87.39
Na	23.17	60.34	43.98
K	191.33	193.85	170.27
Cu	1.69	0.93	0.57
Fe	7.86	11.82	11.37
Zn	2.16	2.26	2.82

*Each value represents the mean of duplicate analyses from *two different samplings*

Table 3. Amino acid profiles of various snail meats

(g/100g protein)

Amino acids	Gray	Yellow	White
Asp	8.37	8.73	8.09
*Thr	4.91	4.93	5.00
Ser	4.37	5.13	4.94
Glu	13.59	14.37	14.61
Pro	7.11	5.57	5.69
Gly	6.38	6.27	6.23
Ala	3.88	4.39	4.39
*Val	6.40	6.46	6.84
*Met	2.46	3.63	3.45
*Ile.	5.35	4.83	4.85
*Leu	7.19	6.64	6.64
*Tyr	2.82	2.31	2.28
*Phe	4.61	4.45	4.46
*His	2.09	3.08	2.95
*Cys	1.43	1.44	1.44
*Trp	0.68	0.53	0.65
*Lys	5.33	4.95	5.00
NH_3	0.55	0.44	0.43
Arg	7.57	7.00	7.05
Total	95.09	95.14	94.99
Total EAA	43.27	43.25	43.56
E/T %	46.00	45.00	46.00

*EAA : essential amino acid

In vitro protein qualities of fresh snail meat

The amino acid composition of edible snail meats did not differ in meat color (Table 3). The predominant amino acids were Asp, Glu, Pro, Gly, Val, Leu, and Arg and the sum of those amino acids were equivalent to 52.5% of total amino acids. The total essential amino acid of all snail meats was 43% to total amino acids. Which meant that contents and profiles of essential amino acid for snail meat is superior to those of wild snail[1] and marine shellfishes[15]. Table 4 served *in vitro* protein qualities and trypsin inhibitor contents of fresh snail meats. *In vitro* protein digestibility of 76.6% for gray meat and 81% for both yellow and white meat were lower than that of shellfish proteins (80~85%)[15] and finfish proteins (89~92%)[16~19]. Trypsin inhibitor content ranged from 22.7 to 36.8mg/g solid which was 10 times higher than that in other shellfishes[15,20] and similar to finfishes[18] and squids[19]. Those lower *in vitro* protein digestibilities could possibly explain the higher levels of inhibitory effect of trypsin inhibitor and extractable mucous materials from snail tissue[21]. There were no reports about C-PER of snail but fresh snail meats had higher C-PER (about 2.3) than shellfishes[15] in spite of its high trypsin inhibitor level and low protein digestibility. The most probable reason that snail meats in our study showed higher

Table 4. *In vitro* protein qualities and trypsin inhibitor content of fresh snail meats

Meats	*In vitro* protein digestibility (%)	C-PER	TI (mg/g solid)
Gray	76.63	2.29	28.97
Yellow	81.05	2.36	36.75
White	80.83	2.24	22.68

C-PER value was due to the excellent essential amino acid content and profiles.

Protein quality of processed snail meats

Extracting mucous material with 10% saline water and boiling (96±1°C) in tap water for 10 minutes were employed to modify the preparating Hors D'oeuvre. The process caused a 2% (white meat) to 6% (gray meat) increase in protein digestibility (Table 5). There was a significant loss of trypsin inhibitor for both white and gray meats compared with fresh snail's but C-PER was not changed during soaking in saline water and boiling in tap water. Canning and sun drying also resulted in better protein quality as digestibility and trypsin inhibitor but those processing did not increase protein quality when compared to soaking and boiling. This discrepancy in the different processing conditions to modify protein quality was due to extraction of the mucous materials prior to boiling, canning and sundrying.

Table 5. Comparison on *in vitro* protein quality of processed snail meats

Sample	*In vitro* protein digestibility (%)	C-PER	TI (mg/g solid)
White meat			
Boiled[a]	82.55	2.24	12.62
Canned[b]	80.41	2.24	20.22
Sun dried[c]	81.42	2.23	19.34
Black meat			
Boiled[a]	82.32	2.24	16.40
Canned[b]	79.84	2.24	19.68

[a] Chopped snail meats were soaked in 10% saline water for 5 min., boiled in tap water for 10 min. and then rinsed with 5% saline water
[b] Without soaking in saline water, boiled in tap water for 25 min. and sterilized at 121°C for 25 min.
[c] Without soaking in saline water, boiled in tap water for 25 min. and sun dried at 20°C for 12 hours

Inhibitory effect of *In vitro* digestibility by mucous materials

When the mucous materials extracted from white snail meat were added to ANRC casein at ratio of 1 : 9, 2 : 8, 3 : 7 and 4 : 6 (mucous materials : casein= v : v), the changes of *in vitro* digestibility of ANRC casein were shown in Fig. 1. With the increase of mucous materials to protein solution, *in vitro* digestibiliy in ANRC casein were decreased gradually, respectively. Judging from these results, it appeared that mucous materials influenced on the decrease of *in vitro* digestibility. Lorand *et al.*[22] reported that snails held adhesive mucous materials in the body, especially skin, cartilage and blood vessel, secreted through

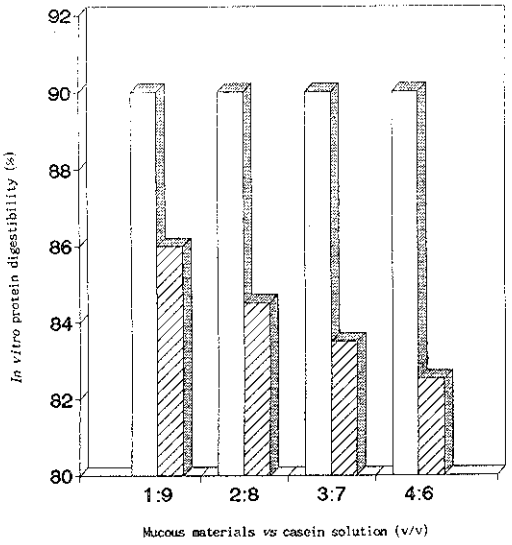

Fig. 1. Changes in *in vitro* digestibility of ANRC casein mixed with mucous materials from snail meat.
□ *In vitro* protein digestibility of ANRC casein
▨ *In vitro* digestibility of ANRC casein mixed with mucous materials.

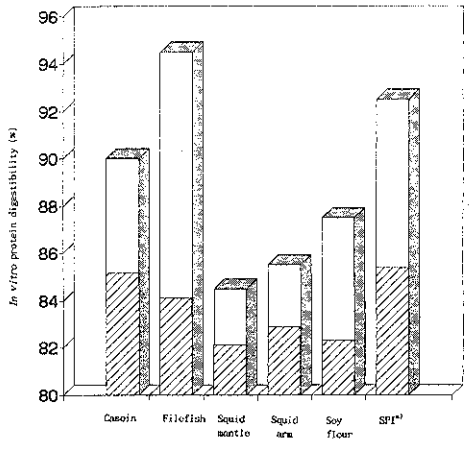

Fig. 2. *In vitro* digestibility of various protein sources mixed* with mucous materials from snail meat.
*Soy protein isolate
*Mixed 2ml of mucous materials with 8ml of protein solution (1g/%N dry base in 10ml of glass distilled water)
□ Original *in vitro* digestibility
▨ *In vitro* digestibility with mucous materials

two glands as high molecular weights. Perhaps, these mucous materials were suggested as mucopolysaccharide that condrotin 4-sulfate was the principal element. On the other hand, inhibitory effects of *in vitro* digestibility of mucous materials against various protein sources (filefish, soy protein isolate (SPI), soy flour, squid mantle and squid arm, ANRC casein) were illustrated in Fig. 2. A significant drop of *in vitro* digestibility was noted in filefish (10.6%), 7% for SPI and 5. 2% for soy flour, respectively. Those results could suggested that mucous materials in snail meats effectively decrease in protein digestibility as the previous report[22].

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식용 왕달팽이의 영양성분과 단백질 품질

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요 약

체색이 다른 세종류(백색육, 황색육, 회색육)의 식용 왕달팽이(Giant snail, *Achatina fulica*)의 일반성분과 무기질을 정량하여 이의 식품학적 가능성을 예측하였으며, 효소를 이용한 단백소화율(*in vitro* protein digestibility), 단백효율비(C-PER, computed protein efficiency ratio) 및 trypsin inibitor 함량을 측정하여 이의 단백질 품질을 평가하였다. 또한 전처리 및 가공조건을 달리한 달팽이 제품의 단백질 품질을 측정하여 바람직한 처리조건을 찾으려 했으며, 달팽이육 중에 다량 포함되어있는 점액성물질이 다른 단백질의 소화율에 미치는 영향도 아울러 실험하였다. 1. 식용왕달팽이의 가식부는 39% 정도로서 해산패류보다 10%정도 높았으며 가식부 100g당 11.5~13.7%의 단백질, 0.9~1.3%정도의 지질이 함유되어 있었다. 무기질로서는 칼슘, 칼륨 및 마그네슘이 풍부하였고 특히 칼슘함량은 굴(oyster)에 비교하여 5~10배 높았다. 2. 아미노산의 함량과 그 조성은 백색육, 회색육과 황색육이 모두 비슷하였고, 주요 아미노산은 aspartic acid, glutamic acid, proline과 glycine으로 총아미노산의 52.5%를 차지하였고 특히 필수아미노산 함량이 총아미노산의 45~46%를 차지하여 균형잡힌 단백질로 판별되었다. 3. 생달팽이육의 단백질 소화율은 76.6%(회색육)~81%(황색육과 백색육)였으며 단백효율비는 2.24(백색육)~2.36(황색육) 범위였으나, trypsin inhibitor함량은 체색에 따라 다양하였다(백색육 22.7mg/g solid, 회색육 28.97mg/g solid 및 황색육 36.75mg / g solid). 4. 10% 식염수에 5분간 침지한 후 10분간 boiling한 달팽이육의 소화율은 생육에 비해 1.7%(백색육)~5.7%(회색육)로 증가하였고, trypsin inhibitor 함량은 12.62mg/g solid (백색육)과 16.40mg/g solid(회색육)로 크게 감소하였으며, C-PER은 가공조건에 따라 변동이 없었다. 5. 생달팽이육에 다량 함유된 점액성물질은 여러가지 단백질의 소화율을 2%(ANRC casein)~11%(filefish protein)로 감소시켰다.