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Nutritional Evaluation of Tofu Containing Dried Soymilk Residue(DSR)
2. Evaluation of Carbohydrate Quality

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Abstract

Dietary fiber content and carbohydrate digestibility of dried soymilk residue (DSR) and tofu containing DSR were evaluated. Insoluble dietary fiber (IDF) content was 37.4 and 49.8%(%, moisture free basis) for common soymilk residue and DSR, respectively. Both soymilk residues contained 12.5% of soluble dietary fiber (SDF, dry basis). Tofu containing DSR, which is partially substituted with DSR corresponding to 10% weight of soybean used, had higher dietary fiber content (30% more for IDF and 45% more for SDF) than tofu manufactured in traditional manner. Carbohydrate digestibility was much lower in all tofu products ranging from 11% to 21%, and there was a negative correlation(r= − 0.9243) between carbohydrate digestibility and total dietary fiber content.

Key words : dried soymilk residue (DSR), tofu, carbohydrate digestibility, dietary fiber

INTRODUCTION

Soymilk residue (called Bi-jee in Korean and Okara in Japanese) has been known as a high nutritive insoluble residue which is produced during the straining process of tofu production. It should be realized, however, that there are probably some problems in providing soymilk residue as food to humans, since it is very bulky and contains about 12% insoluble carbohydrate and fiber[1]. This fraction also has difficulty in feeding due to rapid microbial spoilage and lipid deterioration during storage. Several investigators[2~4] have reported tha. the quality of soymilk residue can be improved by drying and solvent washing. The physical and sensory quality and protein quality of a tofu formula containing 10% dried soymilk residue (DSR) were also studied[5,6].

The purpose of the present study was to provide additional information on dietary fiber content and carbohydrate digestibility of tofu containing DSR, the intermediate products from tofu processing.

MATERIALS AND METHODS

Materials

Fresh soybeans and tofu products were obtained and prepared by the same manner described in the previous paper[6].

Analysis of dietary fiber

Insoluble dietary fiber (IDF) and soluble dietary fiber(SDF) were measured on the basis of enzymatic method of Asp et al.[7] using pancreatin (4 usp unit/g solid, Sigma).

Measurement of *in vitro* carbohydrate digestibility

In vitro carbohydrate digestibility was expressed as reducing power. The amounts of reducing sugars released by the treatment with α-amylase solution (8mg porcine pancreas, 15units/mg solid, Sigma) were determined spectrophotometrically with 3,5-dinitrosalicylic acid (1% in 0.4N NaOH containing 30% sodium potassium tartrate) according to the procedure[8] modified the assay of Bruner[9].

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RESULTS AND DISCUSSION

Composition of dietary fiber

Dietary fiber components can be classified into several types, such as soluble and insoluble dietary fiber and structural and nonstructural dietary fiber. With the recent development of various techniques for determining the dietary fiber contents of foods based on *in vitro* enzymatic digestion, increasing interest has been focused on the soluble and insoluble dietary fiber components of foods. Although all plant foods contain both soluble and insoluble dietary fiber, foods can be differentiated on the basis of their soluble and insoluble dietary fiber content. Beans are known as a well-balanced dietary fiber source and their consumption is associated with health benefits[10]. Fig. 1 shows the various IDF and SDF contents at the different process of manufacture of traditional tofu (TT) and tofu containing dried soymilk residue (TDSR). The dietary fiber contents of tofu products were determined using the method of Asp et al.[7], simple and rapid method for separation of dietary fiber from the solubilized protein and starch in as short time as possible, because the samples used in the experiment have a generally high protein content. As shown in Fig. 1, the IDF *vs* SDF ratio of all samples except tofus was about 3.5 : 1 (w/w, dry basis) and there were no significant ($p>0.05$) differences of both dietary fiber contents between raw soybean and soaked soybean or soymilk. SR1, which was made on a laboratory scale, contained about 40% more IDF and 56% more SDF than those of raw soybean. The difference in dietary fiber contents of SR1 and SR2 is mainly due to the difference in content of seed coats used in soymilk residue processing. As a result of solvent washing, the ratio of IDF *vs* SDF in DSR was changed and its IDF content was increased. Another difference between two tofus is caused by the added DSR contents which have much dietary fibers. However, TDSR had about 30% more IDF and 45% more SDF than TT.

Carbohydrate digestibility

Both tofus have very low carbohydrate contents compared with the raw bean and soymilk residues. But carbohydrate content was increased by 70% and 103% in SR1 and DSR repectively, presumably by removing proteins and other components during the decanting step of soymilk residue preparation (Table 1). Soymilk residues showed the very low carbohydrate digestibility compared to TT. The high level of dietary fibers (Fig. 1) and indigestible carbohydrate[11] will have an effect on the carbohydrate digestibility of SR1 and DSR. As with TDSR, the added DSR is responsible for lower carbohydrate digestibility compared to TT. Analyses indicated that carbohydrate digestibility of tofu products was influenced by

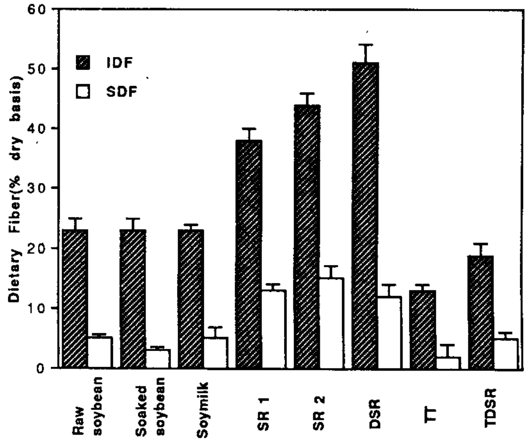

Fig. 1. The content of insoluble dietary fiber (IDF) and soluble dietary fiber (SDF) in the samples at different stages of the conversion into tofu.
Soaked soybean : Soaked in tap water for 24 hours.
SR 1 : Soymilk residue made on laboratory scale.
SR 2 : Commercial soymilk residue.
DSR : Solvent washed soymilk residue.
TT : Tofu manufactured in traditional manner.
TDSR : Tofu containing DSR corresponding 10% soybean used.
Each values are arithmetic mean±S.D. of 3 experimental replicates.

Table 1. Degree of *in vitro* carbohydrate digestibility of tofu products

Sample	Total[a] carbohydrate (%)	Carbohydrate digestibility (%)
Raw soybean	33.40±4.03	18.62±1.84
SR 1	56.65±4.23	10.70±0.82
DSR	68.08±7.62	9.05±0.71
TT	15.22±0.96	21.35±3.06
TDSR	28.33±2.45	12.51±2.45

[a] Eliminate the sum of protein, lipid and ash contents from total solid
Abbreviations were the same as in Fig. 1
Data represent mean±S.D. of three experiments

dietary fiber content and employed cooking methods[12]. It will also depend on the amount of added DSR which may limit the textural characteristics and carbohydrate digestibility of tofu.

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건조비지 첨가 두부의 영양적 품질평가
2. 탄수화물의 품질

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요 약

두부 제조공정 중의 부산물인 비지의 효율적인 이용을 위하여, 유기용매를 이용하여 건조시킨 비지를 원료 대두 중량의 10%가 되게 첨가하여 제조한 두부의 dietary fiber 함량과 탄수화물 소화율을 측정하였다. 또한 두부 제조 공정 각 단계별 시료의 소화율과 섬유소함량도 아울러 측정하였다. 전통적인 방법으로 제조한 두부와 비지첨가두부를 제외하고는 원료대두를 비롯한 전 시료중의 가용성 섬유 및 불용성 섬유의 비율은 1 : 3.5 (w/w, 건물중량 기준)이었으며 비지제품은 각 섬유소의 함량이 상대적으로 원료 대두보다 1.5~2.5배 증가하였다. 또한 섬유소의 함량이 극히 적었던 전통두부에 건조비지를 첨가하면 불용성 및 가용성 섬유소가 각각 30%와 45%씩 증가하여 두부에서도 섬유의 영양적 효과를 기대할 수 있었다. 탄수화물의 소화율은 비지의 경우 10%를 넘지 못하는 수준이었으며 전통두부 역시 20% 정도였다. 비지첨가 두부의 탄수화물 소화율도 비지의 소화율과 별차이를 보이지 않았다(12.5%). 두부 및 관련 제품들의 탄수화물 소화율과 식이 섬유소 함량과의 상관관계가 역의 상관관계 r = -0.9243)를 보였다.