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The Use Of Chicken Feather Fibers As Insulation Material For Winter Top Clothing

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Abstract

Since ancient times, natural materials such as cotton, wool and bird feathers have been used for thermal insulation in winter clothes. Today, although more artificial materials are used for this purpose, natural insulation materials especially lower feathers of water birds have not lost their importance as waterproofing materials. These materials with high heat protection, lightness, softness and long serviceability are very expensive. In contrast, especially recently developed artificial fibers exhibit superior properties than natural fibers at some angles, but they are not as useful as natural fibers in terms of heat insulation, softness and long service. This makes the water bird feathers more expensive, especially the puffer and goose feathers.

Accordingly, as the chicken feathers material is abundant, easily accessible and cheaper than the water bird feathers, the use of chicken feathers in winter clothes as filling material has attracted more attention. On the other hand, about 22 million tons of chickens are obtained as by-products each year in the world, and more than 4 million tons are wasted. This chemically resistant material is buried or burnt.

Chicken feathers are natural heat insulation materials. However, it is not possible to utilize chicken feathers like geese and ducks feathers. Unlike the goose and ducks, there are no down feathers in chickens as non-flying birds. On the other hand, the roughness, weight, fragility and low elasticity of the chicken feather appears to be a problem. In order to overcome these problems, we proposed to utilize the "fibers" obtained by separating the "barbs" part of the chicken feather from the "rachis" part by mechanical cutting as the filling material in the winter clothes. Research has shown that the chicken feather fibers have porous internal structure, which gives them high insulation properties. Our research has shown that the use of chicken fiber as insulation material in winter clothes is not only economical but technically a good alternative to other insulation materials. The winter coats made from chicken feather fibers have the same appearance as the goose down in terms of insulation, yet they have a beautiful appearance.

Keywords: chicken feather, chicken feather fibers, insulation properties of chicken feathers, filling material.

1. INTRODUCTION

For hundreds of years people have been using down feathers of water birds as filling material in winter tops. However, the reasons why these materials have such a high heat retention capability are not fully clarified. There are not enough studies in this regard. In one of these very few studies, the high insulation property of down feathers of water birds is explained in two respects. In the first place, the physical structure (configuration) of down is recorded, so that the down can store plenty of air inside the feather. Air is, as is well known, the best thermal insulation material. The second one is the high elasticity and durability of the feather, which allows the compressed feather to return to its original state [1].

In another study to investigate the features of some of the water birds feather cover, the mechanical and structural properties of down feathers were more likely to be examined.

In this study, the heat-protective properties of the down feathers are linked to the mechanical and structural properties and the lightness of these feathers [2]. According to the study, down feathers of water birds have a complicated configuration consisting of barbs branched from a tiny stem, while the internal structure of the barbs is empty (Fig 1).

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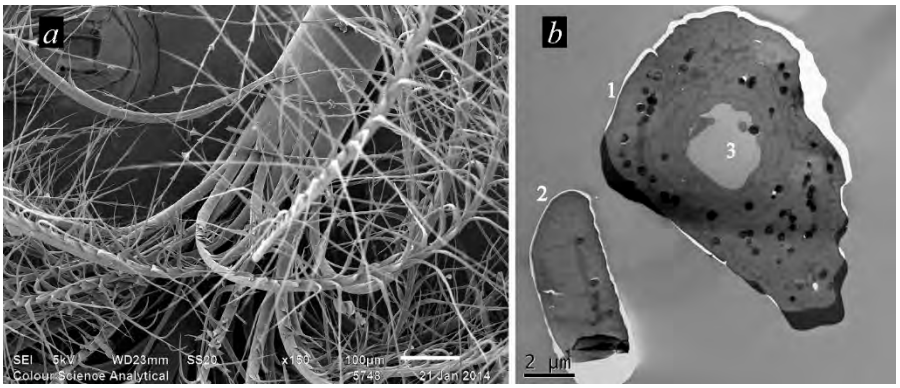


Figure 1. SEM images of the outer (a) and inner structure (b) of the goose down feather [2]

Chickens are lack of down feather because they live on land and can't fly. These birds generally have none or even very few down feathers. But like water birds, chicken feathers also have protein content and they have the same chemical properties.

Chicken feather emerging as a by-product in chicken meat production, which is the most spread animal species in the world, is not widely used. Protein feed is produced from these feathers and the feathers are also used in the construction and furniture sector. An important part of the emerging feather is burnt or buried. It is true that, in recent years, scientists have been paying attention to chicken feathers as a row material and trying to develop products with high added value from this inexhaustible material.

Even though the birds' feathers are the first of them to be used as fillers, their roughness, weight, fragility and low elasticity make it impossible to use chicken feathers as quality filling material. In order to overcome these problems, we proposed to utilize the "fibers" as filler material for winter clothes. These fibers are obtained by separating the "barbs" part of chicken feather from the "rachis" part by mechanical cutting.

The fibers obtained from chicken feathers are not as useful as down feathers of water birds in terms of elasticity and structural configuration. However, in response to this, they have a developed micro-porous internal structure. In Figure 2, SEM images of internal and external structure of chicken feather fibers are given by us. According to us, the micro-pored interior of these kinds of fibers as given in Figure 2b should significantly compensate for the low elasticity of these fibers in terms of insulation.

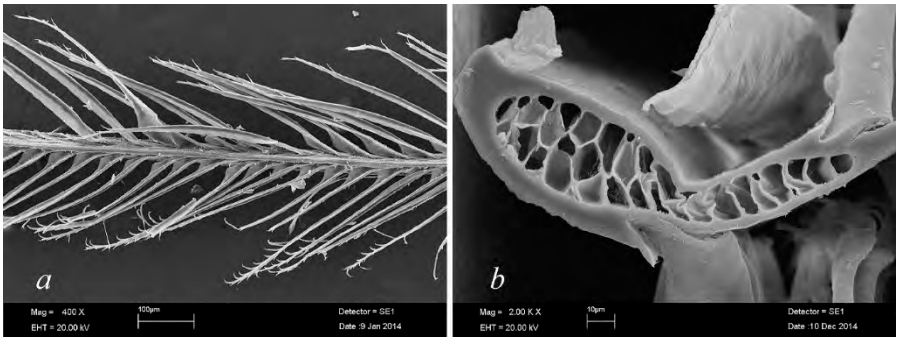


Figure 2. SEM images of external (a) and internal (b) chicken feather fiber [3]

In our unpublished work, a comparative analysis of the thermal properties of chickens, goose down, and some natural and synthetic fillers have been done. Goose down and chicken feather fibers were used as filler material and samples were made of the same size and weight. Measurement results have showed that the thermal conductivity coefficient and specific thermal resistance values of these samples were approximately the same (Figure 3).

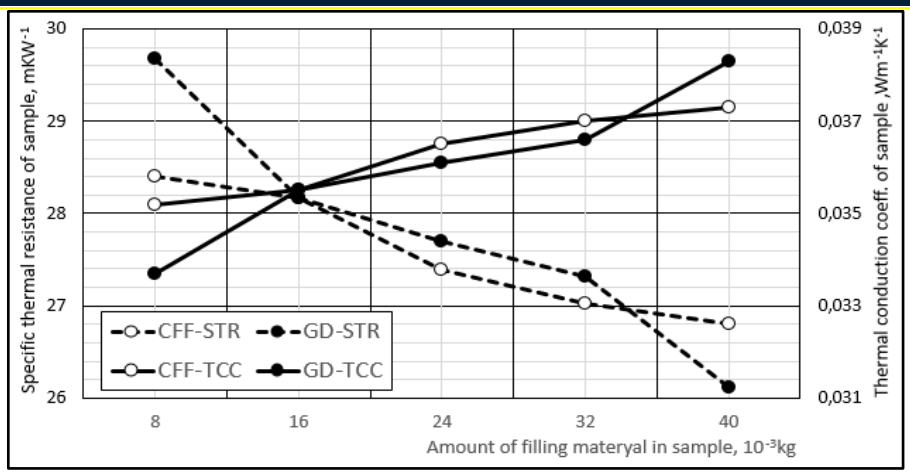


Figure 3. Change of thermal parameters of CFF and GD according to the amount of filler material

In this study, the use of the fiber obtained from chicken feathers as filling material in winter clothes was experimentally performed and the prototype produced product was evaluated by expert method.

2. MATERIALS AND METHODS

2.1. Materials

Two seasonal coats have been made to test the chicken feather fibers as a filling material. Both of the coats have the same medium size and models were produced in the same industrial conditions by one of the leading manufacturers, Maya Textile, in Turkey. On one side, goose feather was used as filling material and on the other side chicken feather fiber was filled (Figure 4).



Figure 4. Experimentally produced coats

2.2. Methods

The expert method was used to evaluate the properties of the product. For this purpose, 10 experts with the same body measurements were selected and they were offered to conduct an active trial of both products at the same climatic conditions for one hour and to evaluate the results.

The following criteria were selected for evaluation:

1. Heat comfort K1
2. Moisture comfort K2
3. Motion freedom K3
4. Weight of product K4
5. Softness K5
6. Body wrap and comfort K6
7. Aesthetic K7
8. Satisfaction K8
9. The price K9

The questionnaire including Table 1 was arranged to determine the weight order of the evaluation criteria. In the questionnaire, it was proposed to rank the evaluation criteria given to each expert according to the degree of importance. The results of these surveys will be used to determine the weight of each criterion in the overall assessment.

Table 1. Table to determine weight order of evaluation criteria

Experts (*j*=1…10)	**Evaluation Criteria K_i (*i*=1…9)**							
	K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_8
1	a_{11}	a_{12}	a_{13}	a_{14}	a_{15}	a_{16}	a_{17}	a_{18}
2	a_{21}	…	…	…	…	…	…	…
...	a_{j1}	…	…	…	…	…	…	a_{ji}

Here, each value of a_{ij} expresses the significance rank determined by the expert *j* for the criterion *i*. The most important criterion is marked with 1, the least important criterion with 9. All values are exact and vary in the range 1 to 9. Separate criteria can be equivalent and at the same time they can be given the same value.

The following formula has been used to calculate the weight of each *i* criterion:

$$A_i = \frac{\sum_1^m a_{ij}}{\sum_1^k \sum_1^m a_{ij}}.$$

In this form, with the weight value given by the expert *j* to the *i* criterion, *aij* is i = 1 ... k, j = 1 ... m,.

In the questionnaire, each expert was asked to make an assessment out of 10 according to the criteria given. The survey results were transferred to the table (Table 2 and Table 3). For each criterion, the arithmetic mean of the expert opinions is taken and the weight coefficient of the criterion is multiplied and divided by the weights of the criteria. Thus, the weighted average for all the criteria is calculated so that the value is the general value given to the product by the experts:

$$\bar{K} = \frac{\sum_{i=1}^k \bar{K}_i A_i}{\sum_1^k A_i}.$$

The compliance score of the expert opinion was evaluated by the concordance correlation coefficient. Kendall W test was applied to the evaluation results. The significance of the concordance correlation coefficient was tested with the *f=k-1* degree of freedom according to the Pirson criterion $\chi 2$.

3. DISCUSSION

Table 2 shows the results of the survey and the processing of the results to determine the evaluation order of expert opinions. In the last row of the table, which is the overall assessment, the weight of the product calculated according to the expert opinion of each evaluation criterion was given.

In Table 3 and Table 4, the evaluation matrices of coats produced from chicken feather fibers and goose down were given.

According to the evaluation results, general evaluation was made for each product based on expert opinions. The overall assessment was calculated based on the average values of the criteria according to experts and

weighted average based on the weights in Table 2. Overall assessment for the coat made from chicken feathers was 8,0 and for the coat made from goose down was 8,7. The compatibility of expert opinions is evaluated by the coefficient of concordance. For this purpose, Kendall W test was applied to the data in Table 3 and Table 4 by using IBM SPSS 25 program. Test results were given in Table 5.

Table 2. Survey results to determine the rank of evaluation

Experts (j=1…10)	Evaluation Criteria K_i (i=1…9)								
	K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_8	K_9
1	1	6	5	7	8	3	2	9	4
2	9	8	7	6	5	1	2	3	4
3	1	7	2	4	3	5	6	8	9
4	1	6	3	2	7	5	4	8	9
5	6	7	3	4	8	2	1	9	5
6	3	9	4	8	7	5	2	6	1
7	7	8	6	9	4	3	1	5	2
8	1	3	2	4	5	7	6	8	9
9	2	7	1	4	9	3	5	8	6
10	4	5	1	8	9	6	2	7	3
$\sum_1^m a_{ij}$	35	66	34	56	65	40	31	71	52
$\sum_1^k \sum_1^m a_{ij}$	450								
$A_j = \frac{\sum_1^m a_{ij}}{\sum_1^k \sum_1^m a_{ij}}$	0,08	0,15	0,08	0,12	0,14	0,09	0,07	0,16	0,12

Table 3. Evaluation matrix of the coat produced from chicken feather fibers

Evaluation Criteria K_i (i=1…9)	**Experts (j=1…10)**										$\bar{K}_i$
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
Heat comfort K_1	8	5	9	9	9	10	9	9	8	8	8,4
Moisture comfort K_2	8	6	10	10	7	7	7	8	8	7	7,8
Motion freedom K_3	10	10	8	10	10	9	10	10	9	9	9,5
Weight of product K_4	10	9	10	8	10	9	10	10	10	9	9,5
Softness K_5	8	7	10	9	10	9	10	10	9	8	9,0
Body wrap and comfort K_6	6	10	9	10	10	8	10	9	9	9	9,0
Aesthetic K_7	5	4	10	10	8	8	9	7	4	8	7,3
Satisfaction K_8	10	5	10	10	10	8	9	9	8	8	8,7
The price K_9	8	8	10	8	9	10	9	9	9	9	8,9

Table 4. Evaluation matrix of the coat produced from goose down

Evaluation Criteria K_i (i=1…9)	**Experts (j=1…10)**										$\bar{K}_i$
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
Heat comfort K_1	10	9	10	10	9	10	9	10	10	9	9,6
Moisture comfort K_2	10	6	10	9	7	7	7	6	9	6	7,7
Motion freedom K_3	7	2	5	8	7	7	9	9	7	6	6,7
Weight of product K_4	9	3	10	9	8	8	10	9	8	8	8,2
Softness K_5	10	5	10	10	8	8	10	10	7	9	8,7
Body wrap and comfort K_6	9	3	8	7	9	8	9	8	7	7	7,5
Aesthetic K_7	8	9	7	10	10	7	9	7	5	8	8,0
Satisfaction K_8	9	10	9	10	8	8	8	9	7	7	8,5
The price K_9	4	4	10	10	7	7	7	8	7	7	7,1

According to the evaluation results, general evaluation was made for each product based on expert opinions. The overall assessment was calculated based on the average values of the criteria according to experts and weighted average based on the weights in Table 2. Overall assessment for the coat made from chicken feathers was 8,0 and for the coat made from goose down was 8,7. The compatibility of expert opinions is evaluated by the coefficient of concordance. For this purpose, Kendall W test was applied to the data in Table 3 and Table 4 by using IBM SPSS 25 program. Test results were given in Table 5.

Table 5. Kendall test results for the evaluation of the coat produced from TTL (a) and goose down (b)

Kendall's W Test *a*

Test Statistics

N			9
Kendall's W[a]			,285
Chi-Square			23,091
df			9
Asymp. Sig.			,006
Monte Carlo Sig.	Sig.		,004[b]
	99% Confidence Interval	Lower Bound	,002
		Upper Bound	,005

a. Kendall's Coefficient of Concordance

b. Based on 10000 sampled tables with starting seed 2000000.

Kendall's W Test *b*

Test Statistics

N			9
Kendall's W[a]			,321
Chi-Square			25,993
df			9
Asymp. Sig.			,002
Monte Carlo Sig.	Sig.		,001[b]
	99% Confidence Interval	Lower Bound	,000
		Upper Bound	,002

a. Kendall's Coefficient of Concordance

b. Based on 10000 sampled tables with starting seed 2000000.

As it is seen on Table 5a, it is χ^2=23,091. The critical value of the distribution of χ^2, which corresponds to confidence level *df = 9* and *P = 0.99*, is 21.67. It can be found on the standard table. 23,091> 21,67 [*df = 6 and P = 0,99*] indicates that the calculated value of the criterion χ^2 is greater than the table value which shows that the expert opinion is compatible. On table 5b, it is χ^2=25,993. 25,993>21,67 [*df*=6 and *P*=0,99] also indicates that the calculated value of the criterion χ^2 is greater than the table value. Accordingly, the conclusion is that the expert opinions are compatible.

4. RESULTS

When we look at the results of the evaluation of coats produced from chicken feather fibers filling material and coats produced from goose down filling material, it is seen that the coat made from chicken feather fibers has a higher score than the goose down in general evaluation. It is observed that goose down coat scores are higher for heat comfort and product aesthetics than the coats produced from chicken feather fibers, humidity comfort and satisfaction of the product scores are close to each other and goose down coats have lower scores for the rest of the evolution.

The compliance of the opinions of the experts was evaluated by the Kendall W test, and it is found compatible.

As can be seen, the fibers obtained from chicken feather are similar to goose down as filler material, but they are more advantageous than goose down in some other indicators, especially in cost indicators.

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