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FIBER PRODUCTION FROM CHICKEN FEATHER WITH INDUSTRIAL METHOD

Purpose. *The aim of the work is to obtain fibers of maximum length when Recycling chicken feathers.*

Methodology. *This study is based on the production of fiber by mechanical cutting of the fibers from chicken feathers. The fibers were produced from chicken feathers at the end of the arrangements on a disperser type machine. In the studies, the method of planning and analysis of the experiment was used.*

Results. *The length of the obtained fibers is between 5-35 mm. Experiments have been carried out to obtained longer fibers based on the operating parameters of the machine. As a result, one-third of the product obtained comprise the fibers which are longer than 15mm. It has been determined that the proportion of moisture contained in the feathers, which is put in the machine, affects the length of the fibers. The results of the experiments showed that the best fiber output is getting when the feathers have 14,66% relative humidity.*

Scientific novelty. *As a result of research, it became possible to obtain fibers from chicken feathers with controlled parameters.*

Practical value. *Natural protein fibers from chicken feathers were produced by the production method.*

Keywords: *chicken feather, chicken feather fibers, production of chicken feather fibers.*

Introduction. Among the downs in industry, the just important thing is pile obtained from the certain part of water bird’s body. These feathers which have high thermal insulation properties and highly soft and elastic are used as filling material at bedding products and winter clothes. In fact, chickens are number one among domestic animals in the world in terms in terms of number [1]. Every year in the world, about 15 million tones are appeared as by-products in the production of white meat [2]. At least one third of this amount is waste without using [3]. This material, which is extremely power-reduced in nature, is buried or burned into fertilizer and this situation causes serious damage to the environment [4].

There are not too facilities in terms of using the chicken feathers with their current form. There are a few reasons. These feathers are chosen because of they are more fragile, have low elasticity, have no pile or very few and havier than goose and duck feathers used commonly as a filler material. All of this makes it unfavorable to use chicken feather as filling material. The fibrous material which is named “chicken feather fibers” is more universal in terms of using and obtained by separation of barbucels from barbs. Accordingly, obtaining the fiber from chicken feathers has attracted the attention of scientists in recent years.

In recent years, research has revealed that chicken feather fibers have many important properties. Beyond anything, these fibers are the lightest among known natural and artificial fibers, with a specific gravity of about 0,8g/cm³ [5,6]. Keratin content of chicken feather fibers is 91% [7]-[9]. Some of the amino acids in the keratin-based proteins have hydrophobic, some have hydrophilic, and the proportion of them in chicken feathers is 60:40 [8]. Thanks to this unique structure, the chicken feather fibers are hydrophobic as well as hydrophilic. The amino acids in the raw material, which consist essence of the chicken feathers, have the ability to absorb moisture even from cool air.

Although it is stated in literature that the length of chicken feather fibers is 3-13mm [10], this value can be up to 4,5cm [6]. The fibers have microporous internal structure with a shape of feather [11]. This feature gives very important properties to the fibers. The reaoson why the length of the chicken feather fibers varies over a wide range is not just the feathers vary in size. The feathers taken from body region of the same chicken are different from one another in terms of length. Economically, chicken feather fibers are extremely have low cost (approximately $0.001/kg), from point of ecologically and accessible they are a renewed natural protein materials.

Accordingly, research has revealed that chicken feather fibers have crucial properties, but todays industrial method of fiber production has not developed. The technology of fiber production from chicken feather with industrial method has being developed at Department of Textile Engineering of Erciyes University.

It is desirable that to utulize from the feathers in different areas of the textile, many long fibers in fiber mass are wanted as possible as. However, mechanical parts of the machine can cause the breaking for fibers during the fiber production.

Objectives. This study is about the selecting the machine’s operating parameters to obtaine maximum amount of long fiber output in the fiber production.

Material and method. The base of the production of fiber from chicken feathers is the removal and separation of the barbucels from barbs with mechanical methods. This process is done with special machine. This machine provides to cut off the fibrous structure of feather from rachis. Depending on the operating parameters of the machine, separated length of fibers varies. In this study, it is aimed to obtain the longest fibers output and multifactorial experiment was carried out for this purpose.

The operating parameters of the machine are the speed of dispergator rotation, density of the air flow which is transport the fibers and the percentage of load of the machine. From this parameters, the speed of dispergator rotation is controlled by the rotation frequency of the machine rotor and the density of the air flow is controlled by special valve. So instead of this parameters, the rotation frequency of the machine motor and the rotation angle of the air valve were took in to account.

To produce sufficiently long and high quality fibers, preliminary experiments have been carried out with machine operating parameters. When examine the preliminary studies, we could not obtain fibers in all study regimens. In other words, there were more or less rachis in fibers mass and were uncut feathers in some regimens.

In this case, the direction of the preliminary experiments was changed, it was found out that which parameters are available to obtain clean fiber mass. For this purpose, single independent experiment was performed. In these experiments, a series of experiments serve to obtain clean fiber mass for each individual variant by keeping the other independent variables is constant and,new change intervals for the working parameters of machine have been determined in order to obtain clean fiber mass. At the end of this experiment series, the determined change intervals are given in Table 1 for machine parameters. The actual variation ranges of the working parameters of the fiber production machine are given at same table.

According to the parameters in Table 1, the length of the fibers obtained from chicken feathers is between 5…35mm. The majority of the fibers have a length of 5…15mm.

A multi-factorial experiment has planned to obtain a clean fiber mass which contains the longer fibers from fiber production machine. In these experiments, the machine speed was accepted in terms of operating parameters and the change intervals of these parameters were accepted the change parameters which serves the obtain cleans fibers mass (Table 2).

Table 1.

Working parameters and variation intervals of the fiber production machine

Experiment factors	**The actual change interval of the machine's operating parameters**	**Change intervals allowed the machine's operating parameters to obtain clean fiber mass**
Rotation frequency of rotor rotation,Hz	0…90	50…90
The angle of rotation of valve, grad	0…90	10…40
The load percentage of machine , %	0…100	20…80

Table 2.

Experiment factors, change intervals and levels

Experiment Factors	**Sign**	**Change interval of factors**	**The levels of factor**		
			-1	**0**	**+1**
Rotation frequency of rotor rotation, Hz	X_1	50…90	50	75	90
The angle of rotation of valve, grad	X_2	10…40	10	25	40
The load percentage of machine , %	X_3	20…80	20	50	80

As an optimization criterion, output parameter has chosen the fibers which has a length greater than 15mm. To determine this parameter, fibers were produced from 0,5kg feather in different working regimes of the machine according to designed experiment plans and placed in sample bags. At the next stage, 2gr of fibers was randomly taken from the middle of the sample bag, and fibers were counted and divided in to 2 groups up to 15mm and greater than 15mm according to the length of fibers. The total number of fibers longer than 15mm in ration of total fiber count have regarded as the output parameter as the ration of the long fibers.

$$Y\{Ratio\ of\ lonf\ fibers\} = \frac{Long\ fiber\ count}{Total\ fiber\ count}$$

Based on these parameters, three-factor experimental design which is 2. grade was designed based on the Box-Behnken plan in the Design –Expert program. The experiment design plan with coded values of the factors is given in Table III. The fibers obtained from chicken feathers and the separated rachis breaks are displayed in Fig 1.

Fig. 1. **Fibers which were obtained from chicken feathers (left) and separated rachis (right)**

Preliminary investigations have shown that the moisture of feathers, which is put in the fiber production machine, affect the length of the fibers. A number of experiments have been carried out in order to ascertain whether the wetness of the feathers may affect the fibers in terms of the length of the fibers. After washing, feathers were dried for 10, 15, 20, 25 minutes in the drying machine and 3gr samples were taken from the dried feathers and kept in the oven at 105ºC for 2 hours, then weighed and determined the amount of water in it's structure. After taking the 250gr feathers from drying machine, fibers were produced according to the determined in the previous experiment parameters and the ratio of long fibers as above was determined in the produced fiber mass. After taking 3gr fiber from the fiber mass, the moisture content was determined.

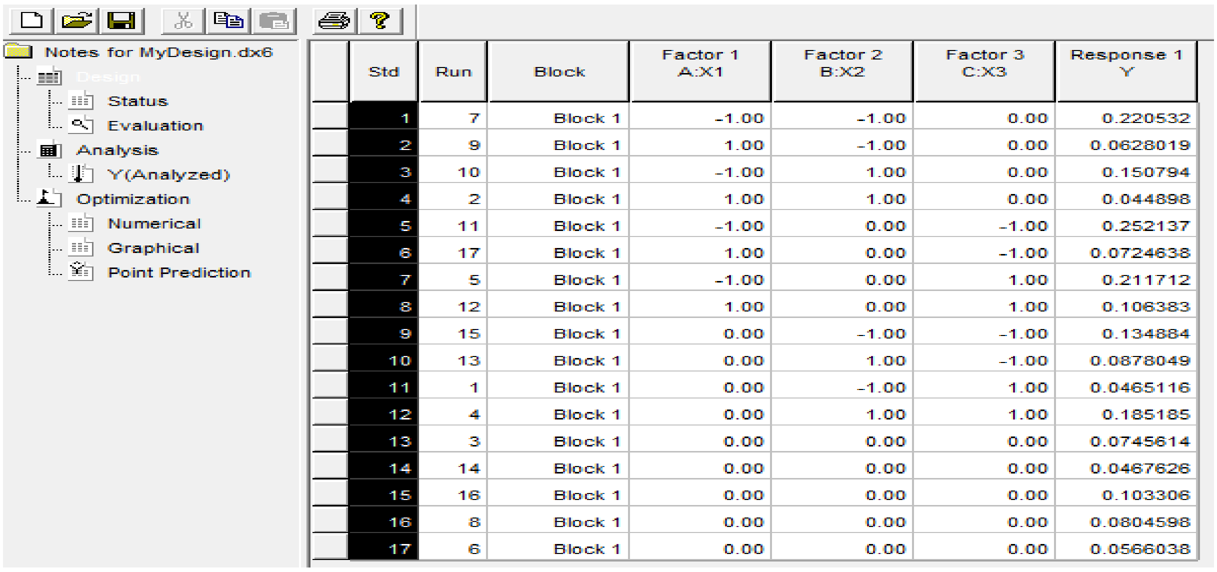
Research results. Experiments were performed according to the randomized Box- Behnken test plan and results were written to the table in the Design-Expert program (Table III). According to the results of analysis the test results, a model is taken as follows:

$$Y = 0,072 - 0,069*X_1 + 0,0004*X_2 + 0,0003*X_3 + 0,047*(X_1\text{^}2) + 0,0002*(X_2\text{^}2) + 0,041*(X_3\text{^}2) + 0,013*X_1*X_2 + 0,019*X_1*X_3 + 0,046*X_2*X_3$$

Current model was tested according to the Fisher criteria and found that it is significant with 95 %. R2:0,91 was taken and it means that selected factors adequately explain the output parameter. The current model has the maximum value at the given point in Table IV. In other words, the ratio of long fibers in the taken fiber mass in these operating parameters of the machine must be maximum with theoretically 95% probability.

Table 3.

Test Results



Std	Run	Block	Factor 1 A:X1	Factor 2 B:X2	Factor 3 C:X3	Response 1 Y
1	7	Block 1	-1.00	-1.00	0.00	0.220532
2	9	Block 1	1.00	-1.00	0.00	0.0628019
3	10	Block 1	-1.00	1.00	0.00	0.150794
4	2	Block 1	1.00	1.00	0.00	0.044898
5	11	Block 1	-1.00	0.00	-1.00	0.252137
6	17	Block 1	1.00	0.00	-1.00	0.0724638
7	5	Block 1	-1.00	0.00	1.00	0.211712
8	12	Block 1	1.00	0.00	1.00	0.106383
9	15	Block 1	0.00	-1.00	-1.00	0.134884
10	13	Block 1	0.00	1.00	-1.00	0.0878049
11	1	Block 1	0.00	-1.00	1.00	0.0465116
12	4	Block 1	0.00	1.00	1.00	0.185185
13	3	Block 1	0.00	0.00	0.00	0.0745614
14	14	Block 1	0.00	0.00	0.00	0.0467626
15	16	Block 1	0.00	0.00	0.00	0.103306
16	8	Block 1	0.00	0.00	0.00	0.0804598
17	6	Block 1	0.00	0.00	0.00	0.0566038

At the best theoretical working parameters in terms of long fiber production of machine, a batch fiber was produced and the proportion of long fibers in the current fiber mass was calculated. The result has written in Table 4.

Table 4.

The best operating parameters of the machine

	Factors			**$\bar{Y}$ – Theoretical value of the output parameter**	***Y* – Experimental value of the output parameter**
	X_1	**X_2**	**X_3**		
For coded values	-0,95	-0,89	-0,98	0,286	0,281
For natural coded	51,2	11,7	20,6		

After washing, the amount of remaining moisture of feathers, which were dried in drying machine for 10, 15, 20, 25 minutes, was determined and written to Table 5. It is shown that in Table 5, the ratio of fibers which are longer than 15mm and the variation range of the fiber length. Moisture content of the samples from taken produced fibers is shown that about approximately 6,7% in all cases. It is understood that, after the fibers are separated, they continue to dry until they reach the exit point in the air stream.

Table 5.

Length parameters of fibers obtained from feathers which have a different moisture content

Drying time in drying machine, minute	**Humidity ration of feathers coming out of the dryer, %**	**Change in the range of fiber length, mm**	**The ration of long fibers in fiber mass, %**
10	22,0	5…35	14
15	14,7	5…35	21
20	8,0	5…25	17
25	6,0	5…25	10

As can be seen from Table V, after decreasing the moisture content of the feathers, the long fiber ratio in the fiber mass is decreasing at first time and then decreasing. When the moisture content in the fibers is higher than 15%, reduce the long fiber output. At 14,4% humidity ration, approximately 20% of the fiber mass forms long fibers. Because of the decreasing the moisture content in the fibers, the fibers increased the theirs's fragility and the long fiber output is getting decreasing. The relationship between the moisture content of fibers mass(x) and the ratio of the long fibers(Y) at the fiber exit was found to be as follows: $Y=-8{,}989+4{,}199x-0{,}144x2$

This linkage was found to be significant with a 0,95 probability and R2:0,94. The model has a maximum at x :14,58. In other words, when the moisture content of fibers is 14,58%, the ration of the long fibers at the fiber output should be maximum, it should be namely $\bar{Y}$ = 22,66.

Conclusions. The study is about fiber production from chicken feathers. Experiments have been carried out to produce useful fibers from chicken feather fibers for textile on a dispersing machine. Machine operating parameters have been determined to allow the maximum proportion of long fibers in fibers. During studies, it was found that the moisture content of fibers had affected the proportion of long fibers at the fiber output. It has been found that a mathematical model between the moisture of fibers and proportion of long fibers at the fiber output, the longest fibers were obtained when the feathers had a moisture content of 14,58%.

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ПРОИЗВОДСТВО ВОЛОКНА ИЗ КУРИНОГО ПЕРА ПРОМЫШЛЕННЫМ МЕТОДОМ

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Цель. *Целью работы является получение волокон максимальной длины при переработке куриных перьев.*

Методика. *Это исследование основано на производстве волокна путем механической резки волокон из куриных перьев. Волокна были получены из куриных перьев в конце компоновки на машине диспергатора. В исследованиях использовался метод планирования и анализа эксперимента.*

Результаты. *Длина полученных волокон составляет от 5 до 35 мм. Были проведены эксперименты с получением более длинных волокон на основе рабочих параметров машины. В результате одна треть полученного продукта содержит волокна длиной более 15 мм. Было определено, что доля влаги, содержащейся в перьях, которые помещаются в машину, влияет на длину волокон. Результаты экспериментов показали, что лучшая выходная мощность волокна возрастает, когда перья имеют относительную влажность 14,66%.*

Научная новизна. *В результате исследований стало возможным получать волокна из куриных перьев с контролируемыми параметрами.*

Практическая значимость. *Производственным методом были получены натуральные белковые волокна из куриных перьев.*

Ключевые слова: *Куриное перо, волокна из куриного пера, производство волокон из куриного пера.*

ВИРОБНИЦТВО ВОЛОКНА З КУРЯЧОГО ПЕРА ПРОМИСЛОВИМ МЕТОДОМ

НАЗИМ ПАШАЕВ

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Мета *роботи полягає в отриманні волокон максимальної довжини при переробці курячого пір'я.*

Методика. *Дане дослідження засноване на виробництві волокна шляхом механічного різання волокон з курячого пір'я. Волокна були отримані з курячого пір'я в кінці компонування на машині диспергатора. У дослідженнях використовувався метод планування і аналізу експерименту.*

Результати. *Довжина отриманих волокон становить від 5 до 35 мм. Були проведені експерименти з отриманням більш довгих волокон на основі робочих параметрів машини. В результаті одна третина витраченого продукту містить волокна довжиною більше 15 мм. Було визначено, що частка вологи, що міститься в пір'ї, які поміщаються в машину, впливає на довжину волокон. Результати експериментів показали, що найкраща вихідна потужність волокна зростає, коли пір'я мають відносну вологість 14,66%.*

Наукова новизна. *В результаті досліджень стало можливим отримувати волокна з курячого пір'я з контрольованими параметрами.*

Практична значимість. *Виробничим методом були отримані натуральні білкові волокна з курячого пір'я.*

Ключові слова: *Куряче перо, волокна з курячого пір’я, виробництво волокна з курячого пір’я.*