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# The Design and Development of Machine for Producing the Natural Dental Floss

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## Abstract

The aims of this research were to design and develop a machine for producing high quality of natural dental floss. Experimental results indicated that appreciate coating was the mixture of coconut oil and beeswax of 2:1. Coating and drying temperature were 80 and 50 degree Celsius, respectively. Mechanical properties of dental floss made in this research were not different from dental floss sale on the market. By analysis of the mechanical property together with user satisfaction, it can be concluded that triple twisted type was a best size of silk thread used to produce natural floss. Moreover, it not found any microorganisms growth in dental floss from microbial testing.

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*Keywords:* dental floss; coating; rolling; mechanical property

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## 1. Introduction

Thailand has been producing and exporting high quality products of silk such as silk fabric, silk thread, and cocoon extract compound etc. for a long time. In 2012, export value of silk products was up to 670 million baht [19]. Products, especially those made of Thai silk are accepting as high quality goods. This is arising from their beautiful, unique and remarkable features. Thai silk thread possesses the toughness, softness and shine. Tensile strength of silk thread is an average of about 7.45 Newton [7]. From study elongation research of silk thread, it was found that the elongation was about 18-23% comparing with original length [7, 8].

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Dental floss is a very effective tool for cleaning teeth. A New Orleans dentist who invented dental floss names Levi Spear Parmly [6, 17]. Dental floss looks like yarn and normally made of poly-ethylene. Dental floss can be inserted into the corner teeth to remove food debris and plaque on teeth niche. Even though dental floss is the efficiency tool for clean teeth but Thai people in rural areas still not using dental floss. Many people in rural areas generally had trouble in their mouth, for example dental calculus, dental caries and tooth remove before reasonable age [6, 19]. All material used to produce dental floss was only imported from aboard; dental floss price was then expensive. Moreover, value of import in each year was very high. If material used to produce dental floss can make in Thailand, their price will possibly cheaper. More people in rural areas may use dental floss to clean their teeth and they probably have better dental health.

From dental problems of rural people and properties in tensile strength and the softness of silk thread, the researcher then had an idea to apply silk thread for producing dental floss. For obtain the dental floss with good quality, the study factors involved with dental floss production are needed[19]. These factors consist of suitable silk race, size of silk thread, mixture of coating etc. Moreover, machine for produce dental silk floss will designed. Machine is composed of three mains parts; coating, drying and storing by rolling. Finally, dental silk floss is then packed in dental floss boxes for sale. If this research is successful, the value of silk thread will increase with privatization, import and order of materials for dental floss and dental floss made from abroad can be reduced. And it can support the floss using in the community. Therefore, the rural people have better oral health. In the past, researcher developed machines for floss produce. There were two models “Takasila 01” and “Takasila 02”. The troubles of the first model (named Takasila 01) were size, transmission system and dental floss quality [14]. Size of Takasila 01 was too large and its transmission system was complicating to adjust speed of rolling part. Tractor gear set, which was heavy and large mechanism, was applied to use in the transmission system. Moreover, the quality of floss produced from Takasila 01 was low quality due to roll process. The fitful coating happened in the roll process thus floss had high humidity and smell rancid [6].

From problems of the “Takasila 01”, researcher has developed the second machine (named Takasila 02) by reducing size, modifying the transmission system, increasing the distance between the coating part and winder. In addition, roll head can be adjusted, and fan set was installed between process of coating and rolling. However, the problems of the “Takasila02” were cleanliness during working. Also the humidity of floss remained high. Hence, silk floss smelled rancid [14].

As it was mentioned above, this research aims to determine the appropriate parameters for the floss production, which included silk races, size of silk thread and mixture of coatings. In addition, a machine producing dental floss was also developed and built. In this research, the quality of dental floss was assessed by measuring the mechanical properties and the satisfaction of the sampling user[13].

## **2. Materials and method**

The dental floss properties normally consisted of the physical properties and quality properties. All physical property was found from standard method, which was followed from past research [1,3,4]. The physical properties mean size, tension, percentage of elongation. The unit of size was presented in deniers [10, 11]. And inoculation method was selected to detect microorganism in dental floss. The detail of inoculation was written in the book of Micro biology [9].

To finding quality properties in dental floss can accomplished by evaluation and analysis the user satisfaction with various products of dental floss. The target audience is people who regularly floss their teeth. Total number of estimation was 100. Questionnaires were heading for the quality of dental floss in the uniformity, smoothness, smell, and overall usability.

### *2.1. Study of the appropriate condition of coating*

The appropriate condition of coating was study by finding the mixture of suitable coatings and coating temperature. The successful coating process gave smooth and silky floss [2,15]. Mixture of coating was significant related to the floss quality. Coatings were made from bee wax mixed with oil which were coconut oil, sunflower oil

and barn oil, in different ratio. There were 1:1, 1:2 and 2:1 of bee wax mixed with oil. All floss was coated by various mixtures at temperature 70, 80, and 90 degree Celsius, respectively. In this research “Nang Noi” silk race was selected to produce dental floss. This was because of results from experiments in the past research. Floss that made from four silk races were compared their mechanical properties, adsorption, and the smoothness. The results shown “Nang Noi” was the best silk race for producing dental floss [6, 14]. From research on drying and yarns size it was found that drying method proportionally affected to yarn size [4,12]. Hence, after coating process, floss then dried at 50 degree Celsius for one hour [6]. Next, various floss were compared from color, smell, silkiness and smoothness by analysis of user satisfaction. Mechanical properties such as tension, elongation of floss also find and compared with the floss sale in general market.

## *2.2. Study of the proper rolling process*

Successful rolling process will provide dental floss which was smooth, flat and regularity coating. From theory of rolling, it wrote that speed of floss passed through roll heads should be constant speed [12]. And this speed also resulted to the tensile of floss. For the experiment done to find the most suitable rolling conditions, all type of silk twisted were used. The spindle speed was subsequently adjusted of 6.3, 12.5, 19, 22, and 25 meter per minute. Next, the tension value was examined and compared to find the best deals. In addition, twisting type of silk thread was besides studied. Size of thread was very important since appropriate size could provide high performance in order to clean teeth. Moreover, user will get more comfortably feel. The different thread of twisting incurred different thread size. In the experiments, single double and triple twisting were compared to find the suitable twisting.

## *2.3. Design machine producing dental floss*

Production process of dental floss consists of dipping the silk thread in coatings, roll floss which already coated to seep coating inside to floss, drying floss, and storing floss at the spindle. Others than production process, the conditions of the machine operation must considered to design machine, such as production rates, temperature of the coating and drying temperature [5,6,13]. Design conditions of machine used to produce dental floss were related with the floss quality. Floss with high quality should be toughness and coating uniformly throughout the fiber length. Six conditions of machine design can be written by the following; production rate of dental floss was 500 meters per hour. This was obtained from calculation the investment and breakeven point of floss production. It was found that production rate should be 10 boxes per hour. And a length of floss in one box was about 50 meters. Next, Boiler contained coating could adjust the temperature from 0 to 100 degrees Celsius. Due to floss is the category of medical devices thus beyond condition was machine must had accessories for disinfection installed inside it. Next, temperature in oven could be set up to 50 degrees Celsius in order to reduce moisture in floss after coated [10]. And for rolling and coating process, spindle speed could be adjusted from 0 to 400 cycles per minute. For the last condition, silk thread used to produce floss was “Nang Noi” variety twisted in single double and triple lines.

From working conditions and production procedures, machine used to produce dental floss can be designed as shown in Fig. 1. From Fig. 1 the details of machine can be described by following; machine structure was made of a steel box. Machine’s overall size of about 1 m long, 1.5 m wide and 1.5 m high, all wall sheets were padded with stainless steel. Machine was divided into two parts. The first part consisted of boiler contained coating and beam of rolling and rolling heads. The second part was drying and storing dental floss, it included a dental floss spindle, light bulbs, and cores for storing floss. The acrylic sheet was used to cover machine for avoiding the contamination. After machine is completely constructed, the performance test of machine will find.

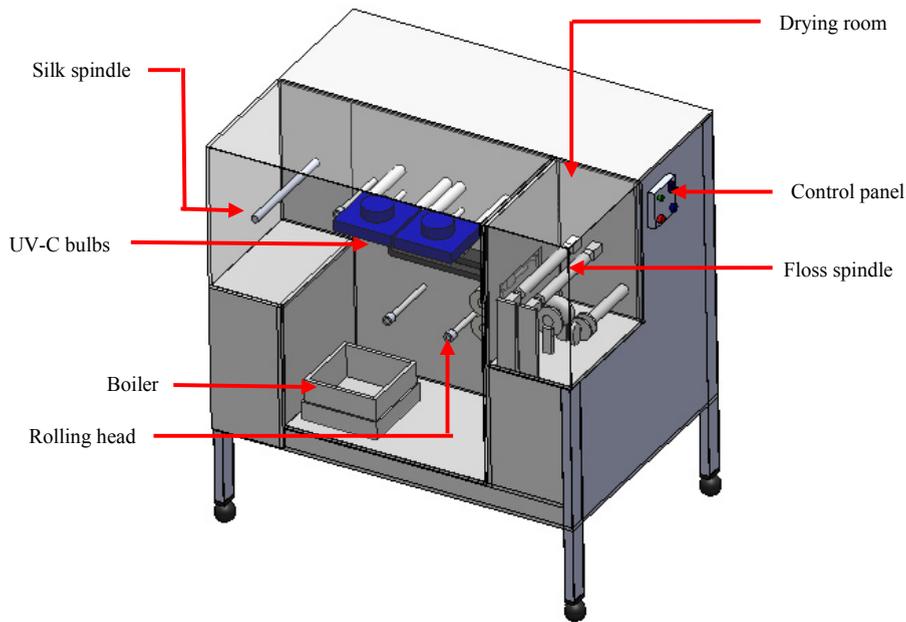


Fig. 1. Drawing of machine used to produce dental floss.

### 3. Results and discussion

#### 3.1. Experimental result for finding the coating ratio of dental floss

In the experiments, coatings were prepared by mixing beeswax with various oil such as rice bran oil, coconut oil and sunflower oil in the ratio of 1:1, 2:1 and 1:2 respectively. Silk thread samples were coated by dip coating method with a temperature of 70, 80, and 90 degrees Celsius. Therefore, 27 samples of silk thread coating were acquired. The proper ratio of coating mixture was found by analysis the user satisfaction together with mechanical properties. Table 1 shows a summary of the best samples (5 samples) based on user satisfaction rating. The questionnaires composed satisfy of color, smell and silkiness. Mechanical properties of all five samples have been shown in Table 1. In the last row of Table 1, dental floss sale in general market were besides evaluated the satisfaction and tested the mechanical properties to compare with floss made from this research. From Table1, it can be described that mechanical properties of all dental floss made in this research were not different from dental floss sale on the market. And user satisfied dental floss which coating by mixture from coconut oil mixed with beeswax in the ratio 2:1 at temperature 80 degree Celsius.

#### 3.2. Result of study proper rolling process

All floss sample was coated by a coating of wax mixed with coconut oil (ratio of 1:2). Floss was rolled and set to move along the rolling the balls with velocity of 6.3, 12.5, 19, 22 and 25 meter per minute. In the experiments, single double and triple twisting were compared to find the suitable twisting. The results of rolling were presented in Table 2. From Table 2, it can be mentioned that, Elongation was reduced when speed of the silk was increased. At speed of 6.3 meters per minute, all type of twisting had largest size. For tension testing, to obtain the maximum tension in floss, floss twisted in single line should be roll at speed 6.3 meters per minute, in the same time, floss which twisted in double and triple lines must simultaneously roll at 12.5 meters per minute. By analysis of the

mechanical properties in comparison with dental floss on the market, it can be concluded that optimal factors in producing dental floss was to use a triple silk twisted with rolling speed of 12.5 meters per minute.

Table 1. The satisfaction and the mechanical properties of silk samples.

Coating Mixture and ratio	Coating Temp (°C)	User satisfaction ( Full marks =20)			Mechanical Properties			User satisfaction in overall image (%)
		Smell	Color	Silkiness	Size	Tension	Elongation	
					(Deniers)	(g)	(%)	
Beeswax : Coconut oil (1:2)	80	16.13	19	18	549.54	1571	28.8	81.71
Beeswax : Coconut oil (1:2)	90	15.70	16	18	549.36	1566	28.5	77.31
Beeswax : Coconut oil (1:2)	70	15.60	18	18	540.54	1543	28.3	72.45
Beeswax : Coconut oil (2:1)	80	15.17	14	17	540.78	1488	27.5	71.08
Beeswax : Coconut oil (1:1)	80	15.20	17	17	540.58	1498	27.3	69.55
Dental floss sale in general market		16.79	20	20	548.46	1617	29	82.68

Table 2. Mechanical properties of various rolling speed .

Floss speed (m/min)	Twisting type	Size (Deniers)	Tension (g)	Elongation (%)
6.3	1	203.04	650	19.3
	2	412.74	1103.03	22.7
	3	594.54	1486.7	27.5
12.5	1	198.00	646.7	18.2
	2	416.34	1113.0	23.5
	3	586.8	1596.0	28.5
19	1	193.2	583.3	17.5
	2	413.28	1093.0	22.0
	3	586.44	1513.0	27.0
22	1	181.7	486.2	16.2
	2	411.8	1083.6	21.0
	3	583.5	1433.6	26.0
25	1	180.4	556.2	15.2
	2	409.3	1030.9	20.4
	3	509.6	1476.6	25.0
Dental Floss sale in market		563.10	1590	29

### 3.3. Result of the creation and development of machinery

Machine for the production of natural floss were performed by the model shown in Fig.1. Procurement of equipment was regarded to the conditions as mentioned in Section 2.3 Machine which was completed construction

are shown in Figure 2. Fig.3a shows the equipment in coating and rolling section whereas Fig.3b shows equipment in drying section.

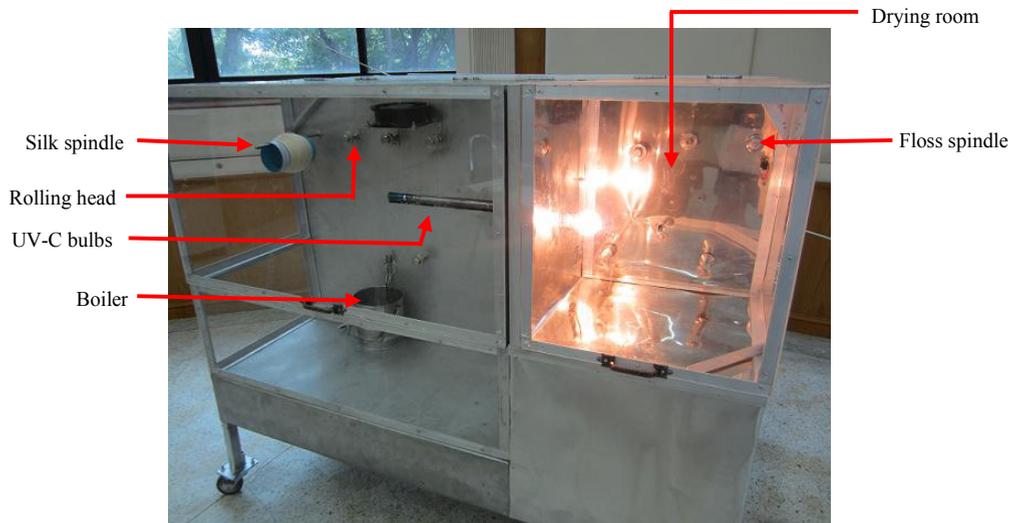


Fig. 2. Machine for natural floss manufacturing.

In machinery building, performance test of machine is generally required. In this research, machine was also tested to find its performance. Procedures and testing systems are as follows. Firstly, heating system in boiler, which contained coating, was tested by measuring the temperature of coating within the boiler. Measured value was then compared with the default settings [15]. Secondly, speed of spindle was examined by determining the length of the thread stored in the rolling head within the setting time. Thirdly, drying system was tested and calculated the accuracy by measuring temperature inside a drying room. From operating follow procedures as mentioned, the results pointed that machine build in this research had high performance for producing natural floss.

To compare machine developed in this research with others machine “Takasila 01” and “Takasila 02”, it can be said that machine of this research could solve troubles of the first machine “Takasila 01” about the transmission system. Transmission system of this machine was not complicating to adjust speed of rolling part. Moreover, the quality of floss produced in this research was higher than floss produced from both machines, in humidity and smell and cleanliness during working.

#### 3.4. Test result for microbial in floss

This testing was conducted by incubating dental floss made from a research in the PCA agar at 37 ° C for 24 hours [9]. The results of the test showed that none of microorganisms growth in dental floss.

#### 4. Conclusion

Machine for producing high quality of natural floss was completely designed and developed. From operations research, the researcher additionally informed the optimal conditions for coating natural floss and rolling. These obtained from analysis of user satisfaction and mechanical properties. From testing the cleanliness of productivity, it was shown that natural floss free from microorganisms. For future plan of research, researcher will be find process for adding flavor smells to floss and design an automatic machine for packaging floss into package box.

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