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A Design and Development of Cattail-Inspired Handbags

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Abstract

Purpose: The purpose of this study is to examine the process of producing cattail fibers and bags, drawing inspiration from the characteristics of cattails through the utilization of traditional local handicraft techniques. The primary objectives of the study encompassed three key areas: first, to experiment with various handicraft techniques in order to produce fiber sheets derived from cattail plants; second, to develop and fabricate prototypes of handicrafts utilizing cattail fibers; and finally, to evaluate the level of consumer satisfaction associated with handicrafts inspired by cattail plants.

Theoretical framework: This study followed a constructed theoretical framework of material development and design. This framework encompasses four significant design processes, namely: 1) material selection of cattail plants; 2) experimentation and development from fibers to sheets; 3) prototype design and development; and 4) customer satisfaction evaluation.

Design/methodology/approach: The research methodology utilized in this study was a mixed-methods approach. The investigation commenced by conducting a thorough examination of the characteristics of cattails through document analysis. An investigation was undertaken to gather experimental materials by conducting a field survey of cattail plant resources. Subsequently, the researcher engaged in a collaborative effort with individuals from the local community to undertake experimental endeavors aimed at the development of cattail fibers. This involved the design and production of prototypes for handicrafts, specifically inspired by the properties of cattail fibers, with a focus on bags. Finally, an evaluation was conducted to gauge the level of customer satisfaction with the recently developed prototypes.

Findings: Initially, the study focused on investigating the efficacy of manual handicraft techniques in the production of fiber sheets derived from cattail plants. Furthermore, the design and manufacturing procedures effectively yielded prototypes of handicrafts inspired by the cattail plant. Finally, the prototypes received a high level of satisfaction from potential buyers. The clients expressed a high level of satisfaction with various aspects of the items, including their function and usage, materials, aesthetics, and shape and structure. Specifically, the mean rating for materials was 4.38 with a standard deviation of 0.60, the mean rating for aesthetics was 4.30 with a standard deviation of 0.69, and the mean rating for form and structure was 4.23 with a standard deviation of 0.72. Nevertheless, the manufacturers were required to enhance the level of care and maintenance, as indicated by a mean score of 3.13 with a standard deviation of 0.69.

Research, practical and social implications: For the research implications, the findings of this study offer a practical approach for utilizing cattails. This methodology has the potential to be utilized for various different categories of plant fiber source materials. For the practical and social implications, the customer satisfaction evaluation of the cattail-inspired handbag quality indicated a high level in function and usage, materials, aesthetics, form, and structure, and a moderate level in care and maintenance. Future studies should direct their attention toward the improvement of care and maintenance.

Originality/value: The significance of this study is in the exploration of the untapped potential of cattails, previously regarded as waste material, in the creation of environmentally sustainable bags inspired by local

cattail resources. These bags not only contribute to the mitigation of environmental issues but also serve as a means to augment the income of the local population.

Keywords: cattail-inspired handbags, eco-friendly handicrafts, product development, and design

1. Introduction

Cattails are distinctive wetland plants that have been found throughout the world over the past several decades. The global distribution and abundance of cattail are increasing as a result of disturbing human natural water cycles and increasing nutrient availability. This is partly because cattail invasion often changes wetlands in an undesirable way. Wetland managers often respond with extensive management efforts. Despite the negative effects, the cattails provide beneficial ecosystem services. This includes reducing pollution through bioremediation and the production of biofuel materials. Numerous scholars in various areas have investigated how to make use of cattails.

2. Literature Review

In the global context, the majority of the prior research studies on the design and development of cattail fiber products are primarily based on science and partly on the social sciences. The studies involve these areas: applied energy, chemistry, biology, technology, material science, environmental science, evaluation of the efficacy of cattail, agriculture and natural resources, and management. Below are examples of each area.

2.1 Prior studies on the use of cattails for applied energy

Studies have been done on applied energy, such as the effects of microwave pretreatment on the anaerobic digestion of cattails by rumen microbes, how the breakdown of the crystalline and physical structure of cattail caused by microwave irradiation pretreatment improved its anaerobic digestibility (Hu et al., 2012), and the performance of wooden and clay-plastered structures in hot environments (Liblik & Just, 2016).

2.2 Prior studies on the use of cattails for chemistry

Cattail wool is used to create hierarchical porous carbon, which has a straightforward synthesis and strong capacitive performance. Several studies propose ways to increase performance. In the study of electroanalytical chemistry, Yang et al. (2021) proposed a straightforward, inexpensive, and highly effective approach for producing porous carbon materials, which have the potential to be used in cutting-edge energy storage and conversion devices. Zhang et al. (2019) suggested cat-tail-shaped mesostructured silica fibers with gold nanowires on them because of how they are made, what they can do, and how they can be used as stretchable sensors. Han et al. (2019) proposed an efficient hydrogen evolution reaction catalyst made of carbon extracted from natural cattail fiber. Yu et al. (2017) created a practical and affordable technique for producing porous carbon from cattail biomass, which is a promising substance with potential for use in a variety of applications. The generated activated carbon may be a potential candidate for an adsorbent and supercapacitor based on its superior adsorption capabilities and electrochemical performance. Other examples deal with effective hydrogen evolution reaction catalysts made from natural cattail fiber (Han et al., 2019) and carbon from cattail fibers that is catalytically active for electrochemical reduction reactions, with a focus on novel connections between renewable energy use, biomass conversion, and environmental benefit (Liu et al., 2019).

2.3 Prior studies on the use of cattails for biology

Biomedical applications and biological macromolecules have been studied in this area. For example, Banik (2022) suggested that certain properties of cattail fiber could be used in biomedical applications. Wu et al. (2021) found that cellulose could be successfully extracted from natural plant fibers, or CFs; that a chemical extraction process could increase CFs' cellulose content (89.72%); that a new type of adsorbent, called ZCCA, could be made; and that the resulting ZCCA had a three-dimensional network structure with ZIF-8 loading reaching 37 wt%.

2.4 Prior studies on the use of cattails for technology

Response surface methodology with a central composite design is used in science and technology for research in this area. For example, the study by Ruangmee and Sangwichien (2013) aims to improve alkali pretreatment of narrow-leaf cattail (Typha angustifolia) using this method. The model was determined to be significant and was capable of correctly predicting the strength response with less than 5% error. The sample's desired cellulosic content rose from 38.5 to 68.3% under this combined optimum condition, while its undesirable hemicellulosic percentage dropped from 37.6 to 7.3%. Another study deals with bioresource technology. Hu et al. (2006) suggest that a response surface approach be used to find the best way to improve cattail acidogenesis in rumen cultures. The results suggested that acidogenesis utilizing rumen cultures is a viable technique for getting rid of cattails. The last example is environmental technology. Cao et al. (2018) structured the cattail fiber assembly's cyclic filtering characteristic for removing oils from wastewater.

2.5 Prior studies on the use of cattails for material science

Due to the cattail's exceptional physical and insulating qualities as well as its favorable effects on the environment, Liu et al. (2013) developed it as a reinforcing material. The findings show that the cattail/PP laminates' tensile and bending performances are comparable to those of jute/PP composites. Cattail/jute/PP laminates with fiber volume fractions of 20/35/45 have better mechanical qualities than laminates reinforced with cattail fibers. Mbeche et al. (2020) suggest that **s**isal and cattail fibers are combined to create hybrid composites with improved mechanical qualities that are made of polyester. Other studies are the production of insulation materials and bio-adhesives (Colbers et al., 2017), overview of conventional, modern, and renewable thermal building insulation materials (Abu-Jdayil et al., 2019), extraction and analysis of cellulose nanocrystals from the stems of large-leaved cattail (Typha latifolia), a reed plant (El Amri et al., 2023), porous carbon fibers made from cattails for high mass loading supercapacitors (Bai et al., 2023), Alkali treatment's effects on the sisal/cattail polyester composites' mechanical and thermal characteristics (Mbeche & Omara, 2020), cattail used to create a new, ecological, and insulating building material (Krus et al., 2014), and a brand-new cattail-based load-bearing insulating material (Krus et al., 2015), and clay plasters with cattail reinforcement used in both new construction and heritage restoration (Georgiev et al., 2013).

2.6 Prior studies on the use of cattails for environmental science

Zhao et al. (2009) found that rumen cultures can simulate the anaerobic digestion of aquatic plants. Georgiev et al. (2014) revealed that clay plaster reinforced with cattails may have a place in environmentally friendly construction. Brinksma et al. (2022, December) proposed typoha as a circular building material. Wang et al. (2022) proposed using supercapacitors to activate carbon fibers made from natural cattail fibers. In textile research, Shadhin et al. (2022) found effects of environmental factors, structural variables, fiber length, and estimators on a probabilistic model for cattail and canola fibers.

2.7 Prior studies on the use of cattails for the evaluation of the efficacy of cattail

Evaluation of the efficacy of cattail (Typha spp.) fiber for oil sorption includes these studies: an analysis of cattail (Typha spp.) fiber's effectiveness as an oil absorbent (Chelst et al., 2017); evaluation of hemp, cattail, and flax fiber composites in comparison (Shadhin, 2021); mechanical characteristics of polyester composites reinforced with sisal and cattail (Mbeche et al., 2020); a whole cattail leaf-based solar evaporator with square water transport channels that is used for efficient solar vapor production (Wang et al., 2023); and evaluation of cattail fiber's wetting properties and oil sorption kinetics (Xu et al., 2020).

2.8 Prior studies on the use of cattails for agriculture and natural resources

Studies in this area involve industrial crops and products. For example, cattail fibers coated with polypyrrole to make a porous biomass foam that is good at photothermal evaporation (Sun et al., 2022), agriculture and natural resources such as the use of pineapple leaf fiber mixed with banana or cattail stem fibers and their paper physical properties for use in packaging (Srichola et al., 2022), the ways to extract and characterize the fibers from Typha leaves (Yu, 2021), and choosing the best kind of alfalfa for optimum protein,

fiber, and nitrogen fixing (Ruhland et al., 2012), natural fiber insulation materials in a circular economy viewpoint on the use of textile and agri-food waste (Savio et al., 2022), complementary and alternative medicine (Fruet et al., 2012), in the trinitrobenzenesulphonic acid model of rat colitis, dietary supplementation with narrow-leaved cattail rhizome flour (Typha angustifolia L.) reduces intestinal inflammation.

2.9 Prior studies on the use of cattails for management

Few studies have been done on management, such as ecosystem services and management (Bansal et al., 2019), integrated watershed management (Grosshans, 2014), and energy conversion and management (Ruangmee and Sangwichien, 2013).

The prior studies above present the use of cattails all over the world. However, it is necessary to survey the use of cattails in the local Thai context, as shown in the next topic.

2.10 Prior studies on the use of cattails in the local context

The development of paper products made from cattail pistillate to help the local economy (Dowcharoenporn et al., 2017), the analysis of the production process from cattail plants for product design for residential use (Wongchansri, 2014), the production of plywood sheets from cattail trees and their uses in crafts (Phoniam, 2016), community participation in the development of cattail as a mosquito repellent to promote community business (Silalai, 2015), development of roof tiles from palm bunch and cattail fibers for communities (Buasri & Surin, 2020), effects of pH and synthetic wastewater on oil and grease absorption efficiency by cattail Chan flowers (Chalermwat & Sariphan, 2020), mechanical and physical properties of polylactic acid composite reinforced with cattail fibers (Pridasakul, 2014), effect of copper on oxytetracycline-containing water treatment by cattail plants (Singthuan, 2015), the potential of cattail, water hyacinth, and bon in treating wastewater (Salae & Wanee, 2021), development of materials from cattail plants for designing home furnishings, reflecting the local identity of the northeast region (Limpapirn, 2018), and design of a shoulder bag from a cattail plant, focusing on a case study of a community enterprise, cattail weaving handicraft group, Bang Kaew Subdistrict, Ban Laem District, Phetchaburi Province (Panalee & Thongsin, 2020).

2.11 Research gap

Drawing upon the prior studies, there is a possibility of digesting cattail plants to obtain fibers that can be further developed to create alternatives and suitable ways to develop textiles mixed with other fibers. At both the international and local levels, scholars ignored this area. It is necessary to examine this issue to extend and produce green textiles that add value to natural materials, with a focus on a specific area, i.e., Khon Kaen Province, Thailand. The province was chosen for these two reasons.

On one side, the province is one of the major sources of cattail plants. From a case study of various water sources in Khon Kaen Province, Bung Kaen Nakhon Lake is the largest natural water source in the center of the province, covering an area of approximately 604 rai, or 234 acres. This area is the center of several activities for the local people and neighboring cities, such as recreation, sports, tourism, and rituals. However, there is a spread of cattail trees everywhere around the lake, which is regarded as an invader because it lives in a way that competes with, replaces, or consumes local organisms, or it could be a parasite or disease carrier that decreases growth rate and the survival of local species, or it may cause the population to be reduced to the point of extinction and may uproot or damage local plants.

On the other side, in this province, weaving is a local handicraft that people in the area are proficient in creating fabrics from threads and silk as usual. It is considered a solution for these people to maximize the utilization of cattail plants in the area that is consistent with the context of the area and can create added economic value for the plants. Therefore, the researcher is interested in studying the fiber forming from the cattail plant to design bags using handicraft methods that are consistent with the local context.

3. Research Objectives

This study was based on the assumption that by bringing natural materials and other materials into the design, it would create more value for materials and products. This integration of studies in parallel with

material development and design work, emphasizing the wisdom inherited from the ancestors and textile innovation, can create value for agricultural waste materials. It is one of the preliminary studies on the utilization of cattail in textile handicrafts, with the following research objectives: 1) experiment on handicraft manual methods in the production of fiber sheets from cattail plants; 2) design and manufacture a prototype of cattail-inspired handicraft products; and 3) evaluate the customer satisfaction of cattail-inspired handicraft products.

4. Research Method

In response to the research objectives, the research method was designed as follows:

4.1 Research Design

This study employed a mixed-methods design. The participants were divided into two groups. The former were raw material and cotton textile manufacturers of Ban Hua Fai Mudmee Silk Weaving Group, Por Daeng Subdistrict, Rural District, Khon Kaen Province, who wished to develop these new products. This group was chosen due to their expertise in handicrafts and their willingness to participate in this initiative in order to expand their local products. The latter included one hundred volunteers for product evaluation. During a local product exhibition week in Khon Kaen Province and the National Research Fair in Bangkok, convenience sampling was used to select volunteers. This sampling selection was suitable for the prototype project and the only option for the one-week exhibition. On each of the seven days, data were collected at random times between 11 a.m. (when the exhibition opened) and 9 p.m. (when the exhibition closed). These volunteers were environmentally-friendly product users in the area of Khon Kaen Province and neighboring cities.

4.2 Procedures for Data Collection

The collection of data followed the procedures shown in the figure below.

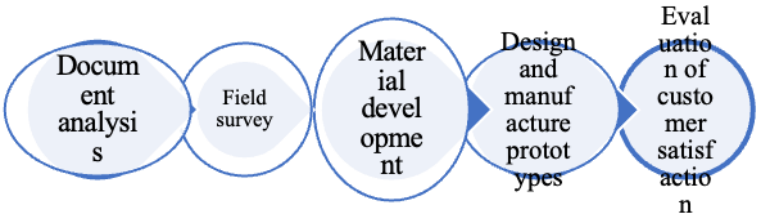

Figure 1: Procedures for Data Collection

Figure 1 illustrates procedures for data collection. The researcher began by gathering relevant research materials from books, textbooks, theses, media, publications, and video media. Then, a field survey of cattail plant resources was conducted in order to collect experimental materials. Next, material experiments and the development of cattail fiber sheets were conducted. Later, the researcher collaborated with locals to design and manufacture prototypes of cattail-fiber-based handicrafts. The newly developed prototypes were then evaluated for customer satisfaction.

4.3 Instruments for Data Collection

Instruments for data elicitation were document analysis, field surveys, material experimentation and development, product design and development, and customer satisfaction evaluation.

4.3.1 Document Analysis

In order to meet the first research goal (which was to try out handicraft methods for making fiber sheets from cattail plants), it was important to analyze this document to learn about the properties and other details of cattail plants. This information is important for choosing materials, experimenting, and developing new products, as well as designing and making new products.

4.3.2 Field survey

A field survey was conducted at Bung Kaen Nakhon Lake, Khon Kaen Province, to select the raw materials most appropriate for experimentation and development in response to the first research objective.

4.3.3 Experimentation and Development

Experimental and development activities were engaged with the process of separating cattail plant fibers and experimenting with a traditional manual method to form cattail fiber sheets, which are materials for product design and manufacturing. The researcher's incorporation with and the chosen material producers and manufacturers of handicraft cotton yarn producers of Ban Hua Fai Mudmee Silk Weaving Group jointly conducted material experimentation to turn cattail tissues into sheets to be used for product design and development in response to the first research objective.

4.3.4 Product Design and Development

Like the process of cattail sheet experimentation and development, the same participants jointly designed and developed the prototypes of cattail products in response to the second research objective (namely, to design and manufacture a prototype of cattail-inspired handicraft products).

4.3.5 Customer Satisfaction Evaluation

Potential customers then evaluated the developed prototypes. A five-scale rating questionnaire was constructed to evaluate customer satisfaction in five areas: aesthetics, form and structure, materials, function and usage, care, and maintenance, in response to the third research objective (namely, to evaluate the customer satisfaction of cattail-inspired handicraft products).

4.4 Data Analysis

The data drawn from document analysis, field surveys, material experimentation and development, and product design and development were qualitatively analyzed. The quantitative survey responses were analyzed, using descriptive statistics (namely, mean and standard deviation). The conclusion of the study was drawn from the qualitative and quantitative analyses.

On reliability and validity checks, the questionnaire was constructed in response to the research objective (namely, to evaluate the customer satisfaction of cattail-inspired handicraft products) and sent to five reviewers for content validity evaluation. The researcher adjusted based on their recommendations. Then, one hundred customers were given the customer evaluation satisfaction questionnaire. Alpha Cronbach reliability was applied to the results, and the value of 0.86 indicates a reliable level.

5. Results of the Study

The results of the study are presented based on the research objectives.

5.1 Experiment and Development of the Cattail Sheet

In response to the first research object, below are the results of the experiment on handicraft manual methods in the production of fiber sheets from cattail plants.

5.1.1 Properties of Cattail Plants

The document analysis revealed the properties of cattail plants, as shown in Figure 2.

(a) Cattail Plants (b) Cattail Leaves (c) Cattail Flowers (d) Cattail Fruit

Figure 2: Cattail Plant Physical Characteristics and Properties

Figure 2 shows cattail plant physical characteristics and properties. The illustrations of sources, leaves, flowers, and fruits were shown with descriptions. The data are used for material selection. (a) Cattails are native to Europe and America. Classified as an herbaceous plant, the rhizome is round, the shoots are short, and the trunk is erect, about 1.5–3 meters high, growing well in wetlands. Propagated by fruit or seed and found in swamps, both freshwater and saltwater basins, along the lake or along the canal, and in open space in general, there is a global distribution in the tropics and in the temperate zone. In Thailand, it can be found all over the region. (b) Cattails have a single leaf. There are alternating leaf sheaths on the same plane. The leaves are striped. It is about 1.2–1.8 cm wide and about 50–120 cm long (some say 2 meters). The lower part of the leaf is flat. (c) Cattail flowers bloom in a reduced bouquet. It has a cylindrical shape. The length of the male flowers is about 8–40 cm. The diameter of the bouquet is about 0.2–0.7 cm. There are about 1-3 decorative leaves that can fall off. The length of the female flowers is about 5–30 cm. Of the bouquet, about 0.6-2 cm, often separated from the male flowers by the sterile peduncle, with a length of about 2.5-7 cm. The flowers are small. no sepals and petals Most of the male stamens are three, surrounded by hairs. The male stamens are short. The anthers are about 1.5–2 mm long. The female flowers have thread-shaped bracts. The stalk of the ovary is slender, about 5 mm long, and pubescent. The stamens are striped or lanceolate and can still bloom throughout the year. (d) The fruit is very small. When it is old, it will split lengthwise. It has an oval shape.

5.1.2 Material Selection

The document analysis and field survey reveal the results of the material selection as follows: The selection of the stem used in the production of the fiber sheet, in addition to the properties of the cattail plant, which is a natural material and non-toxic, has no impact on the environment. It is a local plant that is easy to grow and grows quickly. It is an herb that is lightweight and washable. Including various properties that help promote the cattail plant to be suitable for processing into fibrous sheets. The part used for fiber production is still agricultural waste. It is also a natural and environmentally friendly material, helping to promote the use of materials for value and benefits as much as possible. The selected materials were used for material experimentation and development.

5.1.3 Material Experimentation and Development: From Cattail Fibers to Sheets

An analysis of mycelium extract from cattail plants was conducted. From the fiber separation experiment, the results of the separation of the fibers from the cattail plant for the production of mycelium can be obtained.

Table 1: Separation of cattail mycelium from boiling in a sodium hydroxide (NaOH) solution for different time periods

Quantity (kg.)	**Boiling duration**	**Amount and type of solution (g)**	**Experimental results**
2	1 hr.	Sodium hydroxide (NaOH): 200g per 10 l of water	The resulting fibers are dark brown. There is a large amount of cellulose residue from plants attached to it, and it has hardness.
2	2 hrs.	Sodium hydroxide (NaOH): 200g per 10 l of water	The resulting fibers have a light cream color. A small amount of cellulose from plants is attached to it, making it soft.
2	3 hrs.	Sodium hydroxide (NaOH): 200g per 10	The resulting fibers are light cream in color and slightly white. Very small amounts of plant cellulose residue are

Quantity (kg.)	Boiling duration	Amount and type of solution (g)	Experimental results
		l of water	attached. is very soft (use your hand to crush and tear).

Table 1 shows the separation of cattail mycelium from boiling sodium hydroxide (NaOH) solution for different time periods. When 2 kg of cattail plants were boiled with caustic soda or sodium hydroxide (NaOH) at a ratio of 200 g per 10 l of water, the fibers were light cream-colored and soft-touch. From the results of the separation of the fibers, it was found that the boiled and soaked cattail plants in different solutions were different. resulting in a slight difference in the color of the fibers. The softness of the skin depends on the boiling time. There was no difference in the amount of fiber obtained. Therefore, the experiment of separating mycelium from cattail plants in Table 3, Item 2, has suitable physical properties for forming mycelium sheets.

Table 2: Bleaching of cattail mycelium in sodium hypochlorite with different time periods

Quantity of Cattail (kg.)	Boiling duration	Amount and type of solution (g)	Experimental results
	1 hr.	Sodium hypochlorite (NaOCI): 300 ml per 2 liters of water	The resulting fibers are light yellow to white. The fibers are softer.
	2 hrs.	Sodium hypochlorite (NaOCI): 300 ml per 2 liters of water	The resulting fibers are white. and the fibers are softer.

Table 2 shows the bleaching of cattail mycelium in sodium hypochlorite (NaOCI) with different time periods. When the cattail plants were boiled with caustic soda or sodium hydroxide (NaOH) and then soaked in sodium hypochlorite (NaOCI) for 300 ml per 2 liters of water, white fibers were obtained. and soft-touch skin. From the results of the experimental soaking of such fibers, it was found that the fibers soaked in the solution were different, resulting in different fiber colors. The softness of the skin depends on the soaking time. There was no difference in the amount of fiber obtained. Therefore, the test of soaking the fibers from the cattail plant in Table 3 shows that they have suitable physical properties to be formed into fiber sheets.

Then, the developed materials were brought into another step of the production process. The results were shown in Table 3.

Table 3: Mycelium separation process from cattail plants and production of cattail fiber sheets

Illustrations	Steps and methods for extracting mycelium from cattail plants
 	The cattail plants were cut and dried in the sun (2kg) and boiled at a temperature of 80–100 degrees Celsius with sodium hydroxide (NaOH) of 200g per 10 liters of water for a duration of 2 hours.

Illustrations	Steps and methods for extracting mycelium from cattail plants
 	The fibers obtained from the boiling of cattail plants are bleached with sodium hypochlorite (NaOCI) at 300 ml per 2 liters of water, washed, shredded into small pieces, and stored in a bucket in a pleasant place.
 	The dehydrated mycelium is used to make the mycelium swell and prepare it for forming cattail mycelium sheets.
 	The mulberry paper spoon craft method produces the filaments of the cattail plant. Then let it dry in the sun.
 	Get a sheet of cattail fiber with a craft method like a mulberry paper spoon.

Table 3 shows the separation of mycelium from cattail plants and the handicraft production of cattail fiber sheets. This method extracts mycelium from cattail plants through a series of procedures and techniques. The final product of this development process was cattail sheets for use in the design and development of prototypes.

5.2 Prototype Design and Development

In response to the second research object, the following are the results of designing and manufacturing prototypes of cattail-inspired handicraft products:

5.2.1 Designing and Drafting Prototypes

Below are the drafts of the designed prototypes.

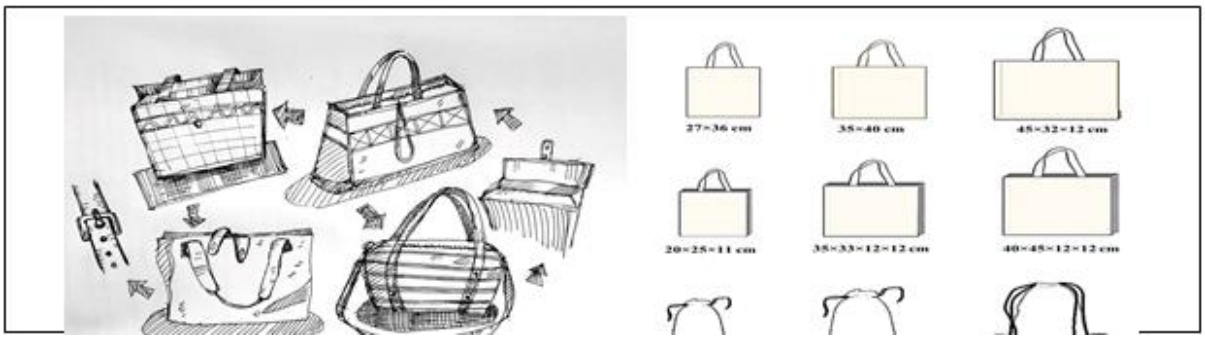

Figure 3: Drafts and Designs of Cattail-Inspired Handbag Prototypes

Figure 3 presents drafts and designs of cattail-inspired handbag prototypes. Conceptually, the designs of handbags were designed to communicate simplicity and create a sense of nature by using a sewing technique and alternating between cattail-inspired bag decoration materials. The researcher adopted the design principles of functions, convenience of use, strength, beauty, and endemic and transport characteristics. The developed product prototypes are shown in the next part.

5.2.2 The Handbag Prototypes

The cattail sheets that were developed from cattail plants in the previous step were used to produce the prototypes of cattail-inspired handbags. The following are the cattail-inspired handbag prototypes:

Figure 4: Cattail-Inspired Handbag Prototypes

Figure 4 shows cattail-inspired handbag prototypes at an exhibition of the National Research Fair in Bangkok, 2017. However, to verify the quality of the developed products, a customer satisfaction evaluation of the prototypes was needed.

5.3 Customer Satisfaction Evaluation

The following are the results of the customer satisfaction evaluation of the prototypes.

Table 4: Results of customer satisfaction evaluations of the prototypes

Items of evaluation	Mean	S.D.	Level of Satisfaction
Aesthetics	4.30	0.69	High
Form and structure	4.23	0.72	High
Materials	4.38	0.60	High
Function and usage	4.46	0.59	High
Care and maintenances	3.13	0.69	Moderate
Total	4.10	0.66	High

Table 4 shows the overall mean scores and standard deviations of potential customer satisfaction evaluations. The overall mean score was high ($\overline{X}$ = 4.10, S.D.= 0.66). The mean scores were arranged as follows: function and usage ($\overline{X}$ = 4.46, S.D.= 0.59), materials ($\overline{X}$ = 4.38, S.D.= 0.60), aesthetics ($\overline{X}$ = 4.30, S.D.= 0.69), form and structure ($\overline{X}$ = 4.23, S.D.= 0.72), and care and maintenance ($\overline{X}$ = 3.13, S.D.= 0.69) respectively. This indicates that the potential customers were satisfied with the prototypes at a high level. However, the products needed to be improved in terms of care and maintenance.

6. Conclusion and Discussion

6.1 Conclusion

Cattails interfere with human natural water cycles, and cattail invasions frequently transform wetlands in numerous environmentally undesirable manners. However, academics have identified applications for cattails in various settings worldwide. Applied energy, chemistry, biology, technology, material science, environmental science, agriculture and natural resources, management, and local context are the subject areas covered. The cattail-inspired textile received little attention from academics. This research sought to address this issue for environmental and economic reasons. The study concentrated on Thailand's Khon Kaen Lake. Approximately

234 acres in size, the lake is the world's largest natural water source. This province is the focus for weaving and handicrafts. As usual, the area's natives are adept at producing fabrics from thread and silk. A method for maximizing the utilization of cattail plants and adding economic value to refuse materials. In order to improve the economic and environmental conditions of the local people, the researcher wanted to study how the cattail plant makes its fibers so that they could design bags using handicraft techniques similar to those used by the local people. The goals were: 1) to experiment with handicraft methods for making fiber sheets from cattail plants; 2) to design and make a prototype of a handicraft made from cattail fibers; and 3) to evaluate the customer satisfaction of cattail-inspired handicraft products.

In response to the research objectives, this study employed a mixed-methods design. Two groups of people participated. Raw material and cotton textile producers of Ban Hua Fai Mudmee Silk Weaving Group, Por Daeng Subdistrict, Rural District, Khon Kaen Province, wanted to develop these new items. This group was selected for its handicraft expertise and desire to join in this endeavor to expand local products. One hundred product volunteers also participated in the customer satisfaction evaluation. Convenience sampling selected volunteers for Khon Kaen Province's local product week and Bangkok's National Research Fair. The instruments for data elicitation consisted of document analysis, field surveys, material experimentation and development, product design and development, and customer satisfaction evaluation. Document analysis, field survey, material experimentation and development, and product design and development data were analyzed qualitatively. The responses to the quantitative survey were analyzed using descriptive statistics. The study's conclusion was derived from qualitative and quantitative analyses.

The results of the study could be summarized as follows: First, the experiment on handicraft manual methods could produce fiber sheets from cattail plants. Second, the designing and manufacturing processes successfully produced cattail-inspired handicraft prototypes. The potential customer satisfaction evaluation revealed that, overall, the potential customers were satisfied with the prototypes at a high level ($\overline{X}$ = 4.10, S.D.= 0.66). In details, the customers were highly satisfied with the following qualities of the products: function and usage ($\overline{X}$ = 4.46, S.D.= 0.59), materials ($\overline{X}$ = 4.38, S.D.= 0.60), aesthetics ($\overline{X}$ = 4.30, S.D.= 0.69), and form and structure ($\overline{X}$ = 4.23, S.D.= 0.72). However, they were moderately satisfied with care and maintenance ($\overline{X}$ = 3.13, S.D.= 0.69). This indicated that the producers needed to improve this issue.

6.2 Discussion

The finding of this study was consistent with the prior studies that make use of cattails (Dowcharoenporn et al., 2017; Wongchansri, 2014; Phoniam, 2016; Silalai, 2015; Buasri & Surin, 2020; Chalermwat & Sariphan, 2020; Pridasakul, 2014; Singthuan, 2015; Salae & Wanee, 2021; Limpapirn, 2018; Panalee & Thongsin, 2020). However, as previously mentioned, researchers in both global and local contexts have overlooked the use of cattail sheets for handicraft handbags. This study provided an alternative study of the utilization of cattails.

7. Implications of the Study and Suggestions for Further Inquiry

7.1 Implications of the Study

Practically, the findings of this study provide a method to make use of cattails. This method can be applied to other types of plant fiber raw materials.

7.2 Suggestions for Further Inquiry

Since the result of the customer satisfaction evaluation of the cattail-inspired handbag quality indicated a high level in function and usage, materials, aesthetics, form, and structure, and a moderate level in care and maintenance. This indicated room for improvement. Future studies should direct their attention toward this improvement.

Declaration of conflict of interest

This research has no conflict of interest.

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