The Property of Screen Ink from Natural Mordant, Colorant, and Additive for Art

Pratoomtong Trirat
Instructor
Department of Printing Technology, Faculty of Mass Communication Technology
Rajamangala Institute of Technology Thanyaburi

Abstract

The present research employed experimental research approach aiming at 1) *comparing the values of density of screen inks using natural mordant derived from banana gum and papaya gum, and additives including copper sulfate, sodium chloride, and aluminium sulfate;* 2) *comparing the L* a* b*values of yellow colorants between curcuma powder and dried chrysanthemum seeds, red between rosella and pitaya, blue between indigo and baphicacan thus cusia, black between rambutan seeds and ebony fruits; and 3) exploring the opinions of product designers, arts teachers, and general people towards screen ink from nature. The sample includes 30 arts teachers and product designers, and 200 general people. The results show the best color fastness given by banana gum and papaya gum as mordant and sodium chloride as additive. However, papaya gum provided better color fastness while banana gum provided more color density. The values of L* a* b*of colors from natural colorants with the same shade were in similar direction. In the designers' views, these colors can be utilized in drawing the patterns of products and in teaching arts that use screen printing system and other combined techniques.*

Keywords: screen ink, natural mordant, banana gum, papaya gum,

Introduction

Colors influence people's life and their living in terms of aesthetics, culture, and belief which affect their emotion and feeling. The use of colors in printing whether they are from synthetic or natural colorants depends on the user's choice. In the past up to present, there have been explorations and utilization of natural materials as colorants from plants such as roots, cores, barks, stems, flowers, seeds, and leaves (IPST: 2015) for various applications as food color, painting color, product color, and printing color. The choice of using these colors is for health benefit of users and manufacturers, these colours are friendly to environment as well. (Knowledge and Technology Center for Northern Textile: 2015) Natural colorants are used in art works by mixing plants or soils with vegetable oil to give a variety of colors such as black from soil, green from grasses, sepia from onion skins, yellow from butter and grey from ashes, and printing onto paper. (DIY Screen Printing and more: online)

Creating the pattern and color on fabric can be done by dyeing, weaving, and printing. Screen printing is another way of adding pattern to fabric. Printing on fabric is one type of art work that apply color and pattern, to transfer the art of aesthetics and serve the use of particular product with fabric as its part or the whole part for direct use in the forms of clothes, home decorations, bedding, or other products. Screen printing system can create better quality and a wide variety of works. (Nongyao and Vichian Jiraganont. 1996:107) The method is to wipe ink through screen which is made of synthetic, nylon, polyester or metallic fibers on which the design is imposed. Through screen stencil, ink will apply onto the material beautiful and colorful image or pattern attractive to viewers. The important part of screen printing is ink which is generally in liquid state with a range of colors.
Printing inks are the mixture in various combinations of different materials in different ratios, and its essential ingredients are colorant, solvent, resin, oil or additive (Aran.2004). However, these synthetic ingredients pose adverse environmental effects and more problems with resulted pollution in several segments of industrial manufacturing. Today, non-toxic ink becomes an alternative for improved environment. In art schools where screen printing is taught, there are concerns on health hazards caused by the solvents used in oil-based inks for screen printing on textiles, hence instead water-based ink was introduced. (Nik Semenoff, 1991) It can be observed that most of liquid printing inks use water as solvent, they are thus without undesirable effects on both human and environment as they were derived from natural materials to substitute those hazardous products.

Natural color is also a common ingredient in human foods. Natural colors have been documented for its long use for over 100 years, which obtained from pigments of animal parts or minerals, for example.

With this cognizance, the researcher saw that the use of natural materials like banana gum and papaya gum as mordant and then mixing with natural colorants and additives for color adhesion based on dyeing method can be an effective ingredient of ink for screen printing. This creativity of work by utilizing natural material and its residuals will serve to reduce not only production cost but also potential pollution and environmental hazards. It can also be used well for those who need to practice screen printing, even for children in doing their art works to protect them from health hazardous colors. It adds to the alternatives of printing on fabrics. Moreover, other new products and artworks can be created, allowing for extended business opportunity.

Research objectives

1. To compare the density of screen inks using adhesive agent of banana gum and papaya gum and additive agents of copper sulfate, sodium chloride, and aluminium sulfate;
2. To compare the L* a* b*values of yellow colorants between curcuma powder and dried chrysanthemum seeds, red between rosella and pitaya, blue between indigo and baphica can thus cusia,black between rambutan seeds and ebony fruits; and
3. To explore the opinions of product designers, arts teachers, and general people towards printing ink from nature.

Research conceptual framework

The study explored and developed screen printing ink from banana gum and papaya gum, colorants and additives from nature. It examined screen printing inks produced by using natural instead of synthetic materials which will include in the experiment various colorants derived from many kinds of plants shown below.

Ingredients of ink from synthetic materials	Ingredients of ink from natural materials
- Colorants, dyes	- Dyes including 4 colorants from nature: 1) Yellow (curcuma powder, dried Chrysanthemum seeds) 2) Red (dried rosella and pitaya) 3) Blue (indigo and baphicacanthus cusia) 4) Black (rambutan seeds and ebony fruits)
- Additives	- banana gum– papaya gum as mordant - water as solvent -cassava for enhanced viscosity - copper sulfate/calcium chloride/ aluminium sulfate for enhanced adhesion.

Figure 1 **Conceptual framework for developing printing ink from natural mordant and colorant**

Research scope

The current research aimed to explore and develop printing ink from banana gum and papaya gum as mordant, and 8 colorants giving 4 colors of yellow, red, blue, and black, for printing on cotton fabric. The researcher identified the following research scope. Formula 1 Use banana gum as mordant, mix with each of the 3 additives, screen and test for the values of color, and bring to wash. If finding the mixture of ink with additive of most adhesive, then use such kind of additive in the formula of ink type 1which is mixed with each of the 8 colorants, i.e. yellow (curcuma powder, dried chrysanthemum seeds), red (dried rosella and pitaya), blue (indigo and baphica can thus cusia), black (rambutan seeds and ebony fruits).Formula 2 Use papaya gum as mordant, mix with each of the 3 additives, screen and test for the values of color, and bring to wash. If finding the mixture of ink with additive of most adhesive, then use such kind of additive in the formula of ink type 2 which is mixed with each of the 8 colorants, i.e. yellow (curcuma powder, dried chrysanthemum seeds), red (dried rosella and pitaya), blue (indigo and baphicacan thus cusia), black (rambutan seeds and ebony fruits).

Definitions of research terms

1. Natural colorant refers to the colorant derived from parts of plants or animals and used as an ingredient of screen ink for printing.
2. Natural mordant refers to the mordant derived from banana gum and papaya gum to be used as an ingredient of screen ink for adhesion.
3. Additive refers to the additive added to enhance the adhesive property of inks which include sodium chloride, aluminium sulfate, and copper sulfate.

Research procedure

Step 1Development of screen ink by using banana gum and papaya gum as mordant, added with sodium chloride, copper sulfate, aluminium sulfate as additive

1. Preparation of materials and tools, banana gum, papaya gum, cassava, colorants, and additives.
1.1 Preparation of banana gum. Chop bananas into small pieces, add water at 1:1 and bring to grind in a blender, filter for liquid portion, keep it in a bottle and store in a fridge.
1.2 Preparation of papaya gum. Chop papaya and bring to boil in water at 1:1, continue to boil for about 10 minutes, filter for liquid portion, keep it in a bottle and store in a fridge.
1.3 Colorants in this study include 8 plants for 4 colorants, i.e. yellow (curcuma powder, dried chrysanthemum seeds), red (dried rosella, pitaya), blue (indigo, baphicacanthus cusia), black (rambutan seeds, ebony fruits)

Preparation of colorants

- *Yellow colorant*
  1) Curcuma powder. Dissolve curcuma powder in water to obtain yellow color.
  2) Dried chrysanthemum seeds. Put 40 gm. of dried chrysanthemum seeds in 1 cup of water and bring to boil at 100°C for 10 minutes, filter for liquid portion, and yellow color is obtained.
- *Red colorant*
  1) Dried rosella. Chop 40 gm. of dried rosella into pieces and put in 1 cup of water and bring to boil at 100°C for 10 minutes, filter for liquid portion, and pink-red color is obtained.
  2) Pitaya fruits. Chop 40 gm. of pitaya in to pieces and put in 1 cup of water and bring to boil at 100°C for 10 minutes, filter for liquid portion, and dark red color is obtained.
- *Blue colorant*
  1) IndigoMix 3 kg. of indigo with alkaline water (pH 13) prepared by soaking ashes in water, add tamarind and mix together, leave it for 5 days during which the mixture is scooped up high and poured down continuously for 10 times in each day.
  2) Baphica can thus cusia Use 40 gm. of baphica can thus cusia and 1 cup of water and bring to boil at 100°C for 10 minutes, filter for liquid portion, and blue color is obtained.
- *Black colorant*

1) Rambutan seeds Use 40 gm. of rambutan seeds and 1 cup of water and bring to boil at 100°C for 10 minutes, filter for liquid portion, and black color is obtained.
2) Ebony fruits Use 40 gm. of ebony fruits and 1 cup of water and bring to boil at 100°C for 10 minutes, filter for liquid portion, and black color is obtained.

1.4 **Preparation of ink mixture**

1) Type 1: Use 200 ml. of banana gum as mordant. Type 2: Use 200 ml. of papaya gum as mordant
2) Add 100 ml. of colorant:
   - Yellow colorant from curcuma powder and dried chrysanthemum seeds
   - Red colorant from rosella and pitaya
   - Blue colorant from indigo and baphica can thus cusia
   - Black colorant from rambutan seeds and ebony fruits
3) Add 15 gm. of cassava
4) Add 1 gm. of sodium chloride/aluminum sulfate/copper sulfate as additive into banana gum/ papaya gum as mordant, and bring to heat at 50°C for 5 minutes, then test for viscosity, screen on fabric and bring to wash.

Step 2Comparison of the quality of printed materials between inks with banana gum and inks with papaya gum, natural colorants, and sodium chloride, aluminum sulfate, copper sulfate as additive.

2.1 Test of ink quality on homespun clothes

1) Preparation of materials and tools for testing screen on homespun clothes

- Screen printing mesh coated with glue and imposed with design for printing
- Materials for test screen printing – cotton fabric
- Densitometer and Spectrophotometer
- Test sheets
- Prepare screen printing mesh for the test

2) Screening steps. Apply ink onto the screen mesh on top of cotton fabric and spread the ink downward and upward to make sure it looks evenly smooth. Repeat the process with all 8 colorants, each one onto 30 cotton sheets, making altogether 240 sheets.

2.2 Measuring the values of density and L*a*b*of colors

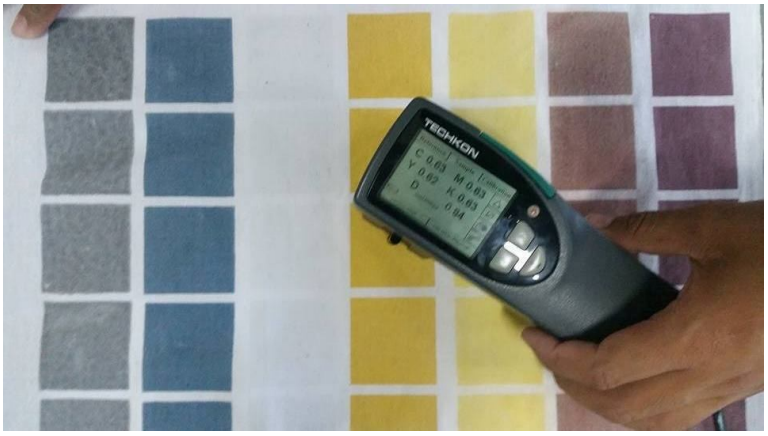

Figure 1 Measuring the values of density and L*a*b*of inks made from natural mordant and colorants

1) Use spectrophotometer to measure the values of density and L*a*b*of colors, then record the results and analyze for mean ($\bar{x}$), and compare the density among inks of each type.

2) Measuring the values of colors

- L*value defines lightness of color. L*= 0 refers to black color, and L*= 100 refers to white color.
- a*value defines redness or greenness (Red-Green). Positive value of a* means redness, negative value of a*means greenness.
- b*value defines yellowness or blueness (Yellow-Blue). Positive value of b* means yellowness, negative value of b*means blueness.

Step 3 Exploring the opinions of 30 art teachers and product designers, and 200 attendants in the demonstration of the technical conference on creativities and designs during 29 – 30 July 2014, using the questionnaire of 5-point Likert-type scale and the following satisfaction criteria.

4.50 -5.00 means most satisfaction
3.50 -4.49 means much satisfaction
2.50 -3.49 means moderate satisfaction
1.50 -2.49 means low satisfaction
1.00 -1.49 means lowest satisfaction

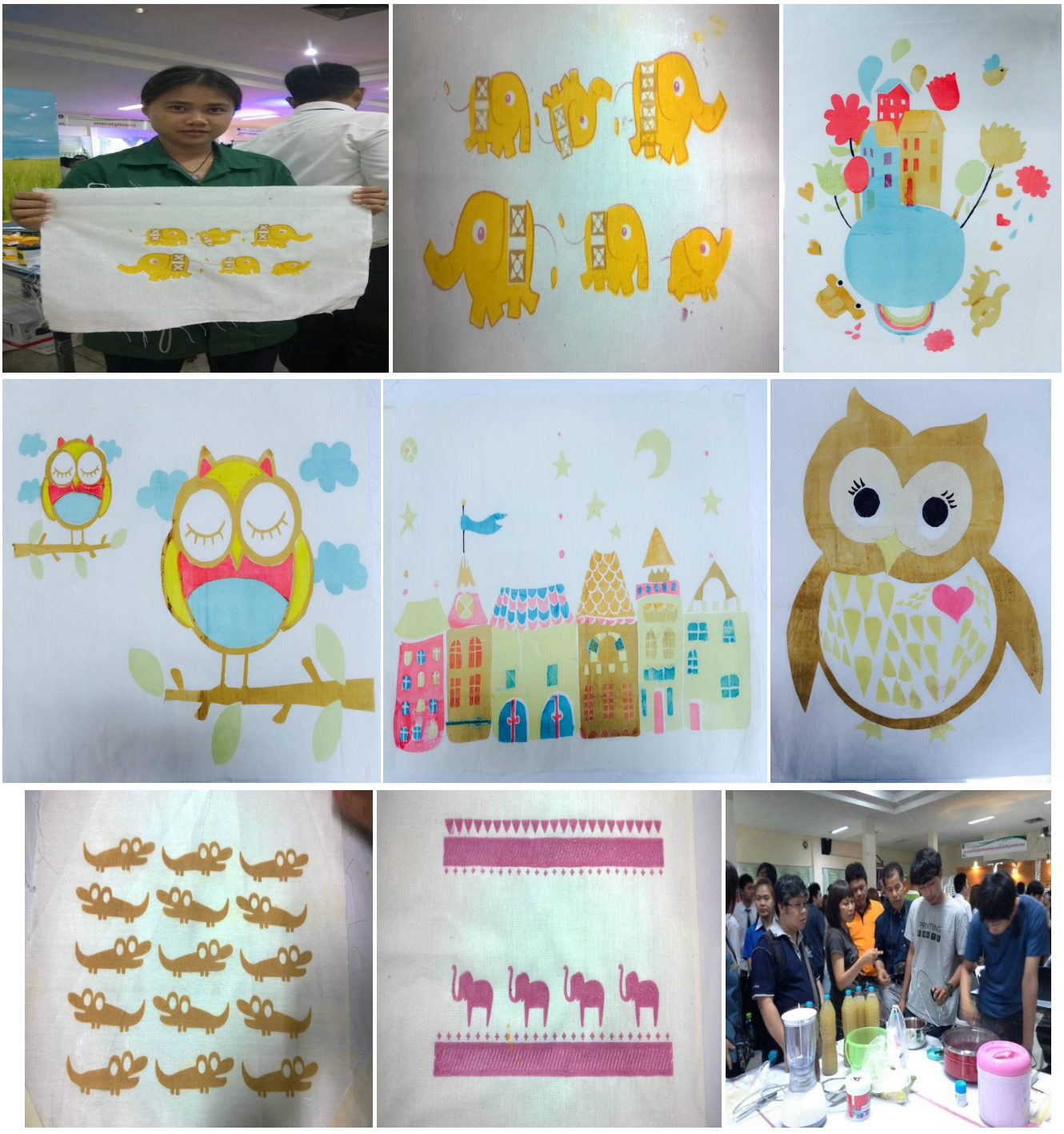

Figure 2 **Screen printing demonstration and Printed images from the demonstration**

Research results

1. The density values of 2 types of inks and the differences of values before and after the washes, with banana gum and papaya gum as mordant.

Table 4.2 **Comparison of means of density values of 2 formulas of inks using banana gum and papaya gum as mordant, before and after the washes**

	Banana gum			Papaya gum		
	before	after	difference	difference	before	after
Yellow - curcuma powder	0.88	0.60	0.28	0.16	0.83	0.60
- dried chrysanthemum seeds	0.82	0.52	0.30	0.29	0.76	0.50
Red -dried rosella	1.12	0.55	0.57	0.24	0.97	0.73
-lac	1.26	0.87	0.39	0.20	1.07	0.87
Blue -indigo	0.80	0.70	0.10	0.09	0.77	0.68
-butterfly pea	0.56	0.37	0.19	0.06	0.54	0.34
Black -charcoal	0.92	0.81	0.11	0.05	0.88	0.75
-rambutan peels	0.90	0.79	0.11	0.05	0.86	0.78

Table 4.2 shows the density of inks in overall after the wash that papaya gum ink displayed less total error than that of banana gum, suggesting better adhesion of inks from papaya gum than banana gum.

2. The density values of 3 types of inks with banana gum as mordant and sodium chloride, aluminium sulfate, and copper sulfate as additive, before and after the washes.

Table 4.1 **Means of density of inks with 3 types of additive and banana gum as mordant, before and after the washes.**

Ink colors	Density values of inks with banana gum as mordant								
	Formula 1 Sodium chloride			Formula 2 Copper sulfate			Formula 3 Aluminium sulfate		
	Before	After	Difference	Before	After	Difference	Before	After	Difference
Yellow - dried chrysanthemum seeds - curcuma powder	0.87	0.70	0.17	0.88	0.68	0.20	0.86	0.66	0.20
Red -lac	0.90	0.83	0.07	0.93	0.85	0.80	0.90	0.82	0.08
-dried rosella	1.05	0.88	0.17	1.06	0.86	0.20	1.02	0.86	0.16
Blue -butterfly pea	1.20	0.86	0.34	1.25	0.80	0.45	1.16	0.84	0.32
-indigo	0.80	0.75	0.05	0.81	0.72	0.09	0.76	0.69	0.07
Black -charcoal	0.60	0.53	0.07	0.62	0.49	0.13	0.58	0.46	0.12
-rambutan peels	0.92	0.82	0.10	0.94	0.79	0.15	0.88	0.80	0.08
	0.90	0.84	0.06	0.92	0.80	0.12	0.87	0.81	0.06

According to Table 4.1, there are not many differences on the values of density of inks with each type of additivebefore washing, however after washing; the inksadded with sodium chloride maintain more density than the other 2 additives.

Table 4.2 **Means of density values of inks with each type of the 3 additives and papaya gum as mordant, before and after the washes.**

Ink colors	Density values of inks with papaya gum as mordant								
	Formula 1 Sodium chloride			Formula 2 Copper sulfate			Formula 3 Aluminium sulfate		
	Before	After	Difference	Before	After	Difference	Before	After	Difference
Yellow									
- dried chrysanthemum seeds	0.85	0.72	0.13	0.83	0.68	0.13	0.81	0.70	0.11
- curcuma powder									
Red	0.86	0.83	0.03	0.84	0.74	0.10	0.81	0.72	0.09
-lac									
-dried rosella	0.94	0.88	0.06	0.92	0.82	0.10	0.88	0.71	0.17
Blue	1.10	0.86	0.14	1.05	0.82	0.23	0.95	0.80	0.15
-butterfly pea									
-indigo	0.74	0.69	0.05	0.71	0.64	0.07	0.69	0.59	0.10
Black	0.56	0.48	0.08	0.54	0.42	0.12	0.51	0.45	0.06
-charcoal									
-rambutan peels	0.87	0.76	0.11	0.85	0.72	0.13	0.87	0.72	0.15
	0.85	0.76	0.09	0.84	0.72	0.12	0.83	0.72	0.11

In Table 4.2, the values of density of inks mixed with each of the 3 kinds of additive display not much difference before the wash, however after the wash, the values of density for sodium chloride additive remain higher than those of the other 2 additives.

Table 4.3 Comparison of the values of colors of inks mixed with papaya and banana gums as mordant and sodium chloride as additive, by the values of L*a*b*on cotton fabric as measured by spectrophotometer

Colors	CIE L*a*b*					
	Type 1 (banana gum)			Type 2 (papaya gum)		
	L*	a*	b*	L*	a*	b*
Yellow						
-curcuma powder	75.88	10.89	46.87	75.55	11.77	62.91
-dried chrysanthemum seeds	80.08	4.76	52.76	78.05	6.9	55.99
Red						
-dried rosella	39.03	26.82	9.33	72.88	16.27	0.84
-lac	40.48	23.77	10.90	52.28	21.39	5.48
Blue						
-indigo	47.00	-5.57	-10.86	52.61	-5.12	-8.64
-butterfly pea	70.86	1.03	-17.06	63.91	1.62	-20.78
Black						
-charcoal	40.53	4.26	3.00	46.15	4.33	3.32
-rambutan peels	40.83	4.22	2.97	46.21	4.15	3.30

As seen in Table 4.3, the value of L* that defines the lightness of ink for yellow color on cotton fabric is closed to 100, indicating that yellow colored ink has higher value of lightness than those of the red colored and blue colored inks. Inks derived from curcuma powder and dried chrysanthemum seeds show positive values of b*, suggesting the highest value of yellow color. Blue colored inks from indigo and butterfly pea have negative values of a*, meaning that there is no value of red color but blue color. Black colored inks from charcoal and rambutan peels have lower values of L* than other colors, high values of a*, and negative values of b*.

3. Results on satisfaction of participants towards natural inks

Table4.4Opinions of art teachers and product designers towards ink quality and application (N=30)

Opinions	Results		
	$\bar{X}$	SD	Meaning
Suitability for the use in art work	4.55	0.75	Most
Suitability of color tone for art work and design	4.70	0.51	Most
Opportunity for creating value of art works and products from fabrics	4.84	0.75	Most
Convenience to use for teaching arts and designs of products from fabrics.	4.85	0.48	Most
Convenience at work	3.67	0.82	Much
Convenience in finding raw materials for producing	4.83	0.75	Most

Table 4.4 reports highest level of opinions of respondents as art teachers and product designers regarding the convenience to use for teaching arts and designs of products from fabrics, opportunity for creating value of art works and products from fabrics, convenience in finding raw materials for producing, suitability of color tone for art work and design, suitability for the use in art work, except high level for convenience at work.

Table 4.5Opinions of general people towards the quality of inks and application (N=200)

Opinions	Results		
	$\bar{X}$	SD	Meaning
Suitability for the use in art work	4.65	0.71	Most
Suitability of color tone for art work and design	4.72	0.61	Most
Opportunity for creating value of art works and products from fabrics	4.85	0.70	Most
Convenience to use for teaching arts and designs of products from fabrics.	4.85	0.49	Most
Convenience at work	4.60	0.75	Most
Convenience in finding raw materials for producing	4.85	0.70	Most

Based on Table 4, respondents as general people expressed their opinions at highest level in all aspects including the convenience to use for teaching arts and designs of products from fabrics, opportunity for creating value of art works and products from fabrics, convenience in finding raw materials for producing, suitability of color tone for art work and design, suitability for the use in art work, and convenience at work.

Discussion

Based on the research result, natural colorants from plants can yield colors for printing similar to dyeing. Banana gum and papaya gum act as adhesive agent instead of resin and provide good result for fastness of screen inks with somewhat reduced density. The finding is consistent with Chaiwat Kaewklaikajornsiri and Pratapjai Sikkha in their study on indigo dyes using banana sap as mordant and found that banana sap helps improve the adhesion of indigo on cotton, reduces the number of dyeing, and increases color fastness to light and to washing. This study also found that using sodium chloride as additive provides better color fastness than aluminium sulfate and copper sulfate. This result agrees to the research conducted by Anongpan Hattamas and Suwapang Srithep (2007) who studied the quality of natural colors of flowers and plant leaves in local areas and used 10 kinds of flowers and plant leaves for their experiment to obtain 8 natural colorants which included rosella, Butterfly pea, Pandanus Leave, Little ironweed Leave, Sea almond Leave, Siam Weed leave, Ebony leave Indigo leave and Mango leave. After boiling them and filtering for liquid portions, 1 teaspoon of sodium chloride was added to enhance adhesive property. These natural inks were used instead of chemical inks to create batik work by painting onto the fabrics. This will increase the quality of work and reduce cost. The batik work looked soft and cold. In the current study, both groups of respondents gave highest level of opinions on natural inks for their convenience at work in teaching arts and product design from fabric. It corresponds to the use of natural colors from plants and soil for art work by mixing them with oil to obtain black color from soil, green from grasses, sepia from onion shells, yellow from butter, and grey from ashes, for printing on papers. (DIY Screen Printing and more : online)

Bibliography

Anongpan Hattamas and Suwapang Srithep. 2007. Use of Natural Colors from flowers and Leaves on Batik for Enhanced Quality of Work Piece. Phetchaboon Rajabhat University.

Chaiwat Kaewklaikajonsiri. A Study of Indigo Dyes on Cotton Using Banana Sap as Natural Mordant. A Thesis on Product Design, Faculty of Applied Arts and Design, Ubon Rachathani University.

Gluey Porch Treatments Adventures in DIY screen printing and more Making natural ink/paint https://mjfchance.wordpress.com/2010/04/07/making-natural-ink-paint/

H.Kipphan, 2001,"Handbook of Print Media", Springer-Verlag, Heidelberg, p. 155.

IPST.http://fieldtrip.ipst.ac.th/intro_sub_content.php?content_id=28&content_folder_id=281

John Stephens, 1996, Screen Process Printing, Blueprint An Imprint of Chapman & Hall, England, Second edition, p. 223-231

Knowledge and Technology Center for Northern Textiles. Natural Dyeing. Chiangmai University.http://www.ist.cmu.ac.th/cotton/naturalColor_Human.php?subnav=3

Nik Semenoff,1991, Artist-in-residence, University of Saskatchewan Producing Tusche Wash Effects in Screen printing using Toner for Images and Simple Pastes as an Ink Base http://homepage.usask.ca/~nis715/scrnprnt.html

Samuel B.Hoff, 1997, Screen Printing A Contemporary Approach, Delmar Publishers, U.S.A., p. 114.