PROCEEDINGS BOOK

INTERNATIONAL MEDITERRANEAN CONGRESS

November 16-18, 2022, Mersin, Türkiye

Edited by
Asst. Prof. Dr. Mehmet Emin KALGI

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by

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IKSAD GLOBAL Publications – 2022©

Issued: 02.12.2022

ISBN:978-625-6380-19-6

CONGRESS ID

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INTERNATIONAL MEDITERRANEAN CONGRESS

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CONTENT

CONGRESS ID	**I**
SCIENTIFIC COMMITTEE	**II**
PHOTO GALLERY	**III**
PROGRAM	**IV**
CONTENT	**V**

Author	Title	No
İrem ERASA AKÇA	NEW DEVELOPING BUDGET APPROACHES IN TURKEY	1
Ümmühan GÜLNAR Faruk GÜVEN Sefa USTA	THE RELATIONSHIP BETWEEN ACADEMICIANS' ON-CAMPUS RECREATIONAL TENDENCIES, PARTICIPATION IN RECREATIVE ACTIVITIES, AND SOCIALIZATION: EXAMPLE OF KARAMANOĞLU MEHMETBEY UNIVERSITY	7
Utku ERSÖZ	STRATEGIC MANAGEMENT PROCESS AND AN EVALUATION ON STRAGEGIC PLANS OF UNIVERSITIES	9
Özden Özer Taşkın	PROTECTION OF THE CHILD'S SOCIAL PERSONALITY VALUES IN THE USE OF CUSTODY RIGHT	18
Aysun MERT Buket ÜNDEMİR	EXAMINATION OF PRE-SERVICE TEACHERS' IMPOSTER PROFILES WITH SOME VARIABLES	20
Mehmet Emin KALGI Taha YILMAZ	AN INVESTIGATION OF THE FUNCTIONS OF MASJIDS AND MOSQUES AS CENTERS FOR ENSURING UNITY AND SOLIDARITY OF THE ISLAMIC SOCIETY IN POSTMODERN SOCIETY	33
Taha YILMAZ Mehmet Emin KALGI	CONTEMPORARY DEBATES ON THE CLOSING OF JURISPRUDENCE IN ISLAMIC LAW	43
Merve BİNGÖL	A LOOK AT THE CONCEPT OF THE KHALIFATE WITHIN THE CONTEXT OF THE ENCOUNTER (Special to the 72nd Verse of Surah Ahzab)	54
Behçet BİBER Prof. Dr. Hüseyin Bekir YILDIZ	MEASURING THE KNOWLEDGE LEVELS OF NURSING STUDENTS ON OCCUPATIONAL HEALTH AND SAFETY BY SURVEY	62
Başak AĞCA Hüseyin Bekir YILDIZ	MEASURING OCCUPATIONAL HEALTH AND SAFETY KNOWLEDGE LEVELS IN PARAMEDIC STUDENTS	64
Muhterem AKAY Hüseyin Bekir YILDIZ	VOCATIONAL AND TECHNICAL ANATOLIAN HIGH SCHOOL MECHANIC STUDENTS' OPINIONS ON OCCUPATIONAL HEALTH AND SAFETY	66
Mehmet DEMİR Ali GİRAY Hüseyin Bekir YILDIZ	OPINIONS OF VOCATIONAL AND TECHNICAL ANATOLIAN HIGH SCHOOLS STUDENTS IN ANIMAL HEALTH AND AGRICULTURE ON OCCUPATIONAL HEALTH AND SAFETY	68
Ece Ozdemir Oktem Fatih Aslan Özkan Özen	CEREBRAL VOLUME ALTERATIONS IN LATE-ONSET MONOCULAR BLINDNESS: A VOLUMETRIC IMAGING STUDY	86
I. Ameziane El HASSANI H. ASSILA K. KARROUCHI F. LAZRAK Y. RAMLI M. ANSAR	SYNTHESIS AND DESIGN OF NEW PYRAZOLE DERIVATIVES WITH POTENTIAL PHARMACOLOGICAL ACTIVITIES	88
OLAJIDE Oluwamayowa Opeyimika OLAYEMI Michael Sunday OLUWAFEMI James Oluwaseyi AJAYI Omolola Felicia	MODELLING THE EFFECTS OF AGE AND GENDER ON PATIENTS WITH HEPATITIS B	89

Gamidov Elshad Gamid oğlu	BOUNDARY VALUE PROBLEMS FOR SECOND-ORDER OPERATOR-DIFFERENTIAL EQUATIONS	454
Ertan GÜNDOĞDU Yunus ATALAN	RATE OF CONVERGENCE ANALYSIS FOR A NEW FIXED POINT ITERATION	458
Esra ÖNCÜL Doğan YILDIZ	COMPARISON OF HAPPINESS LEVELS OF EU MEMBER COUNTRIES AND TURKEY USING ALTERNATIVE METHODS	460
Berrak KOCAMAN	A REVIEW OF STUDIES ON ANALYTICAL THINKING IN TURKEY BETWEEN 2002-2022	462
Vedia Bennu GİLAN Semra ERDOĞAN Saim YOLOĞLU	COMPARISON OF STRATIFIED COX REGRESSION WITH FRAILTY MODELS IN NON-PROPORTIONAL HAZARDS	476
Elif Feyza TOPDAS	LIGHT AND DARK-COLORED CORN SILKS: EVALUATION REGARDING ANTIOXIDANT POTENTIALS	478
Yusuf CEYLAN	DETERMINING THE L50 VALUE OF VIBRATING SIEVES USED IN STRIPED VENUS CLAM FISHERY IN THE BLACK SEA	486
Guzal MASSADIKOVA Meral ÖZOMAY	SILK FABRIC DYEING WITH SALVIA OFFICINALIS L. EXTRACT: INFLUENCE OF SODIUM TETRABORATE DECAHYDRATE MORDANT CONCENTRATION	488
Deniz Damla Altan KAMER	FOOD HYDROCOLLOIDS PRODUCED FROM RECYCLED AGRICULTURAL WASTES: OPPORTUNITIES AND CHALLENGES	502
Gülce Bedis KAYNARCA	FISH GELATIN'S POTENTIAL APPLICATIONS IN THE FOOD INDUSTRY	503
Ayşe Tülin ÖZ Yasemin KIR	THE EFFECT OF HEXANAL APPLICATION ON THE BIOCHEMICAL COMPOSITION OF FRESH CUT 'HICAZNAR' POMEGRANE FRUIT	504
Ayşe Tülin ÖZ Yasemin KIR	DETERMINATION OF THE EFFECT OF POST-HARVEST STEAM APPLICATION ON THE MICROBIAL AND PHYSICAL QUALITY OF FRESH-CUT POMEGRANATE FRUITS	513
Begüm İLKER Özkan GÖRMEZ Belgin GÖZMEN	OXIDATION OF CHLORAMPHENICOL AQUEOUS SOLUTION BY ELECTRO-FENTON METHOD USING BIMETALLIC CATALYSTS	524
Naim CHAIMAE Tizliouine ABDESLAM	GEOMETRIC OPTIMIZATION STUDY OF WAVE ENERGY CONVERSION DEVICES	533
Laiza Costa Santos Nascimento Andrey Souza Pinheiro Polyane Alves Santos Kenedy Marconi Geraldo dos Santos Tagleorge Marques Silveira	"SIMULATION OF IDENTIFICATION SYSTEM TAGS BY RADIO FREQUENCY (RFID) FOR HOSPITAL APPLICATIONS"	534
Andrey Souza Pinheiro Laiza Costa Santos Nascimento Kenedy Marconi Geraldo dos Santos Polyane Alves Santos Tagleorge Marques Silveira	METHODS AND TECHNIQUES FOR ELECTROMAGNETIC CHARACTERIZATION OF DIELECTRICS AND FLEXIBLE CONDUCTORS	535
Emerson Gean Sousa Vieira Rennan Souza Ribeiro Polyane Alves Santos Kenedy Marconi Geraldo dos Santos Tagleorge Marques Silveira	MODELING AND DEVELOPMENT OF DIRECTIVE ANTENNAS WITH LINEAR POLARIZATION FOR LABORATORY MEASUREMENTS	536
Érika Brito Correia Letycia Vilanova Dantas Lucas dos Santos Ribeiro Kenedy Marconi Geraldo dos Santos Polyane Alves dos Santos Tagleorge Marques Silveira	LOW-COST ELECTROMECHANICAL RELAY: CONSTRUCTION TO UNDERSTAND MAXWELL'S EQUATIONS FOR EDUCATIONAL PURPOSES	537

INTERNATIONAL
MEDITERRANEAN
CONGRESS

November 16-18, 2022, Mersin, Türkiye

Proceedings Book

SILK FABRIC DYEING WITH *SALVIA OFFICINALIS* L. EXTRACT: INFLUENCE OF SODIUM TETRABORATE DECAHYDRATE MORDANT CONCENTRATION

SALVIA OFFICINALIS L. (ADAÇAYI) EKSTRAKTI ILE IPEK KUMAŞ BOYAMA: SODYUM TETRABORAT DEKAHIDRAT (BORAKS) MORDAN KONSANTRASYONUNUN ETKISI

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ABSTRACT

Mordanting process with sodium tetraborate decahydrate appears as a method applied to woods before varnishing nowadays. However, mordanting application on textile materials is very limited. This study is designed to examine the effect of the concentration of Sodium Tetraborate Decahydrate on color behavior and fastness in the dyeing of silk fabrics with Luteolin dyestuff. Luteolin *Salvia officinalis* L. is the only dyestuff found in salvia officinalis plant. Sodium Tetraborate Decahydrate was tested in 21 different concentrations in co-mordanting method with mordant-free and between %0 and %20 changing. Similar consequences were acquired in terms of color differences, light washing, staining and friction fastness with a range of 4-5. The most obvious and significant change in dyeing using borax mordant occurred in Lab values, and it was determined that the color became lighter as borax mordant increased.

Keywords: Sodium Tetraborate Decahydrate, natural dyeing, Luteolin, mordant, *Salvia officinalis* L.

ÖZET

Sodium Tetraborate Decahydrate ile mordanlama işlemi günümüzde daha çok vernik işlemlerinden önce odunlara uygulanan bir yöntem olarak karşımıza çıkmaktadır. Ancak tekstil materyalleri üzerinde uygulanması oldukça sınırlıdır. Bu çalışma Luteolin boyarmaddesi ile ipek kumaşların boyanmasında Sodium Tetraborate Decahydrate maddesinin konsantrasyonunun renk davranışı ve haslıklar üzerindeki etkisini incelemek üzere tasarlanmıştır. Luteolin, *Salvia officinalis* L. bitkisinde bulunan tek boyarmaddedir. Sodium Tetraborate Decahydrate, birlikte mordanlama yöntemi ile %0 ile %20 arasında değişen ve mordansız boyama olmak üzere toplamda 21 farklı konsantrasyonda denenmiştir. Renk farklılıkları, ışık, yıkama, lekeleme ve sürtünme haslıkları açısından 4-5 arasında olmak üzere benzer sonuçlar elde edilmiştir. Boraks mordanı kullanılarak yapılan boyamalarda en belirgin ve anlamlı değişiklik Lab değerlerinde gerçekleşmiş, boraks mordanı arttıkça rengin açıldığı tespit edilmiştir.

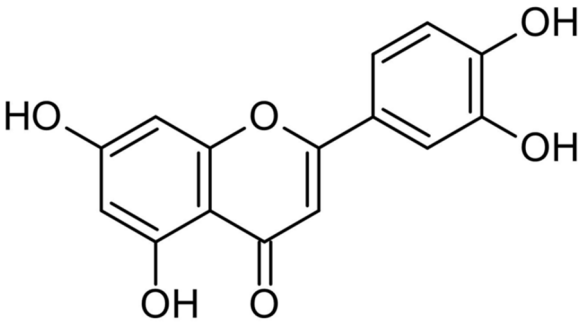
Anahtar Kelimeler: Sodium Tetraborate Decahydrate, natural dyeing, Luteolin, mordant, *Salvia officinalis L.*

INTRODUCTION

Sodium Tetraborate Decahydrate ($Na_2B_4O_7 \cdot 10H_2O$), known also as borax, is the most widely used boron compound with various applications in both industrial and consumer products [1-5]. Borax is used as a bio-mordant substance in dyeing textile materials [6-10]. Utilization of mordant substances in natural dyeing processes is significant in terms of obtaining different color tones and increasing fastness values of dyeing. Natural dyes have many limitations from the point of color fastness and gloss when used on their own [11-15]. Some natural dyes, for instance indigo, are stabled without mordanting. *Rubia tinctorum* and other dyes fastnesses are limited, exposure to light and washing tendency is high [16-22]. Plant-based dyeing used to dye textile products for centuries. Many plant species are used to obtain dyes. One of these herbs is *Salvia officinalis* (Figure 1).



Salvia officinalis L.



Luteolin

Figure 1. *Salvia officinalis* L. and Luteolin

The most important active substance of salvia officinalis is the essential oil between %0,5 and %2,5. When the compound of essential oils is examined, When the composition of essential oils is examined, it is seen that the main substance is thujone except cineole, camphor, borneol, linalool, pinene and bornyl acetate. *Salvia officinalis*, which is widely used, is also used for dyeing silk, wool, carpet, and rug yarns [23-27]. Plant-based dyes are ethically important to an eco-friendly product. Plant based dyes can produce special aesthetic qualities that add value to textile production as a handicraft and industry. This study is designed to examine the effect of the concentration of Sodium Tetraborate Decahydrate on color behavior and fastness in the dyeing of silk fabrics with Luteolin dyestuff. It is expected that this research will guide the silk weavers doing plant-based dyeing in terms of the desired colors and prove the optimum usage amount of Sodium Tetraborate Decahydrate as a mordant with fastness values.

MATERIAL METHOD

Materials

In this research, Alanya silk woven with 100% silk fiber in plain weave was purchased from a local store and used. Fabric weight is 150 g/m^2 scarf density is 32 wire/cm and abb density is 41 wire/cm. Dried form of *Salvia officinalis* was acquired from the region of Antalya. Sodium Tetraborate Decahydrate ($Na_2B4O_7 \cdot 10H_2O$) was obtained from Galenik Ecza ve Kimyevi Maddeler (Turkiye). Besides, sodium carbonate (Na_2CO_3), natural soap and wetting agent (Denwet PB 100) was used for the sericin removal actions.

Method

Sericin removal

Flotte	: 1/50
Soap	: 1g/L
Sodium carbonate	: 2g/L
Wetting agent	: 1g/L
Temperature	: 100^{0}C
Duration	: 60 min.

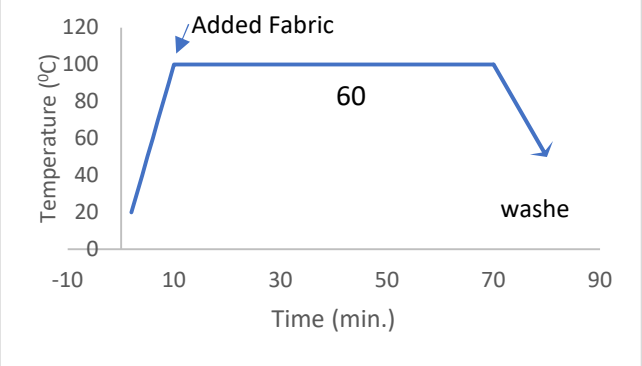


Figure 2: Sericin Removal

Silk fabric was pre-treated at 60' to remove sericin in a bath prepared with 1 g/L Soap, 2 g/L sodium carbonate and 1 g/L wetting agent at 98^{0}C and 1/50 liquor ratio, rinsed in warm water and dried at room temperature (27^{0}C) (Figure 2).

Co-mordanting and dyeing

Preparing extract: 50 g of *Salvia officinalis* L. was boiled in 800 mL distilled water for 1 hour, then left for 24 hours and filtered through a cotton bag. The filtered *Salvia officinalis* L. was reboiled, and the process was continued until there was no colorant left and all the obtained extracts were combined to be used in the dyeing step. 1000 ml extract were acquired in total. The mL of the extract corresponding to 2 g of the plant for 1 g sample was calculated by the ratio-proportional method. Water was added for the rest of the flotte. %200 colorant was used according to material weight (Figure 3).

Flotte	: 1/50
Sodium Tetraborate Decahydrate	: %1-%20
Salvia officinalis L. extract	: %200
Temperature	: 100^{0}C
Duration	: 60 min.

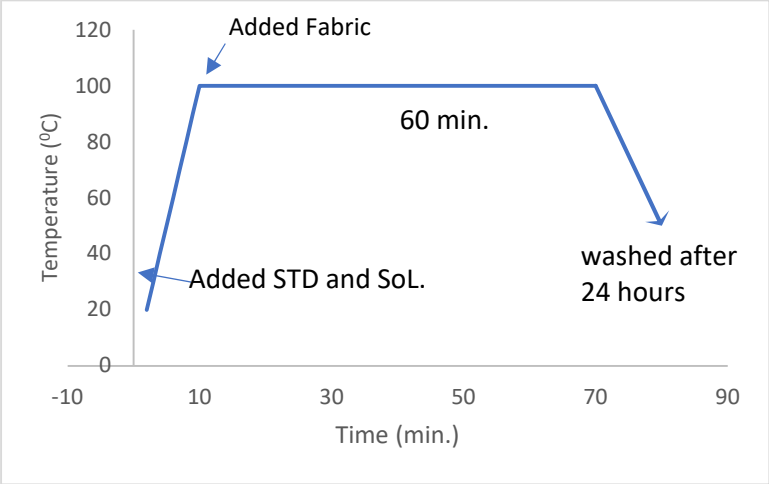


Figure 3: Mordant process

(STD: Sodium Tetraborate Decahydrate; SoL.: *Salvia officinalis* L. extract)

40 mL of *Salvia officinalis* L. extract for 200% dyeing was drawn into the dyebath for 1 g sample. 10 ml water was added for mordant-free dyeing. 20 more of the same dyebaths were prepared for mordant dyeings and 20 different concentrations of Sodium Tetraborate Decahydrate between 1% and 20% were added to each bath. Dyebaths were completed by adding 10 ml water according to flotte ratio. Breakers placed on the stove reached the boiling temperature in 10 minutes. Wet silk fabrics were added to the dye baths that reached the boiling temperature and were processed for 60 minutes with constant stirring. The beakers taken from the stove were left to cool down at room temperature. The fabrics were kept in the dyebath for 24 hours and were rinsed until the rinsing water was completely clear and left to dry at ambient temperature.

Color Measurement

In the measurements performed with Konica Minolta CM-700d spectrophotometer using a 10° standard observer under D65 daylight [28-30], L, a, b and Gloss values were determined for the colors of 100% silk samples after dyeing and are shown in Table 2. In addition, L, a, b and Gloss measurements of the samples after washing and light fastness, as well as ΔL, Δa, Δb, ΔE and Gloss calculations are also given in Table 3 and Table 5.

Color differences with values of $\Delta E*$, $\Delta L*$, $\Delta a*$ and $\Delta b*$ were calculated using the formulas below.

$\Delta E^*_{ab} = (\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2})^{1/2}$ Formula 1

$\Delta L^*2 = (L^*_2 - L^*_1)^2$ Formula 2

$\Delta a^*2 = (a^*_2 - a^*_1)^2$ Formula 3

$\Delta b^*2 = (b^*_2 - b^*_1)^2$ Formula 4

L= fairness – darkness, *a*= redness – greenness, *b*= yellowness – blueness, gloss brightness, Δ*E* represent total color differences. The color difference increases as the ΔE values move away from 0.

Fastness Tests

The washing fastness of the test samples was carried out in a washing fastness test machine (Gyrowash Washer Tester) according to the ISO 105-C06 [31-34] standard, and the evaluation was made according to the ISO

A05 [35-37] standard with a reflectance spectrophotometer. ECE phosphate-free standard detergent was used in washing fastness tests. Evaluation was made with staining and gray scales.

Light fastness was applied together with blue wool references in a light fastness test device (Solarbox 1500E) according to TS 1008 EN ISO 105-B02 standard [38-40] and the total color difference (ΔE*) between the untested sample and the test samples was evaluated in the spectrophotometer.

Wet-Dry friction fastnesses were applied in a friction fastness test device (Test T600SH Manual Friction Fastness Device, crockmeter) according to ISO 105-X12 standard [41-43]. Evaluation was made by using staining scale. The fabric used as a friction cloth (convenient for TS 717 EN ISO 105-X12) was a standard cotton fabric.

RESULTS AND DISCUSSION

The Alanya silk used in the study was made according to the TS 250 EN 1049-2 [44] standard, to determine the number of threads in one centimeter of woven fabrics.

Table 1. Density Characteristics of Alanya Silk

Fiber	Knitting	Density-Scarf	Density- Warping	Fabric Weight
Silk	Plain Weave	32 wire/cm	41 wire/cm	150g/m^2

Table 2. Lab and Gloss Values of Mordanted and Dyed Samples

	Mordant Concentration	Dye Color	L	a	b	Gloss
1	Non-mordanted		74,81	2,74	16,46	0,81
2	%1 $Na_2B_4O_7 \cdot 10H_2O$		73,34	2,81	16,82	0,55
3	%2 $Na_2B_4O_7 \cdot 10H_2O$		74,73	2,77	16,75	1,66
4	%3 $Na_2B_4O_7 \cdot 10H_2O$		76,48	1,77	16,18	1,26
5	%4 $Na_2B_4O_7 \cdot 10H_2O$		76,21	2,49	15,91	2,18
6	%5 $Na_2B_4O_7 \cdot 10H_2O$		77,85	2,23	15,87	1,98
7	%6 $Na_2B_4O_7 \cdot 10H_2O$		76,98	2,45	16,29	1,51
8	%7 $Na_2B_4O_7 \cdot 10H_2O$		79,13	2,02	16,13	1,11
9	%8 $Na_2B_4O_7 \cdot 10H_2O$		78,24	2,32	16,72	2
10	%9 $Na_2B_4O_7 \cdot 10H_2O$		81,35	1,6	15,39	1,54
11	%10 $Na_2B_4O_7 \cdot 10H_2O$		81,22	1,42	15,66	1,84
12	%11 $Na_2B_4O_7 \cdot 10H_2O$		80,42	1,86	15,65	2,27
13	%12 $Na_2B_4O_7 \cdot 10H_2O$		81,39	1,53	15,8	1,9
14	%13 $Na_2B_4O_7 \cdot 10H_2O$		81,9	1,46	15,15	2,62
15	%14 $Na_2B_4O_7 \cdot 10H_2O$		81,66	1,52	15,48	2,42
16	%15 $Na_2B_4O_7 \cdot 10H_2O$		82,47	1,22	15,33	1,94
17	%16 $Na_2B_4O_7 \cdot 10H_2O$		82,26	1,4	15,42	1,71
18	%17 $Na_2B_4O_7 \cdot 10H_2O$		82,36	1,42	15,48	1,3
19	%18 $Na_2B_4O_7 \cdot 10H_2O$		83,2	1,06	15,23	1,86
20	%19 $Na_2B_4O_7 \cdot 10H_2O$		83,31	1,16	15,03	1,46
21	%20 $Na_2B_4O_7 \cdot 10H_2O$		83,52	1,08	14,75	1,47

When Table 2 was examined, it was confirmed that the darkest color in terms of L value was obtained from dyeing with 1% Sodium Tetraborate Decahydrate concentration.

It can be said that Luteolin dyestuff binds more in dyeings using 1% and 2% mordant compared to dyeing without mordant.

It is concluded that the color is lighter at 3% and higher concentrations The a and b values also decreased significantly as the concentration of Sodium Tetraborate Decahydrate increases. Therefore, it was confirmed that the color shifts to green and blue in small proportions that cannot be seen with the naked eye.

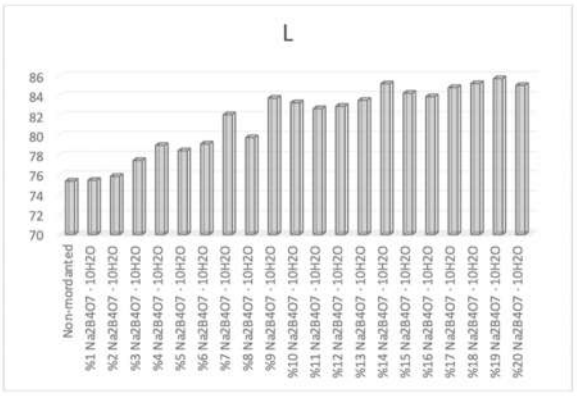


Figure 4: L Values

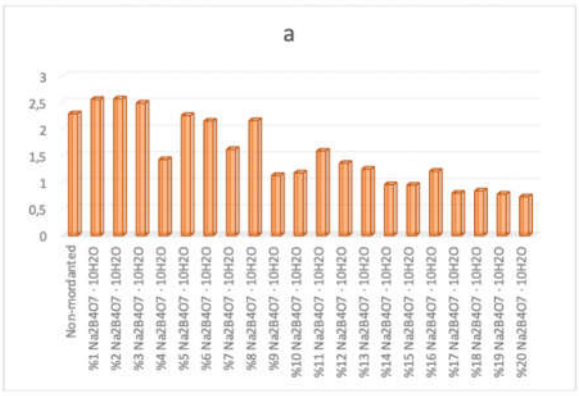


Figure 5: a Values

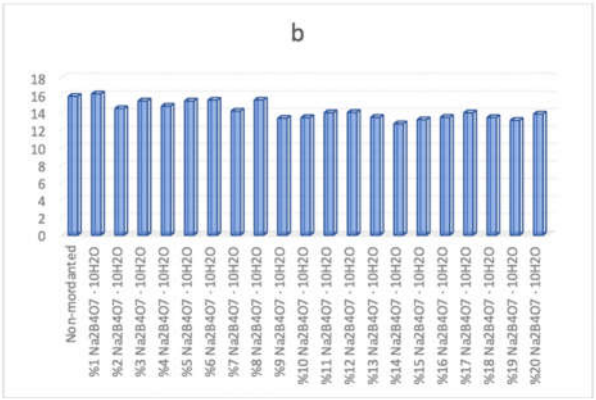


Figure 6: b Values

Table 3. Color Differences After Washing

	L	**a**	**b**	**Gloss**	**ΔL**	**Δa**	**Δb**	**ΔE**
1	75,4	2,29	15,86	1,36	0,59	0,45	0,6	0,95
2	75,49	2,56	16,14	1,74	2,15	0,25	0,68	2,27
3	75,89	2,57	14,48	0,91	1,16	0,2	2,27	2,56
4	77,48	2,49	15,34	1,38	1	0,72	0,84	1,49
5	79,01	1,43	14,75	1,21	2,8	1,06	1,16	3,21
6	78,47	2,26	15,33	1,82	0,62	0,03	0,54	0,82
7	79,15	2,15	15,43	2,3	2,17	0,3	0,86	2,35
8	82,1	1,62	14,19	1,55	2,97	0,4	1,94	3,57
9	79,79	2,16	15,45	1,65	1,55	0,16	1,27	2,01
10	83,78	1,13	13,35	1,97	2,43	0,47	2,04	3,21
11	83,31	1,18	13,43	2,04	2,09	0,24	2,23	3,07
12	82,72	1,59	14	1,15	2,3	0,27	1,65	2,84
13	82,96	1,36	14,03	2,36	1,57	0,17	1,77	2,37
14	83,55	1,25	13,47	3,54	1,65	0,21	1,68	2,36
15	85,22	0,96	12,73	1,96	3,56	0,56	2,75	4,53
16	84,27	0,95	13,2	2,17	1,8	0,27	2,13	2,80
17	83,92	1,21	13,48	2,85	1,66	0,19	1,94	2,56
18	84,85	0,8	13,98	1,64	2,49	0,62	1,5	2,97
19	85,24	0,84	13,44	1,16	2,04	0,22	1,79	2,72
20	85,74	0,78	13,12	1,65	2,43	0,38	1,91	3,11
21	85,07	0,73	13,84	1,27	1,55	0,35	0,91	1,83

When Table 3 is examined, the color change (ΔE difference) after washing fastness in Alanya silk samples dyed with 20 different concentrations of Sodium Tetraborate Decahydrate and *Salvia officinalis* L. without mordant was generally between 2-3.

Table 4. Fading and Staining Values After Washing Fastness

	Color	**STAINING**					
	Fading	Wool	Polyacrylonitrile	Poliester	Poliamid	Cotton	Acetate
1	5	5	5	5	5	5	5
2	4-5	5	5	5	5	5	5
3	4-5	5	5	5	5	5	5
4	5	5	5	5	5	5	5
5	4-5	5	5	5	5	5	5
6	5	5	5	5	5	5	5
7	4-5	5	5	5	5	5	5
8	4-5	5	5	5	5	5	5
9	4-5	5	5	5	5	5	5
10	4-5	5	5	5	5	5	5
11	4-5	5	5	5	5	5	5
12	4-5	5	5	5	5	5	5
13	4-5	5	5	5	5	5	5
14	4-5	5	5	5	5	5	5
15	4	5	5	5	5	5	5
16	4-5	5	5	5	5	5	5
17	4-5	5	5	5	5	5	5
18	4-5	5	5	5	5	5	5
19	4-5	5	5	5	5	5	5
20	4-5	5	5	5	5	5	5
21	5	5	5	5	5	5	5

When Table 4 was examined, it was concluded that Alanya silk samples dyed with 20 different concentrations of Sodium Tetraborate Decahydrate and *Salvia officinalis* L. without mordant did not cause any staining on wool, polyacrylonitrile, polyester, polyamide, cotton, and acetate after washing fastness. Fading values tested after washing fastness were between 4 and 5, and no significant increase or decrease was observed between them.

Table 5. Color Differences after Light Fastness

	L	**a**	**b**	**Gloss**	**ΔL**	**Δa**	**Δb**	**ΔE**
1	74,93	3,3	17,23	0,81	0,12	0,56	0,77	0,96
2	73,84	2,75	15,99	0	0,5	0,06	0,83	0,97
3	75,28	2,79	15,9	0,54	0,55	0,02	0,85	1,01
4	76,13	1,98	15,01	0,35	0,35	0,21	1,17	1,24
5	77,05	2,92	16,78	0,61	0,84	0,43	0,87	1,28
6	77,85	2,51	15,16	1,24	0	0,28	0,71	0,76
7	78,25	2,61	16,26	0	1,27	0,16	0,03	1,28
8	81,77	2,17	15,44	0,98	2,64	0,15	0,69	2,73
9	78,12	2,45	15,26	1,01	0,12	0,13	1,46	1,47
10	81,67	2,02	14,3	1,27	0,32	0,42	1,09	1,21
11	81,31	1,85	13,86	0,97	0,09	0,43	1,8	1,85
12	80,48	2,34	14,91	0,47	0,06	0,48	0,74	0,88
13	81,41	2,01	14,65	0,57	0,02	0,48	1,15	1,25
14	81,78	2,02	13,9	1,08	0,12	0,56	1,25	1,37
15	83,73	1,89	15,69	1,29	2,07	0,37	0,21	2,11
16	83,54	1,74	14,54	1,77	1,07	0,52	0,79	1,43
17	83,37	1,87	14,98	1,55	1,11	0,47	0,44	1,28
18	84,51	1,76	15,09	1,96	2,15	0,34	0,39	2,21
19	86,52	1,14	13,84	2,51	3,32	0,08	1,39	3,60
20	83,63	1,89	15,29	2,87	0,32	0,73	0,26	0,84
21	85,19	1,63	14,55	2,99	1,67	0,55	0,2	1,77

When the ΔE values obtained after the color fastness across the light of the dyed samples were examined, it was concluded that these differences ranged between 1-2, and therefore;

they had a good light fastness value (Table 5).

Table 6. Color Fastness to Light and Friction

	Light	Dry friction	Wet friction
1	5	4-5	4-5
2	5	4-5	4-5
3	5	4-5	4-5
4	5	4-5	4-5
5	5	4-5	4-5
6	5	4-5	4-5
7	5	4-5	4-5
8	4-5	4-5	4-5
9	5	4-5	4-5
10	5	4-5	4-5
11	5	4-5	4-5
12	5	4-5	4-5
13	5	4-5	4-5
14	5	4-5	4-5
15	4-5	4-5	4-5
16	5	4-5	4-5
17	5	4-5	4-5
18	4-5	4-5	4-5
19	4-5	4-5	4-5
20	5	4-5	4-5
21	5	4-5	4-5

When examining 6th table, it was concluded that there is not any difference between their wet and dry friction fastnesses. Wet and dry friction fastnesses are on a good level in each mordant concentration. There is also no meaningful difference between concentrations in terms of light fastnesses. All dyeing processes have very good and good light fastness.

CONCLUSION

According to the staining results after washing fastness, it was determined that different concentrations of Sodium Tetraborate Decahydrate mordant did not have any effect on staining. According to the color change (fading) results after washing fastness, a fading value of 4 and above was determined at all concentrations. In terms of dry and wet friction fastnesses, it was determined that the fastness values of the samples mordanted with Sodium Tetraborate Decahydrate were quite decent. According to the light fastness test results, it has been determined that all concentrations have light fastness in acceptable ranges. The most obvious and significant change in the dyeing processes performed by using Sodium Tetraborate Decahydrate mordant was in the Lab values, and it was determined that the color became lighter as the Sodium Tetraborate Decahydrate mordant increased. According to the lab values, it was determined that the colors of the dyeings made with 1% and 2% Sodium Tetraborate Decahydrate concentration were darker than the dyeings made without mordant and with a concentration of 3% or more.

The dyeing scale can be increased, especially at different concentrations of Sodium Tetraborate Decahydrate up to 5%. For instance: %0,5 - %1 - %1,5 - %2 - %2,5 - %3 - %3,5 - %4 - %4,5 - %5. Sodium Tetraborate Decahydrate effect can be observed in different natural dyestuff sources. Trials can be done by increasing experimental recipes at different temperatures and duration. The effect of Sodium Tetraborate Decahydrate on the physical features of the fabric can be tested on mordanted and dyed samples.

Special Thanks

The authors thank the "Marmara University Textile and Manuscripts Conservation and Restoration R&D Laboratory" for supporting the dyeing and analysis.

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