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FORMULATION DESIGN AND EVALUATION OF NAIL POLISH USING SCALES OF TILAPIA FISH

(*Oreochromis niloticus* OF FAMILY Cichlidae)

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Abstract : This research work is based on a comparison between nail polish derived from collagen and O*reochromis niloticus* fish scales. This study compares the properties and functionalities of nail polish manufactured from collagen and fish scales. Collagen and fish scale are said to give nail polish a unique and striking shine while also strengthening and improving the overall health of nails.

The design of nail polishes with collagen and fish scales is done through Design of Expert software. In this we evaluated 2 factorial 3 level Design where the RWP &NVC are estimated by considering the factors collagen, nitrocellulose and fish scale. Through a series of test with nine formulations of fish scale and collagen were conducted, we obtained the best fit formula as F8 (0,1) & F6 (1,0) respectively. The other parameters evaluated are glossiness of nail polish's surface, non- volatile content, resistance to water permeability, ease of applications and color retention. Initial research indicate that collagen and fish scales can be successfully incorporated into nail polish formulations. Collagen based nail polish provide favorable ease of application. Fish scales-based nail polishes provide promising result in terms of glossiness and color retention. Furthermore, this study explores the potential environment and sustainability aspects of collagen and fish scales as nail polish ingredients.

KEY WORDS: Fish scale, collagen, Nail polish, Resistance to water permeability, Nonvolatile content.

1.INTRODUCTION

Nail polish, also known as nail varnish or nail lacquer, is a viscous lacquer that is applied to the surface of the nail plate of fingernails and to nails to form a water-resistant coating, primarily for cosmetic purposes. It is estimated to be one of the most used cosmetic products in the world in 2011[1]. Nail polish is a type of lacquer used to adorn finger nails and toe nails. Numerous chemicals are used in nail polish since it must be robust, flexible, and resistant to chipping and peeling. This comparison studies main focus is on two un common ingredients- collagen and fish scale as potential replacements for popular nail polish ingredients. Collagen and fish scale have garnered attention as potential ingredients for nail polish with benefits for nail health and appearance. Additionally, some nail polish with collagen giving the nails a unique sheen and iridescent appearance This indicates that the polish has microscopic light- reflecting particles which gives the nails an iridescent, shimmering look [2],[3]. The essential components are colorants, resins, plasticizers, film forming agents and solvents are a few of the crucial ingredients. The primary component of nail lacquer that forms films is nitrocellulose. This coating is oxygen permeable; it strengthens and glosses nails without damaging them.

Design expert is a statistical approach software used for carrying out experimental designs including determining, the most effective preparation formula. Global advancements in nail polish formulas have greater emphasis on longevity and consumer convenience. Both optimization and understanding of the experimental variables are possible with this software. There are three alternatives for software research directions, contingent on the experimental design used. Among the choices are characterization, screening and optimization [4]. Throughout the manufacturing process, quality control must get the utmost attention. Throughout the manufacturing process the nail polish should be examined for a number of important characteristics, including drying time, water resistance, non-volatile content, resistance to abrasion, hardness and viscosity [4],[5]. Interesting prospects for the cosmetic industry are revealed by the comparison of nail polish using collagen and fish scale. The study's findings, which compare these characteristics can assist the cosmetics sector in developing innovative and powerful formula. The study also looks at using collagen and fish scale to give the nail polish its iridescent appearance [6].

This study aims to formulate design and evaluation of nail polish using scales of tilapia (Oreochromis *niloticus* of family Cichilidae). This study has four main objectives as follows; Pre-formulation study of nail polish using collagen and fish scale; Design and optimization of formula using DOE software based on the responses like nonvolatile content and resistance to water permeability

with 3 levels of factors like amount of nitrocellulose, collagen, and fish scale; Selection of best fit formula; Formulation and evaluation of best fit formula of fish scale and collagen. The term tilapia refers to a group of cichlid fishes originally native to Africa and middle east but widely introduced in tropical and subtropical regions around the world. They are highly adaptable, and have been raised commercially in ponds, cages, tropical climate raceways [7],[8].

2. RESEARCH METHODOLOGY

The following materials were used for the research work. The entire chemicals used were of best quality available.

Table no. 1: List of chemicals and Equipment's used in study

Raw Materials	Supplier of Raw Materials	Equipment	Manufacturer of Equipment
Nitrocellulose	Central Drug House(P) LTD. Bombay, New Delhi.	Electronic Balance	Shimadzu Pvt. Ltd Japan
Dibutyl Phthalate	JG Chemicals Pvt. Ltd, Kolkata, West Bengal	Magnetic Stirrer	B&C Industries. Vengola, Kerala, India
Citric Acid	Spectrum Reagents & Chemicals Pvt. Ltd, Edayar, Cochin.	Mixer Grinder	B&C Industries. Vengola, Kerala, India
Ethyl Acetate	Isochem Laboratories, Angamaly, Kochi	Hot Air Oven	M.C Dalal Agencies Chennai, Tamil nadu
Powdered Silica	Spectrum Reagents & Chemicals Pvt. Ltd, Edayar, Cochin	Light Microscope	LABOMED India
Coloring Agent (Eosin yellow and Crimson Red)	Spectrum Reagents & Chemicals Pvt. Ltd, Edayar, Cochin.	ATAGO Viscometer	VISCO™ Japan
Collagen	Dr. Morpen Pvt. Ltd. New Delhi.	—	—
Fish Scale	Collected from Freshly cultured pond near Urumbikkara. Idukki District	—	—
Castor oil	Spectrum Reagents & Chemicals Pvt. Ltd, Edayar, Cochin	—	—

2.1 METHOD OF FORMULATION

Nitrocellulose was dissolved in solvent (Ethyl acetate). Then plasticizer (di-butyl phthalate) along with stabilizing agent (citric acid) and thickening agent (powdered silica) was mixed with nitrocellulose. If needed, add more solvent due to quick evaporation of the solvent. Fish scale (*Oreochromis niloticus*) was added prior to mixing. Mixed thoroughly until dissolves. Coloring pigments was added and blended [9].

Table no 2: Batch manufacturing formula for nail polish using collagen (Maximum 10ml)

SL.NO	INGREDIENTS	NAILPOLISH USING COLLAGEN	NAILPOLISH USING FISH SCALE
1	Nitrocellulose	0.9g	0.9g
2	Castor oil	0.3ml	0.3ml
3	Citric acid	0.005g	0.005g
4	Ethyl acetate	2ml	2ml
5	Powdered Silica	Qs	Qs

6	Coloring Agent	Qs	Qs
7	Collagen	0.25g	-
8	Fish Scale	-	0.25g

3. RESULTS AND DISCUSSION

3.1 PREFORMULATION STUDIES

- **Test for nonvolatile content**

An 8 ml sample was placed in a glass Petri dish with a diameter of roughly 8cm, the samples were distributed evenly. Initial weight was noted. For 1 hour, the dish was baked at 105^0 C. After being taken out, the Petri dish was cooled and weighed. The amount of volatile content in the sample was ascertained by comparing its weight after drying. The weight differential was noted.
It was calculated by the formulae:
Non-volatile content = W3-W1/W2 x 100
Were, W1= weight of the empty dish, W2= weight of the sample before the test, W3= weight of the dish with dried sample [10],[11].

- **Test for resistance to water permeability**

This is a measurement of the film's permeability resistance to water. This was accomplished by covering a surface with a continuous film, letting it dry, and then submerging it in water. Before and after immersion, the weight of the Petri dish was measured. weight increases were computed by comparing the pre and post immersion weights. Lower the water resistance, the greater the weight increases.
It was calculated by using formula:
Water resistance = loss of weight of lacquer/ actual weight x 100.

Table no: 3 Results of RWP, NVC of nail polish prepared from fish scale

Formulation code (X1&X2)	Nitrocellulose (X1) g	Fish scale (X2) g	Resistant to water permeability (RWP) (Y1) g	Nonvolatile content (NVC) (Y2) g
F1(-1, -1)	0.9	0.25	0.18	3.61
F2(+1, -1)	3.6	0.25	0.24	3.74
F3(-1, +1)	0.9	1.00	0.29	3.90
F4(+1, + 1)	3.6	1.00	0.36	4.56
F5(-1,0)	0.9	0.50	0.42	4.37
F6(+1,0)	3.6	0.50	0.54	4.89
F7(0, -1)	1.8	0.25	0.62	5.42
F8(0, +1)	1.8	1.00	0.72	6.27
F9(0,0)	1.8	0.50	0.83	6.85

Table no:4 Results of RWP, NVC of nail polish prepared from collagen;

Formulation code (X1&X2)	Nitrocellulose (X1) g	Collagen (X2) g	Resistant to water permeability (RWP) (Y1) g	Nonvolatile content (NVC) (Y2) g
F1(-1, -1)	0.9	0.25	0.52	0.09
F2(+1, -1)	3.6	0.25	0.63	0.08
F3(-1, +1)	0.9	1.00	0.77	0.22
F4(+1, +1)	3.6	1.00	0.89	0.58
F5(-1,0)	0.9	0.50	0.94	0.13
F6(+1,0)	3.6	0.50	0.98	0.33
F7(0, -1)	1.8	0.25	1.52	0.52
F8(0, +1)	1.8	1.00	1.73	0.63
F9(0,0)	1.8	0.50	1.91	0.53

3.2 OPTIMIZATION OF FISH SCALE BASED NAIL POLISH

Optimization of Nail polish of Fish Scale and Collagen Was done using DOE Software [12],[13],[14],[15].

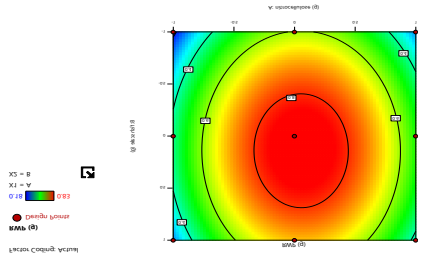
ANOVA FOR QUADRATIC MODEL OF RWP

Table no:5 Anova for reduced quadratic model of resistance to water permeability

Source	Sum of Squares	Df	Mean Square	F-value	p-value	
Model	0.4011	5	0.0802	104.25	0.0015	significant
A-nitrocellulose	0.0104	1	0.0104	13.54	0.0348	
B-fish scale	0.0181	1	0.0181	23.59	0.0167	
AB	0.0000	1	0.0000	0.0325	0.8684	
A^2	0.2964	1	0.2964	385.28	0.0003	
B^2	0.0761	1	0.0761	98.84	0.0022	
Residual	0.0023	3	0.0008			
Cor Total	0.4034	8				

The **Model F-value** of 104.25 implies the model is significant. There is only a 0.15% chance that an F-value this large could occur due to noise. **P-values** less than 0.0500 indicate model terms are significant. In this case A, B, A^2, B^2 are significant model terms. RWP (Y) = constant+A+B+AB-A^2- B^2, Deduced Equation (Y): constant+A+B-A^2-B^2FINAL EQUATION IN TERMS OF CODED FACTORS = Resistance to water permeability (Y) = +0.8533+0.0417A+0.0550B-0.3850A^2-0.1950B^2.

Figure no. 1: Contour plot of RWP of fish scale



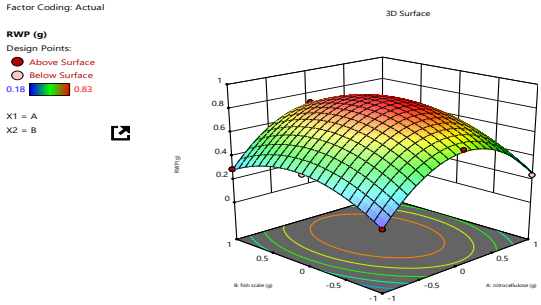


Figure no.2:3D Surface of contour plot of RWP of fish scale

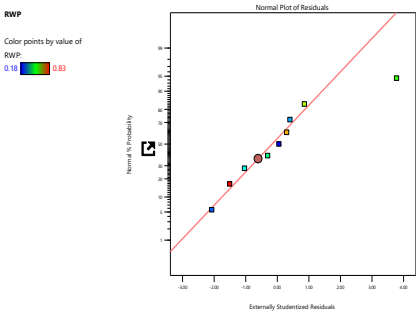


Figure no. 3: Normal plot of residuals of RWP of fish scale

ANOVA FOR QUADRATIC MODEL OF NVC

Table no:6 Anova for reduced quadratic model of non-volatile content

Source	Sum of Squares	Df	Mean Square	F-value	p-value	
Model	10.25	5	2.05	75.09	0.0024	Significant
A-nitrocellulose	0.2860	1	0.2860	10.48	0.0480	
B-fish scale	0.6403	1	0.6403	23.46	0.0168	
AB	0.0702	1	0.0702	2.57	0.2071	
A^2	8.01	1	8.01	293.58	0.0004	
B^2	1.24	1	1.24	45.34	0.0067	
Residual	0.0819	3	0.0273			
Cor Total	10.33	8				

The **Model F-value** of 75.09 implies the model is significant. There is only a 0.24% chance that an F-value this large could occur due to noise-**values** less than 0.0500 indicate model terms are significant. In this case A, B, A^2, B^2 are significant model terms. NVC (Y) = constant +A+B+ AB- A^2-B^2, Deduced Equation (Y) = constant+A+B-A^2- B^2 FINAL EQUATION=non-volatile content (Y) = +6.70+0.2183 A+0.3267 B-2.00A^2-0.7867B^2.

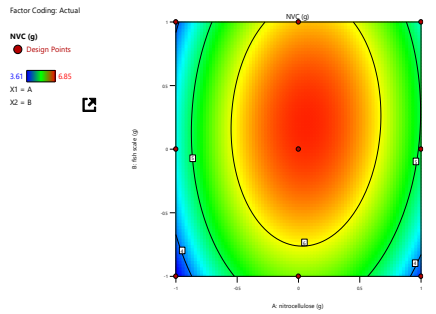


Figure no. 4: Contour plot of NVC of fish scale

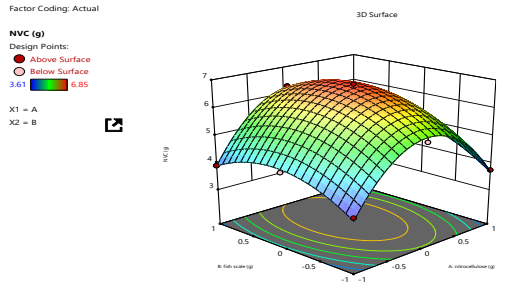


Figure no. 5:3D Surface of contour plot of NVC of fish scale

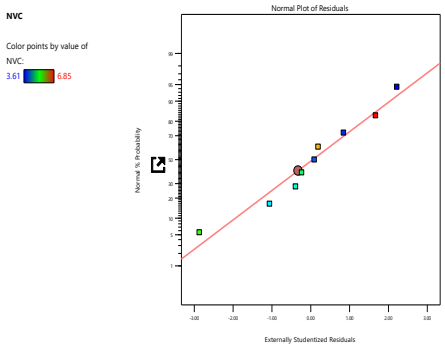


Figure no. 6: Normal plot of Residuals of NVC of fish scale

Table no : 7 RWP and NVC of NTC and Fish scale

Std	Run	Factor 1 Nitrocellulose G	Factor 2 Fishscale g	Response1 RWP g	Response2 NVC G
1	2	-1	-1	0.18	3.61
2	3	+1	-1	0.24	3.74
3	9	-1	+1	0.29	3.90
4	6	+1	+1	0.36	4.56
5	8	-1	0	0.42	4.37
6	1	+1	0	0.54	4.89
7	5	0	-1	0.62	5.42
8	4	0	+1	0.72	6.27
9	7	0	0	0.83	6.85

3.3 OPTIMIZATION OF COLLAGEN BASED NAIL POLISH

ANOVA FOR QUADRATIC MODEL OF RWP

Table no: 8 Anova for reduced quadratic model of resistance to water permeability

Source	Sum of Squares	df	Mean Square	F-value	p-value	
Model	1.98	5	0.3954	410.96	0.0002	significant
A-nitrocellulose	0.0122	1	0.0122	12.63	0.0380	
B-collagen	0.0864	1	0.0864	89.81	0.0025	
AB	0.0000	1	0.0000	0.0260	0.8822	
A^2	1.74	1	1.74	1804.51	< 0.0001	
B^2	0.1422	1	0.1422	147.83	0.0012	
Residual	0.0029	3	0.0010			
Cor Total	1.98	8				

The **Model F-value** of 410.96 implies the model is significant. There is only a 0.02% chance that an F-value this large could occur due to noise. **P-values** less than 0.0500 indicate model terms are significant. In this case A, B, A^2, B^2 are significant model terms. RWP (Y) = constant+A+B+AB-A^2-B^2, Deduced Equation (Y) = constant+ A+B-A^2-B^2FINAL EQUATION =Resistance to water permeability (Y) = +1.90+0.0450 A+0.1200B -0.9317 A^2-0.2667B^2

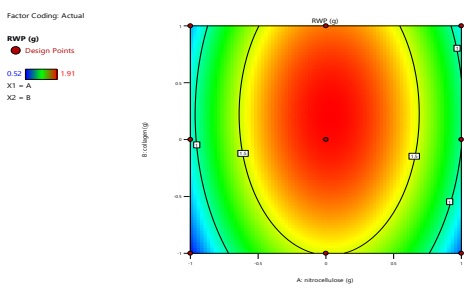


Figure no.7: Contour plot of RWP of collagen

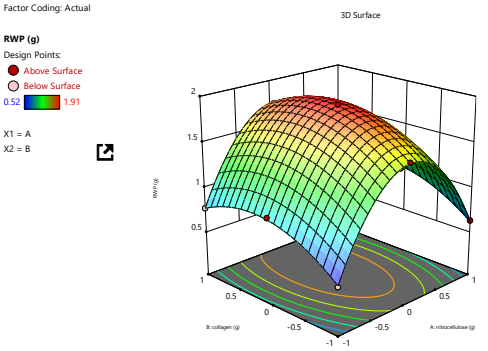


Figure no. 8: 3D contour plot of RWP of collagen

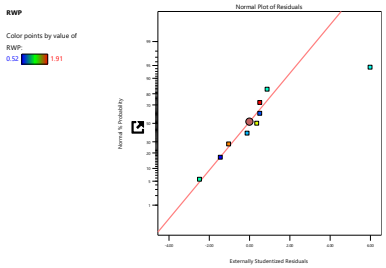


Figure no. 9: Normal plot of Residuals of RWP of collagen

ANOVA FOR QUADRATIC MODEL OF NVC

Table no: 9 Anova for quadratic model of non-volatile content

Source	Sum of Squares	df	Mean Square	F-value	p-value	
Model	0.3839	5	0.0768	15.69	0.0232	significant
A-nitrocellulose	0.0504	1	0.0504	10.30	0.0490	
B-collagen	0.0913	1	0.0913	18.64	0.0229	
AB	0.0342	1	0.0342	6.99	0.0774	
A^2	0.2069	1	0.2069	42.27	0.0074	
B^2	0.0011	1	0.0011	0.2224	0.6694	
Residual	0.0147	3	0.0049			
Cor Total	0.3986	8				

The **Model F-value** of 15.69 implies the model is significant. There is only a 2.32% chance that an F-value this large could occur due to noise. **P-values** less than 0.0500 indicate model terms are significant. In this case A, B, A^2 are significant model terms. NVC (Y) = constant+A+B+AB-A^2-B^2, Deduced Equation (Y) = constant+A+B-A^2, Final Equation=Non-volatile content (Y) = +0.5444+0.0917A+0.1233B-0.3217A^2.

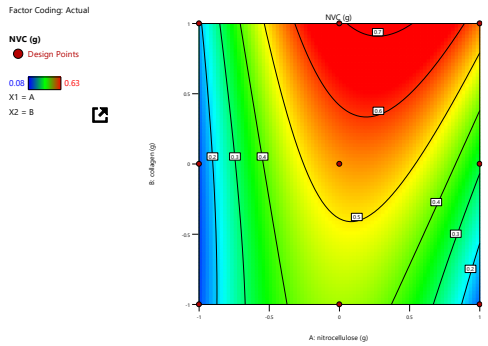


Figure no. 10: Contour Plot of NVC of collagen

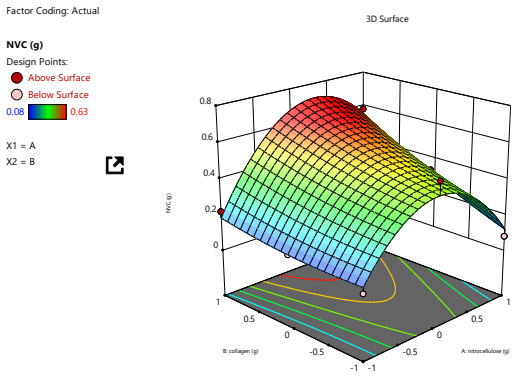


Figure no. 11: 3D contour plot of NVC of collagen

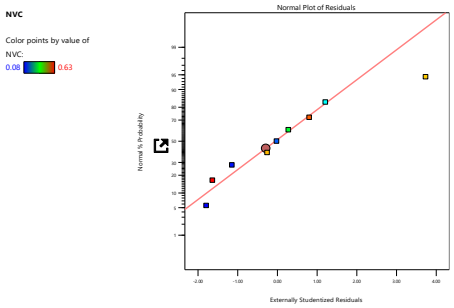


Figure no. 12: Normal plot of residuals of NVC of collagen

Table no:10 RWP and NVC of NTC and collagen

Std	Run	Factor 1 Nitrocellulose (g)	Factor 2 Collagen (g)	Response1 RWP (g)	Response2 NVC (g)
1	1	-1	-1	0.52	0.09
2	3	+1	-1	0.63	0.08
3	6	-1	+1	0.77	0.22

4	4	+1	+1	0.89	0.58
5	9	-1	0	0.94	0.13
6	8	1	0	0.98	0.33
7	5	0	-1	1.52	0.52
8	7	0	1	1.73	0.63
9	2	0	0	1.91	0.53

From the Software suggested formulas, the values we selected are F8 for fish scale formulation & F6 for collagen-based formulation. It is selected on the basis of observing the normal plot of residuals which contains many values aligned over the line which denotes the best fit points. From these points we are selecting the best fit points on the basis of conducting the tests such as rate of drying, smoothness of the film, viscosity, application property, hardness respectively. There by the points which gives the best outcomes or results is chosen as the best fit formula.
Best fit formulas are;

- Fish scale - F8 (0,1)
- Collagen - F6 (1,0)

Table no :11Evaluation of Optimized Formula of Nail Polish using Collagen and Fish scale

Evaluation Parameter	**Formulation Code**	**Fc (Collagen)**	**Fs (Fish Scale)**
COLOR	F6, F8	No Fade in Color	Fade in Color
Rate of Drying	F6, F8	7 Minutes	9 Minutes
Smoothness of Film	F6, F9	Better Smoothness	Less Smoothness
Hardness of Film	F6, F9	Hardness Greater	Less Hardness
Viscosity	F6, F9	34,250mPas	31,426mPas
Application Property	F6, F9	Better Application Property	Less Application Property

4.CONCLUSION

This study demonstrated that both fish scale and collagen can be effectively incorporated into nail polish formulations, each offering distinct benefits. Collagen based nail polish showed superior overall performance with better pearlescence, resistance to chipping, smoother film formation, higher viscosity, and improved application property especially in dry and damaged nails. Fish scale-based nail polish exhibit excellent shine, glossiness, and color stability, though it showed comparatively lower smoothness due to presence of natural particles. Future studies can improve fish scale- based nail polish by focusing on formulation refinement, processing methods, and performance enhancement by purification and particle size reduction, extraction of pure components, surface modification of fish scale particles.

5.ACKNOWLEDGMENT

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