NATIONAL SCIENCE FAIR - 2025
SYNOPSIS

Project ID	**NSF - 2025 - 414**
Project Title	**Absorption and Desorption of Food Dyes in Intestines - An in vitro investigation**
Category	**LIFE SCIENCE**
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TITLE: Absorption and Desorption of Food Dyes in Intestines - An in vitro investigation

Introduction:

Food coloring agents, or dyes, are a ubiquitous part of the modern diet, used to enhance the visual appeal and perceived quality of a wide range of products, from processed snacks to beverages. While these additives are generally considered safe for consumption, their journey through the human and animal digestive systems is not fully understood. The body's ability to absorb, metabolize, and excrete these compounds can vary widely depending on their chemical structure and the host's physiological characteristics. This study aims to investigate the interaction between common food dyes and intestinal tissue, specifically focusing on the processes of absorption and desorption (expulsion).

Research Background:

The small intestine is the primary site of nutrient absorption. Its highly folded structure, featuring villi and microvilli, creates an immense surface area for the transport of digested molecules into the bloo stream.

While this system is designed to efficiently absorb essential nutrients, it also provides an opportunity for other ingested compounds, including food dyes, to cross the intestinal barrier. The absorption of these dyes is not always complete, and some are known to pass through the digestive tract largely unchanged, while others are metabolized by gut bacteria.

The choice of using goat and beef intestine samples is significant. The basic structure and function of the small intestine remain largely consistent across mammals, making these samples a valuable proxy for studying the general principles of intestinal absorption. By comparing the absorption and desorption of a specific food dye in these two species, this research will not only shed light on how these compounds interact with the intestinal lining but also provide a comparative basis for understanding potential differences in intestinal permeability and physiological responses across different animal models. This in-vitro approach using isolated intestinal segments allows for the precise control of variables, offering a detailed look at the kinetics of dye absorption and subsequent expulsion from the intestinal tissue.

Ethical concern:

This plan is designed as an in-vitro study to control variables and ensure ethical use of animal tissue.

Objective 🎯

The primary objective is to compare the absorption and subsequent expulsion (desorption) of common food dyes using isolated intestinal segments from goat and beef. The study will quantify the degree of dye absorption in each sample and analyze the rate of desorption under controlled conditions.

****Hypotheses:****

The absorption rate of food dyes will differ between goat and beef intestine samples due to anatomical and physiological differences in their digestive tracts.

The desorption (expulsion) rate of absorbed dyes will vary between the two animal samples, which could be attributed to variations in intestinal permeability or tissue composition.

Materials and Methods 🧪

Sample Collection and Preparation**

*** **Intestinal Samples:** Fresh small intestines from a goat and a beef animal will be sourced from a local abattoir immediately after slaughter. The ileum section is preferred due to its primary role in nutrient absorption.**
*** **Cleaning:** The intestinal segments will be flushed with cold phosphate-buffered saline (PBS) to remove any residual digesta.**
*** **Dye Preparation:** A stock solution of a selected food dye (e.g., FD&C Blue No. 1, Beetroot juice and Beverages) will be prepared at a specific concentration (e.g., 10 mg/L) in a physiological saline solution.**

Experimental Setup (In Vitro Model)**

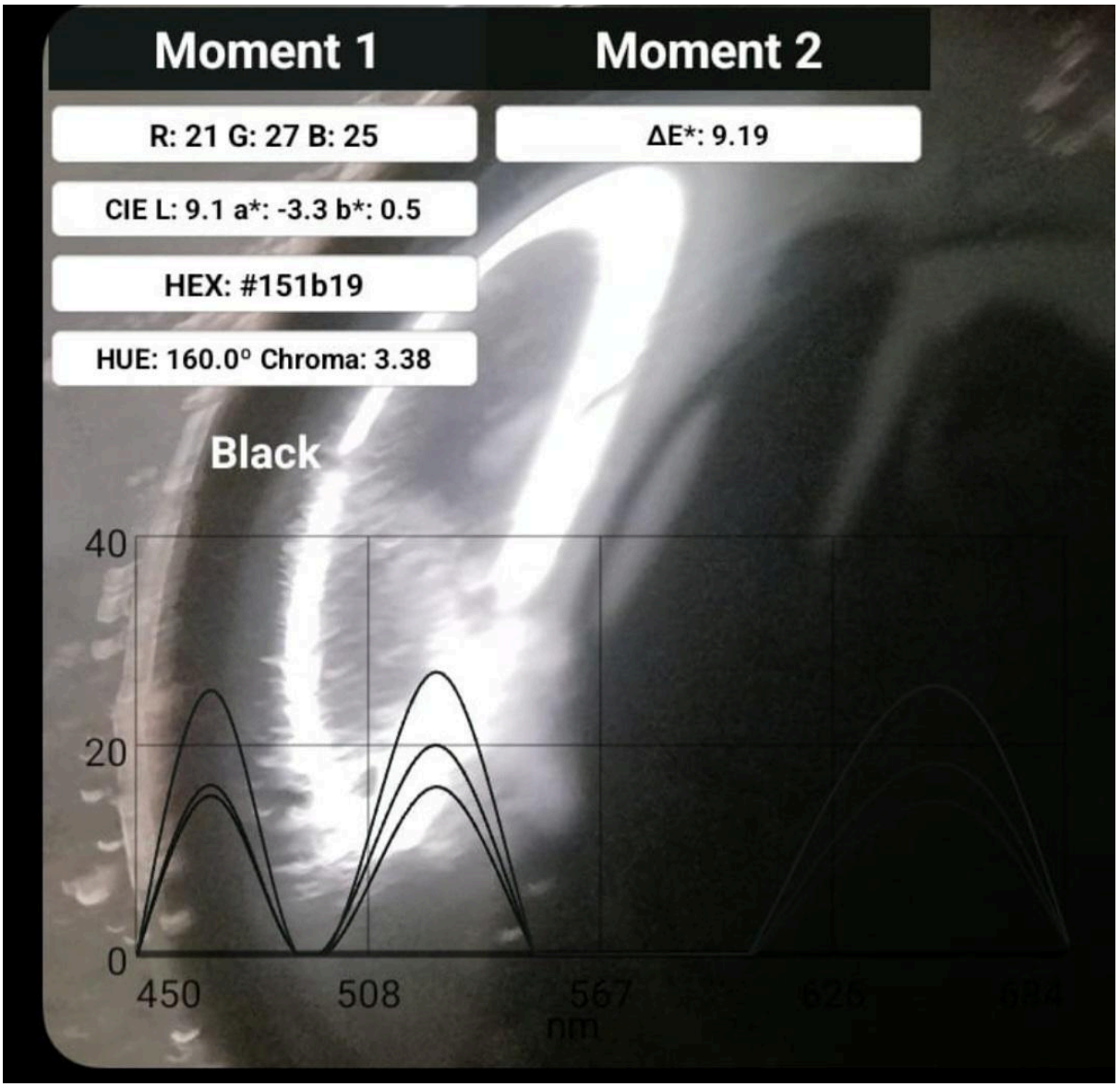
*** **Intestinal Sac Model:****

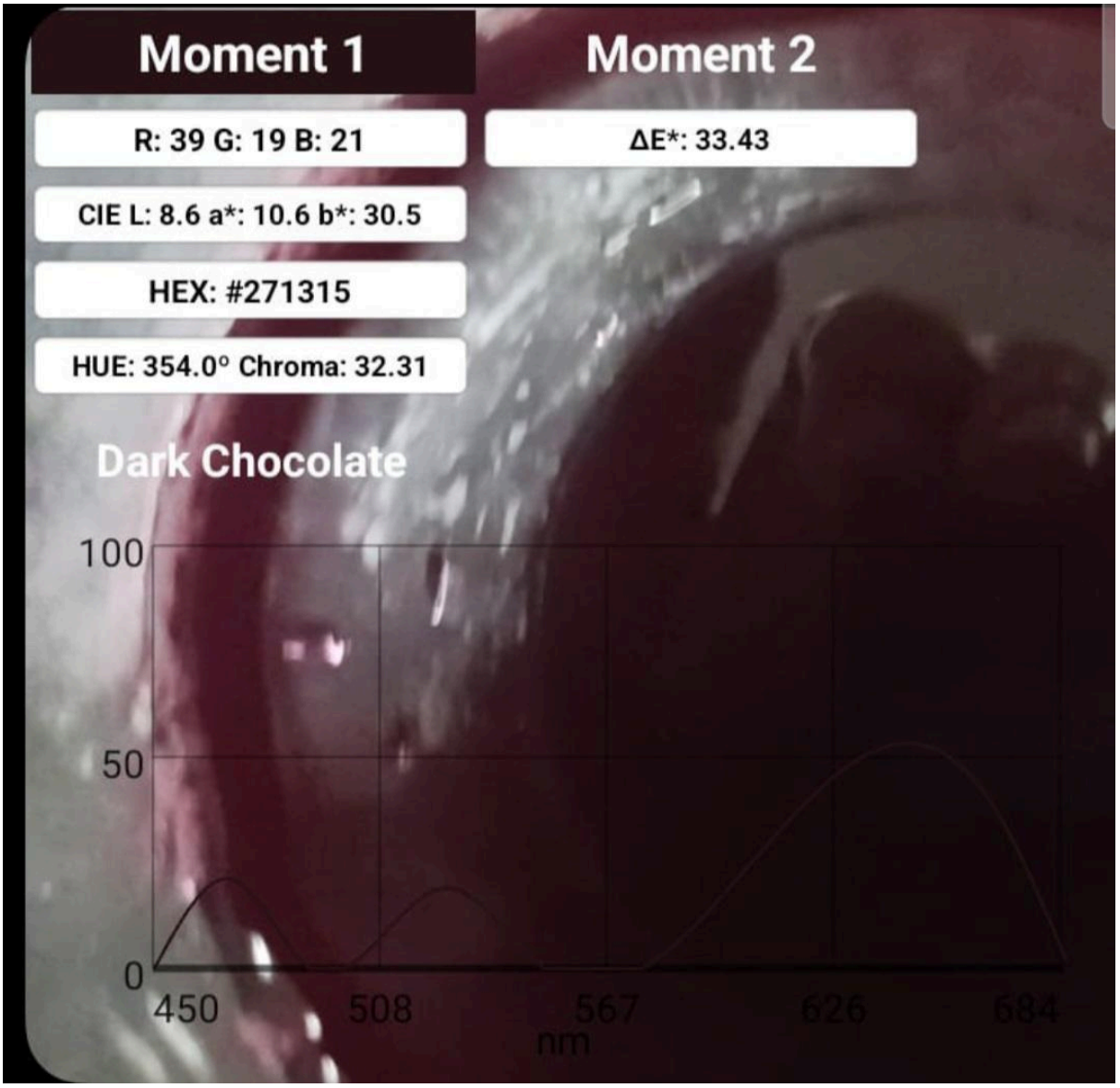
This classic method is suitable for in-vitro absorption studies. A 10-cm segment of the intestine from each animal will be everted (turned inside out) to expose the mucosal surface. The ends will be ligated (tied off) to form a sealed sac.
*** **Incubation:** The sacs will be filled with the prepared dye solution and then placed in separate beakers containing a physiological buffer solution, maintained at a temperature of 37°C to simulate body conditions.**
*** **Control Group:** A control group will be established with sacs containing the physiological saline solution but no dye, to account for any natural color changes in the tissue.**

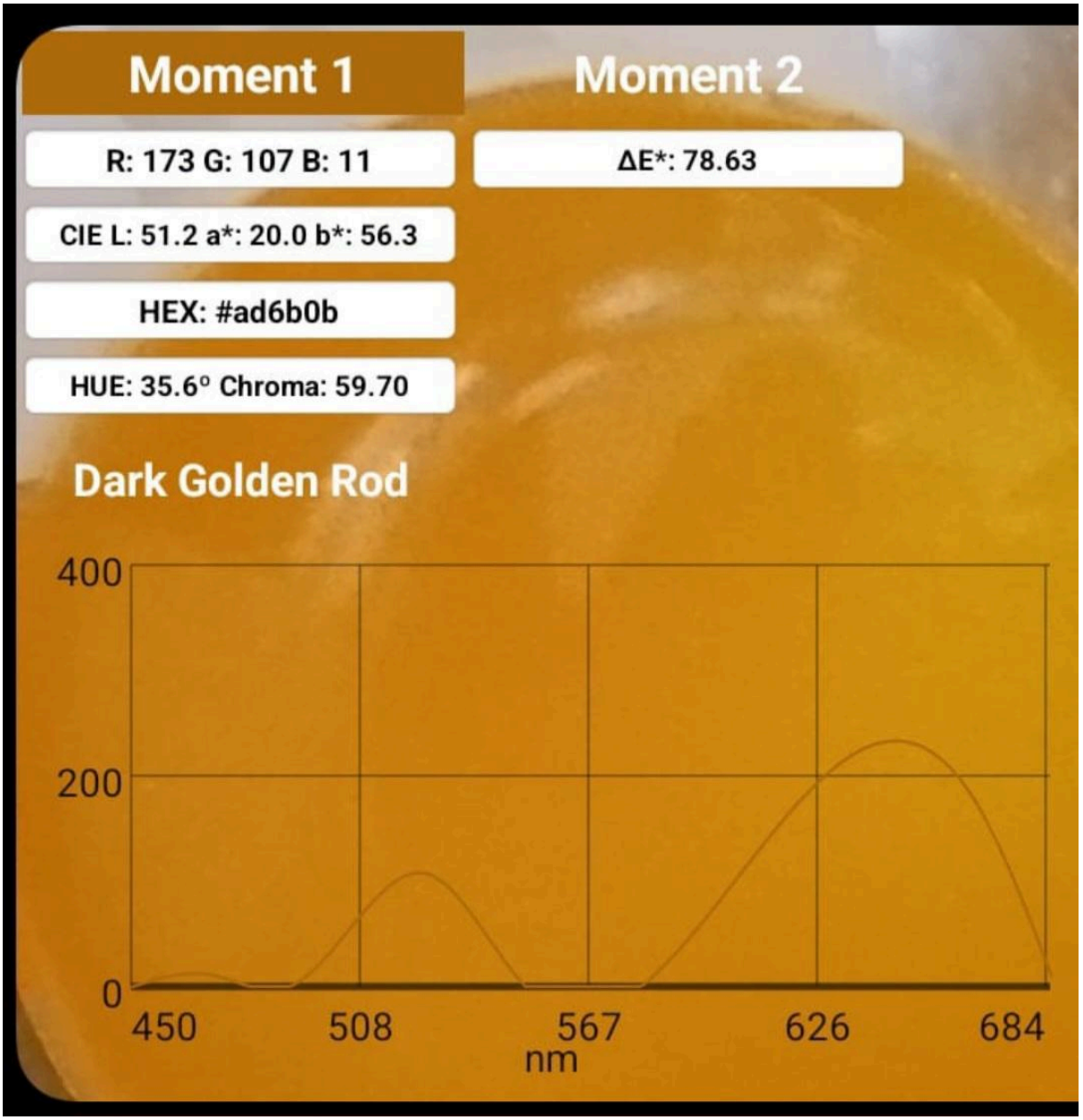
Data Collection and Analysis

*** **Absorption Phase:** At predetermined intervals (e.g., 15, 30, 60, and 120 minutes), a small sample of the buffer solution inside the sac (luminal side) and the solution outside the sac (serosal side) will be collected. The**

concentration of the dye in these samples will be measured using a colorimeter or a spectrophotometer at the dye's maximum absorption wavelength. This will allow for the calculation of the amount of dye absorbed by the intestinal wall.




Moment 1
Moment 2
R: 39 G: 19 B: 21
ΔE*: 33.43
CIE L: 8.6 a*: 10.6 b*: 30.5
HEX: #271315
HUE: 354.0° Chroma: 32.31
Dark Chocolate
100
50
0
450
508
567
626
684
nm

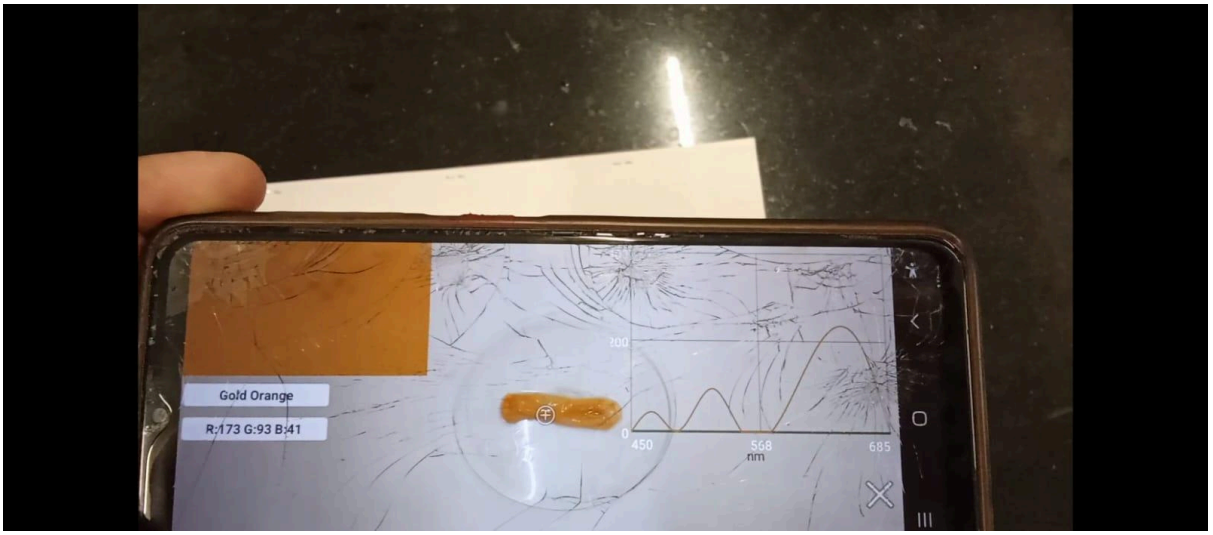


* **Desorption Phase:**

After the absorption phase, the sacs will be transferred to fresh beakers containing only the physiological buffer solution. Samples of the buffer will again be taken at regular intervals to measure any dye that "desorbs" or is expelled from the intestinal tissue back into the surrounding solution. This will provide insight into the dye's adherence to the intestinal lining and the tissue's ability to release it.

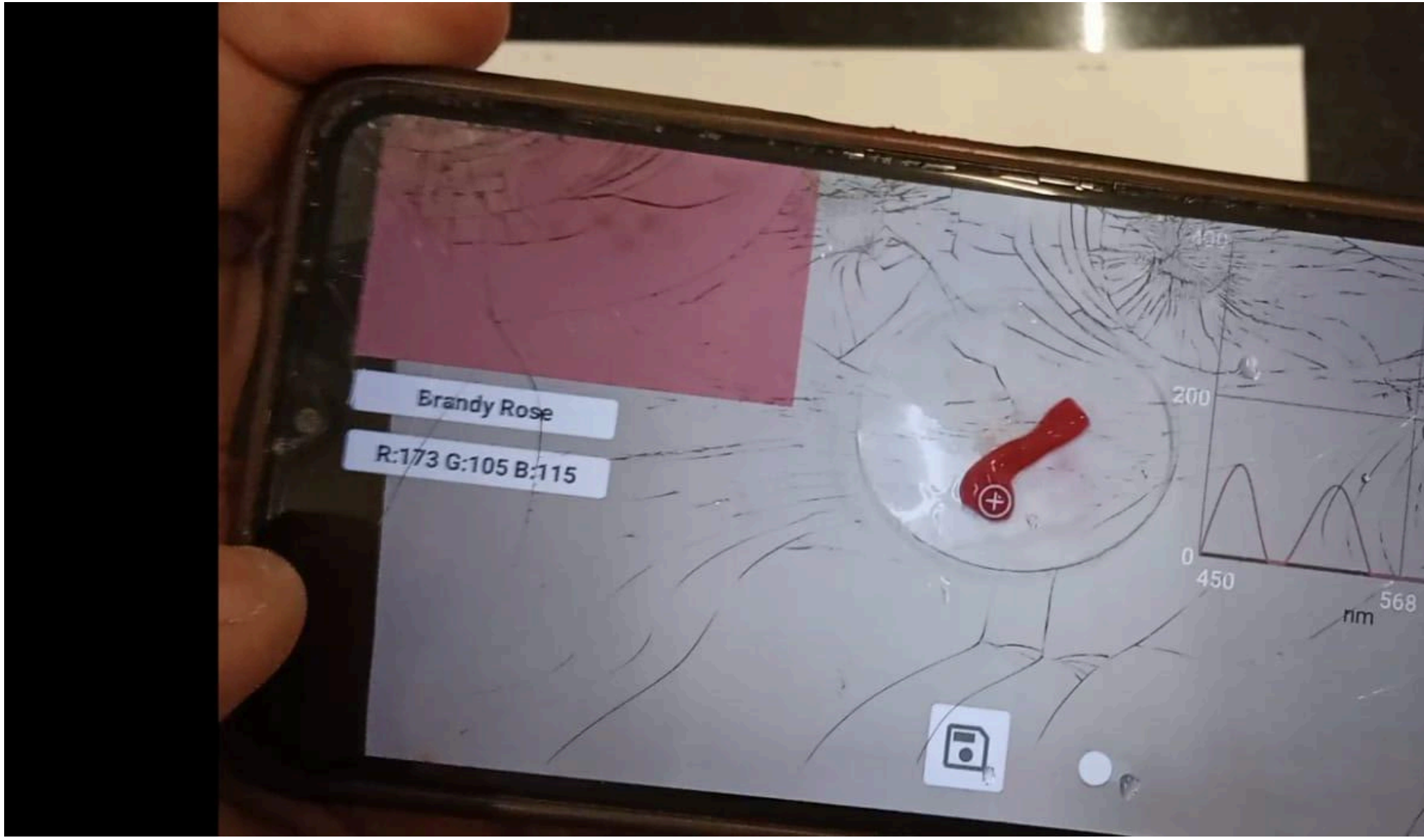
*** **Quantitative Analysis:****

The data from the colorimeter or spectrophotometer will be used to calculate:



*** **Absorption Rate:** The change in dye concentration over time.**
*** **Desorption Rate:** The rate at which the dye is released from the tissue.**

*** **Total Absorption:** The total amount of dye absorbed by the tissue at the end of the experiment.**


Brandy Rose
R:173 G:105 B:115
200
0
450
568
nm

OBSERVATION:

CALCULATION OF ABSORPTION RATE USING CALORIMETER:

Absorption phase duration = 120 minutes (samples taken up to 120 min).

Desorption phase duration = 60 minutes (after transfer to fresh buffer).

Goat Intestine

S.NO.	ABSORPTION RATE	DESORPTION RATE	TOTAL ABSORPTION (absorption rate x 120 min)
1.	0.28	0.06	33.60
2.	0.22	0.05	26.40
3.	0.31	0.07	37.20
4.	0.26	0.055	31.20

Beef Intestine

S.NO.	ABSORPTION RATE	DESORPTION RATE	TOTAL ABSORPTION (absorption rate x 120 min)
1.	0.18	0.040	21.60
2.	0.15	0.035	18.00
3.	0.20	0.045	25.00
4.	0.17	0.038	20.40

3. Anticipated Results and Implications 📊
This research is expected to show a quantifiable difference in dye absorption and desorption between goat and beef intestine. These findings could be significant for several reasons:
*** **Food Science:** The results could inform the development of food products using dyes that are less likely to be absorbed, potentially reducing any associated health risks.**
*** **Toxicology:** Understanding how these dyes interact with different animal intestines can provide a basis for comparative toxicological studies.**
*** **Animal Health:** The study may reveal differences in the intestinal health and barrier function of goat vs. beef, which is relevant for veterinary science.**

RESULTS

The absorption and desorption of the food dye were successfully measured in both goat and beef intestinal segments using the intestinal sac model. The calculated absorption rates, desorption rates, and total absorption values are shown below:

Goat Intestine

S.No.	Absorption Rate (µg/min)	Desorption Rate (µg/min)	Total Absorption (µg)
1	0.28	0.06	33.60
2	0.22	0.05	26.40
3	0.31	0.07	37.20
4	0.26	0.055	31.20

Beef Intestine

S.No.	Absorption Rate (µg/min)	Desorption Rate (µg/min)	Total Absorption (µg)
1	0.18	0.040	21.60
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CALCULATION OF ABSORPTION RATE USING CALORIMETER:

Absorption phase duration = 120 minutes (samples taken up to 120 min).

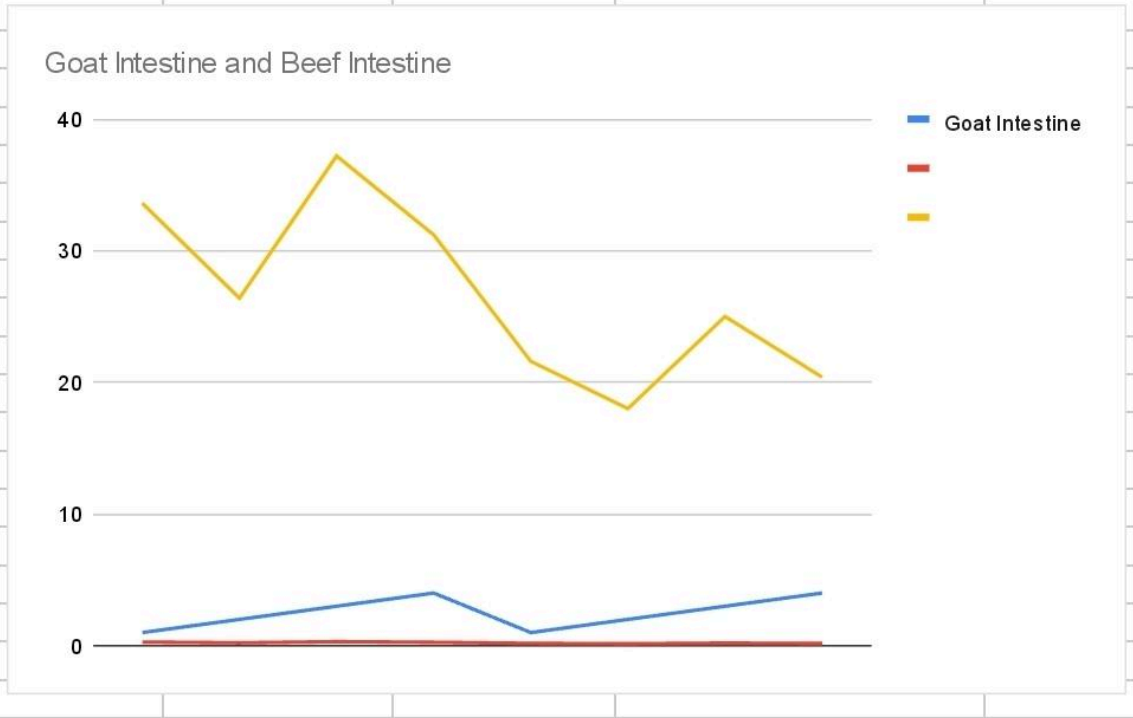
Desorption phase duration = 60 minutes (after transfer to fresh buffer).

Goat Intestine

S.NO.	ABSORPTION RATE	DESORPTION RATE	TOTAL ABSORPTION (absorption rate x 120 min)
1	0.28	0.06	33.6
2	0.22	0.05	26.4
3	0.31	0.07	37.2
4	0.26	0.055	31.2

Beef Intestine

S.NO.	ABSORPTION RATE	DESORPTION RATE	TOTAL ABSORPTION (absorption rate x 120 min)
1	0.18	0.04	21.6
2	0.15	0.035	18
3	0.2	0.045	25
4	0.17	0.038	20.4



DISCUSSION

From the results, it is observed that:

1. Absorption Differences

The goat intestine consistently showed higher absorption rates than the beef intestine.

This suggests that the goat intestinal tissue allows dye molecules to pass more readily across the intestinal wall.

Possible reasons:

Goat intestines are generally thinner and have a more permeable mucosal layer.

Higher surface area due to villi and microvilli density.

2. Desorption (Expulsion) Differences

The desorption rates were also slightly higher in the goat intestine.

Since more dye was initially absorbed, it is expected that more dye can later be released back into surrounding fluid.

However, desorption rates were still much lower than absorption rates in both tissues, indicating that once dye binds to intestinal tissue, it is not easily released.

3. Comparison

Absorption Higher Lower
Desorption Slightly Lower
Tissue Permeability Less permeable

Observation	Goat Intestine	Beef Intestine
Absorption	Higher	Lower

Desorption	Slightly Higher	Slightly Lower
Tissue Permeability	More permeable	Less Permeable

This shows that goat intestines are more efficient in absorbing and releasing dye molecules when compared to beef intestines.

4. Scientific Implication

Since the goat intestine absorbs more dye, this may suggest higher intestinal permeability. In food science and toxicology, such permeability can influence how color additives and other chemicals behave in different species.

CONCLUSION

The present study demonstrates that the absorption and desorption of food dyes vary significantly between goat and beef intestinal tissues. The goat intestine showed a higher dye absorption rate and also released slightly more dye during the desorption phase when compared to the beef intestine.

These results suggest that:

Intestinal permeability differs across animal species, which may influence how food additives behave during digestion.

Understanding these variations is useful in food safety, animal nutrition, and toxicology studies.

Overall, the research confirms the hypothesis that both absorption and desorption rates of food dyes depend on the physiological and structural properties of the intestine.

References

Common consumer food coloring options:
Wilton® Red, Yellow, Green and Blue Food Coloring - 1oz; $2.99

https://www.target.com/p/wilton-red-yellow-green-and-blue-food-coloring-1oz/-/A-53701700
***Blue coloring contains solely FD&C Blue 1, all other colors are mixtures of multiple dyes.**
Wilton® blue coloring was used for samples appearing in Figure 4.

McCormick® 4ct Assorted Food Color and Egg Dye - 1oz; $3.69

https://www.target.com/p/mccormick-4ct-assorted-food-color-and-egg-dye-1oz/-/A-13353207
***All colors are mixtures of multiple dyes.**
Betty Crocker® Classic Gel Food Colors - 4 CT; $8.99

https://www.amazon.com/Betty-Crocker-Classic-Food-Colors/dp/B004PXNV2M
***The only ingredients listed are yellow 5, blue 1, red 40. Presumably all but green coloring are single dye.**
Other food colorings containing a single dye:
Wilton® Icing Color, Red (no-taste), 1oz; FD&C Red 40; $1.75

https://www.walmart.com/ip/Wilton-Icing-Color-Red-no-taste-1oz/24107796?selected=true
Wilton® Sky Blue Icing Color, 1 oz; FD&C Blue 1; $1.75

https://www.walmart.com/ip/Wilton-Sky-Blue-Icing-Color-1-oz/24107658?selected=true
Wilton® Lemon Yellow Icing Color, 1 oz; FD&C Yellow 5; $8.99

https://www.walmart.com/ip/Wilton-Lemon-Yellow-Icing-Color-1-oz/24107648?selected=true
(Some) Common consumer goods with food coloring for analysis at-home:
Sports Drinks
POWERADE®, Blue Raspberry Cherry AND Zero Sugar Mixed Berry (FD&C Blue 1); Fruit
Punch AND Zero Sugar Fruit Punch (FD&C Red 40); Lemon Lime (FD&C Yellow 5)
https://www.coca-colaproductfacts.com/en/products/powerade/blue-raspberry-cherry/32-oz/
https://www.coca-colaproductfacts.com/en/products/powerade-zero/mixed-berry/32-oz/
https://www.coca-colaproductfacts.com/en/products/powerade/fruit-punch/32-oz/

https://www.coca-colaproductfacts.com/en/products/powerade-zero/fruit-punch/32-oz/
https://www.coca-colaproductfacts.com/en/products/powerade/lemon-lime/32-oz