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Examining Temperature and Water Evaporation on Turmeric: An Innovative Product of Turmeric Stick

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Abstract. Turmeric is used by cultural communities to treat nasal congestion in infants with different methods, curcumin in turmeric is scars on the skin, and innovation in turmeric is needed. This study aims to compare the temperature and water evaporation of burnt turmeric (Sample Turmeric A), turmeric mixed with whiting (Sample Turmeric B), and natural turmeric (Sample Turmeric C); determine the appropriate sample treatment to treat nasal congestion in infants; produce innovative products to treat turmeric discoloration on the skin in the use of turmeric. This research is an experiment, a preliminary study in the form of interviews and in-depth observations of the community about the use of turmeric for health that is usually carried out by cultural communities, then analyzed across the fields of STEAM-2C so that comparison results and innovative products are found in the form of Turmeric Stick. It was found that the temperature of the Turmeric A sample was 309.3 K, the B turmeric sample was 305.2 K, and the C turmeric sample was 308.1 K. The comparison of evaporation of turmeric Samples A (95666.49): Sample B (93147.04): Sample C (94925.61) is 1: 1: 1, evaporation of water through the Hertz-Knudsen equation. The conclusion is that variant C is more appropriate for dealing with nasal congestion in infants, and the turmeric innovation product in the form of turmeric sticks is a turmeric packaging solution to overcome the problem of turmeric color that causes scars.

Key words: Innovative; STEAM; Turmeric.

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INTRODUCTION

This research begins by paying attention to the habits of cultural communities that use turmeric as the main ingredient, both ingredients or spices for cooking, beauty, and health. Turmeric (Curcuma domestica) (Rahardjo & Rostiana, 2005) is a spice and medicinal plant from Southeast Asia (Kusbiantoro, 2018) and belongs to the ginger group (Zingiberaceae) (Pekasa *et al.*, 2021) which can treat pain and swell (Silviani *et al.*, 2019; Khasanah, 2018; Mediastari, 2020), such as menstrual pain (Kusbiantoro, 2018; Mawardi, 2020) and itching (Arianingsih, 2021; Rohmah, 2021). In addition, turmeric can also cool the skin and overcome body odor (Asnia, 2019) release excess gas in the intestines (Setiyaningsih, 2018), and reduce stomach acid levels (Safitri & Nurman, 2020). This provides a description that turmeric has content that can have a certain effect on overcoming health problems as believed by the cultural community.

Based on information from the "knowledge machines" search engine, Indonesian turmeric rhizome contains compounds that have medicinal properties, called curcuminoids consisting of curcumin, 10% desmethoxycumin, and 1-5% bisdesmethoxycurcumin (Kusbiantoro, 2018) d-alpha-pelandrene (1%), d-sabinene (0.56%), cineol (1%), borneol (0.5%), zingiberene (25%), thymerone (58%), alcohol sesquitrpen (5.8%), alpha atlanton and gamma-atlanton (Putri, 2019). Turmeric can cure fever and flu in pregnant women (Asnia *et al.*, 2019). This indicates that turmeric is safe to use not only for toddlers but also for fetuses that are still in the womb. It is also stated that turmeric (turmeric rhizome) can cure fever, colds with nasal congestion, rheumatism, diarrhea, dysentery, itching of the skin, swelling, body odor, malaria, heartburn or intestinal thrush, and oral thrush (Winarto & Lentera, 2003).

This study explores how cultural communities use turmeric, especially in the health sector through interviews with cultural communities. In-depth interviews were conducted directly through face-to-face (offline), as well as long-distance communication (online) through the WhatsApp application to cultural communities living in various areas of Kalimantan. West, such as Pontianak City, Singkawang City, and Sambas Regency. The results of exploration through this interview show that cultural communities tend to

use turmeric for various benefits which they have understood from generation to generation from their parents. All cultural communities interviewed in this study revealed that turmeric (or sometimes mixed with a little lime) then applied to the forehead of toddlers can relieve nasal congestion in toddlers when they have a cold. The belief that has emerged in the cultural community to date, is certainly strengthened by the experience people have in using turmeric, although they have not been able to explain the reason scientifically.

Turmeric has properties to cure nasal congestion by burning turmeric and inhaling it to facilitate breathing (Itokawa H *et al.,* 2008) This burning process is intended so that substances in the form of essential oils contained in the turmeric rhizome can evaporate. The aroma of turmeric which contains volatile substances can treat nasal congestion due to colds in toddlers. Turmeric rhizome can be used directly without having to be burned first, but directly smeared on the forehead and around the nose area. With the same concept, the aroma of turmeric rhizome which contains this essential oil evaporates naturally and is inhaled by toddlers. Turmeric can also be combined with a little whiting and applied to the forehead. Thus, the evaporation process of the essential oil in turmeric can be done by burning, mixing with whiting, or natural evaporation by the wind; and the essential oil content in turmeric rhizome has an aroma that can help relieve/treat nasal congestion in toddlers.

In addition, turmeric can also be used as a natural ingredient in cooking so that the food is yellow (Kusbiantoro, 2018; Pekasa, 2021). This causes when interacting with turmeric, it can cause yellow marks on the body parts that touch it. Through more in-depth interviews with two students from a generation Z community group or those born in 2001, it can be revealed that the thing that makes interacting discomfort (holding turmeric) is the effect caused by turmeric, namely the hands become yellow and difficult to remove, it takes a long time to get rid of it. This weakness is the reason why turmeric products need new innovations so that they can be used by every cultural community group in a practical and solutive way so that there is an opportunity for entrepreneurship from the products developed.

This turmeric innovation product can be developed in project-based learning (Project Based Learning, PjBL). This innovative product is produced because it is inspired by the understanding of the cultural community and requires scientific proof (scientific literacy), so PjBL in this research is integrated with Ethno-STEAM (Ethno - Science, Technology, Engineering, Art, Mathematics). Ethno-STEAM immersed in STEAM Ethno-STEAM immersed in STEAM-2C (Science, Technology, Engineering, Art, Mathematics, Culture, Communication), where STEAM-2C is a specific part of Ethno-STEAM integrated with PjBL. Project-based learning model (PjBL) is one of the recommended models for honing students' HOTs (Rusydiana, M., 2020). Project-based learning model (PjBL) has an influence on STEM (Tirka, 2021). The PjBL syntax consisting of planning, creating, and processing (Mahanal & Wibowo, 2009) has similarities to the implementation steps of STEM learning (Diana & Sukma, 2021). Ethno-STEM is integration between ethnoscience and STEM (Sudarmin *et al.,* 2021) while Ethno-STEM has similarities with the STEAM-2C pattern so that it can be immersed/embedded. Thus, in this study, it was analyzed across the fields of STEAM-2C so that the results of the comparison of temperature and water evaporation from the manipulation of turmeric samples were found in accordance with the beliefs and experiences of the cultural community in the use of turmeric, proper treatment in the use of turmeric to treat nasal congestion in infants based on references beliefs and experiences carried out by these cultural communities, and innovative products that can be developed from turmeric to become alternative solutions.

This study aims to compare the temperature and water evaporation of burnt turmeric (Sample Turmeric A), turmeric mixed with whiting (Sample Turmeric B), and natural turmeric (Sample Turmeric C), determine the appropriate sample treatment to treat nasal congestion in infants, and produce innovative products to treat turmeric discoloration on the skin in the use of turmeric.

Through this research, it is hoped that it can provide a description and enlightenment of the cultural community's thoughts on the accuracy of the use of turmeric in overcoming nasal congestion in infants who have been studied through STEAM-2C by determining the comparison of three samples and producing innovative products that are in accordance with the needs of the cultural community in the form of turmeric sticks.

METHODS

The exploration of the beliefs and experiences

of the cultural community carried out in this study through in-depth interviews found that there are three ways of using turmeric by the cultural community to overcome nasal congestion in turmeric, namely, burnt turmeric, turmeric mixed with whiting, and natural turmeric. To determine the comparison of the three samples, a test was carried out by measuring the temperature and calculating the value of evaporation of water with the Hertz-Knudsen equation. This is because turmeric contains essential oils whose aroma/vapor (evaporation water) has the potential to overcome nasal congestion in babies. The different treatments of the three samples have the potential to give different effects of water evaporation values, and this can describe which turmeric use is more appropriate as a solution. The volatile oil contained in turmeric is in liquid form, so the calculation of volatile oil evaporation in turmeric can be calculated mathematically Evaporation of Water through the Hertz-Knudsen equation (Jones, 1991).

"The Hertz-Knudsen equation predicts the absolute upper limit on the rate at which molecules can escape from a liquid or solid interface into a perfect vacuum. In its simplest from it can be written as":

$$w = P_{tr}\sqrt{M/2\pi RT_{tr}} \qquad (1)$$

where:

w = *evaporation rate in g/cm^2. sec*
M = *the molekular weight of the evaporating substance, 18.0152 g/mol for water*
R = *the universal gas constant, 8.314471 X 10^7 joules/K.mol*
T_{tr} = *the absolute temperature in kelvin, K, at the interface*
P_{tr} = *the saturation vapor pressure, in dyne/cm^2, at T_{tr}*

Measurement of the value of water evaporation in turmeric was carried out with various variations of variables. The results of measuring the temperature of turmeric using an infrared digital thermometer on a variety of variables (3 test samples).

(a) Sample A, burnt turmeric (b) Sample B, turmeric mixed with whiting (c) Sample C or Control Variable, natural turmeric

Figure 1. Temperature Measurement of Three Turmeric Samples

By comparing the Hertz-Knudsen equation (1) with sample (x) as a comparison sample or control variable (y) because it was not given special treatment, assuming the P_{tr}, M, and 2πR values in each sample are the same, the comparison equation can be formulated as follows.

$$\frac{w_{sampel}}{w_{sampel-kontrol}} = \frac{P_{tr}\sqrt{M/2\pi RT_{sampel}}}{P_{tr}\sqrt{M/2\pi RT_{sampel-kontrol}}} \qquad (2)$$

$$\frac{w_{sampel}}{w_{sampel-kontrol}} = \frac{\sqrt{1/T_{tr_{sampel}}}}{\sqrt{1/T_{tr_{sampel-kontrol}}}} \qquad (3)$$

$$\frac{w_{sampel}}{w_{sampel-kontrol}} = \frac{(T_{tr_{sampel}})^2}{(T_{tr_{sampel-kontrol}})^2} \qquad (4)$$

Through the Hertz-Knudsen equation, a comparison of the values of temperature and water evaporation is obtained between the three samples. Furthermore, in-depth observations were made through physical testing of the three samples, including sample A of burnt turmeric, sample B of turmeric mixed with whiting, and sample C of natural turmeric. Physical tests use 3 human senses, namely, the sense of smell (nose), sight (eyes), and touch (skin). The sample is smelled, seen in the texture of the color, and felt when touched on the forehead. This can strengthen the explanation of which sample is more appropriate, and the proper way to use the three samples of turmeric to treat nasal congestion in infants.

Furthermore, a new innovation was developed in the form of making turmeric products into turmeric sticks. There are two samples that were tested in producing this innovative product. Sample 1, consists of ingredients such as turmeric, used cooking oil, and wax. Sample 2, consists of materials such as turmeric, used cooking oil, candles, and chalk. The control variable is the turmeric rhizome which has one segment. Each composition of materials is used with the same mass. The addition of lime can minimize the brittleness/brokenness of the Turmeric Stick and when applied, it does not minimize the effect of releasing a lot of lumpy and lumpy turmeric stick material. After the mixture is evenly distributed and thickens, the liquid is put into a container on the heater/stove, then the liquid is quickly poured into a tubular container, and allowed to stand for ±15 minutes, then put in the freezer for ±45 minutes. When it has dried/frozen, it is removed from the molded container, and the tip of the turmeric stick is sharpened with a cater knife and labeled with paper. This innovation is carried out in an integrated Ethno-STEAM project-based learning (PjBL) immersed in STEAM-2C (Science, Technology, Engineering, Art, Mathematics, Culture, Communication) with the Physics Education students of STKIP Singkawang. Thus, through a detailed description of each component of STEAM-2C, this innovative product in the form of a Turmeric Stick is produced.

RESULTS AND DISCUSSION

The turmeric used shows the same temperature results, namely $T_{tr\text{-}k}$ = 35.1℃ or $T_{tr\text{-}k}$ = 308.1K. Through equation (4), the results of the comparison between each sample are obtained against the comparison variable or control variable in the form of turmeric temperature at first. first before being treated (natural turmeric), where $T_{tr\text{-}k\ Sample\ C}$ = 35.1℃ or $T_{tr\text{-}k\ Sample\ C}$ = 308.1K and $T_{tr\text{-}k^2\ Sample\ C}$ = 94925.61K.

Table 1. Results of Evaporation of Essential Oils on Turmeric Rhizome

Sample	Variable	T_{tr} (°C)	T_{tr} (K)	$T_{tr\text{-}k}^2$ (K)	$w_{sample} : w_{control(k)}$
A	Turmeric burned	36.3	309.3	95666.49	1:1
B	Turmeric mixed with whiting	32.2	305.2	93147.04	1:1
C	Natural Turmeric	35.1	308.1	94925.61	1:1

Table 1 data shows that turmeric rhizome that was treated in the form of burning against natural turmeric had a ratio of the average value of water evaporation that was close to the same, compared to turmeric mixed with whiting. Temperature comparison Sample A: Sample B: Sample C = 309.3K: 305.2K: 308.1K. These findings indicate that burnt turmeric has a higher temperature than natural turmeric, while turmeric mixed with whiting causes the temperature of turmeric to drop or lower than natural turmeric. The change in the temperature of the burnt turmeric becomes higher because the turmeric receives heat from the heat of the stove, while the change in the temperature of the turmeric when mixed with whiting causes the turmeric to release its heat. Furthermore, the results of the comparison of water evaporation were also found. Sample A: Sample B: Sample C = 1: 1: 1. The insignificant difference in temperature caused the comparison of the three samples to be the same. This is because the amount of turmeric used, the amount of whiting used, the heat of the fire, and the length of the burning period are at standard levels. This is because the experiments carried out are adapted to in-depth observations of the experiences of the cultural community, which means that the treatment and its intensity are carried out in accordance with what is exemplified by the cultural community.

Based on physical tests through in-depth observations carried out using 3 human senses, it was found that when turmeric was burned the aroma of the inhaled essential oil was stronger than the natural turmeric/control variable, but turmeric mixed with whiting actually reduced the aroma compared to natural turmeric/variable control as well as burnt turmeric. The texture of burnt turmeric turns black, while turmeric mixed with whiting causes a dark reddish-orange color effect compared to natural turmeric/control variables. Burnt turmeric is more appropriate to be used directly to the nostril area to be inhaled (the smell of this burnt turmeric is stronger), but

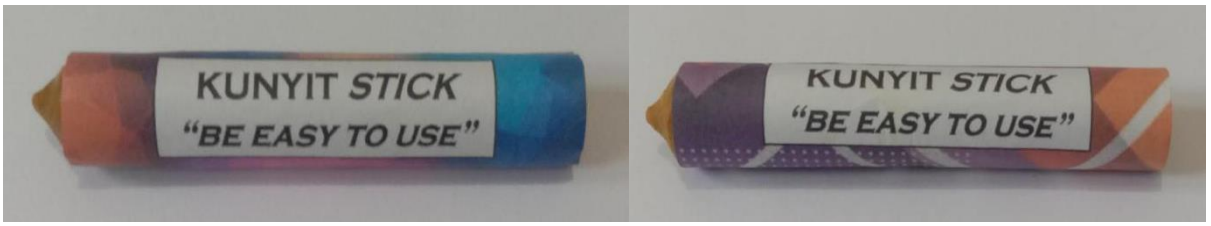
the scorched/black burning effect is feared to irritate and damage the skin if applied to the toddler's forehead; While natural turmeric is more appropriate to be used directly rubbed/smeared on the forehead of toddlers. Turmeric should not be mixed with whiting and rubbed on the forehead of toddlers because this causes a stinging effect on the forehead skin of adults, so babies who have thinner and sensitive skin are not advised to use turmeric mixed with whiting in overcoming nasal congestion in infants. The whiting can harden if exposed to room temperature, so the turmeric liquid which is bound to the compounds contained in the whiting can make the turmeric liquid last a long time along with the whiting which hardens on the baby's forehead, resulting in a stiff forehead. However, whiting that hardens/dries on the forehead changes from a liquid to a solid, resulting in a powder that is feared to be irritating to the eyes of the whiting powder flakes and touches the baby's eyes. Thus, it was found that sample A turmeric which was treated in the form of burning could be used as a medicine to treat nasal congestion in infants with proper treatment in the form of inhalation using the nose (not smeared), turmeric Sample B which was treated in the form of being mixed with whiting should not be used. especially in babies because it causes a stinging effect on the skin, while turmeric C is natural turmeric, the right treatment is used by applying it to the baby's forehead to treat nasal congestion in babies.

Turmeric (turmeric rhizome) contains components of dyes or pigments turmeric, the main one is curcumin, which is as much as 2.5-5%, turmeric also contains many other dyes such as monodesmethoxycurcumin and diodesmethoxycurcumin as much as 0.8% (Kusbiantoro, 2018). This is what causes the turmeric rhizome that interacts with an object (hands) can cause yellow marks. For this reason, the innovative product developed is expected to be a solution so that turmeric can still be used without having to leave a mark. This innovation is carried out through project-based learning (PjBL) integrated with Ethno-STEAM immersed in STEAM-2C (Science, Technology, Engineering, Art, Mathematics, Culture, and Communication) with Physics Education students at STKIP Singkawang so that it is also expected to improve thinking skills at the higher level. (HOTs) of students and foster an entrepreneurial spirit (entrepreneurship). Details of the STEAM-2C component in this study which resulted in new innovation in the form of turmeric sticks can be seen in Table 2.

Table 2. Mapping of STEAM-2C Components

Component	Activity
Science (S)	Collecting references to turmeric compounds and their uses, measuring temperature and calculating the evaporation of turmeric water from three samples with different treatments, and physically testing turmeric samples (color, aroma, and the reaction felt when touched to the forehead).
Technology (T)	Using tools and materials, software systems, or the internet, produces appropriate innovative products as a solution to the problems of the cultural community in the use of turmeric in the form of turmeric sticks.
Engineering (E)	The process in making turmeric stick products.
Art (A)	Variation of the turmeric sample variables in determining the temperature and evaporation of the water, including evaporation by burning, and evaporation by mixing whiting, which is compared with wind-assisted evaporation (natural). Perform variations of turmeric stick innovation products, including turmeric sticks made with a mixture of lime and without lime.
Mathematics (M)	Performing mathematical measurements or calculations, in the form of measuring the temperature of turmeric, and calculating the water evaporation ratio in three samples of turmeric.
Culture (C)	Materials obtained in the surrounding environment or used by cultural communities for generations with certain beliefs, in this study in the form of turmeric which is believed by the cultural community to overcome nasal congestion in infants.
Communication (C)	Conducted interviews and in-depth observations of cultural communities domiciled in West Kalimantan Province, including Pontianak City, Singkawang City, and Sambas Regency.

The product resulting from project-based learning (PjBL) with STEAM-2C on modified turmeric in the form of turmeric sticks is shown in Figure 2.



(a) Sample 1 (b) Sample 2

Figure 2. Modified turmeric (turmeric stick) product of the Ethno-STEAM integrated learning project (PjBL) (embedded STEAM-2C)

Figure 2 shows that turmeric can be modified into turmeric sticks which have the advantages of being easy to carry, not causing excessive marks on the hands, attractive design/shape, and still having the aroma of turmeric (essential oil) for a certain period of time (±2 months) in the open position without packaging. The resulting product has the potential for economic value and becomes a business opportunity (entrepreneurship) because it contains practicality and new innovations and is in line with the needs of the community, especially the millennial generation. To explore further, a more in-depth analysis is needed regarding the effectiveness and product feasibility testing through further research. This research is expected to add insight and creative ideas to science learning through Ethno-STEAM integrated project-based learning (embedded STEAM-2C) and can foster an entrepreneurial spirit through new innovations that have the opportunity to have economic value according to community needs inspired by culture, experience, and belief. cultural community as well as basic materials obtained from the surrounding environment.

CONCLUSION

The temperature comparison of burnt turmeric (Sample A), turmeric mixed with whiting (Sample B), and natural turmeric (Sample C) are 309.3K: 305.2K: 308.1K. Comparison of evaporation water in turmeric Samples A (95666.49), Sample B (93147.04), Sample C (94925.61) sequentially, namely 1:1:1. The right treatment to overcome nasal congestion in infants due to colds, namely samples A is more appropriate to be applied by inhalation, sample B should not be applied to infants, sample C is more appropriate to be applied to the baby's forehead. An innovative product to overcome the color of turmeric in the use of turmeric is in the form of a Turmeric Stick.

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