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FORMULATION AND EVALUATION OF NATURAL ULTRASOUND GEL FOR PHYSIOTHERAPY TREATMENT

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Abstract:

Commercially available ultrasound gel contains lot of chemicals like carbapol R 940 polymer and phenoxyethanol which are allergenic to skin, expensive and not available in enormous quantities. The demand for ultrasound gel is due to its wide range of applications medical and paramedical fields. Hence, our objective was to formulate and evaluate the ultrasound gel made from natural starch powder. The gel was made by heating water with corn starch. The formulated gel was used for physiotherapy ultrasound treatment with the addition of Aloe vera gel to get fast pain relief in the affected area. The results showed that the formulated ultrasound gel and its ingredients were consistent in quality and can be easily used. The formulated ultrasound gel was found to be superior to commercially available gel in part of pain management score. It is concluded that the formulated ultrasound gel can be used for ultrasound physiotherapy treatment. However, further studies are warranted to confirm its effectiveness and also to develop into commercial standards.

Keywords: *Physiotherapy; Ultrasound Gel; Aloe vera; Analgesic; Pain Management*

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INTRODUCTION:

Ultrasound is widely used in rehabilitation, primarily for improving connective tissue extensibility and pain relief in musculoskeletal injuries, and for promoting tissue healing and remodelling. Physiotherapists use therapeutic ultrasound more than any other electrophysiological modality. The level of clinical benefit from therapeutic ultrasound remains uncertain, and depends on the application. Risk of harm is considered low when used properly, making ultrasound for physical therapy a treatment of modest efficacy but low risk. Topical analgesics will activate superficial thermal response receptor, providing hot or cold sensation. Topical agents suspended in aqueous gel are more effective in transmitting ultrasound energy, compared to cream-based agents which are less effective [1-3].

The ultrasound is an excellent technology for physiotherapist in the developing world. It is inexpensive, quick and does not expose the patient to radiation. To transmit sound waves, there must be a gel between the ultrasound probe and the skin. There is commercially available ultrasound gel in the Malaysian market. But, it contains lot of chemicals like carbapol R 940 polymer and phenoxyethanol which are allergenic to skin and also expensive. Hence, in the present study we are interested to formulate novel ultrasound gel without any harmful synthetic chemicals.

Topically applied external analgesics do appear to provide some benefit of pain relief. The active ingredient in most of these is menthol, methyl salicylate, or a combination of the two. Menthol is the irritant that do produce a cooling sensation while methyl salicylate do provide a sensation of heat. The amount of menthol in many of the OTC topical analgesics is 1–16% and the amount of methyl salicylate 0–30%. Previous studies reported that when it is mixed with ultrasound gel, it enhances therapeutic ultrasound by providing fast pain relief [1-4].

Based on our literature we found that *Aloe vera* is one of the plant material known to effectively decrease inflammation and promote wound healing. This brings to a conclusion that *Aloe vera* was having potential analgesic activity and that can be used in this study. About 75 active components available in the inner gel had been identified; the synergistic effects of these various compounds do provide biological activities that able to cure severe disease such as cancer, skin diseases, liver problems and AIDS [5, 6].

The existence of vitamin B1, B2, B6, C and folic acid in the flesh of *Aloe Vera* can reduce the level of PGE_2 therefore decreasing the inflammation reaction [7]. This creature is also known to contain alkaloids and steroidal substances which carries antioxidative properties, giving a strong evidence in its ability to cure cancer. They do assist in reduction of pain by simulating the immune system and decline of prostaglandins. Besides, *Aloe vera* gel could enhance the healing of burns and other cutaneous injuries. Hence, in the present study we are interested to include *Aloe vera* gel as one of the ingredient in ultrasound gel to provide fast pain relief.

MATERIAL AND METHODS:

Plant Collection and Authentication

Fresh *Aloe vera* was purchased at the Natresourceful Park (M) Sdn. Bhd, a nursery in Ipoh, Perak and authenticated by Encik Suhaimi bin Haji Din, Botanist from Plant Biosecurity Department of Kompleks Pertanian Bumbung Lima, Seberang Perai, Pulau Pinang. Upon identification, the freshly collected leaves (Fig 1) were washed thoroughly with distilled water to remove the yellow fluid secretion and residues, if any.

Fig 1: *Aloe vera* leaves

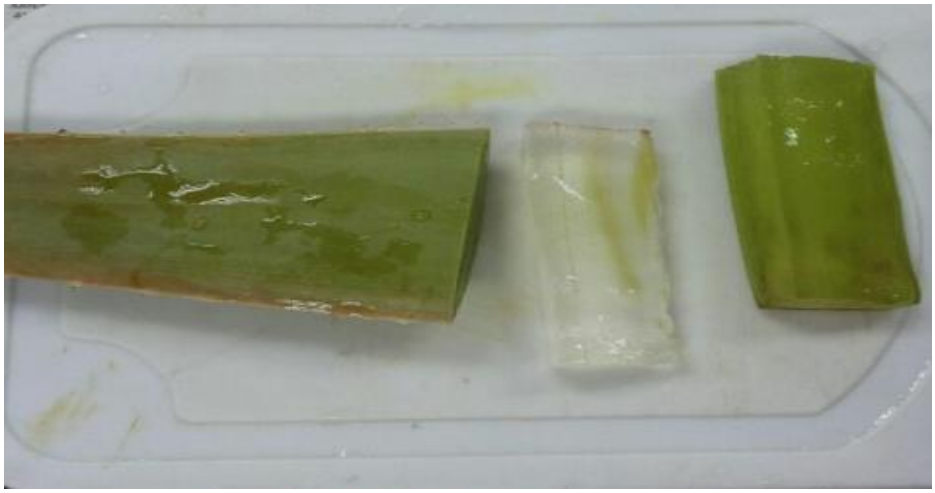

Fig 2: *Aloe vera* gel

Preparation of *Aloe vera* Gel

In this study, there is no any extraction process that had been carried out. The fresh part of the *Aloe vera* gel had been directly added into the formulation. Firstly, the fresh gel of the plant (Fig 2) was separated apart from the leaves and grinded by using mixer grinder into liquid form. After that, the gel was filtered to remove any remaining particulates in the liquid. About 470 g of the *Aloe vera* gel was obtained for the use in this formulation. To avoid any contamination, the freshly prepared Aloe *vera* gel juice was covered with aluminium foil and kept it in the refrigerator throughout the period.

Formulation of Ultrasound Gel

Two different concentration of ultrasound gel were formulated in this study which contains 10% and 20% concentration of *Aloe vera* gel. The composition of the ultrasound gel was listed in the Table 1.

Required quantity of the distilled water was taken in a beaker and heated on the hot plate until it boils, to dilute the corn starch that will be added. Then, the corn starch was sprinkled into the boiling water with a consistent stirring rate with the help of magnetic stirrer, to avoid occurrence of clumping. The solution were boiled until it became a thick gel. Upon completion of boiling, methylparaben and salt were sprinkled into the solution followed by addition of different proportion of *Aloe vera* gel with continuous stirring to form a homogenous gel. The gel was left for continuous stirring for about 1 hour and left aside to let it cool down (Fig 3). In the final step, the gel was transferred into different squeeze bottles and stored at proper temperature until further use.

Table 1: Composition of formulated gel

Concentration of formulated gel (%)	Components	Amount
10%	Corn starch	50 g
	Aloe vera gel	10 g
	Methylparaben	0.5 g
	Salt	10 g
	Distilled water	500 ml
20%	Corn starch	50 g
	Aloe vera gel	20 g
	Methylparaben	0.5 g
	Salt	10 g
	Distilled water	500 ml

Fig 3: Formulated Ultrasound Gel

Physico-Chemical Evaluation of Ultrasound Gel
The following parameters were used to evaluate the formulated gel.

Visual Inspection
Colour, clarity, homogeneity and phase separation of the gel was examined by visual examination.

Determination of pH
About 0.5 g of the gel was weighed and dissolved in 50 ml of distilled water and the pH was measured. The pH of the gel was measured by using a digital pH meter. The results were the mean of three readings.

Spreadability Test
The ease of removal, type of smear formed and the after feel such as emolliency, slipperiness and amount of residue left after application of the gel were examined.

Skin irritation Test
Skin irritation test was performed on human volunteers to detect any irritation problems which could lead to unsuitable use. Three volunteers were selected to check skin irritancy test.1 g of the gel was topically applied to the area near wrist over a 2 square inch. Observation for any lesions, irritation or redness was performed at regular intervals for about 24 hours and recorded.

Accelerated stability test
The gel was divided into three parts and stability tests performed at 8°C ± 0.1°C in refrigerator and at 25°C ± 1°C, and 40°C ± 1°C in oven with 75% RH, and the stability of the gel had been observed for 12 weeks.

Evaluation of Ultrasound Gel [1-3]
With the help of physiotherapist, 30 volunteers, age 20 ± 2 years who are experiencing pain at their shoulder and leg were selected to participate in this evaluation. Before starting the physiotherapy treatment, the volunteers were given briefing about the study and they were also provided with subject information form, informed consent forms and questionnaire on the use and effectiveness of the gel.

3 groups of the volunteers were formed with 10 volunteers in each group. Group A volunteers were tested with commercial ultrasound gel, while for group B volunteers they were tested with 10% formulated ultrasound gel and group C volunteers with 20% formulated ultrasound gel. The participants were randomly placed into a 1-MHz continuous-ultrasound group (n = 10, intensity = 1.25 W/cm^2, time = 10 min). The feedback form which includes sensation elicited after the ultrasound treatment using formulated ultrasound gel, Comfortable warm or cool-burning sensation on their upper or lower limb for several hours after they were treated with formulated ultrasound gel, Sensation of analgesic effect of the formulated ultrasound gel were recorded. By this way the potential benefit of formulated ultrasound gel was determined. The pain was specified by the volunteers by using pain measurement scale (Fig 4).

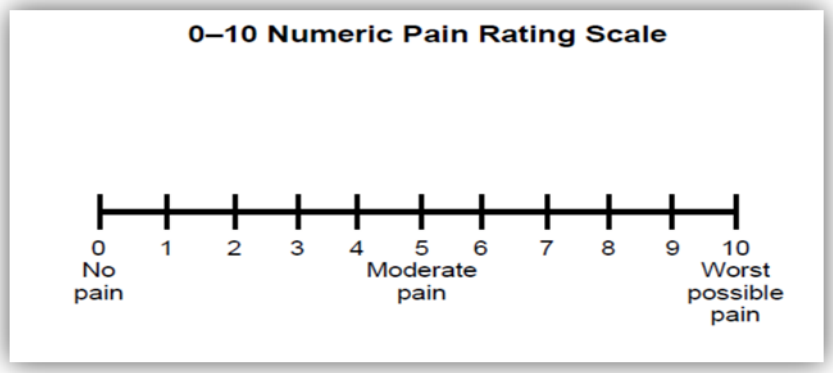

Fig 4: Numeric pain measurement scale

RESULTS AND DISCUSSION:

The formulated gel was evaluated under several physiochemical properties and the results obtained are shown in Table 2. The pH of the gel showed satisfactorily values and recommended pH for the external use purpose. The formulated gel showed acceptable appearance and odour. For appearance aspect, both gels were in milky white colour and in creamy form. There were no any changes in colour that was observed throughout the period.

Table 2: Physiochemical properties of the formulated ultrasound gel

Parameter	Formulation 1	Formulation 2	Formulation 3
pH	6.2	5.5	5.6
Homogeneity	Good	Moderate	Moderate
Appearance	Good	Moderate	Moderate
Odour	Good	Good	Good
Spreadability	Good	Moderate	Moderate
After feel	Good	Good	Good
Type of smear	Non greasy	Non greasy	Non greasy
Removal	Easy	Easy	Easy

Where, Formulation 1 = Commercial ultrasound gel; Formulation 2 = 10% formulated ultrasound gel; Formulation 3 = 20% formulated ultrasound gel

Table 3: Type of adverse effect of the formulation

Formulation	Irritant	Redness	Oedema
Formulation 2	NIL	NIL	NIL
Formulation 3	NIL	NIL	NIL

Table 4: Accelerated stability state of formulated ultrasound gel

Condition	Room temperature				Refrigerator				Oven			
Week	1	2	3	4	1	2	3	4	1	2	3	4
Formulation 2	/	/	/	/	/	/	/	/	/	/	/	/
Formulation 3	/	/	/	/	/	/	/	/	/	/	/	/

Based on the feedback given by the volunteers after the treatment, all of them do agree that there was no sensation produced by the all three formulations (Fig 5). It was indicated that the formulation 2 and 3 were safe as like as commercial ultrasound gel. Thus, it gives a strong evidence about the safety aspect of these formulations.

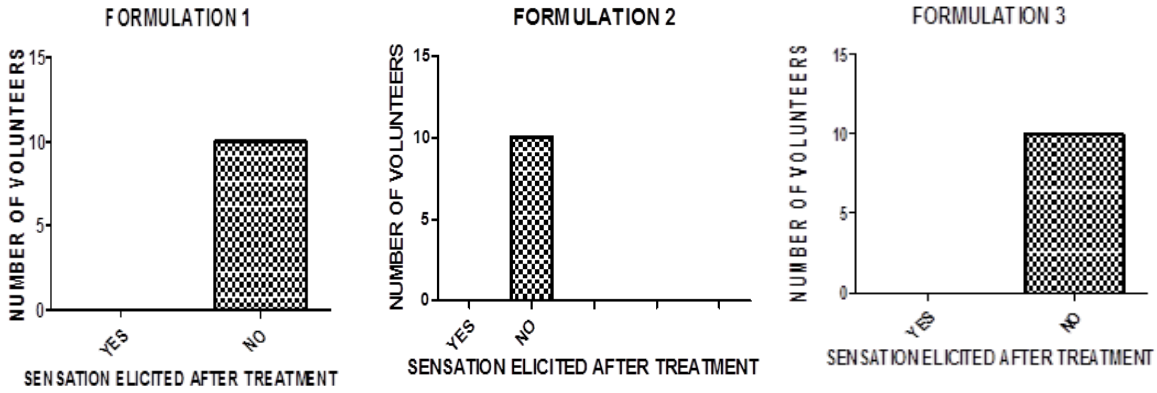

Fig 5: Sensation elicited after the treatment of formulated ultrasound gel

Some improvement are needed to improve the homogeneity of the gel, there were some clumping of starch were observed during application on skin and confirmed by touching. But, the gel are not greasy upon application, the after feel effect were good and can be easily removed by washing with water.

Irritancy test was conducted on 3 healthy volunteers to identify the safety, skin irritation and allergic sensitization. The presence of redness, oedema and irritation by both the formulations were scarce. Thus, the result indicates that both formulations were safe to be used for external application (Table 3). All the physiochemical parameters were maintained during the accelerated stability studies at temperatures 8 °C ± 0.1 °C in refrigerator and at 25 °C ± 1 °C and 40 °C ± 1°C in oven for 12 weeks. The results in Table 4 indicate there were no any particular changes in the physical appearance of the gels.

Most of the topical analgesic preparation contains menthol, producing cool sensation and methyl salicylate, producing hot sensation. Hill and Sumida 2002 [8], reported the warm and cool sensation will decline the pain felt by an individual. *Aloe vera gel* is well known for its cooling effect, it is used widely as soothing agent in most of the skin care products. The analysis showed that formulation 3 provides a better comfortable warm or cool-burning sensation compared to formulation 2 and it had the same ability as the commercial one which was formulation 1.

Aloe vera is well known as *Lidah buaya* in Malaysia and the traditional uses of this plant gain attention of most citizen around this country. Anti-inflammatory, anti-oxidant and wound healing effects are the several significant biological activities of this plant. Much previous research proved that *Aloe vera* is a good natural source of pain relief [9].

The results of pain management score indicates that the formulated ultrasound gel (formulation 2) was significantly reduced the pain from 6.80±0.42 to 1.50±0.27 (Table 5 and Fig 6). This indicated that the formulated can be successfully used for the physiotherapy treatment.

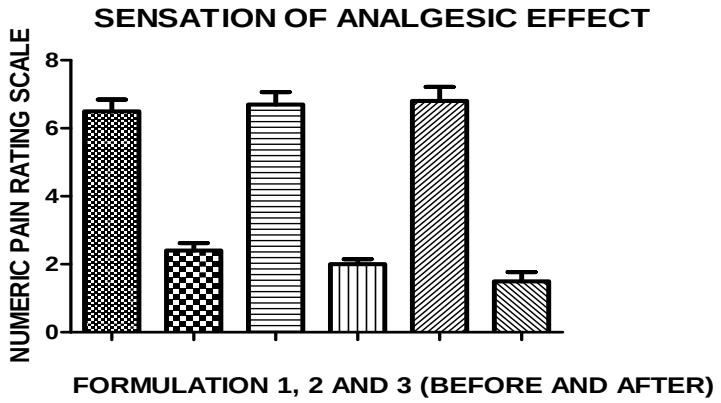

Fig 6: Analgesic effect of formulated ultrasound gel

Table 5: Analgesic effect of formulated ultrasound gel

NUMERIC PAIN RATING SCALE					
FORMULATION 1		**FORMULATION 2**		**FORMULATION 3**	
Before	After	Before	After	Before	After
6.50±0.34	2.40±0.22	6.70±0.37	2.00±0.15	6.80±0.42	1.50±0.27

CONCLUSION:

In conclusion, several participants told us that they experienced a comfortable warm or cool-burning sensation on their upper or lower limb for several hours after they had left the physiotherapy lab. This indicates a potential benefit of sustained pain relief after therapeutic ultrasound treatments with the formulated gel. We also recommend that the formulated ultrasound gel can be used to take medical images during ultrasound scan. In future, the formulation will be further developed into commercial standards and tested with large number of volunteers to confirm its potential analgesic effect.

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