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Research Article

Duration of Antibodies Induced by administration of intranasal Peste des petits Ruminants' Vaccine with mucoadhesive *Boswellia carteri* gum in Small Ruminants

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Abstract

This study describes the duration of antibodies induced by intranasal PPRV vaccination using *Boswellia Carteri* gum in small ruminants. Ninety animals (45 goats and 45 sheep) were selected from three different pastoral herds (30 animals each) in Mudug region, Somalia. Group I had intranasal vaccination with *B carteri* gum, group II had subcutaneous route of vaccination and groups III and IV were gum alone and unvaccinated groups respectively. Serum samples collected from all animals at days 14, 28, 42, 56, 70, 84, 98, 128, 158, 188, 218, 248 and 278 of post vaccination to evaluate antibodies to PPRV vaccine using H-based blocking ELISA. The antibodies rose steadily after immunization in the sheep and goats, and a peak was noted in those vaccinated subcutaneously with an average PI of 68.9±4.4 and 66.7±5.8 respectively, followed by goats and sheep administered *B carteri*-PPR vaccine combination intranasal with an average PI of 67.47±4.3 and 65.4±5.8 respectively. The combined intranasal vaccination of PPRV and *Boswellia* is a potential non-invasive approach, if properly harnessed, can mitigate the recurrent economic losses from PPR since the antibodies could last more than 278 days.

Key Words: PPRV, *B carteri*, Sheep, Goat, Control

INTRODUCTION

The control of infectious diseases in small ruminants like Peste des petits ruminants (PPR) is still a daunting task because the disease is still endemic and so much economic losses are being recorded especially across Africa (Banyard *et al* 2010, Paria *et al* 2015, Parida *et al* 2016). This burden of PPR requires optimal measures, which is being aggressively pursued globally for the year 2030. To achieve this feat, vaccination remains sacrosanct in controlling the infection in small ruminants. However, these animals are randomly distributed in rural villages where vaccination logistics may be complicated coupled with poor immune response and lack of proper delivery system. This means strategic and effective delivery mechanisms are of importance (FAO 2020). The use of attenuated vaccines (Nigeria 75/1 and Sungri 96) is limited because its thermolabile, and require maintenance of cold chain until administration (Diallo *et al* 2007, Mahapatra *et al* 2020), as possible heat stable vaccine for this virus is still far reaching (Mariner *et al* 2017), there is need to harness the possible use of plant gums as delivery of livestock vaccine like PPR vaccine. All the more in this way, intranasal route is a decent option yet mucosal antibody clearannce is regularly a test henceforth there is a requirement for mucoadhesive polymers of organic source which may fill in as a conveyance specialist (Mumin *et al*. 2020, Ezeasor *et al*., 2020).

It is already reported that 90% population of growing economies rely upon restorative plants for essential medical care and drugs (Ekor, 2013). Schippmann *et al* (2002) reviewed thousands of medicinal plants with immense benefits. One of such is Frankincense (olibanum) plant, class Boswellia (Burseraceae). Its product, salai guggal, is delivered overwhelmingly by four different species, B serrata (Thulin and Warfa 1987), B. carterii (Coppens 1995), B frereana (Duperon 1993), and B sacra (Safayhi *et al* 1995). The gum is rich in essential oils, and terpenoids (Chevrier *et al* 2005), holding high percentage of soluble resins and other organic products. Its terpenoids contain boswellic acids (Chevrier *et al* 2005).

Preliminary studies have investigated the use of plant gums with biologic tissues for veterinary application (Emikpe *et al* 2016). Mumin *et al*., (2020) assessed the stimulatory and delivery properties of B. frereana, B. carteri and Commiphora myrrha when combined with PPRV vaccine inoculation in goats and sheep. B. carteri- PPRV vaccine combination at 1:1 elicited optimal immune response in the small ruminants. This study describes the duration of antibodies induced by PPRV vaccination combined Boswellia Carteri gum in small ruminants.

MATERIALS AND METHODS

Animals: 90 animals (45 goats and 45 sheep) were selected from three different pastoral herds (30 animals each) in Mudug region, Somalia. The herds were selected due to their location,

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being mixed small ruminant herd, health, good pasture availability, accessibility, and most importantly immobility of the herd. Each group was housed by the pastoralists in a separate open aired pen with other sheep and goats. Rectal temperature, respiratory rate and pulse rate of all animals were taken and recorded before and after vaccination. Five milliliter of serum samples were collected from all animals at days 14, 28, 42, 56, 70, 84, 98, 128, 158, 188, 218, 248 and 278 of post vaccination. The samples were transported to Galkaio Central Veterinary Laboratory for monitoring anti-PPR virus antibodies.

Ethical consideration: All applicable international, national, and/or institutional guidelines for the care and use of animals were followed.

Vaccination: The intranasal field vaccination was carried out by combining lyophilized PPRV vaccine (Nig. 75/2) with *Boswellia carteri* gum in a ratio of (1:1). This gum was selected because of its high immune response when combined with PPRV vaccine in the pilot study which showed almost similar response level with the standard subcutaneous vaccination (Mumin *et al*., 2020)

Animal grouping: Group I contains 30 animals (15 goats and 15 sheep) and each animal was vaccinated by preparing PPRV dose with a concentration of 10^3 $TCID_{50}$ and *B. carteri* (Mumin *et al* 2020), then the two constituents were added together in an aerosol sprayer (acclimated to convey one ml), completely vortexed, stored, shipped to the field and immediately inoculated to the sheep and goats. In each gathering, inoculation was completed by presenting a solitary shower of the combined mixture straightforwardly into nostrils of the animals as described by Ezeasor *et al.* (2020).
Group II comprise 30 animals (15 goats and 15 sheep) and received 1ml of PPR live-attenuated vaccine with a concentration of 10^3 $TCID_{50}$ subcutaneously.
Groups III contained 15 animals (8 goats and 7 sheep) and received *Boswellia carteri* gum alone by mixing 1.5 gm of the gum with 100 ml PBS and administered intranasally by spraying 1 ml of the mixture in the right nostril. Group IV is unvaccinated 15 animals (8 goats and 7 sheep) living same situation with the other study groups.
All inoculated sheep and goats were checked consistently for conceivable clinical indications after immunization including temperature, beat and breathing rate taken intermittently through the course of experiment.

Serology: Collected serum from both preliminary and the field evaluations were subjected to H-based PPR bELISA (Bodjo *et al*. 2018). The reactivity was presented as percentage of inhibition (PI) and a cut-off of more than 25 was set as positive. The procedure was as described by Bodjo *et al*. (2018).

Statistical considerations: The PI generated was descriptively analyzed and compared using One Way ANOVA on SPSS version 21 at 5% significance.

RESULTS

Immune response evaluation in the field level study: Serum antibody response results of days 14, 28, 42, 56, 70, 84, 98, 128, 158, 188, 218, 248 and 278 of post vaccination readings are presented in Figures 1-2. The titre in the vaccinated sheep and goats in the field evaluation study started rising steadily after immunization, and an increase in the humoral response in goats and sheep vaccinated subcutaneously with an average PI of 68.9±4.4 and 66.7±5.8 respectively, followed by goats and sheep administered *Boswellia carteri*-PPR vaccine combination intranasally with an average PI of 67.47±4.3 and 65.4±5.8 respectively.

Table 1
Titer comparison in the field level study groups of sheep and goats

Source of variation	Sum of squares	Df	Mean sum of squares	F value
Goats	29912.433	3	9970.811	345.116*
Sheep	28639.042	3	9546.347	218.935*

$*<0.05$

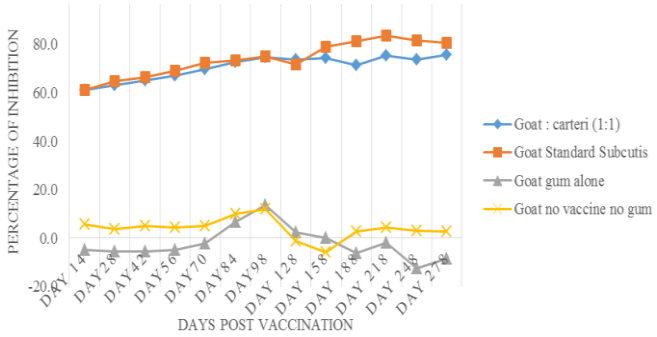

Figure 1
Average percentage of inhibition of *Boswellia carteri*-vaccine combination administered intranasally, vaccine alone administered subcutaneously, gum alone administered intranasally and non-vaccinated goats.

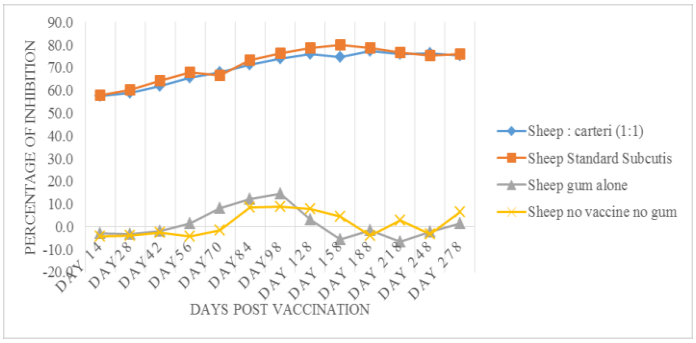

Figure 2
Average percentage of inhibition of *Boswellia carteri*-vaccine combination administered intranasally, vaccine alone administered subcutaneously, gum alone administered intranasally and non-vaccinated sheep.

The combined PPRV and *B carteri* vaccination (1:1) administered intranasal and the conventional subcutaneous approach showed highest and closely similar antibody titer in both sheep and goats. The analysis of variance shows there is significant difference between the different groups (Table 1). Animals administered gum alone intranasal and unvaccinated group did not show any immune response. The first post vaccination reading on day 14 showed higher immune response in goats than sheep but antibody titer of the subsequent readings were almost similar in all group of both species.

DISCUSSION

Though our previous work showed that intranasal PPR vaccination is comparable to the subcutaneous approach (Mumin *et al* 2020), the duration of antibodies induced has not been fully elucidated. This study showed that the combined *Boswellia Carteri* gum and PPRV vaccine elicit antibody level which is relatively high at day 278 post vaccination and can protect against the ravaging PPR in field conditions in both sheep and goats. The sustained response day 278 post vaccinations using intranasal administration is a good indication to fully harness the gum for mass PPR vaccination of small ruminants. Similarly, the close Post immunization observed in both the vaccine alone group and B Carte*ri* gum-PPR combination further underscore the mucoadhesive potential of *B caterri* for non-invasive vaccine application, especially through the intranasal route.

This approach using intranasal route will adequately fit in with large-scale free-range practices and will enhance vaccination coverage unlike the use of parenteral administration which has been reported to have low vaccination coverage (Diallo 2006). The findings further corroborate the initial observations as described by Mumin *et al* (2020).

However, the pattern of the serum antibody titer in the combined gum-PPR vaccinated goat is slightly different from that in sheep. This may be due to the difference in immune correlates in the different animals as fulminant PPR has been observed more in goat than sheep (Emikpe *et al* 2013, Jarikre and Emikpe 2019). The fact that the combined vaccination either through the mucosal or subcutaneous route produce similar humoral response that can last for over 278 days implies that nasal mucosal route has potential for large scale PPR control.

The benefit of the mucosal surface is underscored by it's proportion in the body and contact with the environment (Dietrich *et al* 2003). The interface serves to boost and sensitize memory to immune response (Brandtzaeg 2010). It therefore means that for effective vaccination strategy through the mucosal surface, the interplays of immune mechanism at the mucosal level needs to be fully harnessed (Kunisawa *et al* 2012) .

Rashan *et al* (2019) underscored the potential benefits of Boswellia resins, while the immunopotentiating a property of the boswellic acids was also reported (Chevrier *et al* 2005). The combined PPRV-*B carteri* mixture elicited almost same humoral response in both route of administration and last for over 278 days in small ruminants making it a good measure for PPR control in small ruminants.

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