The Evidence Supporting the Use of Honey as a Wound Dressing

P. C. Molan, BSc, PhD
Department of Biological Sciences, University of Waikato, Hamilton, New Zealand

Some clinicians are under the impression that there is little or no evidence to support the use of honey as a wound dressing. To allow sound decisions to be made, this seminar article has covered the various reports that have been published on the clinical usage of honey. Positive findings on honey in wound care have been reported from 17 randomized controlled trials involving a total of 1965 participants, and 5 clinical trials of other forms involving 97 participants treated with honey. The effectiveness of honey in assisting wound healing has also been demonstrated in 16 trials on a total of 533 wounds on experimental animals. There is also a large amount of evidence in the form of case studies that have been reported. It has been shown to give good results on a very wide range of types of wound. It is therefore mystifying that there appears to be a lack of universal acceptance of honey as a wound dressing. It is recommended that clinicians should look for the clinical evidence that exists to support the use of other wound care products to compare with the evidence that exists for honey.

Key words: evidence, honey, infected wounds, surgical wounds, burns, ulcers

There is a rapidly increasing interest in the use of honey as a wound dressing, although common clinical opinion would appear to be that there is no evidence to support its use as a wound dressing. Even where reviews of clinical evidence for the use of honey have been published, a negative impression is often obtained from consulting these, as the conclusions stated are that the evidence is of low quality and/or that there is a need for more evidence.[1-6] But the myriad of advertisements for modern wound dressings possibly blinds people to the fact that only small, poor-quality trials exist to support the use of these products.[7] For example, if the PubMed database is searched for evidence to support the use of nanocrystalline silver dressings, it can be seen that there is in fact very little published evidence. A recent systematic review of publications on the use of advanced dressings in the treatment of pressure ulcers has found that their generalized use in the treatment of pressure ulcers is not supported by high quality evidence.[8] In evidence-based medicine, decisions should be made on the basis of the available evidence: where randomized controlled trials of the highest quality have not been conducted, it is necessary to consider evidence of a lower quality. It is for these reasons that this perspective article has been written, to allow clinicians to see the large amount of evidence that exists for the effectiveness of honey as a wound dressing. By comparing this with the evidence for other wound-care products, clinicians can then judge for themselves the relative merits of honey as a treatment option for wounds.

The literature cited was found by searching the PubMed, BIOSIS, and ISI Web of Science databases for the term *honey*. Literature not included in the databases but found from citations in papers were included in this search. Excluded were papers where honey was used in a mixture with other therapeutic substances, the 31 case studies found for single cases of wound

Correspondence should be sent to: Professor P. C. Molan, Department of Biological Sciences, University of Waikato, Private Bag 3105, Hamilton, New Zealand; e-mail: pmolan@waikato.ac.nz.

Conflict of interest: The author has received funding from the honey industry for research on therapeutic usage of honey and has had travel to conferences sponsored by companies selling honey for medical usage.

DOI: 10.1177/1534734605286014

treatment with honey, the 21 papers found giving brief reports on the use of honey on wounds, and papers that were expressions of opinion rather than reports of treatment of wounds with honey. Conference presentations were also excluded from this consideration.

CLINICAL EVIDENCE

Many randomized controlled trials have been carried out comparing honey with various other wound treatments. These trials and the results obtained from them are summarized in Table 1. Other clinical trials have been conducted where the form of the trial has been other than a randomized controlled trial. In some of these, the results for the group of patients treated with honey were compared retrospectively with those from the control treatment. In others, the patients were crossed over to treatment with honey after a period of the treatment normally used for that type of wound. The details of these trials and the results obtained from them are summarized in Table 2. Some of the case studies reported for single cases have also involved a comparative study. In these, the patient has had multiple wounds, so honey could be used to treat wounds on one side of the body and normal wound treatment used on those on the other side. The details of these are summarized in Table 3.

There have also been many noncomparative studies reported on the use of honey as a wound dressing. Because many of these cases were not responding to standard treatment for quite some time before dressing with honey was commenced, these provide evidence that is somewhat like that from a crossover trial, although these studies involved no reverse change in treatment such as would be done in a crossover trial. Some of these studies have been with multiple cases. The details of these are summarized in Table 4.

EVIDENCE FROM ANIMAL EXPERIMENTS

Many studies have been performed on the effectiveness of honey in promoting the healing of standardized wounds created on experimental animals. These experiments not only have allowed there to be much more closely comparable controls in trials but also have allowed histological examination of the healing wounds to provide additional data besides the usual measurements of decrease in wound size and time to heal. These experiments and the results obtained from them are summarized in Table 5.

DISCUSSION

The evidence presented in this article amply demonstrates that honey, the oldest wound dressing material known to medicine, can give positive results where the most modern products are failing. Because people generally are unaware of the historical usage of honey as a wound dressing, or know only of its ancient usage, its clinical usage is presumed to be a new development or something that has been "rediscovered."[9] However, a look at the reference list at the end of this article will reveal reports of clinical usage published in the 1950s,[10,11] 1960s,[12] 1970s,[13-16] and 1980s[17-23] as well as the rapidly increasing number since its apparent "rediscovery."

Limitations of Evidence Presented

The evidence presented here that supports the use of honey in wound care includes evidence from many clinical trials. However, none of the findings from these trials would be considered to be evidence of the very highest level, because even though they may have been randomized controlled trials, they have not been double blind. It is near impossible to conduct a double-blind trial of honey as a wound dressing, because of the difficulty of keeping obscured from the patients that a material as recognizable as honey is being used. Even if honey is applied in the form of a manufactured dressing, its aroma is immediately recognized, even a single-blind randomized trial may be difficult to conduct.

However, there are trials and case studies in which the honey and the comparative treatment were used simultaneously on the same patient thereby offering a degree of control. These demonstrate that positive results achieved with honey are not merely a placebo effect. One of these was a prospective randomized controlled trial of honey on split-thickness skin graft donor sites[24] (the last item in Table 1). On patients in this trial who had single donor sites (3 groups of 14 patients), half of the donor site was treated with honey and half with the comparative treatment. On patients with 2 donor sites (3 groups of 15 patients), 1 of the donor sites was treated with honey and 1 with the comparative treatment. (Honey was compared with 3 controls, saline-soaked gauze, paraffin gauze, and a hydrocolloid.) In that trial, the significantly faster healing rates and lower pain scores achieved with honey compared with saline-soaked gauze and paraffin gauze clearly would have been due to physical effects of the honey and not to psychosomatic effects. Further evidence of a similar nature is seen in the results achieved in the case studies summarized in Table 3, although un-

Table 1. Randomized Controlled Trials That Have Been Carried Out on Honey as a Wound Dressing

Type of Wound	Control Treatment	Number in Trial	Results Honey cf Control	Statistics	Other Findings	Reference Number
Superficial burns	Silver sulfadiazine	104	Proportion of wounds becoming sterile within 7 days: 91% cf 7% Mean time that healthy granulation tissue first observed: means 7.4 cf 13.4 days Proportion of wounds healing within 15 days: 87% cf 10% Mean healing time: 9.0 days cf 24.6 days	$P < .001$ Not given Not given $P < .001$	Honey gave better relief of pain, less irritation of the wound, less exudation, a lower incidence of hypertrophic scar and postburn contracture, acceleration of epithelialization, a chemical debridement effect, and removal of offensive smell	56
Fresh partial-thickness burns	OpSite®	92	Mean healing time: 10.8 days cf 15.3 days Cases infected after 8 days: 8 cf 17	$P < .001$ $P < .001$	Honey gave debridement and deodorization, a soothing effect, and ease of removal of dressings with little pain	57
Fresh partial-thickness burns	Amniotic membrane	64	Mean healing time: 9.4 days cf 17.5 days Proportion of patients with residual scars: 8% cf 16.6% Number of cases infected after 7 days: 4 cf 11	$P < .001$ $P < .001$ $P < .001$		58
Partial-thickness burns	Conventional (90 with Vaseline gauze, 90 with OpSite, 90 with Soframycin, 180 dry)	900	Mean healing time: 9 days cf 13.5 days Proportion of wounds infected: 5.5% cf 12% Proportion of cases resulting in scars: 6.2% cf 20%	Not given Not given Not given		59
Fresh partial-thickness burns	Boiled potato peel	82	Mean healing time: 10.4 days cf 16.2 days Proportion of those with positive swab cultures becoming sterile within 7 days: 100% cf 0%	$P < .001$ $P < .001$		60
Superficial burns	Silver sulfadiazine	50	Proportion showing epithelialization by 7th day: 84% cf 72% by 21st day: 100% cf 84% Proportion showing evidence of reparative activity (on histological examination of biopsy samples): on day 7: 80% cf 52% on day 21: 100% cf 84%	$P < .001$ $P < .005$	Honey gave early subsidence of acute inflammatory changes, better control of infection and quicker wound healing. There was eschar in 60% of the cases treated with silver sulfadiazine, none with honey. With silver sulfadiazine, 4 of the superficial burns converted to deep burns requiring skin grafting, none with honey.	50

(continued)

Table 1 (continued)

Type of Wound	Control Treatment	Number in Trial	Results Honey cf Control	Statistics	Other Findings	Reference Number
Moderate burns, half of the total burn area being full-thickness	Tangential excision 3–6 days postburn, then skin grafting	50	Mean percentage blood volume replaced: 21% cf 35% Mean period antibiotics needed: 32 days cf 16 days Proportion of swab cultures positive: 34% cf 10% Mean length of hospital stay: 46 days cf 21 days Proportion with excellent or good wound appearance after 3 months: 55% cf 92%	$P < .01$ $P < .001$ $P < .05$ $P < .001$ $P < .01$	Skin grafting was required on only 11 of the 25 treated with honey cf all of the tangentially excised group	42
Moderate burns, 1/6th total burn area being full-thickness	Silver sulfadiazine	100	Mean healing time: 15.4 days cf 17.2 days Number of swab cultures positive after 7 days: 4 (from 44 at start) cf 42 (from 42 at start) Lipid peroxidation (a measure of inflammation): 4.3 cf 5.3 on day 7 3.8 cf 4.4 on day 14 3.2 cf 4.1 on day 21 Mean length of hospital stay: 22.0 days cf 32.3 days	$P < .001$ $P < .001$ $P < .01$ $P < .01$ $P < .005$ $P < .005$	With honey, 4 required grafting cf 11 with silver sulfadiazine, and there was 1 case of contractures cf 5 with silver sulfadiazine	51
Pediatric burns	Silver sulfadiazine	64	Mean healing time: 11.0 days cf 16.1 days Mean time to form healthy granulation: 6.7 days cf 12.8 days Number of swab cultures positive after 7 days: 24 (from 25 at start) cf 21 (from 24 at start)	$P < .001$ Not given $P < .001$	There were 2 cases of contractures with honey cf 5 with silver sulfadiazine. Honey gave a decrease in edema and exudate, and no eschar.	61
Superficial burns	Silver sulfadiazine	50	100% of cases healed in 10 days cf 70% in 15 days	Not given	Honey gave early subsidence of acute inflammation, and better control of infection. Honey reduced the period of hospital stay and expenses by 30%.	62
Severe postoperative wound infections following abdominal surgery	Washing wounds with 70% ethanol then applying povidone-iodine	50	Mean time to get negative swab cultures: 6 days cf 14.8 days Mean number of days antibiotics were required: 6.88 cf 15.4 Mean healing time: 10.73 days cf 22.04 days Mean size of postoperative scars: 3.62 mm cf 8.62 mm Mean period of hospitalization required: 9.36 days cf 19.91 days	$P < .05$ $P < .05$ $P < .05$ $P < .05$ $P < .05$	With honey, there was mild wound dehiscence in 4 cases, with no need for resuturing: in the control group, there was wound dehiscence in 12 cases, 6 requiring resuturing under general anesthetic	63

(continued)

Table 1 (continued)

Type of Wound	Control Treatment	Number in Trial	Results Honey cf Control	Statistics	Other Findings	Reference Number
Surgically drained pyomyositis abscesses	EUSOL-soaked gauze	32 (43 wounds)	Proportion on day 7 with clean wounds: 100% cf 65.5%	*P* = .007		64
			Proportion on day 7 with granulating wounds: 100% cf 50%	*P* < .001		
			Proportion on day 7 with epithelializing wounds: 86.9% cf 35%	*P* = .001		
			Proportion on day 21 with complete epithelialization: 86.9% cf 55.0%	*P* = .047		
			Mean length of hospital stay: 16.08 days cf 18.61 days (medians 14 days cf 22 days)	*P* = .019		
Chronic leg ulcers (mean duration of 56.5 months)	Phenytoin paste	50	Mean reduction in ulcer size: 27.0% cf 35.5%	Not significant		65
			Mean pain score (on a scale of 1 to 10): 1.8 cf 3.6	Not significant		
Pressure ulcers on orthopedic patients	Saline-soaked gauze	40	Proportion healed in 10 days: 100% cf 70%	P < .05		66
			Mean healing time for ulcers that healed in 10 days: 8.2 days cf 9.9 days	P < .001		
Exit sites of central venous catheters	Povidone-iodine	49	Incidences of blood-stream infections: 12 cf 19 episodes per 1000 catheter-days	Not significant		67
Exit sites of tunneled, cuffed central venous catheters	Mupirocin	101	Incidences of catheter-associated bacteremias: 0.97 cf 0.85 episodes per 1000 catheter-days	Not significant		68
Split-thickness skin graft donor sites	Saline-soaked gauze: also paraffin gauze: also a hydrocolloid (Coloplast)	87 (174 sites treated)	Mean healing time: 9.1 days cf 13.2 days with saline	P < .05	Leakage occurred on 22 dressing changes with the hydrocolloid: no fluid accumulated under the honey dressing. Superior healing was shown with honey.	24
			Mean healing time: 9.4 days cf 12.4 days with paraffin	P < .001		

like with the trial with the skin graft donor sites where the wounds being compared were of a standard nature, there is a possibility the wounds given different treatment for comparison may not have been identical when treatment was started.

The most convincing evidence for the results with honey not being due to a placebo effect comes from the many studies that demonstrated the effectiveness of honey on standard wounds inflicted on experimental animals. Although the participants in these trials may well have been able to detect by smell that honey was being used, they would not have had any psychosomatic effects on healing resulting from beliefs that natural products would be more effective, or from hearing via the news media of the effectiveness of honey in wound treatment.

Table 2. Other Types of Clinical Trials That Have Been Carried Out on Honey as a Wound Dressing

Type of Wound	Form of Trial	Number in Trial	Results	Statistics	Other Findings	Reference Number
Disrupted abdominal wounds from cesarean section	Results from 15 patients treated with honey application and wound approximation by micropore tape were compared retrospectively with 19 similar cases who had their dehisced wounds cleaned with hydrogen peroxide and Dakin solution and packed with saline-soaked gauze prior to resuturing under general anesthesia	15 cf 19	Period of hospitalization required: 2-7 days (mean 4.5) with honey cf 9-18 days (mean 11.5) with control	Not given	With honey, 11 healed within 7 days, the other 4 within 2 weeks. With honey, slough and necrotic tissue were replaced by granulation and advancing epithelialization within 2 days, wounds were made odorless and sterile within 1 week, and no resuturing was required.	69
Fournier's gangrene (necrotizing fasciitis on the scrotum)	20 consecutive cases of Fournier's gangrene managed conservatively with honey plus systemic antibiotics (oral amoxicillin/clavulanic acid and metronidazole) were compared with 21 cases managed in the same period by another consultant, using surgical debridement	41	With honey, within 1 week malodor, edema, and discharge had subsided, all necrotic tissues had separated, rapid epithelialization was occurring. Within 1 week with honey, all swabs were negative: there was no need to change from the routine antibiotics to ones to which the bacteria were found to be sensitive, as was done with the surgically debrided cases.	Not given	A second operation for secondary suturing was needed for all cases surgically debrided, with plastic reconstruction needed for 2 of these. With honey, no surgery was needed, and most healed with very little or no scars. Three deaths occurred in the surgically treated group, none in the honey-treated group.	70
Large infected surgical wounds on infants	Treatment was crossed over to honey dressings after wounds had failed to heal with treatment of at least 14 days using intravenous antibiotics (vancomycin plus cefotaxime, subsequently changed according to bacterial sensitivity), fusidic acid ointment, and wound cleaning with aqueous 0.05% chlorhexidine solution	9	After starting dressing with honey, a marked clinical improvement was seen in all cases after 5 days, and all wounds were closed, clean, and sterile after 21 days	Not given	Six of the patients had systemic antibiotic treatment discontinued when treatment with honey started	71
Venous leg ulcers, nonhealing after at least 12 weeks of compression	Treatment was crossed over to honey dressings used under compression from standard treatment for venous ulcers	40	Pain decreased from an average McGill score of 1.6 to 1.08 in 12 weeks Linear decrease in pain with time Decrease in pain correlated with reduction in wound size Decrease in pain correlated with healing rate The 26 malodorous wounds decreased in odor mean score (on a scale of 1 to 3) in 2 weeks from 1.58 to 0.69.	$P < .02$ $P < .001$ $P < .05$ $P < .05$ $P < .001$	In the 12-week study period, complete healing occurred in 7 cases, with a significant reduction in ulcer size for the rest (mean reduction 32%). There was a high level of patient satisfaction with honey dressings.	72
Burns	A review of all the burn cases in a hospital over the preceding 5 years	156	90.5% of the cases were treated with silver sulfadiazine, 8.5% with honey: the outcomes were similar	Not given		73

Table 3. Case Studies on the Use of Honey as a Wound Dressing Where a Comparison With Other Treatments Was Conducted on Multiple Wounds Within Single Cases

Type of Wounds	Status of Wounds Before Using Honey	Comparison	Results	Reference Number
Multiple chronic leg ulcers, on both legs	20-year history of multiple ulcers on the legs and feet resulting from chronic venous hypertension with secondary lymphedema	The ulcers on one leg were dressed with honey, those on the other leg with Aquacell	At the time of discharge 10 days later, the ulcers dressed with honey had a cleaner wound bed, signs of infection had cleared, and the green exudate had ceased, whereas with the Aquacell, there was copious leakage of green fluid	44
Multiple chronic leg ulcers, on both legs	Ulcers had been there for >5 years. They had features of stasis dermatitis. There was no arterial disease.	The ulcers on one leg were dressed with honey, those on the other leg were debrided with fibrinolysin (Elase R) then dressed with Sorbosan R	Initially, healing was much more rapid with honey. After 1 month, both legs were healing well.	74
Broken-down wound from abdominal surgery	Areas of dehiscence at each end of the wound, of similar appearance	The dehiscence at one end was dressed with honey, on the other end with Debrisan	Healing was complete in 24 days with honey, 32 days with Debrisan	75
Third-degree burns to both arms		Burns on one arm were dressed with honey, the other arm with EUSOL	Granulation was "much nicer" with honey, reducing time to skin grafting	76

Does honey give good results in individual cases studied because those wounds received more attention, or the prior treatment was less than ideal? There are cases where honey has worked even on wounds that had received prior specialist attention. They changed to healing from nonhealing only when treatment with honey was commenced. In many of these cases, the wounds were not responding to best practice with modern dressings, although a recent systematic review of the evidence for the efficacy of modern wound dressings in the treatment of pressure ulcers has concluded that there is no evidence that these are any better than saline-soaked gauze.[8]

Supporting Evidence From In Vitro Studies

Further evidence to support the use of honey as a wound dressing comes from laboratory studies that have clearly demonstrated that honey has bioactivities that would be beneficial in wound care. In work with cultures of leukocytes, honey has been shown to stimulate cytokine production by monocytes.[25,26] The release of cytokines is what initiates the tissue repair process as well as the immune response to infection. Also, stimulation by honey of other aspects of the immune response, the proliferation of B- and T-lymphocytes and the activity of phagocytes, has been shown.[27] Additional to this work with cells in culture, it has been demonstrated that honey stimulates the production of antibodies in mice in response to antigens from *Escherichia coli*.[28] These findings suggest that part of the effectiveness of honey in clearing and preventing infection in wounds that is so widely seen in the clinical evidence may be due to enhancement of the body's own immunity as well as being due to the antibacterial activity of honey.

The number of publications on laboratory studies showing that honey has antibacterial activity with a very broad spectrum is very large.[29] But what is often not taken into account is that honeys can vary as much as 100-fold in the potency of their antibacterial activity.[30] More recent publications have reported on the sensitivity of various species of bacteria to honey, with antibacterial potency near the median level found in surveys of large numbers of samples. This level is a little below that of the various honey wound-care products now on sale manufactured from *Leptospermum* honey, but there are other wound-care products manufactured from honeys not selected to have high levels of antibacterial activity (Activon Tube, Activon Tulle, and Algivon [Advancis], Apinate [Comvita], and Medihoney Barrier and Medihoney Gel [Medihoney]).[31] Laboratory studies with *Leptospermum* honey with antibacterial potency near the median level have shown the MIC (minimum inhibitory concentration, ie, the concentration down to which honey could be diluted by wound exudate and still prevent bacterial growth) to be 2% to 3% for *Staphylococcus aureus*,[32] 3.3% to

Table 4. Reports on the Use of Honey as a Wound Dressing: Studies With Multiple Cases

Type of Wound	Status of Wounds Before Using Honey	Number of Cases	Outcome From Treatment With Honey	Reference Number
16 acute traumatic wounds, 23 complicated surgical wounds, and 21 chronic nonresponding wounds	The chronic nonresponding wounds had all been subjected to other regimens before honey dressings were used	60	One patient withdrew from the trial because the honey was causing pain. Two wounds did not change. The rest healed in a mean time of 3 weeks (range 1–28 weeks). One patient was treated with silver sulfadiazine and antibiotics instead of honey for 1 week because of an infection with *Staphylococcus aureus*. Advanced epithelialization and a decrease in exudate, edema, and wound odor were observed.	77
Recalcitrant wounds and ulcers of varied etiology, such as Fournier's gangrene, burns, cancrum oris, diabetic ulcers, traumatic ulcers, decubitus ulcers, sickle cell ulcers, and tropical ulcers	47 of the patients had been treated for 1–24 months with conventional treatment (such as Eusol toilet and dressings of Acriflavine, Sofra-Tulle, or Cicatrin, or systemic and topical antibiotics) with no signs of healing, or the wounds were increasing in size	59	The 51 wounds with bacteria present became sterile within 1 week, and the others remained sterile. In 1 of the cases, a Buruli ulcer, treatment with honey was discontinued after 2 weeks because the ulcer was rapidly increasing in size. The 58 other cases "showed remarkable improvement." Sloughs, necrotic, and gangrenous tissue separated so that they could be lifted off painlessly and were rapidly replaced with granulation tissue and advancing epithelialization. Surrounding edema subsided, weeping ulcers dehydrated, and foul-smelling wounds were rendered odorless within 1 week. Burn wounds treated early healed quickly, not becoming colonized by bacteria.	17
Wounds from radical vulvectomy with lymphadectomy	Wounds had broken down	12	Wounds became free from bacteria in 3–6 days. Complete healing was achieved in 3–8 weeks. Clean healthy granulation was achieved, requiring minimal surgical debridement. Skin grafting was unnecessary.	13
Wounds of mixed etiology: surgical, accidental, infective, trophic, and burns. The average size of the wounds was 57 cm^2.	Half of the cases had been treated with "the usual topical measures" (an antiseptic), which had failed. One third of the wounds were purulent, the rest were red with a whitish coat.	40	Honey delimited the boundaries of the wounds and cleansed the wounds rapidly to allow skin grafting. Of the 33 patients treated only with honey dressings, 29 were healed successfully, with good-quality healing, in an average time of 5–6 weeks. Two of the 4 who did not heal were suffering from immunodepression, 1 was withdrawn from treatment with honey because of a painful reaction to the honey, and 1 burn remained stationary after a good initial response.	78
Septic wounds, chronic ulcers, burns, pyogenic abscesses	6 patients were diabetic, 5 with a septic foot and 1 with an abscess	11	Healing time was 7–15 days, apart from 1 diabetic who took 56 days and 1, who was ill, in which there was no improvement. Clean healthy granulation was achieved, which allowed skin grafting in 14 days (30 for 1 diabetic), with prompt graft taking.	18
A variety of wounds, including ulcers of various etiologies, pressure ulcers, burns, skin tears, and traumatic wounds		20	In 80% of cases, the wound bed improved (it was cleaner, with less slough and malodor, with movement along the healing continuum). In 20% of cases, there was no improvement. 65% found honey dressings easy to apply, 75% found them easy to remove, 85% found the dressings stayed in place, 65% found them comfortable.	79
Surgical wounds, mostly dehiscent or infected	Pediatric patients receiving chemotherapy, making wounds hard to heal because of profound immunosuppression	16	Wounds became sterile within 1–4 days. The average healing time was 25 days. Four patients undergoing prolonged immunosuppression healed in an average time of 27 days. Healing occurred without complication, apart from 1 small keloid.	38

(continued)

Table 4 (continued)

Type of Wound	Status of Wounds Before Using Honey	Number of Cases	Outcome From Treatment With Honey	Reference Number
Venous leg ulcers that had undergone split-skin grafting	Ulcers were of 12 months or more duration and were not responding to normal treatment such as compression. They were of borderline suitability for grafts. Five had conditions characteristic of insufficient tissue perfusion.	6	The mean healing time was 22 days. There were no postoperative infections or other complications. No regrafting or revision of grafts was needed. There was no recurrence of the ulcers on follow-up (average of 19 months later).	80
Fournier's gangrene	Honey was used following aggressive surgical debridement and triple antibiotic therapy	38	Honey gave rapid healing changes in an average period of 10 days	81
Gangrene in the genitals and perineum		14	The mean time for the debriding action of the honey to cleanse the wounds was 5.2 days, for granulation to be seen was 9.4 days, and for complete healing was 28.7 days	82

4% for coagulase-negative staphylococci,[33] 5.5% to 9% for pseudo-monads,[34,35] 2.7% to 3% for MRSA,[36] and 3.8% to 5% for VRE.[36] The effectiveness of honey in clinical usage in clearing infection with MRSA[37,38,39,40,41] and VRE[37] has been reported. The slow clearance of infection, or failure to clear infection, in some of the cases reported may well reflect the use of honey with a low antibacterial potency. For example, this may have been the case in the randomized controlled trial where honey was found to be less effective than early tangential excision followed by autologous skin grafting in controlling infection in the treatment of burns.[42] The same author, publishing results comparing the MIC values for various types of honey available locally, reported that the MIC for the most potent honey against *S aureus* was 20% to 25%,[43] which means that the honey had only about a tenth of the antibacterial potency of the *Leptospermum* honey used in wound-care products now on sale.

Dressing Techniques

Another reason for variability in results may have been that the honey dressings were not being kept in place on the wound in some cases. The difficulty of achieving this was commented on.[44,45] If the honey is flushed out of the dressing by wound exudate, then its various bioactivities cannot be having any effect on the wound. A case that may be an example of this is where infection in a leg ulcer was reported to recur when compression was commenced.[46] Here it was noted that there was a problem with dressings adhering, which is a clear indication that honey has been flushed out of the dressing by wound exudate.[47] A similar occurrence was reported where honey-impregnated tulle dressings were being used.[48] These have very little absorbency, so honey is easily flushed from them. It was noted in this case that the dressings became saturated with exudate within 1 hour. In another case where poor progress was occurring with honey, it was found that much better progress with healing occurred when more frequent changes of the dressings were made.[49]

Anti-Inflammatory Activity of Honey

It has been noted that if sufficient honey is kept in place, by applying it by way of impregnated dressings and changing these frequently enough, then its anti-inflammatory activity will reduce the amount of exudate and thus remove the need for frequent dressing changes.[47] There is a very large amount of evidence for honey having significant anti-inflammatory activity. As well as the evidence that has come from the many clinical observations summarized in this review,

Table 5. Animal Experiments Carried Out on the Use of Honey as a Wound Dressing

Type of Wound	Control Treatment	Species of Animal	Number in Trial	Results	Statistics	Other Findings	Reference Number
Deep dermal burns (6.7 × 6.7 cm) made with a 170°C brass block	Silver sulfadiazine: also sugar	Yorkshire pigs	3 (36 wounds)	Complete epithelialization achieved within 21 days with both honey and sugar, cf 28-35 days with silver sulfadiazine	Not given		83
				Histological examination revealed less inflammation in wounds treated with honey than in those treated with sugar and with silver sulfadiazine, and a more advanced stage of healing	Not given		
Dermal burns (1.3 × 3 cm) made with a 170°C brass block	Silver sulfadiazine: also untreated (other than a daily saline rinse)	Pigs	2 (27 wounds)	First granulation was observed (histologically) after 5 days with honey, 10 days with the controls	Not given		84
				Less edema and inflammation were observed (histologically) with honey than with the controls	Not given		
Third-degree dermal burns (made with steam), 8.5 cm^2, inoculated with *Pseudomonas aeruginosa*	Silver sulfadiazine: also acetate mafenid	Piglets	60	After 30 days, the mean reduction in wound area was 62% with honey cf 29% with silver sulfadiazine and 22% with acetate mafenid	$P = .000$ for honey cf the other treatments		85
				After 10 days, the proportion of wounds with good granulation covering the major part, suitable for grafting, was 90% with honey cf 44% with silver sulfadiazine and 35% with acetate mafenid	$P < .003$ for honey cf the other treatments		
				The proportion of biopsy samples, taken after 10 days, giving positive microbial cultures was 20% with honey cf 100% with silver sulfadiazine and 95% with acetate mafenid	$P < .00001$ for honey cf the other treatments		
Superficial burns, created on the skin with a red-hot pin (15 mm^2)	No treatment: also, solution of sugars as in honey	Rats	60 (120 wounds)	The mean time to complete healing was 20.4 days with honey cf 30.3 days with no treatment	$P < .01$	Healing was seen histologically to be more active and advanced with honey, and honey was also clearly seen to give attenuation of inflammation and exudation, and less serious necrosis	16
				The mean time to complete healing was 20.4 days with honey cf 28.5 days with sugar	$P < .01$		

(continued)

Table 5 (continued)

Type of Wound	Control Treatment	Species of Animal	Number in Trial	Results	Statistics	Other Findings	Reference Number
Wounds created by cutting away 2 × 4 cm pieces of skin on the back	Nitrofurazone; also sterilized petrolatum	Buffalo calves	6 (24 wounds)	Granulation, scar formation, and complete healing occurred faster with honey, with more proliferation of fibroblasts and angioblasts	Not given	Attenuation of inflammation by honey was also seen (by histological observation)	86
Wounds created by cutting away 2 × 4 cm pieces of skin on the back, infected by subcutaneous injection of *Staphylococcus aureus* 2 days prior to wounding	Ampicillin ointment: also saline	Buffalo calves	9 (90 wounds)	Honey gave the fastest rate of healing compared with the other treatments, also (observed histologically) the most rapid fibroblastic and angioblastic activity in the wounds and the fastest epithelialization	Not given	Attenuation of inflammation by honey was also seen (by histological observation)	87
Wounds created by excising skin (1 × 1 cm)	Saline	Mice	24	Histological examination showed that the thickness of granulation tissue was greater with honey	$P < .001$		20
				Histological examination showed that the distance of epithelialization from the edge of the wound was greater with honey	$P < .001$		
Wounds created by excising skin (1 × 1 cm)	Saline	Rats	15 (30 wounds)	The area of the wound (mm^2) with the honey treatment cf the area with saline was: after 4 days: 47.5 cf 71.4 after 8 days: 33.3 cf 52.2 after 12 days: 9.1 cf 40.5	$P < .01$	With honey, epithelialization was more rapid and there was less edema (both assessed histologically)	88
				The thickness of granulation tissue (mm, assessed histologically) with the honey treatment cf the thickness with saline was: after 4 days: 0.52 cf 0.389 after 8 days: 1.17 cf 0.53 after 12 days: 1.917 cf 0.995	$P < .01$		
Wounds created by excising skin (2 × 2 cm)	Saline	Rats	20	The mean contraction in size of the wounds was 80% with honey, 55% with saline	$P = .001$		89
Wounds created by excising skin (2 × 2 cm)	Saline	Rats	20	After 10 days, the mean area of the wounds was 1.15 mm^2 with honey, 2.38 mm^2 with saline	$P = .002$	There was histological evidence of greater granulation with honey	90

(continued)

Table 5 (continued)

Type of Wound	Control Treatment	Species of Animal	Number in Trial	Results	Statistics	Other Findings	Reference Number
Wounds created by excising skin (2 × 2 cm)	No treatment	Rats	12	The quantity of collagen synthesized was increased by honey cf the control	$P < .001$		91
				The degree of cross-linking of the collagen in the granulation tissue was increased by honey cf the control	$P < .05$		
Wounds created by excising skin (2 × 2 cm)	No treatment	Rats	12	The content in granulation tissue of various markers of connective tissue metabolism increased by honey cf the control:			92
				protein	$P < .01$		
				collagen	$P < .01$		
				hexosamine	$P < .01$		
				uronic acid	$P < .001$		
				The rate of healing was increased by honey cf the control:			
				contraction of wound	$P < .001$		
				epithelialization	$P < .05$		
Incision (6 cm long) made in skin, then sutured	No treatment	Rats	12	The tensile strength of the wounds was increased by 21% with honey cf the control	$P < .05$		92
Full-thickness incisions (3 cm long) made in the skin	No treatment	Rabbits	40	Honey increased the strength of the healed wounds compared with the untreated control:		Less edema was observed with the honey treatment, and	93
				tensile strength (measured after 14 days)	$P < .001$	histological examination revealed that honey	
				ultimate strength	$P < .05$	gave less inflammation and necrosis and more	
				yield strength	$P < .02$	fibroblasts and collagen present	
Full-thickness incisions (1.5 cm long) made in the skin	No treatment	Rats	6	Histological examination of biopsy samples showed: with honey, on day 7, there was epithelial bridging cf inflammatory exudate and no epithelialization with the control; with honey, on day 14, there was complete epithelial bridging with honey cf epithelium yet to cover wound with the control	Not given		94

there is evidence from histological observation of biopsy samples taken in a clinical trial of honey on burns[50] and from biochemical assays of indicators of inflammation in other clinical trials on burns.[51,52] One of these biochemical studies was in the form of a randomized controlled trial with 60 patients, comparing honey with silver sulfadiazine, and it was demonstrated that honey decreased oxidative stress by mopping up the free radicals arising from burns.[52] There is also histological evidence for the anti-inflammatory activity of honey from some of the studies on experimental animals summarized in Table 5. In some of the experimentally induced burns, there was no infection evident, yet honey still brought about a decrease in inflammation. This indicates that the anti-inflammatory activity of honey is a direct action and not a secondary consequence of removal of infection through its antibacterial activity. This is confirmed also by honey giving a positive result in the standard guinea pig wrist stiffness test for anti-inflammatory activity.[53] That honey has a direct anti-inflammatory activity is also indicated by the finding that honey was as effective as prednisolone in a trial on induced colitis in rats,[54] and by its being found to give a highly significant ($P < .001$) reduction in peritoneal adhesions following surgery on the cecum and ileum in another trial on rats.[55] A laboratory study also demonstrated a direct anti-inflammatory activity in honey, as honey was shown to significantly ($P < .001$) decrease the amount of reactive oxygen intermediates released from monocytes in culture that had been stimulated with *Escherichia coli* lipopolysaccharide.[25]

CONCLUSIONS

There is a large body of evidence to support the use of honey as a wound dressing for a wide range of types of wounds. Its antibacterial activity rapidly clears infection and protects wounds from becoming infected, and thus it provides a moist healing environment without the risk of bacterial growth occurring. It also rapidly debrides wounds and removes malodor. Its anti-inflammatory activity reduces edema and exudate and prevents or minimizes hypertrophic scarring. It also stimulates the growth of granulation tissue and epithelial tissue so that healing is hastened. Furthermore, it creates a nonadherent interface between the wound and the dressing so that dressings may be easily removed without pain or damage to newly regrown tissue.

The barrier to using honey that has existed for many clinicians who have been constrained to using only licensed products has been removed now that honey is available in the form of various sterile products licensed for use in wound care. To practice evidence-based medicine, clinicians involved in wound care thus should check what evidence exists for other wound dressing products they may be considering using and weigh this up against the evidence that exists to support the use of honey.

REFERENCES

1. Office of Complementary Medicines. Honey scientific report [Online]; 1998. Retrieved from http://wwwtgagovau/docs/pdf/cmec/honeysrpdf.
2. Fox C. Honey as a dressing for chronic wounds in adults. Br J Community Nurs 2002;7(10):530-4.
3. Gethin G. Is there enough clinical evidence to use honey to manage wounds? J Wound Care 2004;13(7):275-8.
4. Moore OA, Smith LA, Campbell F, et al. Systematic review of the use of honey as a wound dressing. BMC Complement Altern Med 2001;1(1):2.
5. Mwipatayi BP, Angel D, Norrish J, et al. The use of honey in chronic leg ulcers: a literature review. Primary Intention 2004;12(3):107-12.
6. Templeton S. A review of the use of honey on wounds. ACCNS J Community Nurs 2002;7(1):13-14.
7. Vermeulen H, Ubbink DT, Goossens A, et al. Systematic review of dressings and topical agents for surgical wounds healing by secondary intention. Br J Surg 2005;92(6):665-72.
8. Bouza C, Saz Z, Muñoz A, et al. Efficacy of advanced dressings in the treatment of pressure ulcers: a systematic review. J Wound Care 2005;14(5):193-9.
9. Zumla A, Lulat A. Honey—a remedy rediscovered. J R Soc Med 1989;82(7):384-5.
10. Seymour FI, West KS. Honey—its role in medicine. Med Times 1951;79:104-7.
11. Bulman MW. Honey as a surgical dressing. Middlesex Hosp J 1955;55:188-9.
12. Hutton DJ. Treatment of pressure sores. Nurs Times 1966;62(46):1533-4.
13. Cavanagh D, Beazley J, Ostapowicz F. Radical operation for carcinoma of the vulva. A new approach to wound healing. J Obstet Gynaecol Br Commonw 1970;77(11):1037-40.
14. Blomfield R. Honey for decubitus ulcers. J Am Med Assoc 1973;224(6):905.
15. Bloomfield E. Old remedies. J R Coll Gen Pract 1976;26:576.
16. Burlando F. Sull'azione terapeutica del miele nelle ustioni. Minerva Dermatol 1978;113:699-706.
17. Efem SEE. Clinical observations on the wound healing properties of honey. Br J Surg 1988;75:679-81.
18. Farouk A, Hassan T, Kashif H, et al. Studies on Sudanese bee honey: laboratory and clinical evaluation. Int J Crude Drug Res 1988;26(3):161-8.
19. Armon PJ. The use of honey in the treatment of infected wounds. Trop Doct 1980;10:91.
20. Bergman A, Yanai J, Weiss J, et al. Acceleration of wound healing by topical application of honey. An animal model. Am J Surg 1983;145:374-6.
21. Braniki FJ. Surgery in Western Kenya. Ann R Coll Surg Engl 1981;63:348-52.
22. Green AE. Wound healing properties of honey. Br J Surg 1988;75(12):1278.

23. Wadi M, Al-Amin H, Farouq A, et al. Sudanese bee honey in the treatment of suppurating wounds. Arab Medico 1987;3:16-18.
24. Misirlioglu A, Eroglu S, Karacaoglan N, et al. Use of honey as an adjunct in the healing of split-thickness skin graft donor site. Dermatol Surg 2003;29(2):168-72.
25. Tonks A, Cooper RA, Price AJ, et al. Stimulation of TNF-a release in monocytes by honey. Cytokine 2001;14(4):240-2.
26. Tonks AJ, Cooper RA, Jones KP, et al. Honey stimulates inflammatory cytokine production from monocytes. Cytokine 2003;21(5):242-7.
27. Abuharfeil N, Al-Oran R, Abo- Shehada M. The effect of bee honey on proliferative activity of human B- and T-lymphocytes and the activity of phagocytes. Food Agric Immunol 1999;11:169-77.
28. Al-Waili NS, Haq A. Effect of honey on antibody production against thymus-dependent and thymus-independent antigens in primary and secondary immune responses. J Med Food 2004;7(4):491-4.
29. Molan PC. The antibacterial activity of honey: 1. The nature of the antibacterial activity. Bee World 1992;73(1):5-28.
30. d'Agostino Barbaro A, La Rosa C, Zanelli C. Atttività antibatterica di mieli Siciliani. Quad Nutr 1961;21(1/2):30-44.
31. Molan PC, Betts JA. Clinical usage of honey as a wound dressing: an update. J Wound Care 2004;13(9):353-6.
32. Cooper RA, Molan PC, Harding KG. Antibacterial activity of honey against strains of *Staphylococcus aureus* from infected wounds. J R Soc Med 1999;92(6):283-5.
33. French VM, Cooper RA, Molan PC. The antibacterial activity of honey against coagulase-negative staphylococci. J Antimicrob Chemother 2005;56(1):228-31.
34. Cooper RA, Halas E, Molan PC. The efficacy of honey in inhibiting strains of *Pseudomonas aeruginosa* from infected burns. J Burn Care Rehabil 2002;23(6):366-70.
35. Cooper RA, Molan PC. The use of honey as an antiseptic in managing Pseudomonas infection. J Wound Care 1999;8(4):161-4.
36. Cooper RA, Molan PC, Harding KG. The sensitivity to honey of Gram-positive cocci of clinical significance isolated from wounds. J Appl Microbiol 2002;93:857-63.
37. Eddy JJ, Gideonsen MD. Topical honey for diabetic foot ulcers. J Fam Pract 2005;54(6):533-5.
38. Simon A, Sofka K, Wiszniewsky G, et al. Wound care with antibacterial honey (Medihoney) in pediatric hematology-oncology. Support Care Cancer 2005;(In press).
39. Dunford C, Cooper R, Molan PC, et al. The use of honey in wound management. Nurs Standard 2000;15(11):63-8.
40. Natarajan S, Williamson D, Grey J, et al. Healing of an MRSA-colonized, hydroxyurea-induced leg ulcer with honey. J Dermatolog Treat 2001;12:33-6.
41. Dunford CE. Treatment of a wound infection in a patient with mantle cell lymphoma. Br J Nurs 2001;10(16):1058-65.
42. Subrahmanyam M. Early tangential excision and skin grafting of moderate burns is superior to honey dressing: a prospective randomised trail. Burns 1999;25(8):729-31.
43. Subrahmanyam M, Hemmady AR, Pawar SG. Multidrug-resistant *Staphylococcus aureus* isolated from infected burns sensitive to honey. Ann Burns Fire Disasters 2003;16(4):192-4.
44. Alcaraz A, Kelly J. Treatment of an infected venous leg ulcer with honey dressings. Br J Nurs 2002;11(13):859-60, 862, 864-6.
45. Lawrence JC. Editorial: honey and wound bacteria. J Wound Care 1999;8(4):155.
46. Kingsley A. A proactive approach to wound infection. Nurs Stand 2001;15(30):50-8.
47. Molan PC, Betts J. Using honey dressings: the practical considerations. Nurs Times 2000;96(49):36-7.
48. Kingsley A. Practical use of modern honey dressings in chronic wounds. In: White R, Cooper R, Molan P, editors. Honey: a modern wound management product. Aberdeen, UK: Wounds UK; 2005:54-78.
49. van der Weyden EA. Treatment of a venous leg ulcer with a honey alginate dressing. Br J Community Nurs 2005;10(6 Suppl):S21, S24, S26-7.
50. Subrahmanyam M. A prospective randomised clinical and histological study of superficial burn wound healing with honey and silver sulfadiazine. Burns 1998;24(2):157-61.
51. Subrahmanyam M, Sahapure AG, Nagane NS, et al. Effects of topical application of honey on burn wound healing. Ann Burns Fire Disasters 2001;14(3):143-5.
52. Subrahmanyam M, Shahapure AG, Nagane NS, et al. Free radical control—the main mechanism of the action of honey in burns. Ann Burns Fire Disasters 2003;16(3):135-8.
53. Church J. Honey as a source of the anti-stiffness factor. Fed Proc Am Physiol Soc 1954;13(1):26.
54. Bilsel Y, Bugra D, Yamaner S, et al. Could honey have a place in colitis therapy? Effects of honey, prednisolone, and disulfiram on inflammation, nitric oxide, and free radical formation. Dig Surg 2002;19:306-12.
55. Aysan E, Ayar E, Aren A, et al. The role of intra-peritoneal honey administration in preventing post-operative peritoneal adhesions. Eur J Obstet Gynecol Reprod Biol 2002;104(2):152-5.
56. Subrahmanyam M. Topical application of honey in treatment of burns. Br J Surg 1991;78(4):497-8.
57. Subrahmanyam M. Honey impregnated gauze versus polyurethane film (OpSite®) in the treatment of burns—a prospective randomised study. Br J Plast Surg 1993;46(4):322-3.
58. Subrahmanyam M. Honey-impregnated gauze versus amniotic membrane in the treatment of burns. Burns 1994;20(4):331-3.
59. Subrahmanyam N. Addition of antioxidants and polyethylene glycol 4000 enhances the healing property of honey in burns. Ann Burns Fire Disasters 1996;9(2):93-5.
60. Subrahmanyam M. Honey dressing versus boiled potato peel in the treatment of burns: a prospective randomized study. Burns 1996;22(6):491-3.
61. Bangroo AK, Katri R, Chauhan S. Honey dressing in pediatric burns. J Indian Assoc Pediatr Surg 2005;10(3):172-5.
62. Nagra ZM, Fayyaz GQ, Asim M. Honey dressings; experience at Department of Plastic Surgery and Burns Allied Hospital Faisalabad. Prof Med J 2002;9(3):246-51.
63. Al-Waili NS, Saloom KY. Effects of topical honey on post-operative wound infections due to gram positive and gram negative bacteria following caesarean sections and hysterectomies. Eur J Med Res 1999;4:126-30.
64. Okeniyi JAO, Olubanjo OO, Ogunlesi TA, et al. Comparison of healing of incised abscess wounds with honey and EUSOL dressing. J Altern Complement Med 2005;11(3):511-13.
65. Oluwatosin OM, Olabanji JK, Oluwatosin OA, et al. A comparison of topical honey and phenytoin in the treatment of chronic leg ulcers. Afr J Med Sci 2000;29(1):31-4.
66. Weheida SM, Nagubib HH, El-Banna HM, et al. Comparing the effects of two dressing techniques on healing of low grade pressure ulcers. J Med Res Inst Alexandria Univ 1991;12(2):259-78.
67. Mutjaba Quadri KH. Manuka honey for central vein catheter exit site care. Semin Dial 1999;12(5):397-8.
68. Johnson DW, van Eps C, Mudge DW, et al. Randomized, controlled trial of topical exit-site application of honey (Medihoney) versus mupirocin for the prevention of catheter-associated infections in hemodialysis patients. J Am Soc Nephrol 2005;16(5):1456-62.
69. Phuapradit W, Saropala N. Topical application of honey in treatment of abdominal wound disruption. Aust N Z J Obstet Gynaecol 1992;32(4):381-4.
70. Efem SEE. Recent advances in the management of Fournier's gangrene: preliminary observations. Surgery 1993;113(2):200-4.

71. Vardi A, Barzilay Z, Linder N, et al. Local application of honey for treatment of neonatal postoperative wound infection. Acta Paediatr 1998;87(4):429-32.
72. Dunford CE, Hanano R. Acceptability to patients of a honey dressing for non-healing venous leg ulcers. J Wound Care 2004;13(5):193-7.
73. Adesunkanmi K, Oyelami OA. The pattern and outcome of burn injuries at Wesley Guild Hospital, Ilesha, Nigeria: a review of 156 cases. J Trop Med Hyg 1994;97(2):108-12.
74. Harris S. Honey for the treatment of superficial wounds: a case report and review. Primary Intention 1994;2(4):18-23.
75. Dany-Mazeau MPG. Honig auf die Wunde. Krankenpflege 1992;46(1):6-10.
76. Taks JM. Eusol management of burns. Trop Doct 2000;30:54.
77. Ahmed AK, Hoekstra MJ, Hage JJ, et al. Honey-medicated dressing: transformation of an ancient remedy into modern therapy. Ann Plast Surg 2003;50(2):143-8.
78. Ndayisaba G, Bazira L, Habonimana E, et al. Clinical and bacteriological results in wounds treated with honey. J Orthop Surg 1993;7(2):202-4.
79. Robson V, Martin L, Cooper R. The use of Leptospermum honey on chronic wounds in breast care. In: White R, Cooper R, Molan P, editors. Honey: a modern wound management product. Aberdeen, UK: Wounds UK; 2005:103-15.
80. Schumacher HH. Use of medical honey in patients with chronic venous leg ulcers after split-skin grafting. J Wound Care 2004;13(10):451-2.
81. Hejase MJ, Simonin SJ, Bihrle R, et al. Genital Fournier's gangrene: experience with 38 patients. Urology 1996;47(5):734-9.
82. Anoukoum T, Attipou KK, Ayite A, et al. Le traitment des gangrenes perineales et de la sphere genitale par du miel. Tunis Med 1998;76(5):132-5.
83. Postmes TJ, Bosch MMC, Dutrieux R, et al. Speeding up the healing of burns with honey. An experimental study with histological assessment of wound biopsies. In: Mizrahi A, Lensky Y, editors. Bee products: properties, applications and apitherapy. New York: Plenum; 1997:27-37.
84. Kabala-Dzik A, Stojko R, Szaflarska-Stojko E, et al. Influence of honey-balm on the rate of scare formation during experimental burn wound healing in pigs. Bull Vet Inst Pulawy 2004;48(3):311-16.
85. Miri MR, Hemmati H, Shahraki S. Comparison of efficacy of honey versus silver sulfadiazine and acetate mafenid in the treatment of burn wounds in piggies. Pak J Med Sci 2005;21(2):168-73.
86. Kumar A, Sharma VK, Singh HP, et al. Efficacy of some indigenous drugs in tissue repair in buffaloes. Indian Vet J 1993;70(1):42-4.
87. Gupta SK, Singh H, Varshney AC, et al. Therapeutic efficacy of honey in infected wounds in buffaloes. Indian J Anim Sci 1992;62(6):521-3.
88. Karabulut E, Durgun T. The use of honey in wound treatment. Indian Vet J 2004;81(10):1108-10.
89. Oladejo OW, Imosemi IO, Osuagwu FC, et al. A comparative study of the wound healing properties of honey and Ageratum conyzoides. Afr J Med Sci 2003;32(2):193-6.
90. Osuagwu FC, Oladejo OW, Imosemi IO, et al. Enhanced wound contraction in fresh wounds dressed with honey in wistar rats (*Rattus Novergicus*). West Afr J Med 2004;23(2):114-8.
91. Suguna L, Chandrakasan G, Thomas JK. Influence of honey on collagen metabolism during wound healing in rats. J Clin Biochem Nutr 1992;13:7-12.
92. Suguna L, Chandrakasan G, Ramamoorthy U, et al. Influence of honey on biochemical and biophysical parameters of wounds in rats. J Clin Biochem Nutr 1993;14:91-9.
93. Oryan A, Zaker SR. Effects of topical application of honey on cutaneous wound healing in rabbits. J Vet Med Series A 1998;45(3):181-8.
94. Rao GVS, Selvaraj J, Senthil Ramanan R, et al. Efficacy of some indigenous medicines in wound healing in rats. Indian J Anim Sci 2003;73(6):652-3.