Introduction

Renewed interest has been observed in recent years on the multiple activities of natural flavonoids. Curcumin is a major yellow-orange pigment extracted from turmeric, a commonly used spice, derived from the rhizome of the herb Curcuma longa (Maheshwari et al., 2006). It is well known that curcumin has a wide range of biological and pharmacological effects, including antioxidant, anticarcinogenic, anti-mutagenic, anti-diabetic, antibiotic, anti-bacterial, anti-fungal and anti-viral effects (Araujo and Leon, 2001; Chattapadhyay et al., 2004; Maheshwari et al., 2006). There are some evidences that suggest that curcumin may have an anti-inflammatory property. It was reported that curcumin prevented the paw edema in carrageenan and cotton pellet models of inflammation in rats (Mukhopadhyay et al., 1982). Moreover, the anti-rheumatic activity of curcumin has also been established in patients who showed significant improvement of symptoms after administration of curcumin (Deodhar et al., 1980).

The endogenous opioid system, besides its well recognized effect on pain modulation, also affects the inflammatory responses (Walker, 2003). It was reported that morphine attenuated the paw edema induced by intraplantar injection of carrageenan in rats (Amann et al., 2002). Moreover, using the yeast-induced paw inflammation model, Sacerdote et al., (1996) reported an inhibitory effect of beta-
endoorphin on the paw edema in rats. On the other hand, it was found that the intraperitoneal injection of naloxone enhanced the edema induced by intraplantar injection of carrageenan in the hind paw of rats (Planas et al., 1995).

Paw and ear edemas have been induced by local peripheral injection of inflammatory mediators, such as histamine, serotonin, bradykinin, and arachidonic acid in rats and mice (Zhou et al., 2006). Different concentration of formalin injected intraplantarly also produced paw edema in rats (Lee and Jeong, 2002). The pain elicited by formalin is only one component of a local inflammatory reaction induced by this irritant. It has been reported that formalin injection produces an edema and an increase of vascular permeability (Damas and Liejeois, 1999; Taylor et al., 2000).

The present study was designed to investigate the effects of curcumin on the formalin-induced paw edema in rats. In addition, to identify the mechanism that possibly mediating the effects of curcumin on edema, the association of the endogenous opioid system using morphine (an opioid receptor agonist) and naloxone (an opioid receptor antagonist) with curcumin has been assessed.

Materials and Methods

Seventy-six healthy adult male Wistar rats weighing between 220-250g were obtained from the Laboratory Animal Care and Use Center of the College of Veterinary Medicine of Urmia University. They were maintained in polypropylene cages in groups of four with food and water available ad libitum, with controlled ambient temperature (23±0.5°C) and under a light-dark cycle (lights on at 07:00 - 19:00). Eight rats were used in each experiment.

Drugs used in the present study were curcumin (Merck, Darmstadt, Germany), morphine sulfate and naloxone hydrochloride (Temad, Tehran, Iran). Curcumin suspension was freshly prepared in 0.15 M NaCl (normal saline) and was administered orally at the doses of 7.5, 15, 30 and 60 mg/kg once daily for 15 days. Oral administration of curcumin was made in a constant volume of 0.2 ml per rat over a period of 1-2 min using a needle free 1 ml syringe (through licking). The selected doses of curcumin and the time period schedule used in this study were close to other studies performed in rats and mice (Sharma et al., 2006; Gautam et al., 2007; Tajik et al., 2008; Tamaddonfard et al., 2008). Morphine and naloxone were dissolved in normal saline and were subcutaneously injected in the back of neck at the same doses of 1mg/kg using 29-gauge injection needle.

For induction of paw edema, 60 min after the last oral administration of curcumin and 40 and 30 min after subcutaneous injections of naloxone and morphine, respectively, rats were subcutaneously injected with 50μl of 2.5% formalin solution into the ventral surface of the right hind paw using a 29-gauge injection needle. All rats were then returned to their cages. According to Fu et al., (2001), the magnitude of paw edema was assessed by measuring the dorsal-plantar paw thickness with a fine caliper at 1, 4, and 24h after formalin injection. The thickness of both hind paws (injected and non-injected ones) was measured simultaneously. Percent change in paw thickness was then calculated using the following formula (Fu et al., 2001):

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\frac{[(\text{thickness of the injected paw} - \text{thickness of the non-injected paw})]}{\text{thickness of the non-injected paw}} \times 100
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Data were expressed as means ± SEM. Differences among treated groups were statistically evaluated using the repeated measures analysis of variance (ANOVA) followed by Duncan's test. Differences were considered significant at p<0.05.

Results

Intraplantar injection of normal saline produced no edema in the paw. Therefore, the results (0.0±0.0) obtained from normal saline injection are not shown in the figures. Subcutaneous injection of formalin into the ventral surface of hind paw induced a local edema, which lasted up to 24h after formalin injection. Twenty four hours post-formalin paw edema was significantly (p<0.05) lower than that of 1 and 4h after formalin injection. Chronic oral administration of curcumin at the doses of 7.5 and 15
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mg/kg did not produce any significant effect, whereas at the doses of 30 and 60 mg/kg, curcumin significantly (p<0.05) decreased formalin-induced paw thickness at 1, 4, and 24h (Fig. 1).

Morphine (1mg/kg, sc) significantly (p<0.05) decreased formalin-induced paw thickness at 1, 4, and 24h. Naloxone (1mg/kg, sc) used alone produced no significant effect on the paw edema induced by formalin at 1, 4, and 24h. Pretreatment with naloxone before morphine significantly (p<0.05) prevented the anti-edematous effect of morphine at 1 and 24h, whereas the anti-edematous effect of morphine was not completely inhibited by naloxone pretreatment at 4h (Fig. 2).

Discussion

In this study, it was found that intraplantar injection of formalin produced paw edema which lasted up to 24h after formalin injection. Several studies have shown that, after an injection of formalin, paw edema develops rapidly, reaches its peak at 4 to 5 hours and lasts several days after injection (Fu et al., 2001; Lee and Jeong, 2002). It has been reported that inflammatory mediators, such as bradykinin, histamine, serotonin, and prostanoids, contribute to the paw edema and paw vascular permeability induced by intraplantar injection of formalin (Damas and Liegeois, 1999).

In the present study, chronic administration of curcumin at the doses of 30 and 60 mg/kg attenuated...
the formalin-induced paw edema. It has been reported that chronic (5 weeks) dietary application of curcumin at the doses of 1 and 20 mg/kg produces no effect on the immune responses, but at the dose of 40 mg/kg curcumin stimulates the production of IgG that was induced by sheep red blood cells in rats (South et al., 1997). Sharma et al., (2006) reported antihyperalgesic effects of chronic (14 days) administration of curcumin used at the doses of 30 and 60mg/kg in the neuropathic pain of rats. Moreover, pain suppressive effect of chronic administration of curcumin (20 and 40 mg/kg, 8 days) was reported in the writhing test of rats (Tajik et al., 2008).

On the anti-inflammatory effect of curcumin, it has been reported that curcumin lowers the carrageenan-induced paw edema in the foot pads of rats (Reddy and Lokesh, 1994). In addition, Huang et al., (1991) reported an anti-edematous effect of curcumin in the arachidonic acid-induced ear edema in rats. It seems that the anti-edematous effect of curcumin observed by Kim et al., (2005) may be related to antihistaminic and anti-serotonin activities of curcumin. Moreover, the involvements of histamine and serotonin in the formalin-induced edema have been reported (Damas and Liegeois, 1999). JCICM-6 is an extract of an anti-arthritic herbal formula, in which Curcuma longa is one of its components. It was found that JCICM-6 reduced paw edema induced by intraplantar injection of histamine, serotonin, bradykinin, and prostaglandin E2 in rats and suppressed ear inflammation induced by subcutaneous injection of arachidonic acid in the ear of mice (Zhou et al., 2006). In addition to these effects of curcumin, it has been reported that curcumin has the ability to inhibit the activation of other inflammatory mediators, such as nuclear factor kappa B and cyclooxygenase 2, lipoxygenase and inducible nitric oxide synthase products (Bengmark, 2006).

In the present study, morphine attenuated, but naloxone did not change the formalin-induce paw edema. Pre-treatment with naloxone before morphine significantly, but not completely, prevented the anti-edematous effect of morphine, because naloxone did not block the morphine-induced anti-edematous effect at 4h observed in the present study. It has been reported that the highest level of formalin-induced paw edema occurs at 4h after intraplantar injection of formalin (Lee and Jeong, 2002). Morphine acts through mu-opioid receptors (Pasternak, 2001), and naloxone is a competitive antagonist of mu, kappa and sigma receptors with higher affinity for the mu receptors (Helm II et al., 2008). Morphine and naloxone have been frequently used to explore the role of endogenous opioid system in inflammation (Planas et al., 1995; Sacerdote et al., 1996; Taylor et al., 2000). These studies suggested that opioid agonists via naloxone-sensitive and -insensitive receptors were involved in the modulation of inflammatory reactions. Besides opioid mu-receptors, it has been reported that delta- and kappa-opioid receptors participate in the regulation of inflammation by endogenous opioid system (Romero et al., 2005). However, other mechanisms, such as inhibitory effect of morphine on the activation of nuclear kappa factorB(Welters et al., 2000) and antioxidant activity of morphine (Gulcin et al., 2004), in the anti-edematous effect of morphine have been reported.

In this study, morphine potentiated the suppressive effect of curcumin on the paw edema. There is not any report identifying the interaction between curcumin and opioid system in the paw inflammation. In one report, it has been found that curcumin potentiates the effect of morphine on the acetic acid-induced visceral pain (Tajik et al., 2008). In the present study, naloxone did not influence the suppressive effect of curcumin on the paw edema, and in the presence of naloxone plus morphine, the anti-edematous effect of curcumin was not changed. These indicate that curcumin may make use of non-opioid dependent mechanisms to produce an anti-edematous effect. It has been reported that curcumin is able to inhibit the activation of nuclear factor kappa B (Weber et al., 2006). Nuclear factor kappa B positively regulates the production of pro-inflammatory enzymes, such as inducible nitric oxide synthase and cyclooxygenase 2 (Pahl, 1999). Moreover, the antioxidant properties of curcumin
were reported (Gulcin et al., 2004; Sandur et al., 2007; Tamaddonfard et al., 2008). It has been found that reactive oxygen species, such as peroxide, superoxide anion, hydroxyl radical, and singlet oxygen, are involved in the paw edema induced by Ferund's complete adjuvant (Symons et al., 2003).

Finally, it seems that several mechanisms may be involved in the anti-edematous activity of curcumin in the formalin-induced paw edema. In this study, it was shown that anti-edematous effect of curcumin was potentiated by morphine whereas no change was observed with naloxone, and further studies are needed to identify the mechanisms involved.

References

اثر کور کومین، مرفین و نالو کسان بر ادم تجربی پنجه یا در موش های صحراپی

چکیده

در این مطالعه، اثرات کور کومین (ماهی فعال زردشیشه)، مرفین (آکوپتیست گیرنده های ایبوپیدی) و نالو کسان (آنتاکونیست گیرنده های ایبوپیدی) به صورت جداگانه و ترکیبی بر ادم پنجه یا ناشی از فرامین در موش های صحراپی بررسی شده است. تزریق زیر ملی سیتی فرامین (0.3 میکرون) درست در کنار پنجه یا پنجه و تزریق بر ادم پنجه یا ناشی از فرامین در مقدار 1 میلی گرم به 30 میلی فرمین در فاصله 1 میلی گرم به 30 میلی فرمین در 6 ماه بعد به طور مداوم دوره نوردی در حالت کاهشی زیر ملی سیتی فرامین (آنتاکونیست گیرنده های ایبوپیدی) و کور کومین میلی گرم بر ادم پنجه یا پنجه و تزریق بر ادم پنجه یا پنجه در 6 ماه بعد به طور مداوم دوره نوردی در حالت کاهشی زیر ملی سیتی فرامین (آنتاکونیست گیرنده های ایبوپیدی) کاهش دیده.

واژه های کلیدی: کور کومین، مرفین، نالو کسان، ادم پنجه یا موش صحراپی.