Review of Literature
REVIEW OF LITERATURE

The published literature on various aspects of *P. kurroa* has been reviewed under the following headings components:

2.1. Population status of *P. kurroa* in its natural habitat

The high medicinal value of *P. kurroa* coupled with its reckless collection by various pharmaceutical and biotechnology industries has reduced its populations to very low levels, thereby putting it under the category of endangered plant species. The distribution of *P. kurroa* was studied by Jain (1996) in the alpine Himalayas from Kashmir to Sikkim giving details about the description, cultural methods, biology, potential value (as a substitute for Indian gentian), and conservation measures. The distribution pattern, population structure and conservation status of rare and endangered medicinal plant species including *P. kurroa* were studied in Spiti, Himachal Pradesh, India by Kala (2000) wherein the entire study area was stratified into six zones based on geomorphological and phytogeographical variations. In each zone different habitat types for rare and endangered species were identified and sampled using quadrats. A total of 23 rare and endangered medicinal plants were found, distributed over 10 major habitat types. *P. kurroa* plants were localized and found in patches.

In another study by Rai et al. (2000) suggested that indiscriminate and non-systematic collection of medicinal plants has led to severe pressure on the availability of these plants, many of which are now rare, threatened or endangered. Six species (*Aconitum heterophyllum*, *Podophyllum hexandrum*, *Nardostachys jatamansi*, *Picrorhiza kurroa*, *Swertia chirata* and *Bergenia ciliata*) that are claimed to have therapeutic value and whose survival in the wild is threatened. In a study by Kaul and Handa (2000) discussed in detail the response of two high-altitude medicinal plant species, i.e. *Picrorhiza kurroa* (available in the wild from 3300 to 4000 m) and *Heracleum candicans* (2500-3300 m), at linear altitudes. These species were declared as endangered in view of their overexploitation from wild habitats. They were successfully domesticated at Srinagar, Kashmir (1750 m) and Kud, Jammu hills (1600 m). Wild populations of these species from three different habitats in the Himalayan region were screened for different phenological details, yield parameters and the
presence of active principle at different stages of growth. The analysis of comparative data from wild and cultivated populations depicted that both species show favourable response at lower altitudes. Cultivation was recommended for obtaining better yield of raw material with higher active principles. The study also reported that high-kutkin-yielding genotypes of *P. kurroa* showed a tendency to flourish at high-altitude habitats.

Cultivation of *P. kurroa*, a small creeping, highly medicinal and endangered species of the alpine region was observed at comparatively lower altitude than its natural habitat by Nautiyal et al. (2001). For cultivation of *P. kurrooa*, broadleaf variety, forest litter treatment, levelled ground and intercropping with plants able to retain moisture in the soil for growing plants, and altitude of 2200 m were endorsed as best for higher production. Cost benefit analysis after third year of cultivation indicated benefits of Rs 87, 600/ha based on maximum production. Thus the cultivation of *P. kurrooa* can provide not only an alternate income-generating resource, but can also provide the opportunity for self-employment to hill farmers.

Another study by Negi and Bhalla (2002) was conducted to systematically document the collection and marketing system of important medicinal and aromatic plants in the tribal areas of Himachal Pradesh, India, for formulation of a suitable policy or modification exercise. It was found that *Jurinea macrocephala* and *Picrorhiza kurroa* were the 2 most important species collected in the area. These were followed by *Salvia moorcroftiana*, *Viola serpens* and *Acontium* spp. The collector's net share in consumer's rupee for different products was low and ranges from approximately 14 to 23 per cent. Labour charges were the major component of collectors' cost and account for approximately 17 to 10 per cent of the consumer's price for *J. macrocephala* and *P. kurrooa*. It was suggested that marketing of medicinal & aromatic plants need to be streamlined and cooperative efforts may be promoted for collectors to get remunerative prices. An interesting study dealt with the indigenous knowledge on 34 medicinal plants of Kumaun Higher Himalaya used by the Bhotia tribes (Satyal et al. 2002). Most of the species studied were native to the Himalayan region. The plant species *Angelica glauca* and *Allium stracheyi* were of narrow range endemic and *Allium stracheyi*, *Picrorhiza kurroa*, and *Nardostachys grandiflora* were
recorded in the Red Data Book of Indian Plants. Apart from indigenous uses, the majority of the species were used in the pharmaceutical industries. The study suggested that the annual production of medicinal plants was comparable with the annual production of traditional crops. Hence, development of proper agro-techniques for cultivation, harvesting in the proper season and *in situ* conservation of these species was envisaged.

A need for conservation of medicinal plants in Uttarakhand was emphasized by Alam and Kop (2005). The factors responsible for the failure of the policies aiming to promote the cultivation of medicinal plants on a large scale were discussed, including lack of reliable and profitable markets and technical difficulties. The need for interventions to provide the farmers with technical and marketing support so that the risk of cultivating these species is reduced and farmers' income is increased was highlighted. One example of such intervention in Uttarakhand was given, dealing with the cultivation of Kutki (*Picrorhiza kurroa*) for export to a European firm based in The Netherlands.

Information on eight highly traded and locally used medicinal plants (*Aconitum heterophyllum*, *Bergenia stracheyi*, *Heracleum candicans*, *Jurinea macrocephala*, *Podophyllum hexandrum*, *Picrorhiza kurroa*, *Rheum australe* and *Selinum tenuifolium*) was collected from the alpine zones of Chhota Bhangal by Uniyal et al. (2006). The study aimed to quantify the current status of these plants in terms of density, frequency and biomass, and also document the indigenous use of these plants for traditional healthcare. Informal interviews and discussions were held with local people for recording local uses of the plants. Based on the sampling, it was found that different species had different habitat requirements. Steep slopes of Chhota Bhangal had the highest species richness and diversity, while rocky areas had the least. Maximum similarity in terms of species distribution was observed between steep slopes and undulating meadows. It was found that these medicinal plants are regularly used by the local people for curing various ailments such as stomach ache, fever and kidney stones. However, illegal extraction of plants for commercial purposes seems to have affected their population in nature. However, in comparison to few other alpine areas of western Himalayas, the present study area supports higher population of medicinal plants.
Assessment of population structure on the basis of density, distribution and diversity-dominance pattern was carried out in Kedarnath Wildlife Sanctuary, Uttarakhand, India (Semwal et al. 2007). Besides, distribution pattern, population structure and conservation status of rare and endangered medicinal plants were also evaluated. Different habitat types for these species were identified and sampled using vertical belt transects. Out of ten habitats identified, distribution of most of the species was found to be restricted in 2-3 habitats. However, *Picrorhiza kurrooa* showed wide distribution in six habitats, while *Swertia chirayita* was restricted to a single habitat.

2.2. Tissue culture of *P. kurrooa*

The perusal of literature showed that very little work has been done on tissue culture of *P. kurrooa*. In the first report on clonal propagation of *Picrorhiza kurrooa* Royle ex Benth. by using shoot tip culture found that MS medium supplemented with 3.0 to 5.0 mg/litre kinetin supported rapid proliferation of multiple shoots from explants (Lal et al. 1988). Addition of 1.0 mg/litre IAA to the kinetin-containing medium improved the growth of regenerated shoots, but did not alter the frequency of shoot multiplication. Rooting was readily achieved on MS medium supplemented with 1.0 mg/litre NAA. Plantlets were successfully transferred to soil. In another study shoot cultures were initiated from stem cuttings of plants collected in the Western Himalayas and multiplied 36-fold every 4 weeks on MS medium containing 1 X 10-6 M benzyladenine (Upadhyay et al. 1989). On MS medium supplemented with 1 X 10-6 M NAA, 89% of shoots formed roots. Plants were also regenerated from 1 mm long shoot tip explants. When the shoots were stored for 10 months in the dark at 5°C, 70% remained viable, indicating that in vitro germplasm storage is possible in *P. kurrooa*.

The cryopreservation of shoot tips of *P. kurrooa* Royle ex Benth (IC 266698), an endangered medicinal plant of India was investigated (Sharma and Sharma 2003). They reported that shoot tips (about 1 mm in length) excised from four-week-old proliferating shoot cultures were pre-cultured on MS medium supplemented with various osmotica before dehydrating with PVS2 solution at 0°C. The dehydrated shoot tips were directly immersed in
LN2. Following cryopreservation, and after rapid rewarming at 45°C, shoot tips were quickly washed with 1.2 M sucrose solution and then plated on solidified shoot culture medium. Shoot tips were successfully cryopreserved by vitrification, when they were precultured on medium supplemented with 5% DMSO at 4°C for two days before dehydrating in PVS2 for 10-20 minutes at 0°C. Average survival in terms of normal shoot formation after 4 wks of plating was about 20% without callus formation. Cold hardening of shoot cultures for four weeks at 4°C significantly improved the survival and shoot regeneration of cryopreserved shoot tips to 70% and 35%, respectively.

Effects of rooting chemicals on the establishment of micropropagated *P. kurroa* plantlets in the greenhouse were studied by Wawrosch et al. 2003). As part of a micropropagation procedure for the endangered medicinal plant *P. kurroa*, the effect of the rooting conditions on plant establishment *ex vitro* was studied. *In vitro* rooting was performed on MS medium supplemented with IAA, IBA or NAA at 1 micro M. The percentage of rooted shoots was high on all media except for the auxin free control (70%). Root length was low when IAA or NAA were used while IBA and the control induced longer roots. Basal callus was formed on all media but was not a problem when IBA was applied. Establishment of the plantlets in the greenhouse was most successful when the shoots were rooted with IBA medium (100% survival), followed by IAA (84%) and the control medium (76%). Only 24% of the plants rooted with NAA survived hardening, and there was evidence that the survival and development of the plantlets correlated with the amount of basal callusing.

The propagation and conservation of *Pierorhiza kurrooa* Royle ex Benth.: an endangered himalayan medicinal herb of high commercial value was studied by Chandra et al. (2006). Vegetative propagation was achieved by rooting runner cuttings with indole-3-butyric acid (IBA) or alpha -naphtheleneacetic acid (NAA) treatment before planting. Nearly 87% rooting success was achieved by treatment of cuttings with 50.0 µM IBA. Seeds were given a presoaking treatment with gibberelic acid (GA3), 6-benzylaminopurine (BAP) or a combination of both to influence germination. More than 11-fold improvement in germination was recorded in seeds treated with 250.0 µM GA3. *In vitro* shoot multiplication
was achieved through sprouting of axillary buds using nodal segments. Multiple shoots were formed following culture for 3 weeks on Murashige and Skoog (1962) medium containing 1.0 μM BAP. Cent percent rooting success, without basal callus formation, was observed when individual microshoots were placed in MS medium supplemented with IBA. The plantlets raised using conventional as well as tissue culture methods were hardened and successfully established in the experimental field located at 2450 m elevation. In addition, strategies have been discussed to encourage cultivation and in situ conservation of this highly valued medicinal herb so as to reduce pressure on its natural populations.

Biological hardening of micropropagated *P. kurroa* Royel ex Benth was optimized by Trivedi and Pandey (2007). Three plant growth-promoting rhizobacteria viz. *Bacillus megaterium*, *B. subtilis* and *Pseudomonas corrugata* were used for biological hardening of micropropagated plantlets of *Picrorhiza kurroa*. The bacterial isolates antagonized the fungal spp. postulated to cause death of micropropagated plants in plate-based assays and positively influenced survival and growth parameters in greenhouse investigation.

Rootstock biomass production was enhanced in *Picrorhiza kurroa* through growth regulator treatment (Mehra et al. 2007). The effect of different concentrations and dipping time periods of growth regulators, IAA, IBA, NAA and GA on the rooting, field survival and rootstock biomass yield in important endangered alpine medicinal plant *Picrorhiza kurroa* during 2002-05 in Himachal Pradesh, India, revealed that pre-planting treatments of stolon cuttings by IBA at 100 ppm for 24 h resulted in the maximum sprouting percentage (88.89%), field survival (77.18%) and dry rootstock (economic part) biomass yield of 7.8 g/plant after two years. Treated cuttings can be directly field-planted which can reduce the cost. An estimated yield of approximately 577 kg of dry rootstock per hectare can be obtained after two years of field growth.

2.3. Identification and characterization of *P. kurroa* metabolites

The pharmacological importance of *P. kurroa* has been demonstrated to be due to rich source of hepatoprotective picrosides, Picroside-I and Picroside-II and other metabolites like
Picroside-III, Picroside-IV, Apocynin, Androsin, Catechol, Kutkoside, etc (Stuppner et al. 1989) which are obtained from the shoots, roots and rhizomes. Studies on cucurbitacins from *P. kurroa*, an Indian Ayurvedic drug, which may contribute to its pharmacological activity, were reported (Stuppner and Wagner 1989). From the roots, 7 cucurbitacin glycosides were isolated and structurally elucidated, mainly by NMR and mass spectroscopy. Four of them were new and 2 others, the 2-O-glycoside of cucurbitacin B (25-acetoxy-2-beta-glucosyloxy-16,20-dihydroxy-9-methyl-19-norlanosta-5,23-diene-3,11,22-trione) and the 2-O-glicoside of 23,24 dihydrocucurbitacin B (25-acetoxy-2-beta-glucosyloxy-16,20-dihydroxy-9-methyl-19-norlanost-5-ene-3,11-22-trione) were not previously reported as constituents of this plant. The 4 new cucurbitacins could be identified as 2-beta-glucosyloxy-3,16,20,25-tetrahydroxy-9-methyl-19-norlanosta-5,23-diene-22-one, 2-beta-glucosyloxy-3,16,20,25-tetrahydroxy-9-methyl-19-norlanost-5-ene-22-one, the 2-O-glucoside of cucurbitacin Q (25-acetoxy-2-beta-glucosyloxy-3,16,20-trihydroxy-9-methyl-19-norlanosta-5,23-diene-11,22-dione), and the 2-O-glucoside of deacetoxy cucurbitacin B (2-beta-glucosyloxy-16,20-dihydroxy-9-methyl-19-norlanosta-5,24-diene-3,11,22-trione).

In another study by Stuppner et al. (1990) 3 cucurbitacin glycosides were isolated and structurally elucidated mainly by means of UV, 1H, 13C NMR, 2D 1H, 1H-13C NMR and mass spectroscopy. Two of the compounds, 2beta-glucosyloxy-3,16,20,25-tetrahydroxy-9-methyl-19-norlanosta-5,23-diene-11,22-dione and 2beta-glucosyloxy-16,20,22-trihydroxy-9-methyl-19-norlanosta-5,24-diene-3,11-dione, are new and the third, arvenin III, has not been reported previously as a constituent of this plant.

A micellar electrokinetic chromatography method was applied to the analysis of iridoid glycosides of *P. kurroa* (Sturm and Stuppner 2001). Baseline separation was achieved within 16 minutes using a fused silica capillary and a borate buffer solution (100 mM, pH 8.60) containing 30 mM SDS and 1% acetonitrile. The applied voltage was 25 kV and the thermostating temperature was kept constant at 30 degrees C. Injection was performed in the pressure mode for 2 seconds, and the detection wavelength was 205 nm. For optimization of the capillary electrophoresis (CE) method, an iridoid-containing fraction of a methanolic extract of *P. kurroa* was injected. The impact of the electrolyte composition,
pH value, ionic strength, concentration of SDS, influence of organic additives, voltage and temperature on the resolution of adjacent peaks was studied. The optimized method was used for quantitative determination of the main iridoids in crude methanolic extracts of *P. kurooa*. Analysis was also performed by HPLC-mass spectrometry (MS) using an electrospray ionization interface. Conditions were optimized both for efficient HPLC and for the MS system. Mass spectra of all HPLC peaks showed one dominant signal corresponding to [M+Na]+. The good agreement of quantitative CE results with those obtained by liquid chromatography clearly demonstrated the applicability of the presented methods.

The construction of chromatographic fingerprints of complex herbal preparations in combination with mass spectrometry plays an important role in their development and standardization as potential therapeutic agents. Picroliv, an extract from roots and rhizomes of *Picrorhiza kurooa*, is a herbal hepatoprotective drug. Pattern profiling of various constituents of picroliv along with a precise and accurate method to estimate relative concentration of major components in the preparation by liquid chromatography-tandem mass spectrometry was reported (Kumar et al. 2004). In total, 27 components could be detected in multiple reaction monitoring (MRM) mode out of which fourteen could be quantified in terms of their relative concentration. Seven components were structurally correlated and confirmed based on the fragmentation pattern and information available in literature. The detection was carried out using MRM in negative ionization mode with analytes quantified from the summed total ion value of their most intense molecular ion transitions. The separation of various components was achieved using a gradient elution on RP-18 column with acetonitrile and Milli-Q water as mobile phase at a flow rate of 1.0 ml/min. The method was validated in terms of linearity, accuracy and precision (within- and between-assay variation) for 5 days.

Picroside I is a major active constituent of picroliv. A sensitive high-performance liquid chromatographic assay method in plasma has been developed and validated for the determination of Picroside-I in plasma (Diwedi et al. 1997). The method consists of extraction of the drug, after protein precipitation with methanol, from rabbit plasma samples. Separation was achieved using a C18 endcapped reversed-phase column coupled with a
photodiode array detector and acetonitrile-0.1 M acetic acid (25:75) as mobile phase. The lower limit of quantification in plasma was 50 ng/ml. The standard curve was linear over the range of 50-500 ng/ml in rabbit plasma.

A new high performance thin layer chromatography (HPTLC) method for the simultaneous quantification of picroside-I and picroside-II in *P. kurroa* was described (Singh et al. 2005). Separation of picroside-I and picroside-II was achieved by mobile phase of CHCl3:MeOH (82:18, v/v) on precoated silica gel 60 F254 aluminium plate. The densitometric determination of picrosides was carried out at 290 nm, in absorption-reflection mode. The calibration curves were linear in the range of (2-5 micro g). The method is simple, specific, rapid, and reliable for simultaneous determination of Picroside-I and Picroside-II in *P. kurroa*. The proposed method was successfully applied for accurate quantification of large number of samples collected from different altitudes of western Himalayas.

### 2.4. Production of medicinal metabolites through tissue cultures

As such there is no published report on the production of medicinally important compounds in *P. kurroa*, therefore, literature pertaining to the scope of this technology with specific case studies have been given. Tissue culture has been demonstrated to be a sustainable alternative for the production of medicinally or industrially important metabolites in callus, cell suspension, hairy roots or shoot cultures in various plant species (Vanishree et al. 2004; Vongpaseuth and Roberts 2007). From among these studies, the production of berberine from *Coptis japonica* by Mitsui Petrochemicals (Morimoto et al. 1988), production of vincristine and vinblastine from *Catharanthus roseus* (Zhao et al. 2001), production of ginesinosides from *Panax ginseng* (Sivakumar et al. 2005) and production of paclitaxel from different species of *Taxus* (Tabata et al. 2004) are notable case studies wherein the tissue culture processes have been up scaled to a commercial level. On the similar analogy the current study also explored the feasibility of *in vitro* production of picrosides in *P. kurroa*. 

27
2.5. Somaclonal variants with value added traits in medicinal plants

Somaclonal variation has been suggested as a viable source of generating genetic variants with value added traits in different crop plants (Larkin and Scrowcroft 1981). As such no effect has been made as of today on induction of somaclonal variation with enhanced picrosides content in \textit{P. kurroa}. Therefore, literature pertaining to identification of somaclonal variants in other medicinal plants or other crop plants related to metabolites has been reviewed.

Somaclonal variation for plant height, plant spread, leaf shape, leaf size, leaf form, herb yield, essential oil content and 10 important constituents of the essential oil was studied in an Indian cultivar, 'Bourbon' of rose-scented geranium (\textit{Pelargonium graveolens}) (Ravindra et al. 2004). Significantly larger variance was observed among \textit{in vitro}-regenerated plants of the SC1 generation (first generation following an in vitro phase) than among parental plants raised from stem cuttings for herb yield, plant height, leaf size, essential oil content, and for the contents of cis-rose oxide, trans-rose oxide, isomenthone and 10-epi-gamma-eudesmol in the essential oil.

\textit{In vitro} raised shoots of \textit{Mentha arvensis} L. were screened for menthol tolerance level by growing them in media containing 0-100 \textmu g ml\(^{-1}\) menthol (Dhawan et al. 2004). A total of 2850 regenerated shoots were step wise screened for menthol tolerance at the concentrations of 50 \textmu g ml\(^{-1}\) followed by 60 and 70 \textmu g ml\(^{-1}\). In this screening, only 30 individual regenerated shoots were able to survive. The clones from the primary screen were inoculated into rooting medium and, after rooting, transferred to pots in the greenhouse. Ultimately, these 30 menthol tolerant clones were multiplied and grown in the field in replicated plots of 2.5 X 2.5 m sizes. These clones were checked for oil and menthol content and were found to be better than the control plants. Out of these 30 plants, five tolerated 80 \textmu g ml\(^{-1}\) menthol (tertiary level screening) and were found to contain the highest amount of menthol per g leaf biomass. Molecular analysis through RAPD showed distinct variation in the profiles of these five plants, in comparison to the control. Using this method the relationship between the primer OPT 04, menthol tolerance and high menthol content
character of the genotype was established. Further, a cultivar 'Saksham' was released from
the selections by CIMAP for superior performance.

An efficient protocol was established for generating somaclones in the Indian rose-
scented geranium *Pelargonium graveolens* cv. Bipuli, which yields Reunion Island-type
essential oil (Gupta et al. 2002). Murashige and Skoog’s (MS) medium supplemented with
4.5 mg(.)L(-1) BA and 1.0 mg(.)L(-1) NAA was found optimal for induction of callus from
leaf explants. Callus regenerated shoots when transferred to MS medium with 2.5 mg(.)L(-1)
BA and 0.1 mg(.)L(-1) NAA. Characterization of these calliclones for essential oil yield
and quality traits demonstrated induction of variability in all the characteristics examined in
negative and positive directions in comparison with the wild-type parent. This screening led
to the identification of somaclone B22, which out-yielded the wild-type parent as well as the
rest of the somaclones. The quality of the essential oil of B22 was similar to that of the
parent. In another study, altered ploidy arising via somaclonal variation in plants regenerated
via adventitious shoot formation from the medicinal plant *Hypericum perforatum* L. cv.
Topas (2n – 4x – 32) was investigated (Cellarova et al. 1997). Whole 14-day-old seedlings
of *H. perforatum* were incubated in medium with Linsmaier-Skoog salts, Gamborg B5
vitamins, 30.0 g/l sucrose, 2.0 mg/l glycine and 0.4, 2.2, 4.4 or 8.9 uM benzyladenine (BA),
at 22 deg under 35 umol/sq.sec daylight fluorescent irradiance (16 hr photoperiod) and 60%
RH. Diploids, triploids, tetraploids and mixoploids were detected, and chromosomal
instability was transferred to progeny. Cytogenetic diversity was observed in some cases.
There was a correlation between content of hypericin (a viricide) and ploidy over 2 yr in R0
somaclones and R1 and R2 progeny.

Palmarosa grass (*Cymbopogon martinii* (Roxb.) Wats. Var. motia) is an important
essential oil-yielding plant of the tropics and subtropics. A wide range of variation in
important quantitative traits, e.g. plant yield (200% more than the donor line), height, tiller
number, oil content (100-200% more than the donor line) and qualitative changes in
essential oil constituents, such as geraniol (more than 85% of total oil), geranyl acetate,
geranyl formate and linalool, was observed among the 120 somaclones screened (Patnaik et
al. 1999). 8 Somaclones were selected on the basis of high herb and oil yield over the donor
line and high geraniol content in the oil. Based on performance in field trials, 3 superior lines were selected and maintained for 5 clonal generations.

Somaclonal variation has been observed for various agronomic traits in plants, such as great variability was found for total alkaloid production among protoplast-derived regenerants of *Hyoscyamus muticus* (Oksman-Caldentey et al. 1987). Significant variation was found for scopolamine contest among somaclonal variants of *Hyoscyamus muticus* (Oksman-Caldentey et al. 1986) and for high herb, oil yield and high geraniol content in the oil over donor plants in *Cymbopogon martini* (Patnaik et al. 2009).

2.6. Medicinal Value of *Picrorhiza kurroa*

The medicinal importance of *P. kurroa* is due to its pharmacological properties like hepatoprotective (Chander et al. 1990), antioxidant (particularly in liver) (Ansari et al. 1980), antiallergic and antiasthmatic (Dorch et al. 1991), anticancerous activity particularly in liver (Joy et al. 2000) and immunomodulatory (Gupta et al. 2006). A hepatoprotective drug formulation, Picroliv has been prepared from the extracts of *P. kurroa* (Ansari et al. 1991; Dwivedi et al. 1997). Picroliv also provides protection against other ailments such as immunostimulating effect in hamsters and prevention of infections (Puri et al. 1992; Gupta et al. 2006).

2.6.1. Medicinal values of *P. kurroa*

<table>
<thead>
<tr>
<th>Medicinal importance</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hepatoprotective</td>
<td>Rangasamy et al. 1999</td>
</tr>
<tr>
<td>Nerve growth factor-potentiating</td>
<td>Li et al. 2000</td>
</tr>
<tr>
<td>Antitumour and anticarcinogenic</td>
<td>Joy et al. 2000</td>
</tr>
<tr>
<td>Antiulcerogenic</td>
<td>Rangansamy et al. 1999</td>
</tr>
<tr>
<td>Pharmacological importance</td>
<td>Reference</td>
</tr>
<tr>
<td>----------------------------</td>
<td>------------------------------------------------</td>
</tr>
<tr>
<td>Hepatoprotective</td>
<td>Chander et al. 1990; Visen et al. 1991, 1995; Mittal et al. 1998</td>
</tr>
<tr>
<td>Stimulates liver regeneration</td>
<td>Srivastava et al. 1996; Saksena et al 1995</td>
</tr>
<tr>
<td>Antihapatotoxic</td>
<td>Ansari et al. 1991; Diwedi et al. 1992</td>
</tr>
<tr>
<td>Source of antioxidants</td>
<td>Rastogi et al. 1995</td>
</tr>
<tr>
<td>Immunostimulant</td>
<td>Puri et al. 1992</td>
</tr>
<tr>
<td>Hypolipidaemic</td>
<td>Khanna et al. 1994</td>
</tr>
<tr>
<td>Hepatocurative</td>
<td>Rastogi et al. 2000</td>
</tr>
<tr>
<td>Protective activity</td>
<td>Singh et al. 2005</td>
</tr>
<tr>
<td>Epithelialization and Angiogenesis</td>
<td>Singh et al. 2007</td>
</tr>
</tbody>
</table>

2.6.2 Pharmacological importance of Picroliv- a commercial drug formulation of *P. kurroa*