Potato varieties for table and processing

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CPRI, Shimla
Potato originated in high Andean region of South America.
Till 16th century it was unknown to rest of the world.
Potato moved from South America to Spain (1570) and UK (1590).
Potato’s global voyage began in the 17th century from Europe.
In India & Sri Lanka, potatoes were introduced in early 17th century.
Potatoes, became one of the most important world crops in a span of 300 years.
In Andes of South America, potato was adapted to short days, tropical highlands (2,000 and 4,000 m).

Its equatorial origin makes potato essentially short-day dependent for tuberization.

In Europe, tuber formation was inhibited under long photoperiod (long days).

**Long-day acclimation for tuberization** to achieve higher tuber yields in Europe.

Breeding over more than 150 years led to plants tolerating long day condition.

The **mutations in tuber formation regulator** allow potatoes to escape the original short day regulation mechanism suited to the Andes, so potatoes can be grown in Europe & other northern latitudes of world.

Mutations in the tuber formation regulator gene which occur in different combinations in modern potato cultivars, giving rise to early, medium and late varieties, depending on the combination of the gene variants present in the tetraploid crop (Kloosterman et al. 2013).

Potato Breeding

- Cultivated potato is auto-tetraploid and highly heterozygous.
- Heterosis is observed on crossing diverse parents.
- Breeding of potato involves hybridization between identified parents and selection of superior clones from the progeny.
- The genetic constitution of the genotype obtained following hybridization is fixed in seedling stage.
- Due to vegetative propagation the genetic constitution of potato genotype with all its intra- and inter-locus interactions responsible for its phenotypic expression are maintained in the clonal generations.
- Hence, a clone if perceived desirable can be multiplied for commercial cultivation even though initially it may be present as a single plant.
- More than 50 traits should be combined in a modern potato variety (Ross, 1986).
- An ideal potato variety affects not only yield and quality but also production cost, environmental issues, post harvest and yield of future crops (Struik and Wiersema, 1999, Collard and Mackill, 2008).
- It can take 10 to 15 years to release a variety.
Potato breeding has resulted in the release of over 4000 cultivars in more than 100 countries.
### Need of potato Breeding in India

<table>
<thead>
<tr>
<th>Parameters</th>
<th>India</th>
<th>Europe/America</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Growing season</strong></td>
<td>Winter</td>
<td>Summer</td>
</tr>
<tr>
<td><strong>Temperature during planting &amp; harvesting</strong></td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Planting: 25-32°C</td>
<td>Harvesting: Less than 20°C</td>
<td></td>
</tr>
<tr>
<td>Night: 3-15°C</td>
<td>Day: 20-25°C</td>
<td></td>
</tr>
<tr>
<td>Night: 5-20°C</td>
<td>Day: 20-25°C</td>
<td></td>
</tr>
<tr>
<td><strong>Crop duration (d)</strong></td>
<td>Short (60-100)</td>
<td>Long (150-180)</td>
</tr>
<tr>
<td><strong>Photoperiod</strong></td>
<td>10 hrs/day</td>
<td>14 hrs/day</td>
</tr>
<tr>
<td><strong>Frosting</strong></td>
<td>Common</td>
<td>Absent</td>
</tr>
<tr>
<td><strong>Post harvest handling</strong></td>
<td>Difficult (high temps.)</td>
<td>Easy (low temps.)</td>
</tr>
<tr>
<td><strong>Result</strong></td>
<td>Low yields, less dry matter, and more reducing sugars</td>
<td>High yields, high dry matter &amp; low reducing sugars</td>
</tr>
</tbody>
</table>

- European varieties were long-day adapted
- Progressive accumulation of degenerative viral diseases
- Physiological limitations on storage & utilization in hot/humid summers
- Varieties: Craig’s Defiance, Great Scot, Up-to-Date and Magnum Bonum
Potato breeding in India

- **1935:** Potato breeding programme at Potato Breeding Station, Shimla.
- **1949:** CPRI at Patna (Bihar)-Regular breeding programme.
- **1956:** CPRI at Shimla (HP) to facilitate hybridization & seed health.
- **1963:** Seed Plot Technique.
- Potato breeding system developed.
- This approach yielded for potato improvement and potato seed production.
- CPRI varieties prefixed with ‘KUFRI’ as a memento to place of crossing.
Germplasm collection and evaluation

- Collection
- Field/Glass house maintenance
- Evaluation

Selection for
- Vigorous plant type
- Short duration
- Desirable tuber attributes
- Early bulking
- High tuber yield, tuber number, average tuber weight
- High dry matter
- Good keeping quality
- Processing attributes
- Late blight resistance
- Water stress
- Heat stress
- Nutrient use efficiency
- Nutrition quality
Total: ~ 4375 (40 countries)

- Indian varieties and parental lines: 305
- Tuberosum: 2218 (30C, 241CC)
- Andigena: 770 (5C, 77 CC)
- Wild spp.: 1082 (5C, 118 spp.)

Nearly 14,000 accessions in CIP gene bank
Nearly 6000 accessions in US potato gene bank
Nearly 1500 accessions in Commonwealth potato collection
## Sources of resistance to various diseases in potato

<table>
<thead>
<tr>
<th>Diseases</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viruses - PVX</td>
<td><em>S. acaule, S. berthaultii, S. tuberosum subsp. andigena</em></td>
</tr>
<tr>
<td>PVY</td>
<td><em>S. phureja, S. demissum, S. stoloniferum</em></td>
</tr>
<tr>
<td>PLRV</td>
<td><em>S. acaule, S. demissum, S. tuberosum subsp. andigena</em></td>
</tr>
<tr>
<td>Late blight Vertical</td>
<td><em>S. demissum, S. verrucosum, S. stoloniferum</em></td>
</tr>
<tr>
<td>Horizontal</td>
<td><em>S. berthaultii, S. chacoense, S. microdontum, S. vernei</em></td>
</tr>
<tr>
<td>Wart</td>
<td><em>S. acaule, S. berthaultii.</em></td>
</tr>
<tr>
<td>Common scab</td>
<td><em>S. chacoense, S. tuberosum ssp. andigena</em></td>
</tr>
<tr>
<td>Bacterial wilt</td>
<td><em>S. Chacoense, S. microdontum,</em></td>
</tr>
<tr>
<td>Cyst nematodes</td>
<td><em>S. tuberosum subsp. andigena, S. berthaultii. S. vernei</em></td>
</tr>
<tr>
<td>Root knot nematode</td>
<td><em>S. spegazzinii</em></td>
</tr>
<tr>
<td>Aphids</td>
<td><em>S. berthaultii.</em></td>
</tr>
<tr>
<td>Frost</td>
<td><em>S. acaule, S. ajanhuiri</em></td>
</tr>
<tr>
<td>Heat tolerance</td>
<td><em>S. chacoense, S. commersonii</em></td>
</tr>
<tr>
<td>High protein content</td>
<td><em>S. phureja</em></td>
</tr>
</tbody>
</table>

Most commonly used are: *S. berthaultii, S. bulbocastanum, S. chacoense, S. microdontum, S. multidissectum, S. phureja, S. sparsipilum, S. stenotomum, S. tarigense, S. vernei, S. demissum*
Breeding Programmes in India

Breeding for table potatoes (Indo-gangetic plains)
  • North-western plains
  • West-central plains
  • North-eastern plains

Breeding for late blight (hills)
  • North-western hills
  • North-eastern hills
  • Southern hills
  • Darjeeling & Sikkim hills

Special breeding programmes
  • Breeding for processing attributes
  • Breeding for heat tolerance
  • Breeding of drought tolerance
  • Breeding for nutritional quality
  • Breeding for Kharif potatoes
  • Breeding for nutrient efficient varieties
  • Breeding of PCN resistance
Potato breeding methodology

Parental preference
i) *S. tuberosum* ssp. *tuberosum* (commercial varieties, breeding lines, stocks in on-going programmes, old land races)
ii) *S. tuberosum* ssp. *andigena*
iii) Primitive cultivated species
iv) Wild tuber bearing species
v) Wild non-tuber bearing species

Selection of parents

Hybridization

1) Establishing parents
2) Pollen fertility estimation (2% Aceto-carmine)
3) Emasculation
4) Pollen collection & pollination
5) Berry, TPS extraction, storage

Assessment of segregating population

Evaluation of clones (*F₁C₁*-*F₁C₇*)

Initial evaluations (*F₁C₁*-*F₁C₃*): Un-replicated trials
Advanced evaluations (*F₁C₄*-*F₁C₇*): Replicated trials

DUS, DNA fingerprinting
Multi-location & on-farm trials under AICRP (P)

Multi-location trials: 2 years
On-farm trials: 1-2 years

Release & notification of variety

Seedling stage: Good vigour, desirable tuber colour, shape, eye depth, no-cracking, irregularity

AICRP (P): 25 (18+7)

10-15 years of concerted effort
### Potato breeding strategy

<table>
<thead>
<tr>
<th>Area</th>
<th>Season</th>
<th>Traits</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Indian hills</td>
<td><strong>Summer</strong> (April-Sep.), <strong>Spring</strong> (Jan/Feb-May/June) &amp; <strong>Autumn</strong> (Aug-Nov/Dec.)</td>
<td>Long-day adapted, resistant to late blight, resistant to late blight &amp; frost, good keeping quality</td>
</tr>
<tr>
<td>North Indian plains</td>
<td>Spring (Jan.-April-May) and <strong>Autumn</strong> (Oct.-Jan./Feb. or Nov.-March)</td>
<td>Short-day adapted, early bulking, moderately resistant to late blight &amp; frost, good keeping quality</td>
</tr>
<tr>
<td>Plateau region</td>
<td><strong>Kharif</strong> (July-September), <strong>Rabi</strong> (Nov.-Feb.)</td>
<td>Early bulking, <strong>ability to tuberize under high temperatures</strong>, resistant to bacterial wilt, tuber moth and mites, slow rate of degeneration</td>
</tr>
<tr>
<td>South Indian hills</td>
<td><strong>Summer</strong> (April-Aug.), <strong>Autumn</strong> (Sep.-Dec.), <strong>Spring</strong> (Jan.-May)</td>
<td>Early bulking, <strong>resistant to late blight and cyst nematodes</strong></td>
</tr>
<tr>
<td>North Bengal hills &amp; Sikkim</td>
<td><strong>Autumn</strong> (Sep.-Dec.)</td>
<td>Medium maturing, resistant to late blight, immune to wart, red skinned tubers</td>
</tr>
</tbody>
</table>
## Potato varieties released by CPRI (52)

<table>
<thead>
<tr>
<th>Year</th>
<th>Varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td>1958</td>
<td>Kufri Kisan, Kufri Kuber, Kufri Kumar, Kufri Kundan, <strong>Kufri Red, Kufri Safed</strong></td>
</tr>
<tr>
<td>1963</td>
<td>Kufri Neela</td>
</tr>
<tr>
<td>1967</td>
<td><strong>Kufri Sindhuri</strong></td>
</tr>
<tr>
<td>1971</td>
<td>Kufri Muthu</td>
</tr>
<tr>
<td>1972</td>
<td>Kufri Lauvkar</td>
</tr>
<tr>
<td>1973</td>
<td>Kufri Dewa</td>
</tr>
<tr>
<td>1979</td>
<td>Kufri Badshah</td>
</tr>
<tr>
<td>1980</td>
<td>Kufri Bahar</td>
</tr>
<tr>
<td>1982</td>
<td><strong>Kufri Lalima</strong></td>
</tr>
<tr>
<td>1983</td>
<td>Kufri Sherpa</td>
</tr>
<tr>
<td>1985</td>
<td>Kufri Swarna</td>
</tr>
<tr>
<td>1989</td>
<td>Kufri Megha</td>
</tr>
<tr>
<td>1996</td>
<td>Kufri Jawahar, Kufri Sutlej, Kufri Ashoka</td>
</tr>
<tr>
<td>1998</td>
<td>Kufri Pukhraj, Kufri Chipsona-1, Kufri Chipsona-2, Kufri Giriraj</td>
</tr>
<tr>
<td>1999</td>
<td>Kufri Anand, <strong>Kufri Kanchan</strong></td>
</tr>
<tr>
<td>2005</td>
<td><strong>Kufri Arun, Kufri Pushkar, Kufri Shailja</strong></td>
</tr>
<tr>
<td>2006</td>
<td>Kufri Surya, Kufri Chipsona-3, Kufri Himalini</td>
</tr>
<tr>
<td>2008</td>
<td>Kufri Himsona, Kufri Sadabahar, Kufri Girdhari, Kufri Khyati</td>
</tr>
<tr>
<td>2009</td>
<td>Kufri Frysona</td>
</tr>
<tr>
<td>2010</td>
<td>Kufri Chipsona-4, Kufri Neelma</td>
</tr>
<tr>
<td>2012</td>
<td>Kufri Gaurav, Kufri Garima</td>
</tr>
<tr>
<td>2013</td>
<td><strong>Kufri Lalit, 2015 (Kufri Mohan)</strong></td>
</tr>
</tbody>
</table>
Developed 52 improved varieties

Number of varieties

- Early (70-80 days): 9
- Medium (90-100 days): 33
- Late (100-110 days): 10

Northern hills: 7 (red) + 4 (green)
Plains: 6 (blue) + 17 (red) + 3 (green)
Plateau: 3 (blue) + 3 (red) + 1 (green)
Darjeeling hills: 3 (blue)
Southern hills: 3 (red) + 2 (green)

Processing-6, Heat tolerant-1

2(CS)-21(IxI)-21(IxE)-8 (ExE)=85
Breeding for Indo-Gangetic Plains
(Jalandhar, Modipuram & Patna)

Requirements:

65-85 days early maturing varieties
To fit into Rice – Potato – Wheat
Late blight resistance - not required essentially

Procedure:
Hybridization at Kufri
Parents – Tuberousum, Improved Andigena

- Seedlings/Early generations \((F_1C_1 - F_1C_3)\): Tuber characters
- Advance Generations \((F_1C_4 - F_1C_6)\):
  a. Yield trials
  b. Keeping quality
  c. Cooking quality

- Multilocation Trials:-
  (2 years – Replicated
  (under AICRP)
  2 years – on farm)

- Release and Notification
Breeding for Northern hills  
(CPRI, Shimla; CPRS, Shillong)

Requirements:
- 100-110 days medium maturing varieties
- High level of Late blight resistance required

Procedure:
- Hybridization at Kufri & Shillong
  Parents – Tuberosum, Improved Andigena, wild species
- Seedlings: „ Late blight in lab
- Early generations (F₁C₁ – F₁C₃) :- Tuber characters & LB
- Advance Generations (F₁C₄ – F₁C₆) :- a. Yield trials (Plains & hills)
  b. Keeping quality (Plains)
  c. Cooking quality
- Multilocation Trials:- (2 years – Replicated
  (under AICRP)
  2 years – on farm)
- Release and Notification
Breeding for Southern hills
(CPRS, Ootacamund)

Requirements:
• 100-110 days medium maturing varieties
• High level of Late blight resistance required
• Resistance to cyst nematodes essential

Procedure:
• Hybridization at Ootacamund & Kufri
  Parents – Tuberosum, Improved Andigena, Vernei clones
• Seedlings: :- Late blight
• Early generations (F₁C₁ – F₁C₃) :- Tuber characters, LB,CN
• Advance Generations (F₁C₄ – F₁C₆) :- a. Yield trials
  b. Keeping quality
  (Dormancy)
  c. Cooking quality
• Regional Multilocation Trials:- (2 years – Replicated
  2 years – on farm)

Regional Release and Notification
Breeding for Heat Tolerance

Requirements:
- 75-90 days early/medium maturing varieties
- Suitable for early planting in west-central plains
- Suitable for non-traditional potato growing areas
- Some level of late blight resistance – desirable

Procedure:
- Hybridization at Kufri
  - Parents – Tuberosum, Improved heat tolerant lines
- Seedlings: Under normal conditions at Modipuram
- Early generations: Early planted crop Modipuram
- Advance Generations:
  - Yield trials: Modipuram and plateau
    - Keeping quality
    - Cooking quality
- Multilocation Trials: (2 years – Replicated under AICRP) 2 years – on farm
- Regional Release and Notification
Breeding for Processing

Requirements:

- 90-100 days medium maturing varieties
- High dry matter, Low reducing sugars
- Tuber characters - Suitable for chips & French Fry
- Late blight resistance – required

Procedure:

- Hybridization at Kufri
  Parents – Tuberosum, Improved Andigena
- Seedlings: - Tuber characters
- Early generations - Quality and tuber characters
- Advance Generations
  a. Yield and quality trials
  b. Quality tests at factory
  c. Keeping quality

Multilocation Trials:
(Under AICRP)
(2 years – Replicated)
(2 years – On farm)

Release and Notification
Breeding for TPS populations

Requirements

- 90-100 days early/medium maturing populations
- Uniformity in tuber characters and early bulking
- Late blight resistance required
- Good seedling survival as transplant

Procedure

- Hybridization at Kufri/Modipuram/Patna
- Seedling evaluation for transplant crop - Shillong
- Seedling evaluation for seedling tuber production - Modipuram/Patna/Shillong
- Multilocation testing in North-eastern region
- Multilocation trials under AICRP
- Recommendation/Release
Some Popular Indian Potato Varieties

**Kufri Jyoti:**
wide adaptability, early bulker,
slow rate of degeneration, immune to wart,
moderately resistant to late blight and early blight

**Kufri Bahar:**
For North Indian plains,
early bulker, immune to wart,
Resistant to Gemini virus (PALCD)

**Kufri Pukhraj:**
For North Indian plains and plateau,
Suitable for low input, early bulker, immune to wart,
moderately resistant to late blight and early blight
**Kufri Ashoka:**
For Indo-gangetic plains, early maturity

**Kufri Chandramukhi:**
For North Indian plains and plateau, early maturity

**Kufri Badshah:**
For North Indian plains and plateau, medium maturity, moderately resistant to late blight and early blight, resistant to PVX

**Kufri Sindhuri:**
For North Indian plains, late maturity, moderately resistant to early blight, tolerant to PLRV
**Kufri Kanchan:**
For North-Bengal hills and Sikkim, medium maturity, immune to wart, moderately resistant to late blight, slow rate of degeneration

**Kufri Swarna:**
For southern hills, medium maturity, resistant to cyst nematodes, immune to wart, resistant to late blight and early blight

**Kufri Lauvkar:**
For plateau, early maturity, heat tolerant

**Kufri Surya:**
For plateau, early maturity, heat tolerant
**Kufri Chipsona-1:**
For North Indian plains, medium maturity
high dry matter, low reducing sugars, low phenols
resistant to late blight

**Kufri Chipsona-3:**
For North Indian plains, medium maturity
high dry matter, low reducing sugars, low phenols
resistant to late blight, immune to wart

**Some latest releases**
1. Kufri Pushkar
2. Kufri Khyati
3. Kufri Sadabahar
4. Kufri Himalini
5. Kufri Himsona
6. Kufri Girdhari
7. Kufri Gaurav
8. Kufri Garima
9. Kufri Mohan
## Recent releases from CPRI

<table>
<thead>
<tr>
<th>S. N.</th>
<th>Variety</th>
<th>Selection number</th>
<th>Year of release</th>
<th>Parentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>36</td>
<td>Kufri Arun</td>
<td>MS/92-2105</td>
<td>2005</td>
<td>Kufri Lalima x MS/82-797</td>
</tr>
<tr>
<td>37</td>
<td>Kufri Pushkar</td>
<td>JW 160</td>
<td>2005</td>
<td>QB/A 9-120 x Spatz</td>
</tr>
<tr>
<td>38</td>
<td>Kufri Shailja</td>
<td>SM/87-185</td>
<td>2005</td>
<td>Kufri Jyoti x EX/A 680-16</td>
</tr>
<tr>
<td>39</td>
<td>Kufri Surya</td>
<td>HT/92-621</td>
<td>2006</td>
<td>Kufri Lauvkar x LT-1</td>
</tr>
<tr>
<td>40</td>
<td>Kufri Chipsona-3</td>
<td>MP/97-583</td>
<td>2006</td>
<td>MP/91-86 x Kufri Chipsona-2</td>
</tr>
<tr>
<td>41</td>
<td>Kufri Himalini</td>
<td>SM/91-1515</td>
<td>2006</td>
<td>I-1062 x Bulk pollen (CP2132-Tollocan)</td>
</tr>
<tr>
<td>42</td>
<td>Kufri Himsona</td>
<td>MP/97-644</td>
<td>2008</td>
<td>MP/92-35 x Kufri Chipsona-2</td>
</tr>
<tr>
<td>43</td>
<td>Kufri Sadabahar</td>
<td>MS/93-1344</td>
<td>2008</td>
<td>MS/81-145 x PH/F-1545</td>
</tr>
<tr>
<td>44</td>
<td>Kufri Girdhari</td>
<td>SM/93-237</td>
<td>2008</td>
<td>Kufri Megha x Bulk Pollen (10 genotypes)</td>
</tr>
<tr>
<td>45</td>
<td>Kufri Khyati</td>
<td>J/93-86</td>
<td>2008</td>
<td>MS/82-639 x Kufri Pukhraj</td>
</tr>
<tr>
<td>46</td>
<td>Kufri Frysona</td>
<td>MP/98-71</td>
<td>2009</td>
<td>MP/92-30 x MP/90-94</td>
</tr>
<tr>
<td>48</td>
<td>Kufri Chipsona-4</td>
<td>MP/01-916</td>
<td>2010</td>
<td>Atlantic x MP/92-35</td>
</tr>
<tr>
<td>49</td>
<td>Kufri Gaurav</td>
<td>JX576</td>
<td>2010</td>
<td>JE 812 x K. Jyoti</td>
</tr>
<tr>
<td>50</td>
<td>Kufri Garima</td>
<td>MS/99-1871</td>
<td>2011</td>
<td>PH/F 1045 x MS/82-638</td>
</tr>
<tr>
<td>51</td>
<td>Kufri Mohan</td>
<td>MS/5-1543</td>
<td>2015</td>
<td>MS/92-1090 x CP 1704 (Claudia)</td>
</tr>
<tr>
<td>51</td>
<td>TPS Population</td>
<td>83-P-47 (I) x D-150 (I)</td>
<td>2007</td>
<td></td>
</tr>
</tbody>
</table>
Potato: Many uses

- Starch
- Par-fried
- Snacks & extruded products
- Cooked
- Dried (Granules, flakes etc.)
Need for breeding processing varieties

- All the 29 varieties bred by CPRI till 1998 were mainly for table consumption
- Processing was at a low ebb till 1998
- With the entry of MNC’s in potato processing sector in 1998, a need was felt for suitable processing varieties having high dry matter and low reducing sugars
- In the absence of Indian processing varieties, an American variety Atlantic was introduced in India, which gave lower yields under short day conditions and was susceptible to late blight

Cont.....
Need for breeding processing varieties

- A challenge was thrown to the CPRI for developing indigenous processing variety

- After 8 years of dedicated efforts, India’s first processing varieties namely, Kufri Chipsona-1 and Kufri Chipsona-2, were released

- Another improved processing variety, Kufri Chipsona-3, producing higher proportion of processing grade tubers with no tuber defects was developed in 2005

- An exclusive chipping variety, Kufri Himsona, was released for hilly regions of India in 2007
### Quality requirements of potatoes for different forms of processed products

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Dehydrated</th>
<th>French fries</th>
<th>Chips</th>
<th>Canned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuber shape</td>
<td>Round to oval</td>
<td>Oblong</td>
<td>Round to oval</td>
<td>Round to oval</td>
</tr>
<tr>
<td>Tuber size, mm</td>
<td>30</td>
<td>&gt;75</td>
<td>45-80</td>
<td>20-35</td>
</tr>
<tr>
<td>Eyes</td>
<td>Shallow</td>
<td>Shallow</td>
<td>Shallow</td>
<td>Shallow</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>1.080</td>
<td>1.080</td>
<td>&gt; 1.080</td>
<td>&lt; 1.070</td>
</tr>
<tr>
<td>Dry matter, %</td>
<td>&gt;20</td>
<td>&gt;20</td>
<td>&gt;20</td>
<td>&lt;18</td>
</tr>
<tr>
<td>Reducing sugar (% fresh wt)</td>
<td>0.15</td>
<td>0.15</td>
<td>&lt; 0.1</td>
<td>0.5</td>
</tr>
<tr>
<td>After cooking discoloration</td>
<td>Slight</td>
<td>Slight</td>
<td>-</td>
<td>Nil</td>
</tr>
<tr>
<td>Texture</td>
<td>Fairly firm to mealy</td>
<td>Fairly firm</td>
<td>Fairly firm to mealy</td>
<td>Waxy</td>
</tr>
</tbody>
</table>
Desirable biochemical attributes for breeding processing varieties

Parents selected for breeding varieties should have following traits

- The dry matter should be >20% and reducing sugar content should be <0.1% on Fresh wt basis
- No enzymatic browning
- The glycoalkaloid content should be <20 mg/100 g Fresh wt
Salient features of Indian processing varieties

Kufri Chipsona-1

• Selection from the progeny of the cross CP 2416 x MS/78-79 made in 1990

• The plant has medium compact canopy with white flowers and the tubers are white cream, ovoid with shallow eyes and white flesh

• The variety is well adapted to north-Indian plains and has a maturity period of 90-110 days

• It has resistance to late blight and gives an average yield of 300-350 q/ha and possess very good storability
Salient features of Indian processing varieties

Kufri Chipsona-2

- Selection from the progeny of the cross CP 2346 (F-6 from Peru) x QB/B 92-4 made in 1991

- The plant has medium compact canopy with white flowers and the tubers are white cream, round with shallow eyes and creamy flesh

- The variety is well adapted to north-Indian plains and has a maturity period of 100-110 days. It is resistant to late blight and gives an average yield of 300-325 q/ha
Kufri Chipsona-3

- Selection from the progeny of the cross Kufri Chipsona-2 x MP/91-86 made in 1996

- The plant has medium compact canopy with white flowers and the tubers are yellow, ovoid with medium-deep eyes and creamy flesh

- The variety is well adapted to north-Indian plains and has a maturity period of 90-110 days. It is resistant to late blight and gives an average yield of 350-400 q/ha
Kufri Himsona

- Selection from the progeny of the cross MP/92-35 x Kufri Chipsona-2

- The plant has medium canopy with purple flowers and the tubers are white to creamy, round-oval with shallow eyes and cream pale yellow flesh

- The variety is adapted to hilly regions of the country and has a maturity period of 120-140 days

- It has field resistance to late blight and gives an average yield of 250 q/ha.
Features of French fry variety Kufri Frysona (MP/98-71)

- Total yield: 38.3 t/ha
- French fry grade yield: 19.8 t/ha
- Dry matter: 23.0%
- Excellent fry colour
- Very good storability at 10-12 °C with CIPC
Features of promising early maturing hybrid MP/01-916 (Kufri Chipsona-4)

- Higher total and processing grade yield
- Excellent chip colour
- High specific gravity (1.083) and dry matter (24.3%)
- Low level of reducing sugars (0.03%)
- Moderately resistant to late blight in comparison to popular variety Kufri Jyoti and exotic Atlantic
## Biochemical traits and suitability of Indian processing varieties

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Dry matter (%)</th>
<th>Reducing sugars (mg/100 g FW)</th>
<th>Suitability for Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kufri Chipsona-1</td>
<td>21-24</td>
<td>45-100</td>
<td>Chips, French fries, flakes, flour, dehydrated products</td>
</tr>
<tr>
<td>Kufri Chipsona-2</td>
<td>21-25</td>
<td>45-95</td>
<td>Chips, flakes, flour, dehydrated products</td>
</tr>
<tr>
<td>Kufri Chipsona-3</td>
<td>21-24</td>
<td>50-70</td>
<td>Chips, flakes, flour, dehydrated products</td>
</tr>
<tr>
<td>Kufri Himsona</td>
<td>22-26</td>
<td>45-65</td>
<td>Chips, flakes, flour, dehydrated products</td>
</tr>
<tr>
<td>Kufri Frysona</td>
<td>21-23</td>
<td>80-100</td>
<td>French Fries</td>
</tr>
</tbody>
</table>
Impact of Indian processing varieties

• The long pending demand of the industries was met as Indian processing varieties contained >21% dry matter and low reducing sugars (<0.1% on fresh wt)

• All these varieties are suitable for chips and dehydrated products

• Kufri Chipsona-1 due to its oval to oblong tuber shape is utilized both by the chipping and French fry industries

• These varieties have brought revolution in the Indian processing scenario within a span of 10 years
Future thrust

- Development of French fry varieties
- Development of cold chipping variety
- Development of early maturing chipping variety
Thanks