

# Spin-off Technologies from 2<sup>nd</sup> Generation Biofuel : Potential Game Changer for Up-Grading Cereal Straws and Stovers for Livestock Feed

## Rational

- Lignocellulosic biomass the most abundant renewable biomass on earth, yielding 10 to 50 Billion metric tons per annum
- High content of nutritive pentose and hexose sugars that 2<sup>nd</sup> generation biofuel technologies attempt to make more accessible, with billions of US\$ invested in research and development
- Livestock nutrition can leverage these investments to up-grade available lignocellulosic biomass for animal feed
- Livestock production and productivity would increase concomitantly with reduced feed costs and arable land and water requirements

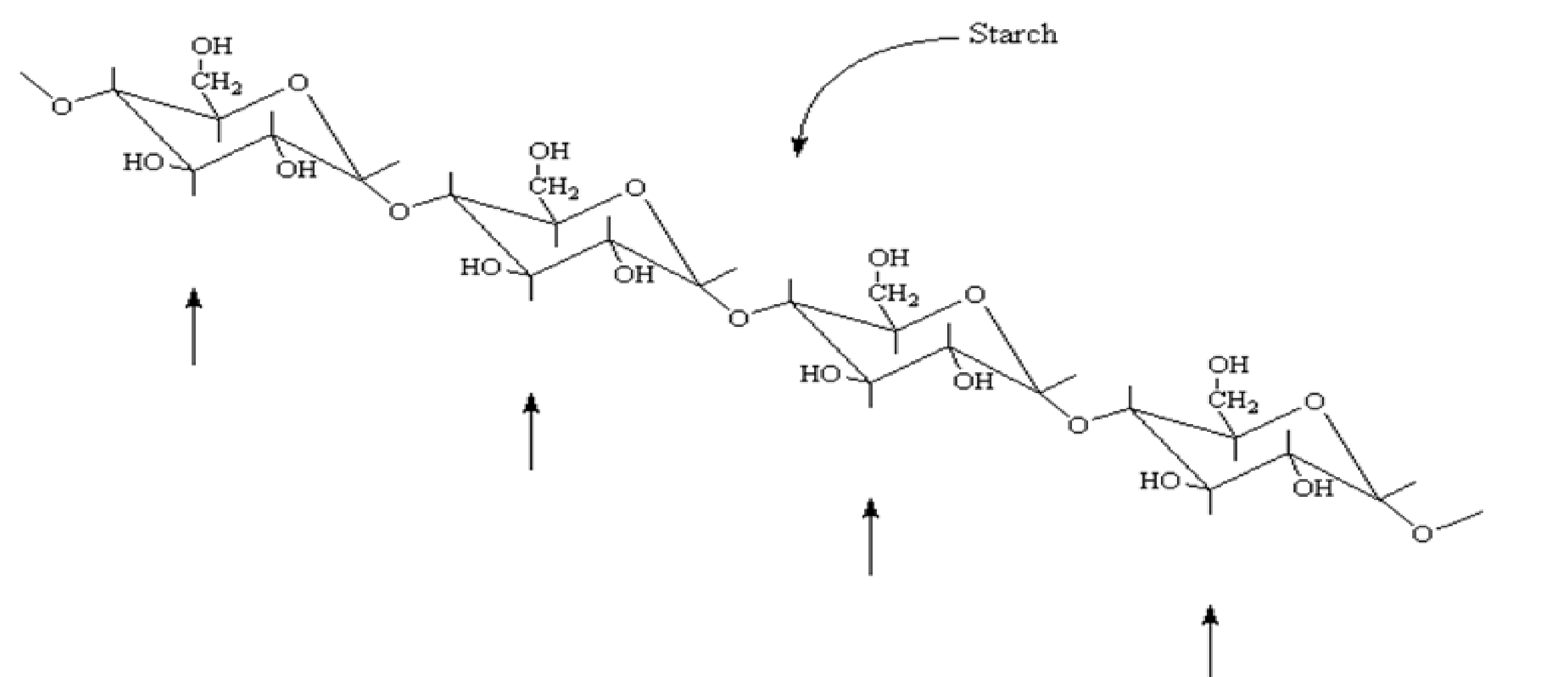
## Opportunities

Cellulose trapped in lignocellulose matrix:

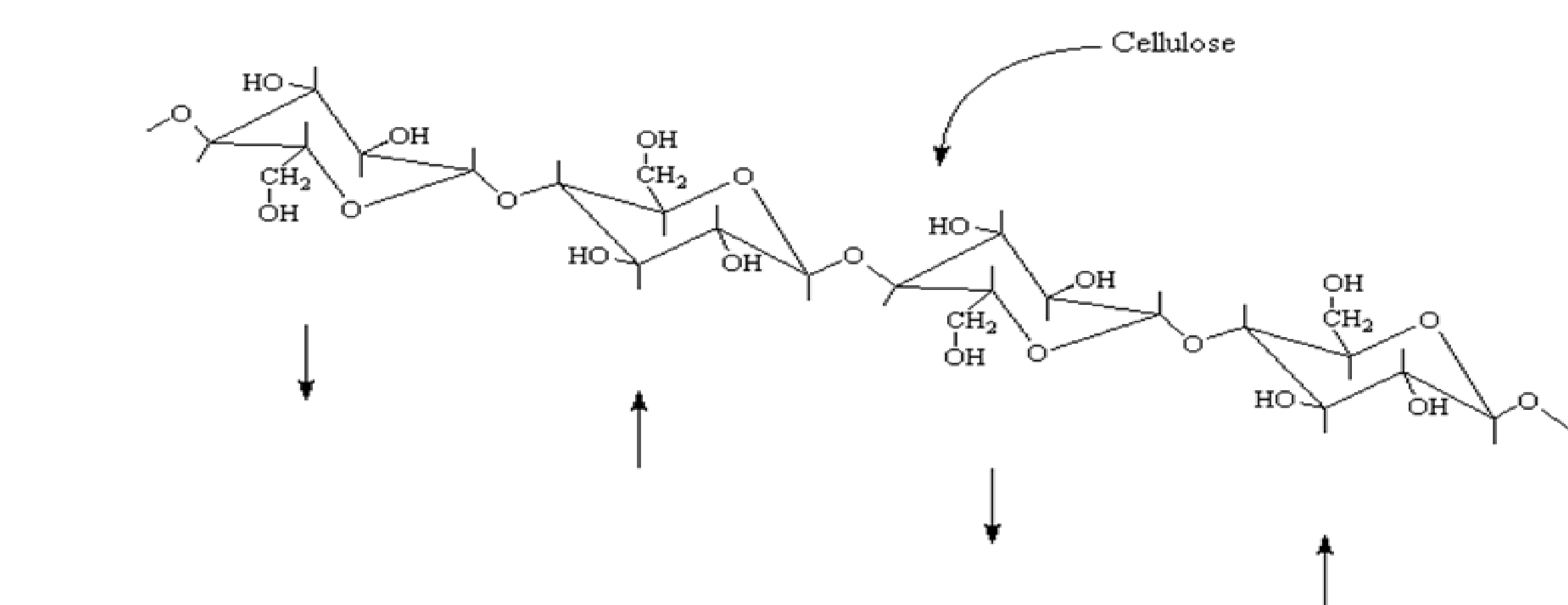
- Limits its accessibility to microbial enzymes resulting in reduced digestibility

Cellulose shares basic structure with starch:

- Bioavailability restricted by the  $\beta$ -glucosidic linkages



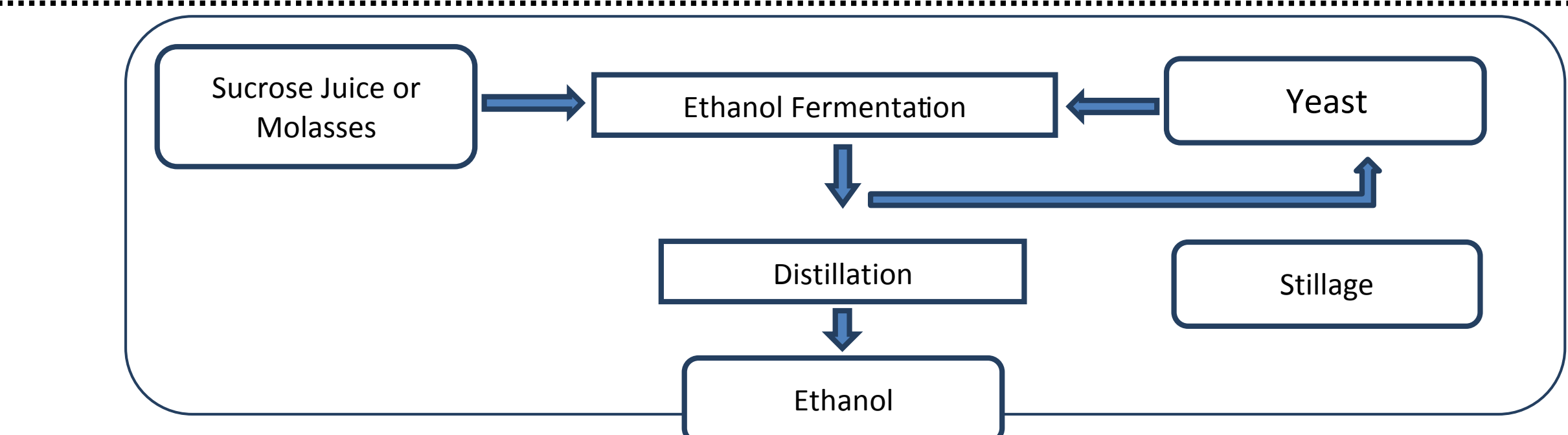
In starch, all the glucose repeat units are oriented in the same direction. But in cellulose, every other repeat unit is rotated 180 degrees around the axis of the backbone, relative to the previous repeat unit.



- Efficient harvest and collection of high volume-low density biomass
- Balance central versus decentralized approach
- Optimize physical form-transport-susceptibility to pre- treatment-voluntary feed intake

- Swell and disrupt hemicellulose-cellulose-lignin matrix
- Partially hydrolyze xylan structure
- Increase surface and porosity of fiber structure

- Unclear benefit for ruminant nutrition, more research with new enzymes/enzyme cocktails needed
- Demand/potential for monogastric nutrition
- "One pot" complete enzymatic conversions



Process steps in second generation bio-fuel technology of interest to livestock nutrition(Blümmel et al.,2014)

## Approaches

Three potential spin-off technologies investigated:

- Steam treatment (ST); Ammonia Fiber Expansion (AFEX) and; Two Chemical Combined Treatment (2CCT)

Lignocellulosic biomass investigated were:

- Rice and wheat straws and; maize, sorghum and pearl millet stovers.

Effects tested:

- *In vitro* gas production and true digestibility

## Results

All treatments had significant effects increasing *in vitro* digestibility.

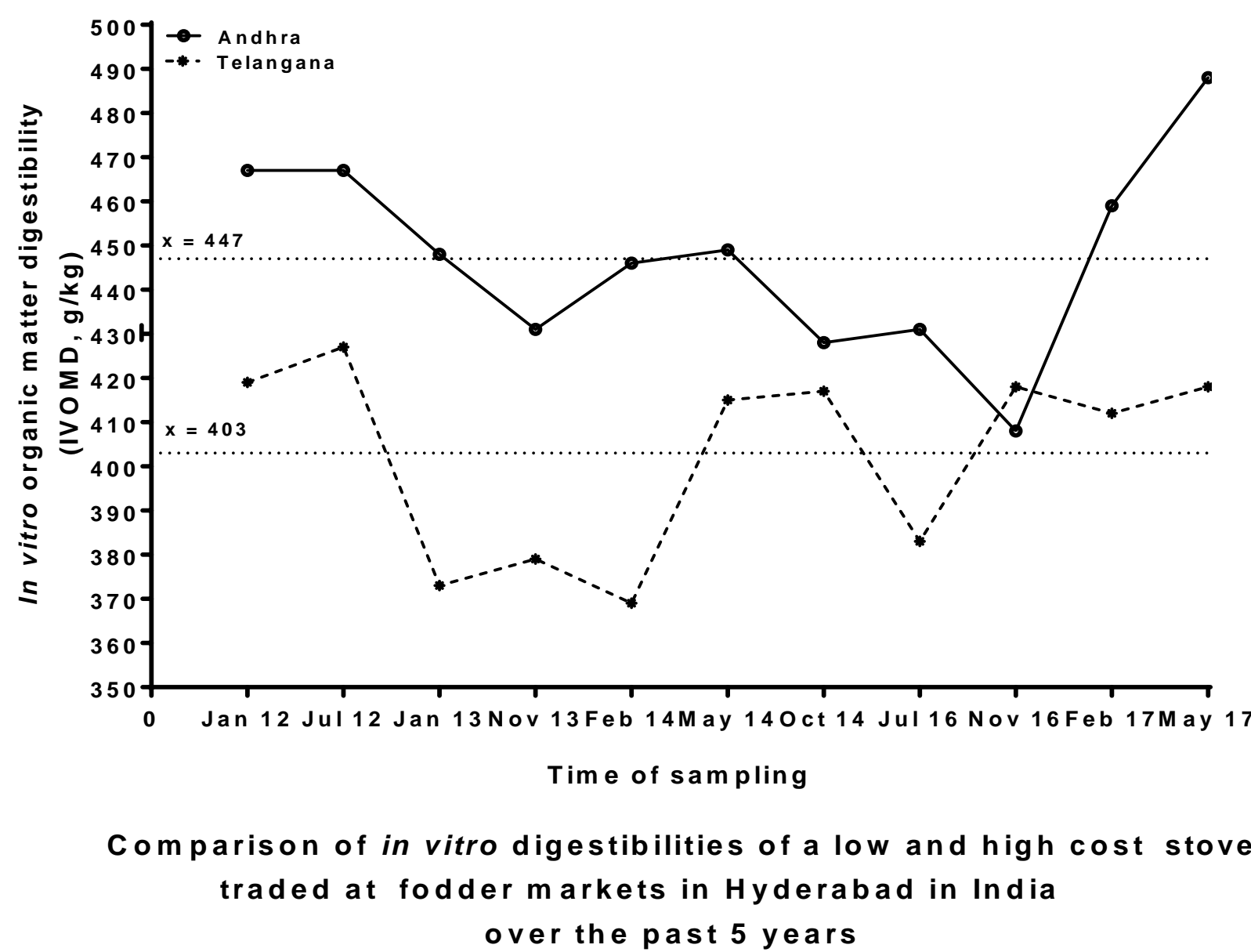
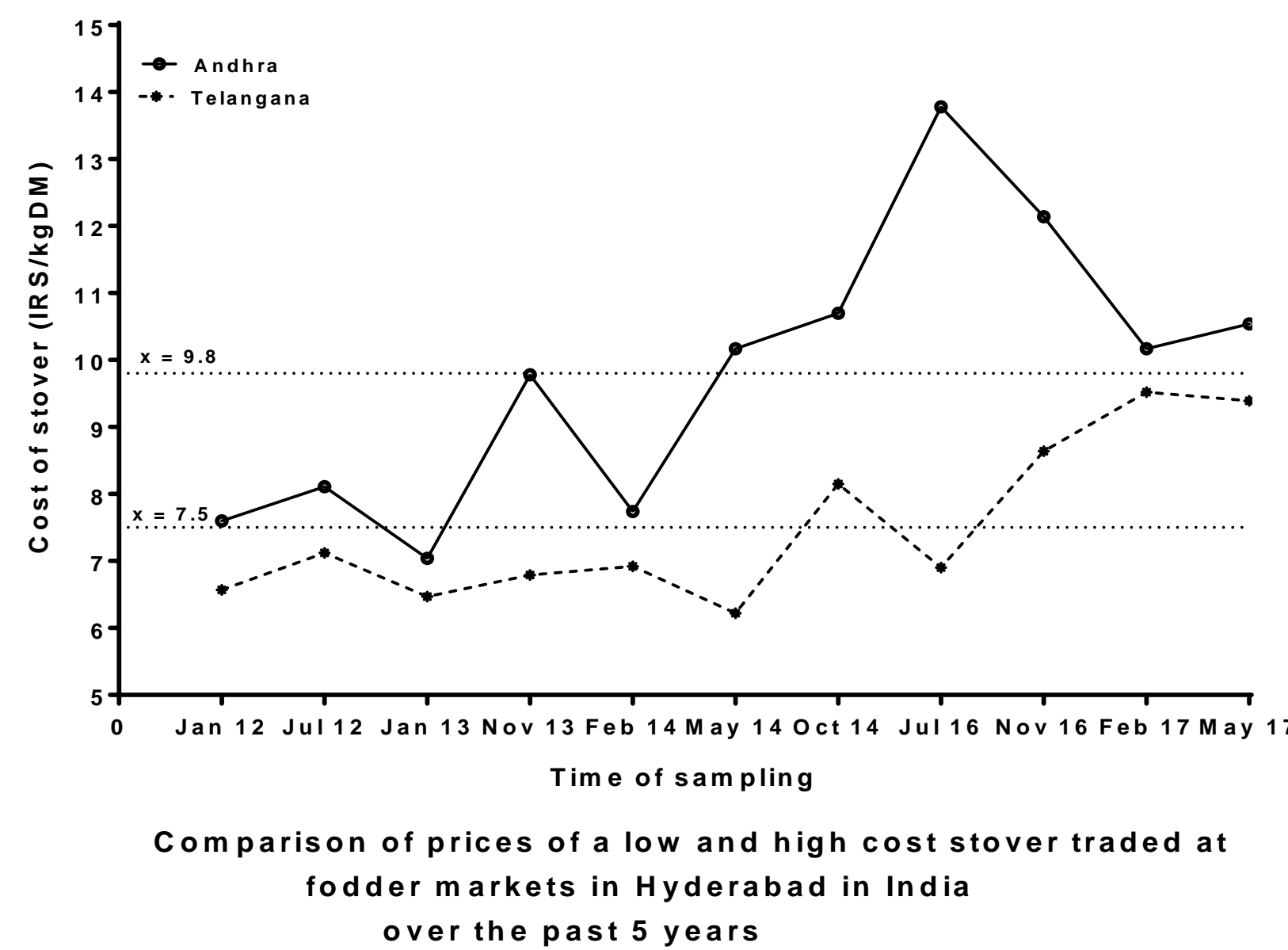
Greatest effect obtained by 2CCT which effectively turned crop residues into concentrates with *in vitro* true digestibilities of greater than 90% (Table 1).

Based on fodder market studies in India, cost benefit ratio is estimated at about 1:2.

Table 1: Summary of effects of steam, ammonia fiber expansion and 2CC treatment on *in vitro* gas production (GP) and true *in vitro* digestibility<sup>-1</sup> after 48 h of incubation.  
U = untreated; T = Treated

| Spin-off technology | n  | <i>In vitro</i> GP after 48 h (ml/200 mg) |      | True IVOMD after 48 h (%) |      |
|---------------------|----|-------------------------------------------|------|---------------------------|------|
|                     |    | U                                         | T    | U                         | T    |
| Steam Treatment     | 4  | 48.6                                      | 53.6 | 62.9                      | 71.8 |
| AFEX Treatment      | 10 | 42.9                                      | 51.5 | 65.1                      | 84.4 |
| 2CC Treatment       | 11 | 39.7                                      | 66.7 | 55.9                      | 94.1 |

<sup>-1</sup> The average difference between true and apparent IVOMD is about 12.9 percentage units



## References:

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- Blümmel, M, Steele, B., Dale, B. E., 2014a. Opportunities from second generation biofuel technologies for upgrading lignocellulosic biomass for livestock feed. CAB Reviews 9, No 041.
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## Conclusions and Outlook

- Very promising laboratory results and cost-benefit estimates
- Livestock productivity trials required: intake; food safety; animal health/welfare
- Explore decentralized pilot treatment units by small and medium enterprises
- More spin-off technologies, and their combinations, remain to be explored

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