

POLITECHNIKA KOSZALIŃSKA
WYDZIAŁ MECHANICZNY

Katedra Procesów i Urządzeń Przemysłu Spożywczego



Influence of chosen cereal raw materials on technical and technological aspects of the wort production

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Introduction

The beer can be produced with malted grains or with raw cereals. A long time ago for that purpose bread was applied.

Beer production is based on the extraction of soluble compounds from the malt and unmalted adjuncts. Obtained wort is later boiled with hops, after cooling and clarification wort undergoes fermentation.



Introduction

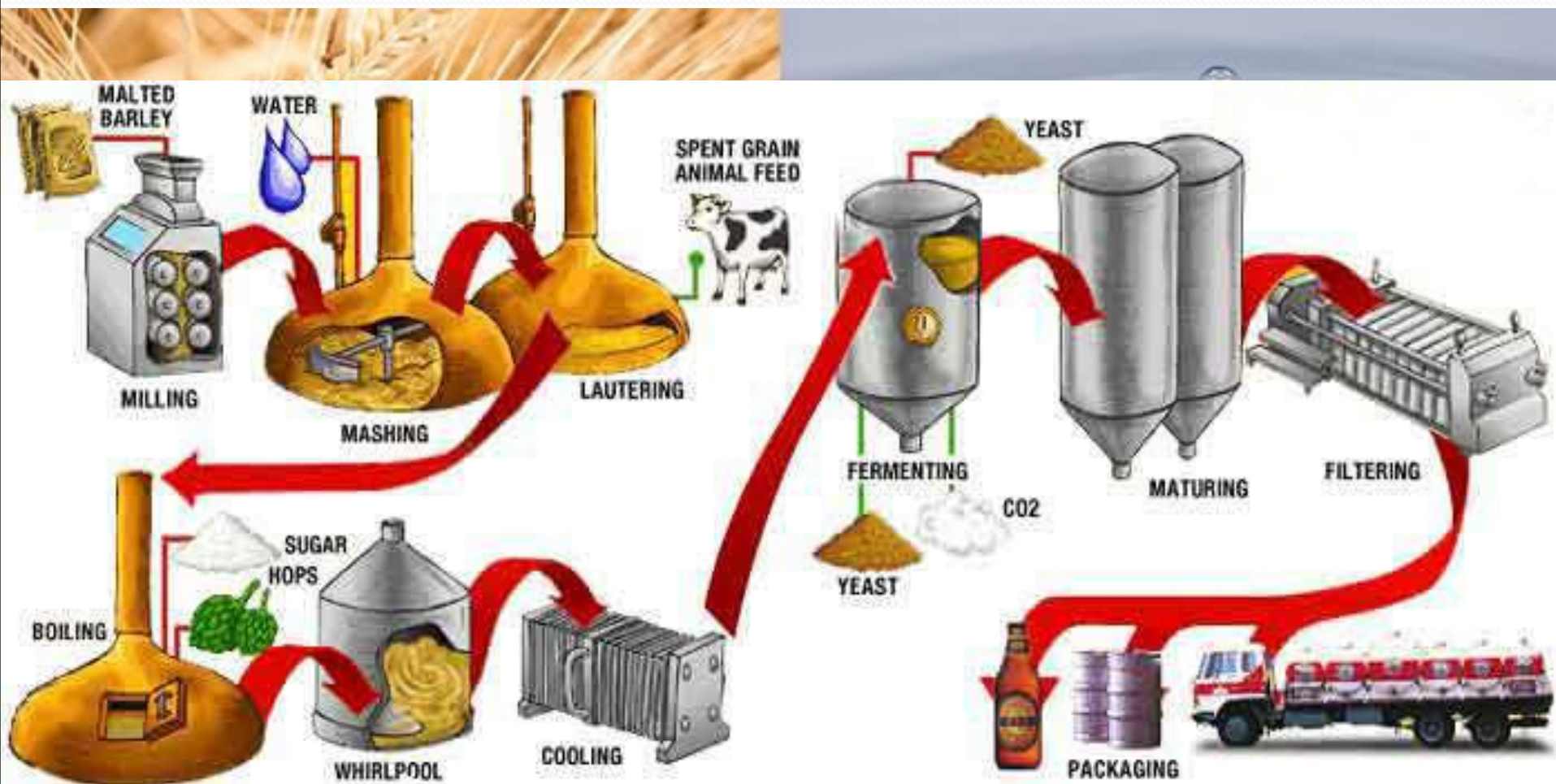
Addition of unmalted grains has mainly economic reason.

The unmalted cereal crops also give a possibility to create products with new, unusual taste.

Rice is used to make gluten-free beers for people with the coeliac disease.

Beers with the addition of fruit juices become more and more popular.

Flow chart of beer production



Cereals in beer production

Grains are a basic brewing raw material, because they deliver sugars, proteins, vitamins and the minerals essential for the fermentation.

With time various cultures adapted different cereal crops as their main raw material, so the technology of the beer manufacture varies.

Grains

Malted

Unmalted

Malt

Malting serves the purpose of converting insoluble starch to soluble starch, simplifying proteins, generating nutrients for yeast and the development of enzymes. The three main steps of the malting process are steeping, germination, and kilning.

The purpose of steeping is to evenly hydrate the endosperm in the raw barley kernel.

The malt's protein modification and enzyme content is set as the grain undergoes germination.



Sprouted malt is moved to the kiln to dry. This step arrests further modification of the kernel, influences the malt taste, aroma and color.

The malt style determines the temperature and length of the kilning and the roasting process to follow.

Malt



MALT - grain (such as barley) softened by steeping in water, allowed to germinate, and used especially in brewing; provides starch, proteins, fats, sugars, minerals and enzymes.

Base malts:

Pilsner

Pale ale

Dark malts:

Vienna

Munich

Brown

Caramel malts:

Dextrine

Light caramel

Medium caramel

Dark and very dark caramel

Specialty malts:

Wheat

Rye

Acidified

Smoked

Roasted malts:

Chocolate

Black

Cereal adjuncts

Adjuncts improve foam stability and prevent haze because they provide little to no soluble proteins and polyphenols.

Commonly term "adjunct" includes table sugar, honey, molasses, juices, and spices.

Adjuncts		
Milled products	Cereal	Syrups and sugars
Flours	Corn	Syrups
Grits	Rice	Sugars
Flakes	Barley	Sucrose
Torrified cereals	Wheat	Dextrose
Refined starches	Oats	Caramel
		Invert sugar

Cereal adjuncts

Malt replacements are classified as follows:

➤ Mash tun adjuncts:

✓ if $GT \leq T_{opt}$ β -amylase \rightarrow infusion mashing (e.g. barley adjunct),

✓ if $GT > T_{opt}$ β -amylase:

✪ pre - gelatinized starch (e.g. corn flakes, or micronized or torrified cereal),

✪ gelatinization of adjuncts with adjunct boiler.

➤ Copper adjuncts:

✓ sugar,

✓ syrup.

Barley

(H. vulgare L.)



Barley is the most important raw material for the beer production. Varieties with low gelatinization temperature are preferred.

- Addition of the unmalted barley should not exceed 50%:
 - ✓ To avoid lautering problems an infusion process starting at 50°C is applied and exogenous β -glucanases are added,
 - ✓ If the ratio of unmalted to malted barley exceeds of 50%, the addition of exogenous hydrolases, such as protease, α -amylase and β -glucanase, as well as separate mashing conditions are mandatory.
- Barley can be added in gelatinized form; the raw grain must be treated:
 - ✓ With IR light or microwave radiation in advance and then be milled or flaked,
 - ✓ Extrusion is alternative treatment, whereby the grain is gelatinized at pressures of 45 – 75 bar and temperatures of 120– 160°C.

Wheat

(Oryza sativa L.)



It is used in both malted and unmalted form.

- Bavarian beers are produced with the wheat malt.
- Belgian wheat beers contain as far as 50% of raw wheat grain supplementation.
- Technological aspects:
 - ✓ The wheat has low gelatinization temperature, can be added directly to the mashing.
 - ✓ It is possible to add wheat in a form of plain bakery flour.
 - ✓ Wheat as an adjunct improves the taste and elevates wort extract.
 - ✓ The roasted wheat more and more often becomes an alternative to the roasted malt as the source of the aroma and the color for dark beers.

Oats

(Avena sativa L.)



Malted and unmalted oats from most contemporary varieties are only of little use for beer production. Oats are known for their high contents of protein, fat and β -glucans.

- Worts made with the oat malt or unmalted oats have low extract, high protein content, higher viscosity and cloudiness.
 - ✓ Oats are usually supplemented at around 15%. It is possible to produce good quality beer with 40% addition without exogenous enzymes.
 - ✓ Manufacturing the beer with 100% unmalted oats is possible, carrying oat - typical taste and turbidity.
- Technological aspects:
 - ✓ Hammer mills must be applied.
 - ✓ Low efficiency of operation of: mixing up, pumping, mashing, wort boiling and cooling and of clarifying/filtrations.

Rye

(Secale cereale L.)



The rye is a cereal crop of North Europe.

- The malt from the rye is characterized by a very high viscosity - high content of pentosane.
- Beers made fully from rye malt or with the addition of the unmalted rye are characterized by cloudiness and have slightly sour/spicy taste.
- Technological aspects:
 - ✓ Wort aeration should be strictly avoided.
 - ✓ The rye absorbs the considerable amounts of water during mashing and provides a lot of β -glucans.
 - ✓ The rye can be added to the mash in both gelatinized and raw form.

Sorghum

(Sorghum bicolor L.)



Sorghum originates from Ethiopia and is traditional raw material for African beers. The grain has higher starch gelatinization temperature compared to barley.

- The use of whole grains significantly increase viscosity and requires heat-resistant α -amylase.
- Addition of 10-40% of raw sorghum results in viscosity drop, because of low β -glucan content.
- Technological aspects:
 - ✓ The filtration of wort with sorghum addition above the 40% requires filters.
 - ✓ No adverse effect on the fermentation was observed for up to 50% of sorghum substitution.
 - ✓ The addition above 25% lowers the stability of the foam.
 - ✓ Substitution of barley malt with the sorghum at 40% considerably lowers the content of gluten in the beer.

Maize

(Zea mays L.)



Traditionally used for the production of Chicha - beers from the Andes.

- Addition of corn grits improves wort filtration made from poorer barley malts.
- 40% substitution with corn grits requires exogenous hydrolytic enzymes for the fermentation.
- Technological aspects:
 - ✓ The grits contribute to lower the viscosity, improve filtration and clarification.
 - ✓ Wort with the addition of the maize has a lower content of soluble nitrogen and free amino acids.
 - ✓ The application of maize flakes shortens the mashing time significantly.
 - ✓ Grit's gelatinization takes place during mashing.
 - ✓ Corn contains considerable quantities of fat - removal of the germ is necessary.

Rice

(Oryza sativa L.)



Rice is excellent raw material for the gluten-free beer.

- It has the highest content of starch out of all cereals.
- Production of the rice malt is possible but requires selection of the parameters according to the variety of the rice.
- Full rice starch gelatinization requires the addition of CaCl_2 and the lactic acid.
- Wort is very bright.
- The rice as an adjunct:
 - ✓ It has a neutral taste, giving clean-tasting beer.
 - ✓ Rice for brewing is a by-product of the edible rice milling industry.
 - ✓ The rice starch swells greatly during the gelatinization and can lead to burns of the viscous paste.
 - ✓ Flaked rice has the advantage of being pre-gelatinized.

Buckwheat

(Fagopyrum esculentum M.)



The buckwheat is another essential raw material for producing gluten-free beer.

- Protein content is the highest of all raw materials.
- This pseudo-cereal does not contain gluten.
- Beer made purely with buckwheat malt requires enzyme supplementation.
- Buckwheat provides nut aftertaste in the beer.
- Technological aspects:
 - ✓ It is recommended to use no more than 40% of buckwheat malt.
 - ✓ The buckwheat can be added in the unmalted form.
 - ✓ The enzymatic content of buckwheat and its malt is significantly lower than that of barley malt.
 - ✓ Due to their very high viscosity, buckwheat congress wort and mash cannot be easily filtered.

Proso zwyczajne (*Panicum miliaceum* L.)



Milletts are significant crops in the semiarid tropics of Asia and Africa, with 97% of millet production in developing countries.

- It is used to make gluten-free beer.
- This cereal contains more proteins than the barley.
- The millet beer is darker than the barley beer and scores lower than both the sorghum and barley beers with tasters.
- Technological aspects:
 - ✓ Very high gelatinization temperature of starch: 75-78°C.
 - ✓ Average extract content from millet is low - loss in mashing efficiency.
 - ✓ Poor filtration - low β -glucanase content.
 - ✓ The soluble nitrogen is low - unsatisfactory flavor.
 - ✓ High content of the glucose in the wort- very fast fermentation.

Sugars, syrups and other adjuncts



Licorice root



Coriander



Cinnamon

Belgian Candi



Ginger



Hibiscus



Orange peel

Cukry:
Lactose,
Maltodextrin,
Rice sugar,
Corn syrup,
Maple syrup,
Honey.



Oak cubes



Conclusions

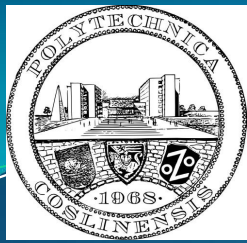
The higher proportion of adjuncts used in a mash the more difficult it is to achieve good extract recoveries. Wort viscosity is often increased, runoff is slowed and fermentability is reduced.

The addition of soluble sugars or syrups to the wort effectively increases the capacity of the brewhouse and provides a simple method for generating high-gravity worts and adjusting wort fermentability.

Fruit extracts and spices provide an easy way to expand market offer.

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