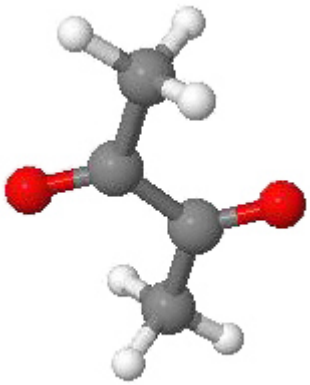
#1):-

– Diacetyl {Butane-2,3-dione} [$CH_3COCOCH_3$]



Diacetyl (a vicinal diketone) is a metabolic by-product of both yeast alcoholic (beer, wine, spirits) and malolactic fermentations (wine); it is also associated with spoilage microorganisms such as *Pediococcus* and *Lactobacilli*. Diacetyl is a volatile compound whose buttery character plays an important role in alcoholic beverages; the contribution of diacetyl to beverage quality is complex and is mainly dictated by its concentration and the concentration of other flavor volatiles.

***Typical descriptors*: Butter, butterscotch, movie popcorn, [nutty or toasty for wines] (also tactile; can confer "oiliness" or "slickness" on the palette.). When in excessive levels confers an overwhelmingly sickly sensation.**
***Typical Thresholds*: [Note: threshold values, in general, have been/were determined on certain "standard" beverages (often of lighter overall flavor intensity) and so values given here may not apply to your own style of beverage. Values should be taken as guidelines only. For distilled spirits there are widely scattered references to the topic though Scotch whisky still remains the best studied distilled beverage from a flavor standpoint.]**
Beer: Threshold varies with beer style but typically given as 80 ppb (parts per billion).
Wine: Detection threshold for diacetyl also varies according to wine style but is reported in the range from 0.2-2.8 mg per liter or parts per million (200-2800 ppb).
Whisky: with nosing, diacetyl has a reported detection threshold of 20 ppb, a recognition threshold of 40 ppb and, in tasting, recognition threshold is at about 200 ppb.

***Typical Diacetyl Levels in Beverages*: Beer: 8-600 ppb. An arguably desired flavor note in some English ales. A major flavor fault if detected in lagers and lighter (flavored) beers.**
Wine: Typical range of content (as mg per liter or ppm): White wines: 0.02-5.4 (20-5400 ppb): Red wines: traces. Diacetyl may attain to levels that produce a sweet buttery or butterscotch odor. Low concentrations in delicate wines constitute negative spoilage factor influences but higher concentrations can contribute a desirable complexity in more robust wines. Regarded in "spoiled" wines as an off-odor (at up to 7.5 mg per liter – 7500 ppb). Distilled spirits: No values immediately available for most spirit beverages (whisky

best studied) but we note that there is a (desirably?) rich buttery (toffee-sweet) character in some darker rums.

***Source*: Diacetyl is formed outside of the yeast cell. Its precursor (an intermediate in amino acid metabolism) is excreted into the surrounding medium (wort, wine) and is spontaneously converted to diacetyl. The reaction is enhanced by low pH and by increased temperature.**

***Comments: Control of diacetyl production*. During maturation of beer (or final stages of wine fermentation) yeast efficiently reduces diacetyl in the medium to less flavor active compounds including acetoin (with a much higher threshold value).**
Brewers: The amount of diacetyl produced depends upon fermentation conditions (wort nitrogen levels, pH and temperature). Careful control of brewing parameters can, therefore, attain a reduction in final levels of diacetyl. Limit the amount of precursor (alpha acetolactate) by operating at lower fermentation temperature, by ensuring good yeast growth (healthy yeast and nutrition) and by adequate aeration. Accelerate the conversion of precursor to diacetyl by performing a "diacetyl rest" at slightly elevated temperatures before cooling the fermented beer; if yeast are healthy and in sufficient concentration (numbers) diacetyl will be reduced. Bacterial contamination (*pediococcus* or *lactobacillus* species) can give rise to substantial amounts of diacetyl and lactic acid giving rise to a buttery sour-milk note to the beer; maintain hygiene standards and avoid contamination!
Winemakers: As for brewing, diacetyl is produced during fermentation (see controlling factors above). At issue though for wine is the action of spoilage lactic acid bacteria and lactic acid bacteria carrying out malolactic fermentation. Wines rarely contain excessive concentrations of diacetyl at the end of primary fermentation. Diacetyl production during malolactic fermentation may be up to three times the peak concentration found during alcoholic fermentation.
Distillers: Fermentation oxygen can influence spirit diacetyl content. [See also comments for brewers above.]

***Analytical Determination:* Simple odor filter test for diacetyl in beer. Spectrophotometric determination, following steam-distillation, can be used for total vicinal diketones which largely represent the diacetyl levels. Headspace Gas Chromatography, with electron capture detection, is the best method for determination (and discrimination) of diacetyl and related vicinal diketones. Testing can look at current (actual total) and potential levels (precursors present can be converted during beverage storage) of diacetyl.**

***References:* Please contact us for references to this topic and/or for advice on test kits available for training in determination and recognition of diacetyl and other flavor notes.**